

# Legal Traceability of Length for Electronic Distance Measurement Equipment

Procedure Manual

SIG/2013/505 Version 1.01



Queensland  
Government

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| Position                                  | Name               | Signature  | Date |
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| Director, Cadastral and Geodetic Services | Russell Priebsenow | (Original signed copy in departmental file CBD.041230) |      |

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Prepared by:

Cadastral and Geodetic Services, Land and Spatial Information  
Department of Natural Resources and Mines

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## About This Procedure Document

In accordance with Regulation 73 of *National Measurement Regulations 1999* (Cwlth), hereafter referred to as the National Measurement Regulations, in force under the *National Measurement Act 1960* (Cwlth), hereafter referred to as the Act, the Department of Natural Resources and Mines (DNRM), hereafter referred to as the department, is appointed as a Verifying Authority (VA) for the verification and re-verification of the physical quantity *length*. As a prerequisite for appointment as a Verifying Authority, the department is formally accredited by the National Association of Testing Authorities (NATA) for its technical competence in providing calibration services in accordance with the requirements of *AS ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories*, hereafter referred to as *ISO/IEC 17025* or the *ISO Standard*.

The department is committed to achieving a high standard of quality in all aspects of its Electronic Distance Measurement (EDM) baseline calibration and instrument comparison activities, in order to provide legal traceability of length for surveying EDM equipment (EDME). The department is also committed to maintaining its technical competency in these areas as per the requirements and procedures described in the *ISO/IEC 17025* and the relevant NATA documents.

This document is intended to be the first point of contact for all enquiries, information, policies or procedures regarding legal traceability of length for EDME (LTOLE) in Queensland. The focus of this document is to direct the reader to the required information through a logical hierarchy which is based on the ISO Standard.

This document details the overarching management system employed by the department for all policies and procedures pertaining to legal traceability of length; in particular EDM baseline calibrations and EDME comparisons in Queensland, by addressing all relevant criteria listed in *ISO/IEC 17025*. Sub-sections from *ISO/IEC 17025* not addressed in this document are deemed not applicable to the department's LTOLE service. This document shall, wherever possible, refer to other relevant documentation and sources to avoid duplication of technical or procedural content.

# 1. LTOLE Service Overview

The department assumes the responsibility for providing both the infrastructure and the means for surveyors to obtain legal traceability of length for their electronic distance measurement equipment, as required under the *Survey and Mapping Infrastructure Regulation 2014* (SMI Regulation). This responsibility requires the department to become a Verifying Authority, and this accreditation is made subject to the provisions of the National Measurement Regulations 1999 (Cwlth) (the National Measurement Regulations), in accordance with the *National Measurement Act 1960* (Cwlth) (the Act).

To maintain appointment as a Verifying Authority with the National Measurement Institute (NMI), the department is required to maintain sufficient competency in every facet of the chosen method for achieving LTOLE. To maintain competency, the department's LTOLE program is periodically assessed through scheduled auditing and review of the management system and personnel, conducted both externally by the National Association of Testing Authorities (NATA) and internally by the Calibration Management Section.

The method chosen to provide the means for LTOLE in Queensland is through the utilisation of EDM baselines. This method has proven to be most economical, efficient and suitable for use in Queensland and requires a Verifying Authority (the department) to verify the baselines used as subsidiary standards (or Reference Standards of Measurement). Verification is carried out by periodically calibrating these baselines via the approved method and procedures and then issuing Regulation 13 Certificates. Surveyors may perform an EDM instrument comparison over these verified baselines to achieve legal traceability of length.

The management of the department's legal traceability system is conducted mainly by the following department staff:

Quality Manager (Senior Spatial Information Officer, Geodesy & Positioning)

State EDM Calibration Officer (NATA and NMI signatory)

Regional EDM Calibration Officers (Authorised Officers/Surveyors).

The primary management component is located in Brisbane and consists of the Quality Manager (QM) and the State EDM Calibration Officer (SCO). To support the management section, Regional EDM Calibration Officers (RCO) are appointed where the EDM baselines are within their departmental region. Baselines within regions where there is no departmental surveyor stationed at the regional office will be allocated to the nearest RCO.

The system of management is designed to meet the criteria described in section 4 of the *ISO Standard (17025)*, which provides the minimum requirements for the competence of all testing and calibration laboratories in Australia. The majority of the relevant management and technical policies and procedures are detailed within **sections 4 and 5** of this document respectively.

For a graphical overview of the department's LTOLE documentation structure, refer to **Appendix A**.

## 2. Legislation

The department is recognised as lead agency for surveying in Queensland, and assumes the responsibility of providing LTOLE infrastructure and services to assist Queensland surveyors to comply with their obligations under the Survey and Mapping Infrastructure Regulation 2014.

To provide the means for Queensland surveyors to obtain legal traceability for EDME measurement, the department is required to maintain appointment as a Verifying Authority (VA) for length under provisions of the National Measurement Regulations 1999 in accordance with the *National Measurement Act 1960*.

### 2.1. Survey and Mapping Infrastructure Act & Regulations

One of the key purposes of the *Survey and Mapping Infrastructure Act 2003* (SMI Act) is to develop, maintain and improve the State survey and mapping infrastructure by means of making standards and guidelines for achieving an acceptable level of survey quality and integration.

It is for this purpose of the SMI Act that the department assumes the responsibility for providing and maintaining the necessary infrastructure (EDM baselines) and procedures that will allow surveyors to achieve LTOLE.

Under Section 20 of the SMI Regulation 2014, Queensland surveyors have an obligation to ensure that any survey equipment (or EDME) used for cadastral purposes is **standardised**. Refer to **section 9** of this document for definition of the term standardise.

### 2.2. National Measurement Act & Regulations

A key purpose of the *National Measurement Act 1960* (Cwlth) (the Act) is to establish a national system of units and standards of measurement of physical quantities.

For all legal metrology in Australia, any physical measurements carried out for a legal purpose (including measurements subject to regulations by law or government decree), are to be made in terms of the relevant legal units. The Act describes the Australian legal units of measurement to be the Standard International (SI) units, for which the SI unit for length is the metre.

The process by which the link between the physical measurement and the relevant standard (or SI unit) can be proven is known as traceability.

Regulation 73 of the National Measurement Regulations allows a person or entity to be appointed as a Verifying Authority. Appointment under Regulation 73 allows the Verifying Authority to determine Reference Standards of Measurement that are suitable to distribute the standard more economically, through issuing certificates under Regulation 13 of the National Measurement Regulations in accordance with the Act.

## 3. Verifying Authority Requirements

The department is required to be appointed as a Verifying Authority in order to assume responsibilities under the legislation outlined in **section 2**. As a result the department has developed policies and procedures to ensure that the department's LTOLE service in Queensland continues.

There are requirements specified by authorities such as NMI and NATA which the department must satisfy at scheduled intervals, in order to maintain appointment as a Verifying Authority. These requirements are based on a three year cycle of: assessment of competence, auditing of procedures and review of work activities.

### 3.1. Department Policy (SIG/2013/395) – Service for Legal Traceability

The focus of this department policy is the provision of a service that gives legal traceability of length to the national standard for distance measurements made using electronic distance measurement equipment (EDME).

#### Rationale

Section 20 of the Survey and Mapping Infrastructure Regulation 2014 requires surveyors to ensure that their equipment is standardised. The department therefore offers a service to enable surveyors to validate the traceability of their equipment to the national standard.

The service is based on the department being appointed as a Verifying Authority for length under the provisions of the *National Measurement Act 1960* (Cwlth).

The department is formally appointed as a Verifying Authority for length by the National Measurement Institute (NMI). As a prerequisite for appointment as a Verifying Authority, the department is assessed for its technical competence in providing calibration services by the National Association of Testing Authorities (NATA), in accordance with the requirements of *AS ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories*.

#### Policy

1. The department will maintain its appointment as a Verifying Authority for length with the National Measurement Institute.
2. The department will continue to provide and maintain the infrastructure and procedures that are necessary for the community to achieve legal traceability for their EDME.

This will be carried out through two services:

**a. Baseline Calibration**

The department will maintain certification of approved baselines, in accordance with Regulation 13 of the National Measurement Regulations.

The department may certify any approved non-departmental baselines and reserves the right to recover costs.

The department will respond accordingly to reported instability or disturbance to the monumentation of approved baselines.

**b. EDME Traceability**

The department will ensure that both the approved software and the recommended procedures are made available to the community for the purposes of achieving traceability of length for EDME.

## 3.2. National Measurement Institute (NMI)

Appointment as a Verifying Authority (VA) is given to an entity or person provided that certain criteria are met. Competency in the proposed area of verification must be proven before the Chief Metrologist of the NMI can grant an appointment as a VA.

Appointment as a VA lasts for a three year period, and only whilst the scope of appointment remains valid. Once this period is nearing expiry, the NMI should be contacted to obtain the forms required for reappointment as a VA. These forms need to be completed by the SCO and signed by the Director General of the department, or the appropriate delegate.

NMI appoints the person holding the position of Director-General of the department as the Verifying Authority for the verification of reference standards of measurement under Regulation 13 of the National Measurement Regulation. Under the *National Measurement Authorisation (NO 1) 2013*, the Director-General authorises any officer of the department who is accredited by NATA as an Authorised Signatory for the class of test 1.10.09 to sign Regulation 13 Certificates for that class of test on the Director-General's behalf. The SCO must be an Authorised Signatory for this class of test.

**Appendix E** Item 1 lists the link to the directory where the current appointment as a verifying authority is stored.

More information about the National Measurement Institute, including contacts, can be found on the NMI website listed in **Appendix E** Item 2.

## 3.3. National Association of Testing Authorities (NATA)

The department is required to be a member of NATA before appointment as a VA can be granted by NMI. Membership with NATA is on an annual basis, so long as the scope of accreditation remains valid, and the department must undertake periodical internal audits focused on maintaining competency in the performance of verification work.

External surveillance visits are performed by a representative of NATA and are scheduled every 18 months, alternating between technical visits and management visits. The technical visits will usually coincide with the NMI reappointment interval.

NATA requires that two department officers be listed as contacts; the Nominated Representative (manager) and the Laboratory Contact (technical officer). It is recommended that the Quality Manager should be the Nominated Representative and the SCO should be the Laboratory Contact.

The department's current scope of accreditation with NATA can be viewed on the NATA website by searching for a facility using the department's name or membership number (15032). The NATA website is listed **Appendix E** Item 3.

Contact information can be found on the NATA website and also in **Appendix E**.

## 4. Management Procedures

This section is intended to specify the management procedures set in place for all managerial activities relating to the department LTOLE service.

This management procedure section incorporates all relevant criteria addressed under section 4 of the *ISO Standard* as the minimum requirements for all calibration and testing laboratories in Australia.

### 4.1. Organisation

The facility through which the department provides the LTOLE service is Geodesy and Positioning (GAP), which is part of Cadastral and Geodetic Services within Land and Spatial Information (LSI). GAP is responsible for all quality management and technical operations. The regional offices are responsible for technical (field) assistance and support services.

Land and Spatial Information's function is to provide critical geospatial infrastructure supporting the management of the State's valuable resources. A key direction for Land and Spatial Information is to provide a service for legal traceability of length for EDM (LTOLE) in Queensland.

GAP maintains the responsibility of providing and managing the LTOLE service on behalf of the department, and has support from the regional offices that are located in various regions throughout Queensland.

As required in section 4.1 of the ISO Standard, the department is an organisation that can be held legally responsible for LTOLE activities and as such, the laboratory is required to carry out all activities in such a way as to meet the needs of customers, regulatory authorities and organisations providing recognition. In addition, all personnel involved with the LTOLE service are required to conduct their duties in accordance with these procedure documents, departmental policy and code of conduct in order to provide a quality service that is free from conflict of interest.

It is the responsibility of the Calibration Management Section to ensure that all officers performing duties within the LTOLE service are trained and have the required authority to carry out their duties. The management section shall also endeavour to minimise any potential departure from the management system or procedures by officers performing critical calibration activities, to ensure continuity of the LTOLE service.

All Authorised Officers and other departmental staff associated with the LTOLE service, regardless of their work area and/or activities, shall adhere to the department's *Fraud and Corruption Control Plan* and *HR Protocol - Declarations and Conflicts of Interest CHB/2013/733*.

The department has relieving procedures in place to ensure that critical services are continued in the event that a staff member is unavailable to carry out their designated duties.

The organisational structure of the department is available on the department intranet.

### 4.2. Management System

The calibration management system for LTOLE covers all EDM baselines, departmental regional offices (where authorised personnel are located) and the office where the management section is located.

Due to the wide distribution of EDM baselines across Queensland, the calibration management system is designed so that the management section can be based in Brisbane but still retain regional support for the EDM baselines and survey industry from nearby departmental regional offices. The management section appoints Regional Calibration Officers (RCO) from the regional offices to support the State Calibration Officer (SCO).

Refer to **the LTOLE webpage** for the contact details of departmental LTOLE officers. The link to this webpage is listed in **Appendix E** Item 4.

### 4.2.1. Calibration Management Section

The Calibration Management Section is comprised of the Quality Manager (QM) and the State EDM Calibration Officer (SCO) from GAP, and also the Regional Calibration Officers (RCO) from the corresponding departmental regional offices. This section is responsible for all matters relating to legal traceability of length for EDME service that is provided by the department.

The structure of the Calibration Management Section is designed so that the officers carrying out calibration activities have the necessary support and resources required to achieve a high standard of service.

Quality management is maintained by a GAP senior staff member, who is also the supervisor of the State EDM Calibration Officer. The technical operations (both field and office) and management activities are conducted by the Legal Traceability role (Surveyor). This role is known within the department as the State EDM Calibration Officer (SCO).

The technical and surveying industry support services are conducted by authorised personnel known as Regional Calibration Officers (RCO) of the Regional Service Delivery section operating within each regional office.

Within the Calibration Management Section, a deputy may be appointed by the Manager – Geodesy and Positioning, where required. Deputation of the role of State EDM Calibration Officer for the purpose of producing and signing Regulation 13 Certificates must only be made to a person who is listed as an authorised signatory with NMI and NATA.

**Section 8** lists the roles and responsibilities for all personnel involved with LTOLE activities.

The structure of the Calibration Management Section, as explained previously, is shown below in Figure 1: Calibration Management Structure.

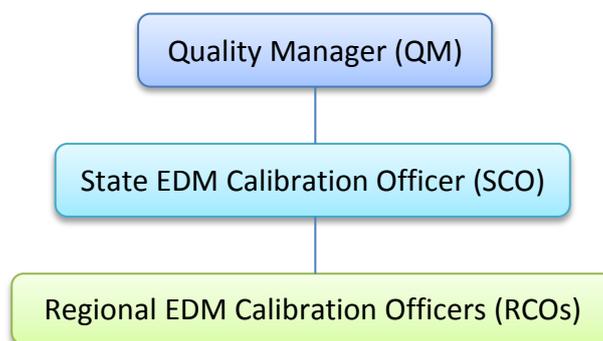


Figure 1: Calibration Management Structure

## 4.3. Document Control

Under the *Public Records Act 2002*, the department is required to document and record all work activities relating to the LTOLE service indefinitely.

For some areas of LTOLE, confidentiality must be upheld as the information could be sensitive to clients and surveyors, and therefore access must be controlled. This information includes, but is not exclusive to, EDME comparisons and calibrations, along with financial transactions and client contact details.

However, most of the documents and records generated within LTOLE are not access controlled. Such documents, like procedures and blank booking sheets, are intended for distribution among departmental and external surveyors to ensure that the most up to date procedures are implemented throughout the industry.

The SCO shall maintain a register of all documents that are controlled, and the level of control (or restriction level of access) applicable to those documents. In the event that these controlled documents are updated or changed, the SCO shall duly notify the relevant personnel of the update or change.

### **4.3.1. General**

The department has a policy in place to ensure documents are recorded according to specific standards. To view this policy, refer to the department's policy register for *Recordkeeping Policy IMP/2013/123*.

For all LTOLE activities, the facility shall comply with this policy and all those under **section 4.3** of this procedure document wherever possible. If an authorised officer is unable to employ this system then a similar system may be utilised upon approval by the QM.

Where required, the management of all documents associated with LTOLE management activities shall be carried out according to the departmental policy and procedure, Queensland Government information standards and legislative requirements.

#### **4.3.1.1. Hardcopy Documents**

In the context of paper-based document management, the department's recordkeeping policy operates in conjunction with recordkeeping policy and procedures given within the Information Policy Framework, Queensland Government Enterprise Architecture (QGEA). In this context refer to information standards *IS31 Retention and Disposal of Public Records*, *IS40 Recordkeeping* and the associated *Best Practice Guide to Recordkeeping*. These information standards are available on the Queensland Government Chief Information Office website <<http://qgcio.qld.gov.au>>.

All appropriate hardcopy documents and records relating to the management of LTOLE shall be filed under the departmental file *CBD.041230*, and the technical equivalent shall be filed under the departmental file *CBD.041242*. The hardcopy file location is with the SCO in Cadastral and Geodetic Services located on L9, Landcentre in Woolloongabba.

**Appendix B** contains a basic list of the LTOLE activities considered either technical or managerial.

All hardcopies are to be kept, either in the corresponding LTOLE departmental file or in the relevant LTOLE folder. Both of these hardcopy storage locations are maintained by and located with the SCO.

It is preferable that hardcopies be kept to a minimum, however hardcopies are mandatory for, but not exclusive to, any LTOLE document or record that:

- requires a signature by client and/or authorised personnel

- is an output from data processing software that contains marks, notes, initials or a signature as part of quality assurance and checks.
- is used to manually record field observations and data (i.e. booking sheets)

All hardcopy documents and records that relate to the above categories must also be converted into electronic format and stored under an appropriate shared file server directory. If deemed appropriate by the SCO or QM, these documents and records should also be stored in the departmental record keeping system (see **section 4.3.1.3**).

#### **4.3.1.2. Electronic Documents**

All electronic documents and records for LTOLE, either managerial or technical, are to be kept in an appropriate directory structure on a shared file server. This structure should accommodate for unambiguous version control and approval, for documents that require continual revision and updates (i.e. procedures). The directory structure on the shared server that is currently in place is described in **section 4.3.1.4**.

Authorised Officers shall refrain from using personal files or local drives on desktop computers as a file storage location for records of LTOLE activities.

If any documents or records requiring hardcopy storage and archival as outlined in **section 4.3.1.1** are in electronic format only, they must also be produced in hardcopy and stored according to the requirements specified in that section.

#### **4.3.1.3. Departmental Record Keeping System**

The department maintains a record keeping system that should be utilised where appropriate to ensure that critical documents and records are kept indefinitely. Where appropriate, all authorised officers should consider using the departmental record keeping system for important documents and records.

Any documents or records stored in the departmental record keeping system must be named and stored appropriately so that duplication of names is avoided.

#### **4.3.1.4. LTOLE Shared Server Directory**

The departmental shared servers provide adequate backup of documents and records to ensure that historical information is retained and can be recovered if corrupted or tampered with. The shared servers can also provide access restrictions to unauthorised staff and should be utilised when dealing with controlled documents.

The directory currently used by the management section for all LTOLE management and technical activities is listed in **Appendix E** Item 6.

Only officers within the Geodesy and Positioning section have access to this directory, and the administration of files within this directory shall remain the responsibility of the SCO. Documents stored in this directory may be made temporarily available by the SCO, at the request of an RCO.

#### **4.3.1.5. Emails and other Correspondence**

Emails and other electronic correspondence may be stored in the relevant officer's personal email folder. Consideration should be given as to whether emails should be stored on the shared server directory and the departmental record keeping system. If desired, hardcopies may be produced and filed appropriately.

The department has a policy for email record keeping which can be viewed on the department policy register using the reference: *Recordkeeping – Email Policy and Procedure IMP/2013/125*.

#### **4.3.1.6. Departmental Website for LTOLE**

The department has a designated website for LTOLE. This website should be continually updated with all the required information, software and documents that are intended to be distributed externally to the department.

The website address for LTOLE is listed in **Appendix E** Item 4.

Any updates or changes to this website are to be authorised, carried out and approved in a manner similar to that of document approval and document changes specified in the following **sections 4.3.2** and **4.3.3** respectively.

### **4.3.2. Document Approval and Issue**

All changes to LTOLE policy and procedure documents are to be proposed by the SCO and authorised by the QM. Once the proposed changes are authorised the SCO may undertake the proposed changes. Changes should be made according to **section 4.3.3** and require approval prior to being released.

To issue or release a policy document, it must be approved by the Director of Cadastral and Geodetic Services or another authorised delegate, and then submitted to the GAP administration staff to be uploaded onto the departmental policy register and the appropriate LTOLE webpage on the department's website.

When issuing authorised procedure documents, they must be approved by the Director of Cadastral and Geodetic Services or another authorised delegate, and then uploaded onto the appropriate LTOLE webpage on the departmental website.

The LTOLE Master Document List spreadsheet lists all current and relevant documents used for the LTOLE service and should be used to control document approval and issue. See **Appendix E** Item 5 for the location of this file.

Documents that have been superseded are to be marked accordingly using a watermark or similar effect. These documents are to be immediately removed from current or working directories and archived.

### **4.3.3. Document Changes**

Changes to LTOLE documentation shall be carried out by the SCO only, and authorised by the Quality Manager. Updates and modifications may be reviewed by other Authorised Officers within the Calibration Management Section or the Cadastral and Geodetic Services team.

Modifications and updates should be made to the current electronic version of the document stored in the shared server directory, and immediately saved as a draft in the relevant directory. It is recommended that 'track changes' be used while making changes to a document to provide a history of the revisions made.

The updated documents with track changes should be provided to the administration staff within the GAP section for proof reading and then be handed to the relevant approving officer prior to being released or issued. Once the updated document has been released or issued, it becomes "current" and is to be stored accordingly in the shared server directory. The preceding version now becomes a superseded version, labelled with an appropriate watermark and archived accordingly in the relevant directory for that document.

The draft version including track changes shall be retained as a record of the changes made. This document should include the word "draft" as a watermark and also in the file name. Drafts must then be stored with the superseded versions once the update has been approved. The insertion of comments into a draft is encouraged so that the reasons for the changes are clear.

Hand written notes on hardcopies are acceptable; however the use of these should be kept to a minimum and should only be used while the SCO is in the field or otherwise unable to access the electronic version. Handwritten notes must be transferred into the electronic draft document as soon as practicable.

Authorised Officers are required to make a note of any changes, modifications or comments they feel are necessary, and refer this to the SCO for action.

The LTOLE Master Document List (see **Appendix E** Item 5) has the provision to record general descriptions of the changes made to LTOLE documents and shall also be used in conjunction with a track changes draft copy to record the changes made.

## **4.4. Requests, Tenders and Contracts**

Requests for tender and contracts relating to LTOLE shall be the responsibility of the SCO and if needed, approval should be sought from the QM or other officer with the required financial delegation level.

The department's policy and procedure listed within **section 4.6** shall be employed when receiving or issuing any requests for tender or contracts.

### **4.4.1. Issuing Requests for Tender or Contracts**

A request for tender may be issued for:

- calibrating the EDM baseline calibration equipment (i.e. EDM instrument and meteorological equipment)
- purchasing new equipment.

The department does not outsource EDM baseline calibration work and therefore does not issue a request for tender for EDM baseline calibrations.

## 4.4.2. Receiving Requests for Tender

Traditionally, the department receives very few requests for tender or contracts regarding LTOLE. However, if this occurs, the SCO is responsible for the administration of requests for tender and contracts. Any request for tender or contract received by the SCO must have specific details as to the extent and type of work to be carried out, along with any conditions that may affect the methodology or results of calibration work.

Typically, once every two years, the Northern Territory Government issues a contract to calibrate their EDM baselines. This has been carried out by the department for the last decade and has proven to be mutually beneficial. The SCO is required to contact the relevant officer or any client for whom the department has performed EDM baseline calibrations, and notify them of any Regulation 13 Certificates that are nearing expiry and offer to perform calibration work to renew these certificates.

If a request for tender or contract is received, the SCO shall respond to the request for tender or contract, addressing at minimum, the following criteria:

- The response to the request for tender is given using an official departmental letterhead and in a professional format.
- The criteria/terms of the request for tender or contract is clearly addressed and acceptable to both the department and the vendor.
- The facility (or laboratory) has sufficient resources and personnel to carry out the request for tender or contract.
- The methods to be employed are adequately described, are suitable for use and will meet the specified requirements within a designated timeframe.
- The pricing is fair and reasonable, and in line with relevant departmental policies as not to compete with the private sector.
- Any deviations from the work that has been agreed to by all affected parties through the request for tender or contract must be corrected following **section 4.11**, unless the deviations have been specifically requested for change and approved in writing by all affected parties.

## 4.4.3. Review of Requests for Tender or Contracts

Periodically, and upon the issue or response to a request for tender or entering into any contract, the SCO shall review the above procedure to ensure that a satisfactory outcome is achieved for both clients and the department, by addressing the following criteria:

- Can / should the department continue to deal with tenders/contracts and requests?
- Does the department have the capability and resources to meet the requirements of recent and potential requests/tenders and contracts?
- Has the department received useful feedback and what are the implications of this feedback?
- Is the department's procedure for issuing and receiving requests/tenders and contracts still suitable?
- Is there anybody or party that is affected (and what are those effects), if the department continues to carry out requests/tenders or contracts?

## 4.5. Subcontracting of Tests and Calibrations

The department does not subcontract LTOLE work and therefore should not enter contracts relating to LTOLE activities that the department itself is unable to perform.

## 4.6. Purchasing of Services and Supplies

The department's procurement policy and procurement procedures must be followed when purchasing supplies or services, and are available on the department's intranet. In accordance with departmental policy, equipment or items that are over a pre-determined value are listed on the departmental asset register. Any items or equipment on this asset register will have an agreed lifespan after which they will be due to be replaced. The LTOLE scientific equipment on the asset register is the EDM instrument and the meteorological instruments.

A list of all the current equipment used for EDM baseline calibrations and the calibration history of this equipment can be found in the LTOLE Equipment Calibration History spreadsheet and the LTOLE Field Equipment Checklist. Both of these documents can be accessed via the link to the LTOLE Master Document List as per **Appendix E** Item 5.

All service providers and suppliers are to be evaluated as per the requirements of the ISO Standard. These evaluations should be kept in the LTOLE Actions Register spreadsheet, the link for which can be found via the LTOLE Master Document List as per **Appendix E** Item 5.

The following sections outline the minimum requirements for instruments used. It is expected that instruments meeting these minimum requirements will also meet the Estimated Measurement Uncertainty (EMU) as part of the scope of accreditation. If instruments do not meet these requirements and if any change of instrumentation occurs, reassessment of the least uncertainty in the EMU is required.

See **section 5.4.6** for more information on the EMU.

### 4.6.1. EDM Baseline Calibration Instrument Requirements

When purchasing a new EDM calibration instrument to be used for the calibration of EDM baselines, the following minimum requirements must be satisfied:

#### Angle Measurement:

Accuracy (standard deviation, *ISO 17123-4*) 1"

#### Distance Measurement:

Range (average atmospheric conditions) 2000 m

Accuracy (standard deviation, *ISO 17123-4*)  $\pm (1 + 1 \times 10^{-3} \times L)$  mm Where L is length in m <sup>1</sup>

Display resolution: 0.1 mm

#### Data storage

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<sup>1</sup> Survey EDM manufacturers may still refer to the accuracy scale component as Parts per Million (PPM). I.E 1mm + 1PPM

Internal memory:  
External memory:

Capacity > 512 MB  
Removable storage card of capacity > 512 MB

The department requires the most precise equipment to remain competitive in providing distances of the highest accuracy and quality available. Consideration must be given to the data output formats of any equipment purchased to ensure that it is easily compatible with any reduction software used within departmental LTOLE technical procedures. New or serviced EDM must be verified (calibrated) by the appropriate Verifying Authority, prior to being used for LTOLE activities (i.e. EDM baseline calibration).

## 4.6.2. Meteorological Equipment Requirements

In past years the instruments selected required an additional officer to assist when taking the remote meteorological observations. All new equipment purchased should now have the functionality to observe all required meteorological observations and log these observations to on-board memory which can then be downloaded after field observations are completed. This method reduces the chances of transcription and reading errors during the field observation process.

The minimum precision requirements for the meteorological instruments are listed below:

**Temperature** must be observed to a precision of  $\pm 0.1^\circ \text{C}$  or better.

**Pressure** must be observed to a precision of  $\pm 0.5 \text{ hPa}$  or better.

**Relative Humidity** must be observed to a precision of  $\pm 3 \%$  or better.

**Observation rate** must allow for observations to be recorded at least every 30 seconds.

**Connectivity** of device to PC should accommodate USB and/or serial.

**Data storage** should be internal or alternatively an external SD card and at least 128MB.

All new or serviced meteorological equipment must be verified (calibrated) by the appropriate Verifying Authority, prior to being used for LTOLE activities (i.e. EDM baseline calibrations).

## 4.6.3. Equipment Calibration & Supplier Evaluation Procedures

As per the procedure laid out in this document, prior to conducting the field work for calibrating an EDM baseline, the EDM baseline calibration instrument and meteorological equipment must be calibrated and certified to achieve traceability for the measurements. Prior to sending the equipment to the certification authorities, the State Calibration Officer must verify that each of the nominated certification authorities are a NATA accredited facility/laboratory for the required fields of calibration.

For EDM baseline calibrations the electronic distance measuring equipment (EDME) must have observations that are traceable to the national standard. Traceability can only be acquired for the department's EDM baseline calibration instrument through calibration by the National Measurement Institute. The meteorological effects of temperature and pressure on the distance are significant enough that traceability is also required for temperature and pressure. Due to the minimal effect of relative humidity on distance, it is preferable but not essential for relative humidity to also have traceability.

In order to verify the repeatability of the calibration results provided by the relevant certification authority, comparisons should be made between the latest results and the previous results tabulated in the Equipment Calibrations History document which is available via the LTOLE Master

Document List as per **Appendix E** Item 5. This calibration history file should be updated by the SCO to monitor the results received from external calibration authorities.

If significant changes (i.e. changes greater than 10%) have been detected in the calibration constants or precision of those constants, efforts must be undertaken to verify the correctness of the calibration results with the calibration authority. In the event that the calibration results are shown to be correct (i.e. there are significant changes) and/or it can be proven that the equipment is malfunctioning, the faulty equipment must be replaced with new equipment, which in turn must be calibrated and certified prior to commencing field calibration work.

Refer to **Appendix C** for a list of the suppliers chosen in the past to undertake the calibration of the EDM Baseline calibration equipment.

## 4.7. Service to the Customer

The department is committed to achieving a high standard of quality in all aspects of its electronic distance measurement (EDM) baseline calibration and instrument comparison in order to provide legal traceability of length for surveying EDM equipment (EDME).

As a result the department shall, where possible, actively seek feedback from customers and clients so that the Calibration Management Section can be notified of any issues that may affect the quality of service provided.

Opportunity for feedback should be provided directly to the Calibration Management Section via the contact information on the departmental website. See **Appendix E** Item 4.

The SCO and RCO are responsible for addressing any feedback that has been submitted by customers to the department regarding the LTOLE service. The SCO is required to maintain a register of the feedback received and the responses given. The feedback register is included in the LTOLE Actions Register which can be located via **Appendix E** Item 5.

## 4.8. Complaints Management

All complaints relating to the LTOLE service shall be dealt with according to the departmental Complaints Management Framework CHB/2016/1982 which is available on the department intranet.

Complaints arise when members of the public are dissatisfied with the service provided by departmental representatives. Requests for information or questions relating to normal service requests made by the public to departmental representatives are not complaints, but these could escalate into a complaint if the question or problem is not resolved in a suitable time after initial contact.

Normal requests for EDME baseline information or requests for the EDME comparison service are primarily received by regional calibration officers. The most likely causes for complaints arising from LTOLE activities are usually of a technical nature arising from private sector surveyors:

1. Having difficulty getting an instrument to pass statistical tests for an EDME comparison.
2. Suspicious of movement and/or disturbance to the monuments of an EDM Baseline.

It is the responsibility of the Regional Calibration Officers to deal with complaints initially. If the cause of any complaint can be resolved by the RCO receiving the complaint, then the SCO should be

notified and approve of the response before corrective action is carried out by the RCO. Otherwise the complaint must be forwarded on to the SCO and any response must be approved by the Quality Manager before corrective action is carried out. All timeframes are as per the above mentioned policy and procedure. If the complaint cannot be resolved informally by the regional calibration officer or the SCO at the time of initial contact, then the matter may be formally recorded as a complaint.

Complaints can be formally submitted using any of the methods defined in the departmental procedure *Complaints Management Policy and Procedure*. If any complaint is not of a technical nature but is instead concerning the conduct of any departmental staff, then the complaint should be formally lodged as per departmental procedure. These complaints will be recorded into the departmental Ministerial and Executive Correspondence System (MECS) and be elevated to the appropriate division or region for assessment, resolution and response.

The SCO shall always be notified and involved in the complaint process for all LTOLE complaints, and as such shall be responsible for keeping a special register of complaints and the corrective actions taken. The latest version of the comments and feedback form can also be used as a method to capture technical feedback generated by surveyors utilising departmental LTOLE resources.

## 4.9. Control of Nonconforming Calibration Work

The SCO must be notified of any incorrect or nonconforming calibration work immediately. It is the responsibility of the SCO to ensure that anyone who is potentially affected by any incorrect or nonconforming work is notified, so that all stakeholders are aware of the nonconformity. Should such instances occur, notification shall be via any or all of the following mediums that is deemed appropriate by the QM and SCO.

1. Departmental Survey Alerts
2. Relevant department webpages
3. Email to RCOs and forwarded to their external surveyor / town group email addresses.

The appropriate corrective action must be implemented to undo any harm or adverse effects caused by the nonconforming work. Preventative actions can then be taken to ensure that the incorrect or nonconforming work is not repeated in the future. The SCO shall also maintain a register of any nonconforming calibration work and the action taken in response. This register can be located via the LTOLE Master Document List as per **Appendix E** Item 5.

Below is an outline of the procedure that should be followed in the event that incorrect or nonconforming calibration work is detected.

### 4.9.1. Disturbed and/or Moving Baseline Monuments

1. The person who initially detects or suspects the movement or disturbance must immediately report this to the SCO, either directly or to an RCO or other departmental surveyor who in turn will inform the SCO.
2. The SCO should notify all relevant personnel (internal and external surveyors) of the suspected movement or disturbance of the baseline. See **section 4.9** above for the mediums to be used for this type of notification.

3. The SCO and the RCO responsible for the disturbed baseline shall determine the extent of the disturbance or movement of the baseline monument/s through physical measurement of the baseline.
  - a. If nonconforming calibration work is confirmed then the SCO will follow through the following steps. If not then the SCO shall inform the person who initially suspected disturbance and other relevant personnel of the result of investigation and update the register.
4. SCO must notify affected persons (including the QM and appropriate RCO) and determine the magnitude of the nonconformity. The department's webpage for LTOLE must also be updated to warn surveyors of the confirmed nonconformity.
  - a. If required, the SCO may need to void any certificates (or reports) that have been rendered invalid as a result of the nonconformity
5. SCO is to establish the corrective action required and suitable timeframe<sup>2</sup>
  - a. QM to approve the corrective action and timeframe
6. SCO is to implement the corrective action
  - a. This may include the re-issuing of calibration certificates and/or comparison reports at no cost to affected persons and/or customers
7. SCO must then take preventative action to ensure that the nonconformity does not reoccur<sup>3</sup>
  - a. Preventative actions must also be approved by the QM.
8. If a serious non-conformance occurs in calibration work, the QM will initiate and oversee an internal audit of the work activities in which the nonconformity was involved in order to derive its origin, cause and effects.
  - a. Additional corrective and preventative action resulting from the internal audit may need to be addressed by the SCO and approved by the QM within a suitable timeframe.
9. The SCO must update the corrective and preventative actions register
  - a. The internal audit, if carried out, must be filed appropriately according to **section 4.3**

The SCO and QM must then review the nonconformity, the corrective and preventative action (including the internal audit if carried out), and assess the suitability of this procedure for dealing with nonconforming calibration work.

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<sup>2</sup> According to **section 4.11**

<sup>3</sup> According to **section 4.12**

## **4.10. Improvement**

The department is committed to achieving a high standard of quality in all aspects of its electronic distance measurement (EDM) baseline calibration and instrument comparison activities through scheduled quality management activities.

### **4.10.1. Quality Management**

The department employs a quality management system to ensure that the LTOLE service is of the highest standard. The quality management system includes:

- Document reviews
- Management reviews
- Internal and External Audits
- Analysis of calibrations results (of baselines, EDME and calibration instruments)
- Corrective and Preventative Action
- Quality assurance, including the “Combined Run” Calibration Methodology
- Pre-tour and Post-tour Instrument checks on the primary baseline

These areas of quality management are described in more detail in the relevant sections of this document.

## **4.11. Corrective Action**

The Calibration Management Section is responsible for carrying out and overseeing the corrective actions undertaken when either nonconforming calibration work or a departure from departmental procedures are identified. The SCO shall ensure that the Corrective and Preventative Actions Register is updated as required, and can be accessed via LTOLE Master Document List as per **Appendix E** Item 5.

The following sub-sections outline the requirements and procedure for establishing the corrective action for any nonconformity or deviation from departmental policy or procedure.

### **4.11.1. General**

The corrective action is to be determined and carried out by the SCO with support from any RCO (or other personnel) involved with the nonconformity. The QM must oversee and authorise the proposed corrective action and specify an appropriate timeframe to complete the corrective action.

### **4.11.2. Cause Analysis**

The SCO shall investigate the cause of the nonconformity (or deviation from policy or procedures). As the cause of nonconformity is often difficult to determine, the SCO must analyse all possible

aspects of the work that was carried out that led to the non-conformance. This may require any of the methods listed below.

**Possible methods to find the cause of nonconformity:**

- Physical testing on and inspection of baselines to identify disturbances or movement of monumentation, and validity of current Regulation 13 Certificates.
- Inspection of and testing of suspicious equipment and consumables to determine the integrity of any equipment used. This may also lead to re-calibration of the equipment if testing confirms suspicions of faulty equipment, or discontinuation and replacement of faulty consumables.
- Analysis of EDM calibration/comparison booking sheets and output reports to determine likely causes of faults in observations, reduction of data or field procedures etc.
- Analysing instrument logs (if available) for any clues relating to instrument failure, loss of power, faulty recording etc.
- Backtracking through documentation/correspondence of personnel involved to determine if any faults in documentation or procedures are present, and to confirm the correctness of any processes employed by those personnel.
- Assessment of officers involved to ensure they possessed the required skills, training and authorisation in order to undertake the task that they performed at the time the task was performed.
- Review of audit findings and management review to determine if any recent concern was raised for this type of potential nonconformity, but had not yet been addressed.

### **4.11.3. Selection and Implementation of Corrective Action**

The SCO shall be responsible for selecting any of the following methods for implementing any corrective action required. Methods not listed below must be approved by the QM prior to being implemented.

**Possible corrective actions (not listed above):**

- Revocation of previously issued reports and/or certificates that have been rendered invalid due to the non-conformance. This usually results in the re-issue of reports and/or certificates that are revoked.
- Maintenance, upgrades and/or repairs to baseline monumentation, and re-issue of the baseline Regulation 13 Certificate. When re-issuing a Regulation 13 Certificate for a baseline that has been disturbed or is moving, a period of baseline monitoring will be required prior to re-issue of the Regulation 13 Certificate to ensure that the baseline is stable and suitable for certification.
- Baseline monitoring. This usually requires a series of scheduled baseline calibrations over a set period of no less than three months, to allow sufficient time to gather evidence that the baseline is either still moving or stable enough to re-issue a Regulation 13 Certificate. In some circumstances, the SCO may delegate the baseline monitoring duties to the RCO of that baseline, provided that the RCO has sufficient training and suitable equipment.
- Maintenance upgrades and/or repairs to EDM and/or other baseline calibration equipment. If it is the case that equipment is suspected of causing the non-conformance, that equipment shall be serviced and/or repaired by the manufacturer immediately. Once the equipment has been returned, it must then be re-calibrated by the appropriate authority.

After recalibration, the SCO shall recheck the calibration values to ensure that there are no obvious inconsistencies, and then re-commission the equipment through physical testing on a stable baseline.

#### **4.11.4. Monitoring of Corrective Actions**

The QM is responsible for monitoring the SCO during implementation of the corrective actions. This is to ensure that the corrective actions are being implemented correctly and that they are sufficient to achieve the desired outcome.

The QM is also responsible for reviewing the SCO and the corrective action process to ensure that the SCO has the required authorisation, staff and resources required to carry out the corrective actions.

Monitoring of the corrective actions may be carried out via the LTOLE Actions Register.

This register can be accessed via the LTOLE Master Document List as per **Appendix E** Item 5.

#### **4.11.5. Additional Audits**

In the event that nonconformity occurs and casts doubt on the laboratory's compliance with either a departmental policy, procedure or the International Standard, (*ISO/IEC 17025*) the QM shall initiate an internal audit.

The internal audit must be focused on the appropriate areas of the LTOLE service, and follow the procedure set out in **section 4.14.1**.

Internal audits may result in additional corrective and/or further preventative action being required.

### **4.12. Preventative Action**

Preventative action can arise through audits, meetings, reviews or work activities and is an opportunity to be proactive toward the improvement of the LTOLE service. When any improvement or potential nonconformity is identified, the SCO must be notified so that the required action can be performed. As per **section 4.9**, it is the responsibility of the SCO to carry out and record any preventative action taken, and is the responsibility of the QM to approve and supervise any action taken.

Monitoring and assessment of preventative action is the responsibility of both the SCO and QM to ensure that any action is suitable and effective. The department should endeavour to be proactive with preventative action, rather than be reactive to problems occurring and then requiring correction.

Preventative actions must be recorded in the LTOLE Actions register maintained by the SCO, and can be accessed via the LTOLE Master Document List as per **Appendix E** Item 5.

### **4.13. Control of Records**

The department requires records to be controlled and kept for all activities within the LTOLE service. For most LTOLE activities, controlling records is similar to controlling documents. This section will briefly outline the requirements for controlling records as **section 4.3** details the procedure for controlling documents and the storage systems and locations for both documents and records. Refer to **section 4.3** for more detailed information about the storage locations and record keeping system.

The QM is responsible for ensuring that all relevant technical and managerial records are controlled in the appropriate manner.

The SCO shall maintain a list of all records that are controlled, and the level of control (or restriction level of access) applicable to those records. In the event that these controlled records are updated or changed, the SCO shall duly notify the relevant personnel of the update or change.

### 4.13.1. General Records

All general records that do not have a control status clearly displayed on the record shall be treated as uncontrolled. All procedure documents for LTOLE must have a control status displayed. The following records are to be controlled regardless of the control status that may be displayed:

- financial transactions (or details of)
- contracts
- authorisations
- audits and reviews
- corrective and preventative actions
- all raw and original data from EDME comparisons or EDM baseline calibrations
- EDME comparison reports
- draft policies and procedures

### 4.13.2. Technical Records

Technical records should always be controlled as they are usually vital to computations and the production of certificates and reports. This data must be stored in its original and untouched form (raw format) wherever possible. A copy of the raw data or a converted format should be used when carrying out data processing or reductions.

All information and data that is vital to producing a baseline calibration certificate should have a calibration identification, so that all items relating to a particular baseline calibration are visibly linked together to show the chain of evidence. The calibration identification must follow the style listed below:

Calibration ID:            JJJ.BBBBN.YYMMDD

Where:            JJJ        =        (max) 3 characters of the jurisdiction which the baseline is in  
                      BBBBN =        baseline abbreviation (first 4 characters) and version number  
                      YY        =        last 2 digits of the year when field observations were taken  
                      MM        =        2 digits of the month when field observations were taken

DD = 2 digits of the day of month when field observations were taken

Examples:

QLD.MARO1.110325 = Original Maroochy baseline, calibrated on 25<sup>th</sup> March 2011

NSW.KING2.101106 = Second version of the NSW Kingscliff baseline (after new pillars were constructed), calibrated on 6<sup>th</sup> November 2010

## 4.14. Audits

As required by NATA, audits are scheduled to ensure the quality of EDM calibrations is maintained to a high standard. The audits are designed to find potential faults and areas of improvement within the work activities in order to prevent adverse situations.

### 4.14.1. Internal Audit

In accordance with the NATA rules and this procedure document, at least one internal audit must be conducted in between NATA scheduled external audits, to verify that the legal traceability operations of GAP continue to comply with the requirements of the quality management system and *ISO/IEC 17025*. The internal audit program shall address all elements of the management system, including selected LTOLE activities. If the Quality Manager is unable to undertake the internal audit, the Quality Manager may delegate this role to a senior staff member within GAP.

It is desirable that the auditor has completed the internal audit training provided by NATA, and has a basic to moderate understanding of the work activities. This knowledge allows the auditor to ask more specific questions while carrying out the audit from as much of an external point of view as possible. The NATA Laboratory Assessment Worksheet is to be used in recording the audit findings, with the appropriate corrective action described and carried out by the relevant authorised personnel. A formal report summarising the audit findings and responses should then be produced and stored with the NATA Laboratory Assessment Worksheet.

### 4.14.2. External Audit

The external audits are set by NATA and are scheduled every 18 months, alternating between a major audit to minor audit. The major audit usually coincides with the renewal of membership with NATA and the reappointment as a Verifying Authority with the NMI. The minor audit is an intermediate 'check-up' midway between major audits, to ensure that responses from major audits are being carried out.

The major external audit is usually conducted by a lead assessor and a technical assessor and will assess the facility on selected sections of the *ISO/IEC 17025* standard. The lead assessor is a representative from NATA and the technical assessor is another professional from a similar background of work activities to the facility being assessed. Minor audits only have a lead assessor from NATA (usually the same person as the major audit).

The major audit can expand over multiple days however is usually about two full days including a technical operations demonstration based at one of the calibration sites. It is advisable that this technical demonstration is carried out close to the management office (Brisbane) to minimise time wasted during travel, and a site with minimal access restrictions should be chosen. Approximately

one full day should be allocated for minor audits as no technical or field demonstrations are part of this audit.

Once an audit is complete, the assessor/s will arrange a time to discuss the audit findings with the auditee and management personnel or supervisors. The lead assessor from NATA will then send a copy of the audit findings to the facility so that the SCO and QM may respond to the audit findings.

Audits generally contain three levels of finding: Condition, Minor and Observation. Conditions require evidence that the issue has been dealt with appropriately, minor findings require a statement about what the facility (or laboratory) intends to do about the issue, and observations are suggestions that the facility (or laboratory) may wish to consider.

Once the audit responses have been finalised and returned to NATA, approval of the audit may be given and the facility's membership can be renewed. The NMI should then be notified of this approval.

## **4.15. Management Reviews**

The Quality Management System must be reviewed at least once a year, and as a minimum, shall include a review of:

1. the suitability of calibration and testing policies and procedures
2. reports from managerial and supervisory personnel
3. the outcome of recent internal audits of the calibration and testing procedures
4. corrective and preventative actions
5. assessments by external bodies (such as NATA)
6. results of inter-laboratory comparisons or proficiency tests
7. changes in the volume and type of work
8. client feedback
9. complaints
10. recommendations for improvement
11. other relevant factors, such as quality control activities, resourcing and staff training

All actions and tasks resulting from a management review must be allocated a timeframe for the action or task to be completed by.

### **4.15.1. Calibration Management Review Meetings**

Calibration Management Review Meetings (CMRM) of the Quality Management System shall be conducted involving the Manager of GAP, QM and SCO. Where possible the RCOs should be notified of the CMRM agenda and given the opportunity to discuss or comment on the above mentioned criteria along with any new events that affect the quality or procedures of work activities.

These review meetings shall be on an annual basis and shall follow the agenda outlined on the latest version of the Calibration Management Review Meeting (CMRM) template, as per **section 4.15** of the *ISO/IEC 17025* standard. The CMRM template is accessed via the LTOLE Master Document List as per **Appendix E** Item 5.

## **4.15.2. Document Reviews**

All LTOLE documents must be reviewed periodically (determined by the document's next scheduled review date) to ensure that procedures, policies, delegations, authorisations and contacts are current and up-to-date.

All document reviews are to be completed by the SCO and approved by the QM before being signed by the Director of Surveys (Director, Cadastral and Geodetic Services) and released to all departmental and external surveyors (online).

For some documents, the RCO may also be required to confirm details relating to their regional EDM Baselines. This should be done prior to approval by the QM.

## 5. Technical Procedures

This section is intended to specify in detail the technical procedures that are set in place for activities such as EDM baseline calibration, EDME comparison procedures, and others that relate to technical aspects of the departmental LTOLE service.

This technical procedures section adheres to section 5 of the *ISO Standard* as the minimum requirements for all calibration and testing laboratories in Australia.

Most of the technical content in this section is derived from the work of J.M Rüeger (1989); hereafter referred to as Rüeger's book. To avoid the duplication of technical content this document shall refer to Rüeger's book where possible.

### 5.1. Staff Training and Competency

Only authorised officers and those having demonstrated competence in relevant areas of LTOLE shall carry out the requirements and procedures within this document. This is to ensure that a high level of quality is maintained throughout all LTOLE activities (in particular the practical field components), to sustain a rigid legal traceability linkage from measurement instruments in Queensland to the National Standard.

#### 5.1.1. Authorised Officers

The Personnel Authorisation Database lists the personnel authorised (Authorised Officers) to carry out the LTOLE work described in this document. This list is maintained by the SCO only, and can be found via the LTOLE Master Document List as per **Appendix E** Item 5. Staff selected to perform LTOLE tasks must be checked against this database to ensure they are competent to do so.

The State Calibration Officer must be a NATA and NMI Authorised Signatory, and as such will have displayed a high level of competence in all areas of LTOLE activities.

A description of the levels of authorisation attributed to authorised officers, and the associated activities they are authorised to carry out, is also detailed in this database.

The following section lists the general requirements for assessing personnel competency.

#### 5.1.2. Competency Requirements

Competency is based on two major criteria within LTOLE; Management and Technical. Staff are awarded competency upon demonstrating to the SCO sufficient understanding and proficiency in both management and technical activities, to a degree that is appropriate to the level of competency or authorisation sought.

The authorisation of any staff member for LTOLE work is at the discretion of the State Calibration Officer, and assessment of competency should be based on the skills and knowledge criteria given below.

All personnel involved in LTOLE calibration activities must have completed a surveying degree or similar spatial science qualification that is to be approved by the SCO and QM.

#### 5.1.3. Competency Criteria Overview

While this is not intended to be a comprehensive list of criteria, competency should be focussed on demonstrating understanding and proficiency in the following areas (in no particular order), to a level set by the SCO and befitting of the level of competency sought.

#### **5.1.3.1. Management**

- Conforms to the department's recordkeeping standards and procedures outlined in this document.
- Medium-level computer skills.
- Understanding of the relevant standards, legislation, concepts and requirements associated with Verifying Authorities and legal traceability in general.
- Liaising with NATA, NMI, other state and/or territory jurisdictions, and members of the surveying industry.
- Sound communication and inter-personal skills.
- Knowledge of methods and procedures both contained, and referred to, within this document.
- Audits, reviews and meetings.
- Webpage and document updates.
- Ability to train and supervise subordinates.

#### **5.1.3.2. Technical**

- Use and maintenance of a range of high precision survey and meteorological equipment, particularly Leica Total Stations, Wild ZNL optical plummets, and Delta OHM Multifunction Data Loggers.
- Recording of general survey information and measurements, both manually on field sheets and electronically using the instruments on-board memory. Survey reduction techniques, computations and analysis.
- Least squares adjustments and general statistical theory.
- Measurement uncertainty and associated sources of error.
- Competence in the use of the departments EDM calibration software.
- Ability to perform tests and to interpret the test results generated by the software.
- Ability to solve complex problems.

It is generally accepted that persons holding a recognised surveying degree will be competent in most technical activities.

#### **5.1.4. Staff Training**

The SCO may offer training to the RCO (and other staff if required or requested) during each calibration tour, to ensure that the RCOs are aware of updated procedures, and maintain their competency. Training may not be necessary if the critical procedures and authorised personnel have not changed.

Training may be provided by the SCO or an RCO, but then only to an officer of a lower level of authorisation. Training should be flexible and based on individual requirements and past competence.

All Authorised Officers (including the SCO and QM) should consider undertaking some form of training or professional development relating to LTOLE whenever the opportunity arises, in order to maintain competency. Assisting the SCO with a baseline calibration during a calibration tour is a preferred method for maintaining competency for RCOs.

### **5.1.5. Training Modules**

Authorised Officers are required to demonstrate the required level of competence in order to attain the corresponding authorisation flag. Authorisation is given upon completion of training modules for the required criteria of LTOLE activities.

There are no fixed training modules that have been pre-developed within LTOLE. The intention is that the SCO will develop training modules as required, based on the skills and experience of the staff seeking authorisation.

When an officer has completed the training modules set by the SCO or has been deemed competent, either through extensive experience, university degree or through other training, these skills must be evaluated for authorisation to be awarded.

The applicant must demonstrate their competence to the SCO in relation to each relevant criteria. Assessment does not have to be all at once or in any particular order. However, it is desirable to demonstrate the full procedure of any module in order from start to finish. Any officers who have been denied authorisation due to failure to demonstrate the required competence in any module are able to request training from the SCO or a recommended RCO, and undertake the evaluation again at any time. This can occur as many times as necessary until the SCO is satisfied that competency has been demonstrated.

Awarding authorisation to an officer and evaluating the demonstrated competence is at the discretion of the SCO.

## **5.2. Personnel**

All departmental LTOLE activities in Queensland must be carried out by one of two types of personnel; those who have been authorised (Authorised Officers) and those deemed to be competent (Competent Personnel) in the execution of LTOLE procedures. This includes both field and office procedures, and the operation of all equipment.

For a list of the Authorised Officers and Competent Personnel within the department, refer to the latest version of the Personnel Authorisation Database which is maintained by the SCO, and can be accessed via the LTOLE Master Document List as per **Appendix E** Item 5.

### **5.2.1. Authorised Officers**

It is essential that the department appoints authorised personnel to carry out specific tasks and to approve LTOLE activities. There are several levels of authorisation and as such, Authorised Officers have been trained and assessed as competent in certain areas of LTOLE activities so that they may perform specific duties without the need for supervision by the State Calibration Officer. Authorised Officers may also supervise and train competent personnel in their duties. Authorised Officers are able to sign off on their duties and the work of competent personnel within their designated region.

The State Calibration Officer and the Regional Calibration Officers are required to be Authorised Officers. For LTOLE activities, certain procedures and tasks are required to be carried out or supervised by specific Authorised Officers. Because of this, each Authorised Officer has been awarded a particular level of authorisation or Authorisation Flag.

### 5.2.2. Competent Personnel

Competent personnel are officers who have been given competency in specific areas of LTOLE activities. They may perform verification work, and support Authorised Officers in LTOLE work, but are not permitted to sign off or approve any of these tasks.

### 5.2.3. Communication

Most LTOLE work is based on electronic communication due to the spread of management officers and the remote location of the management office and multiple locations of EDM baselines. Therefore all communication should be recorded appropriately according to the procedures outlined in **section 4.13** of this document and the relevant departmental record keeping policies.

Communication should be made to multiple officers wherever possible to ensure that important information is acted upon in a timely manner by one of the recipients.

All verbal communication should be noted so that it can be referred to when required, and any meetings should have adequate minutes taken.

Good communication strategies are the responsibility of all management officers and authorised personnel, to ensure a high level of quality in LTOLE activities is preserved.

## 5.3. Environmental and Testing Conditions

EDM baselines are located outdoors in various regions across Queensland, and as such it is impossible to control the environmental and testing conditions.

Because of this, all atmospheric conditions that affect the distance measurements are to be monitored as accurately as possible and corrections applied when processing the observations. This ensures that any environmental effects on the distance measurements are eliminated from the results or otherwise significantly reduced.

The key environmental conditions, and corresponding magnitudes, that effect EDM observations are:

- **Temperature**

An error of 1 °C  $\approx$  an error in distance of  $(1 \times 10^{-3} \times L)$  mm, where L is Length in m

- **Pressure**

An error of 1 hPa  $\approx$  an error in distance of  $(0.3 \times 10^{-3} \times L)$  mm, where L is Length in m

- **Relative Humidity**

Omitting Relative Humidity from atmospheric corrections equates to an error in distance of between  $(0.5 \times 10^{-3} \times L)$  mm and  $(1.5 \times 10^{-3} \times L)$  mm, where L is Length in m for typical atmospheric conditions experiences during testing.

Of the above mentioned conditions it is the temperature that has the greatest effect on the distance measurement. Due to frequent fluctuations in temperature throughout the LTOLE field procedures, greater care must be taken during the observations to ensure that this effect is negated. Pressure has a far lesser effect than temperature and the humidity affects the distance measurement the least. While carrying out distance observations for EDM testing, the temperature, pressure and relative humidity should be observed at least every minute and averaged for each set of distances.

For all EDM baseline calibrations, meteorological observations (temperature, pressure and relative humidity) should be taken and recorded every 30 seconds at three points over the baseline for the entire duration of the calibration. This enables the determination of the average atmospheric conditions over the section that is being measured for a particular period. Once the average atmospheric conditions are determined then corrections can be applied for the effects of this. This method also allows for better determination of errors and uncertainty due to fluctuations and variations of atmospheric conditions throughout the day.

For more information on the effect of atmospheric conditions on EDM instruments, refer to Section 5 of Rieger's book.

## **5.4. Test and Calibration Methods**

### **5.4.1. General**

There are two procedures that are employed by the department, one of which refers to EDM baseline calibrations and the other refers to EDM comparisons.

### **5.4.2. Selection of Methods**

Both procedures are based on the procedures described in Rieger's book, and have been selected based on the practicality and suitability of these methods to the department's LTOLE service. These methods are described in further detail below.

#### **5.4.2.1. EDM Comparison Procedures**

A successful EDM comparison requires the determination of the following instrument corrections, via comparison of instrument distance measurements against standardised values (Regulation 13 Certified baseline distances):

- Additive Constant
- Scale Frequency Error
- Cyclic Error

These instrument corrections are determined by measuring 21 unique inter-station distances on a typical 7 station baseline, and correcting these distances for atmospheric and environmental effects, slope and also for height datum and alignment for the baseline. The fully corrected distances are then adjusted via a least squares adjustment to obtain the instrument correction values (constant and scale components) and their associated uncertainties at a 95% confidence level.

The department has a more specific procedure document for EDM comparisons and is based on the procedure detailed in Rieger's book. The latest version of this procedure is freely available on the department LTOLE website (See **Appendix E** Item 4).

### **5.4.2.2. Baseline Calibration Procedures**

The baseline calibration procedure is an extension to the EDM comparison procedure. A baseline calibration involves measuring from each station to all the others using an NMI calibrated EDM instrument, giving a total of 42 independent inter-station distances. There are, however, only 21 unique inter-station distances on a typical 7 station baseline. A baseline calibration measures each unique inter-station distance twice, once in each direction. (I.E. station 1 – 2 and then again from 2 – 1).

The 42 inter-station distances are corrected for environmental effects, baseline alignment and slope and datum reduced level. A least squares adjustment of this dataset produces the best estimate of the 6 baseline distances for each station from the first, rather than the instrument corrections.

The LTOLE EDM Baseline Calibration procedure document describes this procedure in more detail and can be accessed via the LTOLE Master Document List as per **Appendix E** Item 5.

### **5.4.3. Laboratory Developed Methods**

Any laboratory developed methods for the LTOLE service are predominantly used as checks on equipment and procedures. These methods are usually carried out separate to calibration activities and largely do not affect the result of a calibration or comparison.

The only exceptions to this are the methods used for observing atmospheric conditions, and the sequence in which the distance measurements are taken. Although these methods are based on the standard methods described in Rüeiger's book, it is designed to be more accurate and efficient and to minimise the effect of human error by automating the observation and recording processes.

### **5.4.4. Non-Standard Methods**

The department does not employ non-standard methods for any part of the LTOLE service.

### **5.4.5. Validation of Test Methods**

The methods adopted by the department for LTOLE are based on the methods detailed in Rüeiger's book. The methods in this book have been widely accepted within the department, and across Australia, as the standard procedure for the calibration and verification of EDM instruments.

As the department's recommended procedures are either based on or an extension to the accepted standard procedure, there are no known areas of LTOLE in Queensland that would be required to be validated in this document.

#### **5.4.5.1. EDM Comparison**

This procedure, as mentioned in **section 5.4.2.1**, is based on the procedure described in section 13 of Rüeiger's book, and as such is not required to be validated in this document.

The results obtained from the EDM comparison procedures are validated by statistical analysis to ensure the results are reliable.

#### **5.4.5.2. Baseline Calibration**

As this procedure is an extension to the EDM comparison procedure and based on Rüeger's book, validation of this procedure is also not required in this document.

The "combined-run" method is an independent check within itself which is incorporated in the baseline calibration procedure. This creates enough redundancies within the observations to ensure that erroneous values are detected.

A statistical analysis of all the processed observations from the baseline calibration ensures that outliers are detected and that results are reliable and acceptable. Values resultant from the least squares adjustments are also checked for major differences to previously calculated values. These built in checks to the procedures ensure that results meet the required standard.

#### **5.4.6. Estimation of Measurement Uncertainty (EMU)**

The department is required to maintain an uncertainty budget for all LTOLE activities listed in the current scope of accreditation (through NATA and NMI). Therefore this only includes EDM baseline calibrations and not EDM comparisons. The procedure for calculating the Estimation of Measurement Uncertainty is listed below.

The associated uncertainties for the department's LTOLE service are calculated with the departmental EDM calibration software. However these uncertainties are only relating to the distances which have been corrected for atmospheric and environmental effects. There are also other uncertainties that the software does not account for during LTOLE, and are consequently accounted for in the EDM baseline calibration uncertainty budget. These uncertainties include but are not limited to:

- methodology assumptions (including centring and plumbing)
- calibrated instrument uncertainties
- meteorological observations
- baseline uncertainties and movement

##### **5.4.6.1. Estimation of Measurement Uncertainty Procedure**

The standard procedure for calculating the Estimation of Measurement Uncertainty (EMU) is set by NMI and is supported by NATA.

Uncertainties for LTOLE are to be calculated in accordance with the principles in JCGM 100: 2008 Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement, to give an interval estimated to have a confidence level of 95% at the time of verification.

##### **5.4.6.2. Uncertainty Budget**

The department's uncertainty budget for EDM baseline calibrations is calculated using the LTOLE EMU spreadsheet. The spreadsheet itself contains the instructions for proper calculation of the uncertainty, and is based on the Guide to Expression of measurement Uncertainty as mentioned in the previous section. These instructions are supported by comments and notes throughout the

spreadsheet. All reviews, updates and modifications to this spreadsheet should be carried out by the SCO only and documented in the history section of the spreadsheet.

See the LTOLE Master Document List (**Appendix E** Item 5) for the location of the LTOLE EMU spreadsheet.

### 5.4.7. Control of Data

The LTOLE management system places a high priority on data control, to ensure that quality is maintained in all facets of LTOLE, and that an adequate record keeping system is utilised.

Since the field data capture component is the crucial element that determines the overall quality achievable, it is imperative that all data captured in the field should be recorded in a reliable manner.

All EDM observations should be recorded electronically on the memory card of the measurement instrument in use. Ancillary information and metadata (e.g. sequence order of observations, instrument and target heights etc.) should be recorded manually on the specified booking sheet for baseline calibrations. This booking sheet can be located via **Appendix E** Item 5.

Meteorological observations are to be recorded electronically in the internal memory of the instrument.

Electronic data that is recorded should be downloaded from instruments as soon as possible and backed up. This ensures that critical data is not lost, that errors (especially in transcription) can be identified if present, and that results can be reproduced without the need for data recapture in the field.

Upon completion of the field observations, all hard copies and booking forms should be backed up electronically (scanned) and then filed appropriately.

Electronic observation data (including scanned copies of booking forms) must be stored under the LTOLE directory on the departmental shared server (see **Appendix E** Item 6), or similar directory approved by either the appropriate RCO or the SCO.

It is mandatory that for electronic data, a copy is to be on the shared departmental server in the LTOLE directory (See **Appendix E Item 6**), to ensure that a backup is always available and that other Authorised Officers have access to these records.

The instrument operator should be the officer to process the field observation data and any results produced from field observations must be stored with the original data.

## 5.5. Equipment

Typically EDM equipment is sensitive and expensive scientific equipment that must be treated with care. Often these instruments are required to be transported between locations and packaging is required to ensure that the integrity of the instrument is maintained.

Due to the sensitivity of this equipment, only the SCO or a person instructed by the SCO is to handle this equipment.

When transporting EDM equipment, only specifically designed protective cases are to be used. These cases are usually supplied by the manufacturer, however if these cases are not suitable then a sturdy and lockable hard plastic case with foam lining should be used.

The department has consistently utilised “pelican” style cases and sent them to be custom fitted with moderate to high density foam in the shape that neatly fits the desired equipment. These cases are lockable, sturdy, have a high level of resistance to weather damage and are moderately water-tight.

If for any reason that EDM baseline calibration equipment is suspected of being faulty the equipment should be immediately labelled accordingly and sent to the SCO for assessment as soon as possible. From this assessment the SCO shall then determine the most appropriate course of action. Any equipment that is repaired or replaced must be calibrated before it can be used for baseline calibrations.

When equipment is needed it should be inspected to assess its condition and put on charge (if possible) prior to removal from storage. Once equipment is no longer required, it should be returned to its correct position in storage. The EDM calibration equipment storage is located at the office where the SCO is positioned<sup>4</sup>.

If for any reason, calibration equipment goes outside the direct control of the laboratory, the SCO or QM must ensure that the function and calibration status of the equipment is satisfactory prior to being returned to service.

## 5.6. Measurement Traceability

For the department to provide legal traceability of length for EDM (LTOLE) to Queensland, it must ensure that all measurements taken as part of LTOLE are traceable to the national standard and international standard for length (the metre).

It is also required that any equipment used in the EDM Baseline Calibration Procedure is also calibrated by a NATA accredited organisation to ensure that these procedures and measurements are also traceable to national standards.

### 5.6.1. Legal Traceability

Legal traceability is the requirement that all physical measurements carried out for any legal purpose, must be made in terms of the relevant legal (SI) units. This is broken into two parts and explained more accurately by the following terms as described by NMI.

*“Legal Metrology comprises all measurements carried out for any legal purpose, including measurements that are subject to regulation by law or government decree.”*

*“Traceability is the hierarchy of standards by which a physical measurement can be related through the national metrological pyramid back to the relevant SI unit”<sup>5</sup>*

Refer to the NMI website for more information on legal traceability (see **Appendix E** Item 2).

In Queensland, the department is recognised as a Verifying Authority for length and can provide legal traceability of length for the observations of an EDM instrument so long as the following conditions are met:

- The instrument must be tested on an approved baseline that holds a valid Regulation 13 Certificate (issued by the SCO or an authorised delegate of the department) at the time of field observations.

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<sup>4</sup> Level 9 Landcentre, 867 Main St, Woolloongabba, QLD, 4102

<sup>5</sup> Definitions acquired from the National Measurement Institute website ([www.measurement.gov.au](http://www.measurement.gov.au))

- The integrity of the monuments on the baseline being utilised for an instrument verification/calibration at the time of field observations, has not been compromised to an extent that insufficient valid observations can be obtained on that baseline.
- The field and office procedures have been done according to the procedures specified by the department.
- Observations are reduced using the software provided by the department.
- The additive constant and scale factor corrections have been successfully determined and the associated uncertainties (standard deviations) are within manufacturer's specifications.
- The results from the reduction pass the required tests.

For more information regarding measurement traceability and the measurement system in Australia, refer to the NMI website: [www.measurement.gov.au](http://www.measurement.gov.au)

## 5.6.2. From EDM Measurements to the International Standard

EDM instruments in Queensland are considered legally traceable if the approved and accepted comparison methods set by the department are employed on EDM baselines that are calibrated and maintained by the department. This gives EDM instruments in Queensland a traceable link between their measurements and the Regulation 13 certified EDM baselines maintained by the department.

These baselines are calibrated by the department's EDM calibration instrument and issued with a Regulation 13 Certificate under provisions of the *National Measurement Act 1960* and its Regulations. The EDM calibration instrument is calibrated in turn by the National Measurement Institute thus giving the EDM baselines, and Queensland EDME, a traceable link to the national standard. Under the *National Measurement Act 1960*, the national standard for length is the metre, which is also the international standard.

All other equipment that records observations during EDM baseline calibrations (including meteorological instruments) are also calibrated by NATA approved entities to ensure reliability of all physical observations.

**Appendix D** shows the traceability link between surveyors' EDME and the international standard.

## 5.7. Sampling

The department does not undertake sampling as part of LTOLE activities.

## 5.8. Handling of Test and Calibration Items

Staff should not handle any test and/or calibration items without the approval of the SCO.

Only the manufacturer's container or designated container should be used when transporting test and/or calibration items. These containers are designed to provide sufficient padding and support for the instruments when transported via aircraft or vehicle.

The SCO is to ensure that all documentation corresponding to transportation of test and/or calibration items is completed and retained according to **sections 4.3 and 4.13**.

The SCO shall be notified of any test or calibration items that are suspected to be faulty or erroneous. The equipment should be sent to the SCO who will then ensure that the items in question are clearly identified as faulty and not to be used. The SCO shall record any details relating to abnormalities or faults with test or calibration items, before being sent for servicing and/or repairs as required.

Storage of all test and calibration items is the responsibility of the SCO. Adequate storage of these items should be as a minimum, a temperature controlled storeroom in a secure place located with the SCO.

Expired or superseded equipment should be labelled and stored accordingly so as not to confuse these items with new and current instruments.

## 5.9. Quality Assurance

Quality assurance is built into specific stages of the procedures to ensure that the results obtained from the reduction of field measurements can be quickly and easily identified as satisfactory.

Any corrective action taken as part of quality assurance should be carried out according to **section 4.11** and followed by **section 4.12** to minimise or eliminate potential reoccurrence.

### 5.9.1. Quality Control in Procedures

The field procedures are designed in such a way that an excess of observations is taken over what is normally required to obtain a result when processing the data. These redundancies assist in reducing the uncertainty of the results and also allows for easier and quicker detection of suspect observations and outliers, so that they can be investigated and removed from further data processing if required.

All calibration equipment and physical monuments are maintained and calibrated at determined intervals, which are usually specified on the calibration certificate or reports. The results are recorded electronically within spreadsheets to easily identify any significant differences which may indicate the presence of errors.

Only the instruments that are within their current calibration period are used for LTOLE activities. These items are then checked against one of the more stable and known value baselines as a general indication check on instrument performance.

Inter-laboratory comparisons and proficiency testing is carried out to ensure procedures and methods are comparable within the industry.

Correlation of results is difficult to determine due to environmental conditions, however checks between consecutive measurements and baseline certifications can indicate possible correlation.

### 5.9.2. Quality Control in Data Analysis

The office procedures incorporate statistical tests that the data must pass before any result can be declared satisfactory. These tests are designed to identify suspicious data and outliers which are then investigated by trained personnel. Actions taken as a result of the investigation are based on the statistical test results and specific analysis of the data itself.

Further tests in the procedure require independent checks to be performed on the input and output of any software used. This is to ensure that the data collected is accurately transferred into the

software and the output results of the software are correctly transferred to any report or certificate before it is signed.

### **5.9.3. Quality Assurance of Calibration and Test Results**

To assist in the verification of the quality of the calibration results, two methods have been incorporated into the procedure. Firstly, the procedures described above incorporate a “combined–run” methodology. This method is detailed in the baseline calibration procedure and can be accessed via **Appendix E** Item 5.

In addition to the combined–run methodology, a significantly large number of meteorological measurements are taken. The most important correction made to the observed distances is the meteorological correction. To minimise any errors in the application of these corrections, meteorological observations are taken every 30 seconds during a base calibration. The significantly high number of measurements increases the stability of the solution and provides greater confidence in the detection and removal of outliers.

The calibration instrument is used on the Primary Baseline<sup>6</sup> prior to and on completion of any calibration tour or exercise. This provides confidence that the calibration instrument has consistently maintained its state of calibration for the duration of the tour or exercise.

In the event that a post tour discrepancy occurs on the primary baseline, the SCO and QM shall investigate the discrepancy and if required, determine and implement appropriate action.

Possible action may include:

- Physical assessment of the baseline equipment and testing on a baseline to identify potential faults or errors
- Assessment of data and results to identify errors
- Sending baseline calibration equipment for recalibration followed by recalibration of the affected baselines (in more serious circumstances).

Prior to producing Regulation 13 certificates, all calibration values are entered into the baseline monitoring spreadsheet. This serves as a gross error check whereby any values that do not fit the historical trend of that baseline can be investigated. The Regulation 13 certificate template sources the baseline monitoring spreadsheet for the specified calibration values, eliminating the possibility of transcription errors. Both the baseline monitoring spreadsheet and Regulation 13 certificate template can be accessed via **Appendix E** Item 5.

As the final check on calibration values and test results, the QM reviews a draft of each Regulation 13 certificate before it is signed.

## **5.10. Reporting the Results**

All results shall be recorded in the appropriate manner as specified in this document.

### **5.10.1. General**

All reports and certificates are to be accurate, clear and unambiguous.

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<sup>6</sup> The current Primary Baseline for QLD is Maroochy which has proven to be the most stable and secure over a long period of time.

All results from tests and calibrations that are in the form of a report (for tests and comparisons) or a certificate (for calibrations) must contain the required information as listed below. Only successful calibrations can be issued with a certificate, failed calibrations are issued with a report only and must be re-calibrated until a certificate can be issued.

### **5.10.2. Test Reports and Calibration Certificates**

Each test (EDME) report and calibration (Regulation 13) certificate is to contain at minimum the following information:

- a) title (e.g. EDME Comparison Report or Certificate of Verification)
- b) name and address of the testing laboratory and location where testing was carried out
- c) unique calibration identification
- d) name and address of customer (or instrument owner)
- e) test or calibration method used
- f) description and identification of item tested or calibrated
- g) test or calibration results
- h) date of calibration

NOTE: *ISO/IEC 17025* also requires the date of receipt of test items and also a reference to the sampling plan and procedures on test reports and calibration certificates. These are not required as testing received items, and sampling of test items is not part of the LTOLE service.

### **5.10.3. Test (Comparison) Reports**

A computer generated report is issued for all EDME comparisons. To ensure that all the required information is recorded in an EDME report, the software used for processing the data requires the user to enter this information before proceeding.

The information included in these software reports should include where relevant, all the items listed in section 5.10.3 of the *ISO/IEC 17025* standard.

Comparison reports are explained in more detail in the EDME Comparison Procedure document (see **Appendix E** Item 5 for the location of this document).

### **5.10.4. Calibration Certificates (Regulation 13)**

When an EDM baseline is due for re-calibration, either due to the expiry of a current Regulation 13 Certificate or when the baseline monuments are assessed as having moved, then the department may issue a new Regulation 13 Certificate. A Regulation 13 Certificate can only be issued to an EDM baseline by an authorised signatory and only if the observations on the baseline are carried out according to the relevant departmental procedure and that the data has been processed successfully.

As per the NMI and NATA requirements, all Regulation 13 Certificates are required to display the relevant items listed under section 5.10.2 of the *ISO/IEC 17025* standard.

All Regulation 13 Certificates are to be produced using the latest version of the LTOLE Regulation 13 template maintained by the SCO. This template automatically retrieves the current calibration

values from the LTOLE Baseline Monitoring spreadsheet, provided these values have been entered into it. The location of the LTOLE Reg13 template is listed in the LTOLE Master Document List (See **Appendix E** Item 5).

### **5.10.5. Opinions and Interpretations**

Provided that the data being processed has passed the statistical tests in the designated software, then the values stated on the report or certificate accurately represents the condition of the test item.

Any opinions and interpretations based on the result of the test or calibration must not be stated on the report or certificate. They may, however be communicated by direct dialogue that accompanies the report or certificate. Such dialogue must be recorded in writing.

### **5.10.6. Testing and Calibration Results Obtained from Subcontractors**

The department does not subcontract any part of the LTOLE service.

### **5.10.7. Electronic Transmission of Results**

Test or calibration results can be transferred electronically according to **section 4.3**.

### **5.10.8. Format of Reports and Certificates**

The format of reports and certificates are set by designated templates and automated outputs generated by the software used to process the test data.

This format should not be changed unless required due to noncompliance with the *ISO/IEC 17025* standard.

### **5.10.9. Amendments to Test Reports and Calibration Certificates**

If possible, any amendments to test reports and calibration certificates shall be made by issuing a new report or certificate to replace the original. The new report or certificate should be identified accordingly and with reference to the original, as per section 5.10.9 of the ISO 17025 standard.

## **5.11. Department LTOLE Software**

The department has software that allows EDM observations to be reduced and processed to derive instrument corrections for EDM comparisons and also baseline distances for Regulation 13 Certificates. The department currently utilises a software package developed by the Western Australia Landgate authority. This software package comprises of two major versions; the Baseline Calibration Software version and the EDM Comparison Software or commonly referred to as a "Distribution" version.

### **5.11.1. Baseline Calibration Software**

The Baseline calibration software shall be used exclusively by the SCO unless another authorised signatory is directed to do so by the QM. The purpose of this is to maintain integrity in the baseline calibration software and a suitable level of control for calculating Regulation 13 certified distances.

This version of the calibration software is continually updated with new baseline values after a baseline has been calibrated. This version has the ability to create and edit EDM baselines, as well as create a distribution version based on the current baselines and values contained within it.

The software has a comprehensive built in help manual to assist users with correct operation.

### **5.11.2. EDM Comparison Software (Distribution Version)**

Distribution versions of the software are produced periodically by the SCO using the baseline calibration version of the software. A distribution version of the software contains all current Regulation 13 certified baselines and their calibration values. This version is locked to prevent unauthorised modification of the baselines and their associated calibration values. All distribution versions come with a built-in help directory which explains how to use the software. The current distribution version is available on the department's LTOLE webpage, and is updated whenever a baseline is recalibrated.

## 6. Quality Management

The department is committed to achieving a high standard of quality in all aspects of its electronic distance measurement (EDM) baseline calibration and instrument comparison activities, in order to provide legal traceability of length for surveying EDM equipment (EDME) in Queensland. The department is also committed to maintaining its technical competency in these areas as per the requirements and procedures described in *ISO/IEC 17025* and the relevant NATA documents.

As a result, the Calibration Management Section (see **section 4.2.1**) strives to ensure that an appropriate portion of quality assurance is incorporated into LTOLE activities and procedures wherever possible.

The quality assurance components in LTOLE are usually incorporated as (but not limited to):

- Specific components within field procedures that
  - give suitable checks on equipment used and standards maintained
  - restrict data to a set format and structure which allows easier detection of blunders
  - minimise errors and areas of uncertainty when taking field measurements
  - ensure consistency when taking and recording field measurements
  - ensure ease of data transfer thus minimising human and transcript errors
  - result in an excess of data observations to provide sufficient redundancy
  
- Specific components within office procedures that
  - ensure ease of data transfer thus minimising human and transcript errors
  - ensure consistency when using the software for data reductions
  - ensure that adequate records are kept
  - assist in identifying outliers and errors within the data
  - clearly show a fail or pass for test and calibration results
  - ensure data and results are checked at specific intervals before progressing
  - ensure any report or certificate is complete and accurate before being signed
  
- Specific components not part of field or office procedures, that ensure
  - staff are trained and authorised to carry out designated duties
  - procedures used are in line with that of industry standards and similar laboratories
  - overall competency is maintained
  - succession planning to continue the LTOLE service

See **section 5.9** for more information on the quality assurance components within the LTOLE service.

## 7. Reference Standards and Infrastructure

The verification of EDM against EDM baselines is the method employed in providing LTOLE in Queensland, and consequently the EDM baselines are required to be verified as Reference Standards of Measurement.

The department maintains a list of these standards for the verification of the physical quantity length.

These standards include:

- the State EDM calibration instrument
- Queensland Regulation 13 EDM baselines
- Northern Territory Regulation 13 EDM baselines

A list of the calibration instruments that are maintained can be accessed via the LTOLE Master Document List as per **Appendix E** Item 5.

The current EDM baselines that the department maintains and calibrates are listed on the department LTOLE webpage as per **Appendix E** Item 4.

The EDM calibration instrument is required to be sent to NMI so that it can be calibrated against the national standard. The intervals between calibrations are determined by NMI and are stated on the calibration certificate for the instrument. This instrument is then used to calibrate the EDM baselines in Queensland, and produce Regulation 13 Certificates. The Northern Territory Government elects not to be appointed as a VA with NMI through NATA due to increasing VA requirements. Because of this the department has, for many years, been successful in regaining the contract to calibrate the NT baselines.

Regulation 13 Certificates for EDM baselines are valid for a period of two years from the date of verification<sup>7</sup>, provided that the baseline monuments<sup>8</sup> remain undisturbed<sup>9</sup>. For financial purposes, both the Queensland and Northern Territory baseline calibration tours are carried out within the same financial year.

The Queensland tour, and likewise with the Northern Territory tour, is scheduled to calibrate all EDM baselines in current use in each jurisdiction regardless of how recently the baselines have been previously calibrated<sup>10</sup>.

For more information regarding EDM baselines in Queensland, refer to the relevant baseline information document on the department LTOLE website (**Appendix E** Item 4).

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<sup>7</sup> Or date of field observations

<sup>8</sup> Monuments include pillars and ground marks

<sup>9</sup> Monument disturbances include movement, damage and obstructions to visibility between monuments.

<sup>10</sup> Baselines should be re-verified as soon as practical if any disturbance to baseline monuments is confirmed.

## 7.1. EDM Baseline Construction

This section applies to the construction and maintenance of the EDM baselines that are the responsibility of the department.

Newly constructed baselines shall be monitored at intervals determined by the SCO until the SCO determines that stability has been established. Stability can be confirmed through testing and calibrations on the baseline.

Bases which are currently operational and hold Regulation 13 Certificates are listed in on the department website for LTOLE (see **Appendix E** Item 4).

Design and construction plans for pillared and non-pillared baselines are held on the shared server directory (see **Appendix E** Item 6) and should be obtained from the SCO.

### 7.1.1. Funding

Upon determining the need for an EDM baseline, consideration should be given to the provision of funding. Where financial constraints permit, the construction of a pillared base is recommended.

Advice should be obtained from the department's SCO before construction is commenced.

### 7.1.2. Desirable features for a calibration base

The technical content for baseline design can be found in section 13.2 of Rüeiger's book, and should be referred to when designing a baseline. The baseline design spreadsheet held by the SCO should be used to determine the inter station distances for new baselines based on the Heerbrugg (Schwendener) style and can be accessed via **Appendix E** Item 5.

- The base should be established on relatively even ground with a regular gradient, which is preferably slightly concave. All baselines should clear intervening ground by more than one metre, the longer the line the more clearance preferred.
- Physical features which might influence meteorological conditions along the base should be avoided, e.g. cuttings, close proximity to buildings, walls or any other feature that may cause wind blockage, shade interference or other variations to conditions along the baseline.
- The soil type should be the most stable available in the area. A close underlying rock formation would be ideal so that all marks could be fixed to bedrock.
- The desirable length of a base for testing short range EDME should be between 600 and 1100 metres, contain seven stations, and sited so that extensions of up to 0.5 km may be possible by placing additional marks. The basic course distances should be so distributed to give an even spread of distances throughout the length of the base. The inter-station distance can be calculated using Rüeiger's formula for Heerbrugg (Schwendener) type baselines. The fine distances will depend upon whether or not a cyclic test is to be included. Final bay lengths will generally depend upon the actual topography of the site. Once the length of a bay has been provisionally selected, it may have to be moved in multiples of the chosen unit length of the baseline to retain the cyclic or non-cyclic factor<sup>11</sup>. Fine distances are the metre and decimals thereof but not including the tens of metres of the distance.

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<sup>11</sup> Refer to section 13.2.1 and 13.2.2 of Rüeiger's book for more information on baseline design.

- The layout of the bases should be such that the shortest distance between stations on the baseline is not less than 19.5m, and the total length of the baseline is not greater than 1150m, as per the department's scope of accreditation with NATA and the Appointment as a Verifying Authority for Reference Standards of Measurement with NMI.
- If the stations were placed in a straight line on ground that is flat or of even gradient, then each tripod or pillar would obstruct the line of sight to those behind. This can be avoided by off-setting each station from the straight line by varying amounts. These offsets should be kept to the minimum needed to obtain a clear sight. If the two criteria of regular ground and minimum offset are observed, tabulated corrections for reduction to straight and horizontal lines can greatly reduce field reduction time. A base over concave terrain will reduce the need for offsets.
- The layout of a total station testing base will vary considerably and be spread over a wider range of area and heights to allow for horizontal and vertical angle comparisons, as well as distance. These should be designed individually according to the topography involved.

### **7.1.5. Marking the base**

In selecting the type of marking to be established there are several factors to be considered:

- Stability of the soil and underlying rock type and depth
- Cost of materials, e.g. pillars vs. ground marks
- Securing the integrity of monuments (e.g. prevention against vandalism, environmental effects and disturbances by vehicles, machinery and livestock etc.)
- The type of instruments intended to be used on the baseline (i.e. high precision instruments will require pillared baselines for fixed centring).

In the case of ground monumentation, it is preferable to use standard permanent marks that are grouted into bedrock. Where they cannot be grouted to bedrock, a concrete footing of 1-2m depth should be used, with the base belled out and levelled to counteract both up-thrust and down thrust.

An alternative ground monument is a galvanised star picket, driven its full length or to refusal (to a depth of not less than 1.5m) with a hole punched or drilled in top. A 0.1m auger hole should surround the top of the star picket to a depth of .75m to allow for a collar and be back-filled with light gravel or sand lightly tamped. A concrete cap should be placed over it free from any contact with the star picket and flush or below surface level. The marks should be protected against disturbance caused by heavy machinery moving over or adjacent to the station by the use of witness posts.

Where pillared monumentation is to be installed every care must be taken to ensure stability of the pillars. Badly anchored base pillars may experience cyclic movement, pivoting at the surface in a manner similar to that of a pendulum. One solution is the grouting of the pillar to stable bedrock. Other partial solutions are ensuring the amount of pillar below ground is at least twice that above ground, and having a concrete footing of sufficient size and volume to ensure relative stability. Precautions must be taken to ensure that vehicles and machinery cannot run over any part of the pillar or base. This may be achieved by the placement of guide posts or bollards.

Provision should also be made to support a beach umbrella to shade instruments, reflectors and meteorological equipment during calibrations and comparisons.

## 7.2. Maintenance

Each RCO is responsible for overseeing the maintenance of each baseline designated to their region. The following sections outline the key priorities in baseline maintenance.

### 7.2.1. Inspection

At periods dependent upon local conditions, but not exceeding six months, EDM bases shall be inspected to ensure:

- lines of sight are kept well clear of obstructions
- protective markers are still in place and visible
- areas near the markers are kept clear of rubbish
- there has been no deterioration of marks by vandalism or accidents
- the station numbering system remains unambiguous

## 7.3. Access

Information on access to and the current status of EDM bases shall be updated on the department LTOLE webpage by the SCO as soon as it becomes available. Each RCO should inform the SCO of any factors that may impact on a surveyor's ability to utilise a baseline in their designated region.

Access requirements are detailed in the relevant baseline information document found on the department's LTOLE webpage (see **Appendix E** Item 4).

## 8. Roles and Responsibilities

This section aims to give an indication of the tasks that are likely to be performed in the LTOLE service and what tasks each level of Authorised Officer is generally responsible for carrying out or overseeing. The tasks on these lists are not exhaustive and are not intended to cover every aspect of the LTOLE service, but are intended to be used as a guide. Personnel unsure of the role or responsibility of a particular task should refer to the SCO or QM.

### 8.1. Calibration Quality Manager (QM)

The QM is largely responsible for overseeing all LTOLE activities and ensuring that the SCO has sufficient resources, the required level of authorisation and the necessary support from key personnel in order to carry out their designated tasks.

The QM is responsible for:

- overseeing the quality of all work relating to legal traceability of length for EDME in Queensland
- ensuring that the SCO is adequately trained and has the managerial support required to perform his/her duties
- maintaining competence of the facility in accordance with the NATA accreditation requirements
- appointing an auditor and specifying a timeframe for scheduled internal audits
- overseeing training and professional development of the SCO
- overseeing the management of all LTOLE activities
- ensuring that an appropriate level of quality assurance and control is maintained within the facility
- conducting management reviews
- Inform the SCO of any relevant information and may affect the LTOLE service as a result of correspondence with NATA and/or NMI.

### 8.2. State EDM Calibration Officer (SCO)

The State EDM Calibration Officer is primarily responsible for all technical activities and most of the managerial activities that relate to the LTOLE service.

The SCO is responsible for:

- undertaking or supervising all calibration work in Queensland
- overseeing the managerial and technical content in LTOLE documents to ensure compliance with all requirements
- ensuring that all suitable baselines are calibrated according to the relevant procedures and issued with a current Regulation 13 Certificate
- signing Regulation 13 Certificates on behalf of the department under the relevant delegation
- maintaining currency with new developments regarding the calibration of baselines
- ensuring that all LTOLE documents and procedures are current and validated

- commissioning all new baseline calibration equipment
- ensuring that all RCOs are competent in carrying out their designated duties
- conducting proficiency testing as required by NATA
- maintaining the department's membership with NATA and NMI to ensure that the LTOLE service is continued
- organising preparations for NATA/NMI external audits
- managing and/or undertaking all baseline calibration activities mentioned in this document
- making the required tools and reference material available to Queensland surveyors so they can carry out equipment testing to fulfil their obligations under the SMI Regulations.
- ensuring the department website for LTOLE is updated with current information and items
- training and authorisation of all staff involved in LTOLE activities
- implementation and improvement of all LTOLE management and technical activities
- the continuation of the LTOLE service provided by the department
- supporting the Quality Manager with quality management activities
- dealing with calibration contracts, particularly the biennial Northern Territory Baseline Calibration Tour
- Liaising with other jurisdictions on legal traceability and calibration matters.

### 8.3. Regional Calibration Officers (RCO)

The RCOs are responsible for:

- administration of the LTOLE service in their region
- ensuring that departmental support for surveyors is available in their region
- ensuring that all departmental EDME in their designated region complies with **section 2.1**
- the management and maintenance of all operational baselines in their region, where practical
- supporting the SCO when calibrating baselines in their region
- ensuring regional staff are trained and competent in performing EDME comparisons
- implementation and improvement of relevant LTOLE activities
- advising the SCO of any details or events that may affect the quality of LTOLE activities
- dealing with external surveyors regarding LTOLE matters.

## 9. Definitions

| Term                         | Definition   |
|------------------------------|--|
| AO                           | Authorised Officers include the QM, SCO and RCO, along with any departmental employee involved with providing or maintaining the LTOLE service. The SCO holds and maintains a list of the AOs within the department.   |
| AS                           | Australian Standard  |
| Australian National Standard | The <i>National Measurement Act 1960</i> and the <i>National Measurement Regulations 1999</i> require that all Australian legal units of measurement of a physical quantity are to be made in terms of the SI unit of that physical quantity.  |
| Australian Legal Units       | Under the <i>National Measurement Regulations 1999</i> , the Australian legal units are SI units.  |
| ASIC                         | Aviation Security Identification Card (ASIC). Information regarding the acquisition of an ASIC can be obtained from a regional airport, CASA or from the SCO.  |
| Baseline                     | Queensland utilises EDM Baselines as a means to calibrate and/or verify EDME. Traditionally, Queensland has adopted the Schwendener baseline design and usually consists of at least seven stations set out at specific distances up to 1100m.   |
| Calibration <sup>12</sup>    | A set of operations that establish, under specific conditions, the relationship between values of quantities indicated by a measuring system, or values represented by a material measure or a reference material, and the corresponding value realised by standards.  |
| Department                   | The Department of Natural Resources and Mines (DNRM)   |
| DNRM                         | Department of Natural Resources and Mines  |
| EDM                          | Electronic Distance Measurement  |
| EDME                         | Electronic Distance Measuring Equipment or survey EDM instruments (total stations). For the purposes of this procedure document, the term 'EDME' does not include scanners, distance meters, GNSS equipment, or reflector-less mode on total stations.   |
| EMU                          | Estimation of Measurement Uncertainty  |
| Facility                     | The laboratory defined under ISO/IEC 17025. For the purposes of NATA accreditation, the nominated facility within the department is <i>Geodesy and Positioning</i> .   |
| Instrument operator          | The person who utilised the instrument to carry out the observations required for processing. The instrument operator is also responsible for all activities performed on the day of field work.   |
| IEC                          | International Electro-Technical Commission   |
| ISO                          | International Organisation for Standardisation   |
| Legal Metrology              | Legal Metrology comprises all measurements carried out for any legal purpose and includes measurements that are subject to regulation by law or government decree.   |
| Legal Traceability           | All measurements of physical quantities that are carried out for legal purposes or are subject to regulation by law or government decree are required to be made in terms of the legal SI units. The link between the physical measurements and the relevant SI unit is known as traceability. See <i>Traceability</i> . |
| LTOL                         | Legal Traceability of Length   |
| LTOLE                        | Legal Traceability of Length for EDME  |
| NATA                         | National Association of Testing Authorities (Australia)  |

<sup>12</sup> Definition acquired from the National Measurement Institute website ([www.measurement.gov.au](http://www.measurement.gov.au))

| Term  | Definition   |
|---|--|
| NMI   | National Measurement Institute   |
| PPM   | Parts Per Million is the term commonly used in surveying to describe the scalar component of an accuracy. When referring to length, 1PPM should be expressed as $(1 \times 10^{-6} \times L)$ m or as $(1 \times 10^{-3} \times L)$ mm depending on the desired units. For both expressions, L is Length in m.   |
| Primary Baseline                                | The Primary Baseline is the most stable and least likely to be disturbed baseline in Queensland. A Primary Baseline must have sufficient calibration records over multiple years so that stability and security can be proven. The current Primary Baseline is Maroochy.   |
| QM  | EDM Calibration Quality Manager  |
| RCO   | Regional Calibration Officer   |
| Reference Standard of Measurement <sup>13</sup> | A standard generally having the highest metrological quality available at a given location or in a given organisation from which measurements made there are derived. See also <i>State Primary Reference Standard</i>   |
| Regulation 13 Certificate                       | A certificate of verification of a reference standard of measurement (length) issued by the SCO (NATA signatory) on behalf of the Director General of the department in accordance with the requirements of Section 20 of the <i>National Measurement Act 1960</i> and Regulation 13 of the <i>National Measurement Regulations 1999</i> . Certification is valid for a period of two years provided that an EDM Baseline is calibrated to within the tolerance required for its prescribed use and that the baseline monumentation remains undisturbed. |
| SCO   | The State EDM Calibration Officer (SCO) is an officer delegated by the Director General of the Department who is responsible for the management and calibration of EDM Baselines and verification of EDME. The SCO is required by the Department to be a NATA Authorised Signatory as per the NATA Rules 2006.   |
| SI  | The SI (Standard International) unit for length is the Metre (m).  |
| Standardise <sup>14</sup>                       | To bring to or make of an established standard quantity or quality.  |
| State Primary Reference Standard                | The department verifies EDM baselines as a Reference Standard of Measurement under Regulation 13 of the <i>National Measurement Regulations 1999</i> (Cwlth), in accordance with the <i>National Measurement Act 1960</i> (Cwlth).   |
| Traceability                                    | Traceability is the property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards through an unbroken chain of comparisons all having stated uncertainties.   |
| VA  | Verifying Authority. In accordance with Regulation 73 of <i>National Measurement Regulations 1999</i> (Cwlth), in force under the <i>National Measurement Act 1960</i> (Cwlth), the department is appointed a Verifying Authority for the verification and re-verification of the physical quantity <i>length</i> .  |

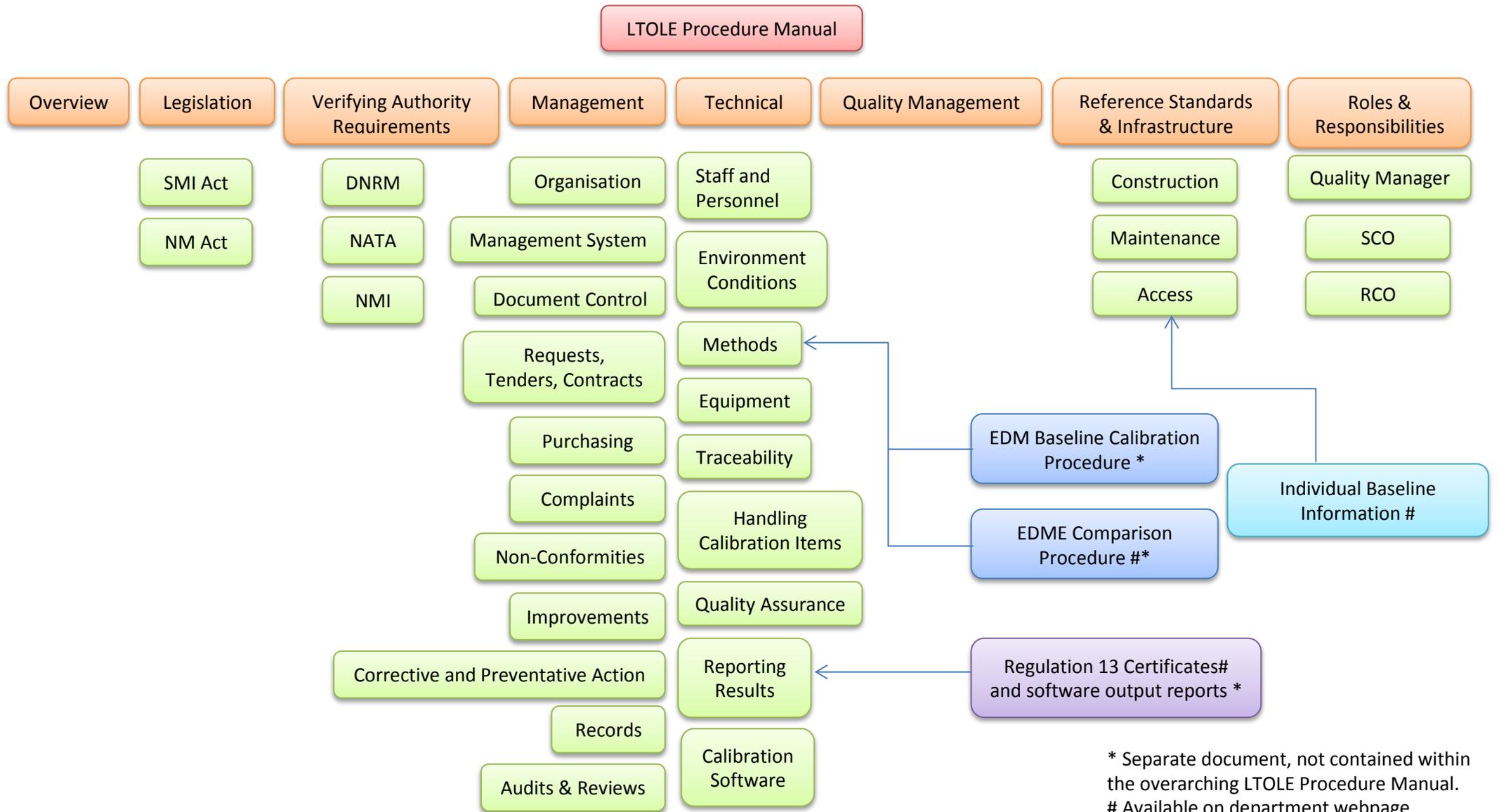
<sup>13</sup> Definition acquired from the National Measurement Institute website ([www.measurement.gov.au](http://www.measurement.gov.au))

<sup>14</sup> Definition acquired from Australian Macquarie dictionary

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# Appendix A LTOLE Documentation Structure Diagram



## Appendix B LTOLE Activities Listing

| Management                                      | Technical                                    |
|---|--|
| Memberships (NATA, NMI)                         | EDM Baseline Calibrations                    |
| Delegations                                     | EDME Calibrations                            |
| Policies  | EDME Comparisons                             |
| Procedures                                      | Meteorological Equipment Calibration         |
| Authorisations and Personnel                    | EDM Software maintenance/testing/updates     |
| Audits  | Regulation 13 Certificates                   |
| Reviews/Meetings                                | EDME Specifications (including C & D Values) |
| Purchasing                                      | Baseline Designs (including Offsets and RLs) |
| Training/Conferences/Seminars                   | Observation reductions and computations      |
| Correspondence                                  | Baseline and Equipment testing               |
| Authorised Personnel                            | Baseline monitoring                          |
| Complaints                                      | Estimation of Measurement Uncertainty        |
| Quality Assurance                               |  |
| Enquiries                                       |  |
| Contracting (NT Quote)                          |  |
| Proficiency Testing                             |  |
| Budget & Finance                                |  |
| Booking Sheets, Forms and Templates             |  |
| Baseline Information Documents                  |  |
| Dealings with external parties (e.g. NMI, NATA) |  |
| LTOLE webpage updates                           |  |
| Record Keeping                                  |  |

This list is only intended to be a guide in sorting activities as either management or technical and as such does not list every activity that may be carried out within the department's LTOLE service.

## **Appendix C Equipment Calibration Contacts and other External Contacts**

### **External Verifying Authorities (for calibrating Meteorological Instruments)**

**ABSTEC Calibrations Pty Ltd**                      A.C.N: 074 824 847                      A.B.N: 91 751 155 014

Richard Lange                      Authorised Signatory  
PH: (08) 8244 1355                      F: (08) 8245 1377  
79 Ledger Rd, Beverley, SA, 5009  
E: sales@abstec-calibrations.com.au  
W: www.abstec-calibrations.com.au

*Contact this officer regarding calibration of the EDM Meteorological Instruments*

### **National Measurement Institute (also for calibrating EDM Instruments)**

**Department of Innovation, Industry, Science and Research**                      A.B.N: 74 599 608 295

#### **Sydney (Headquarters)**

36 Bradfield Road, Lindfield, NSW 2070  
(PO Box 264, Lindfield, NSW 2070)  
T: +61 2 8467 3600  
F: +61 2 8467 3610  
Web: <http://www.measurement.gov.au/>

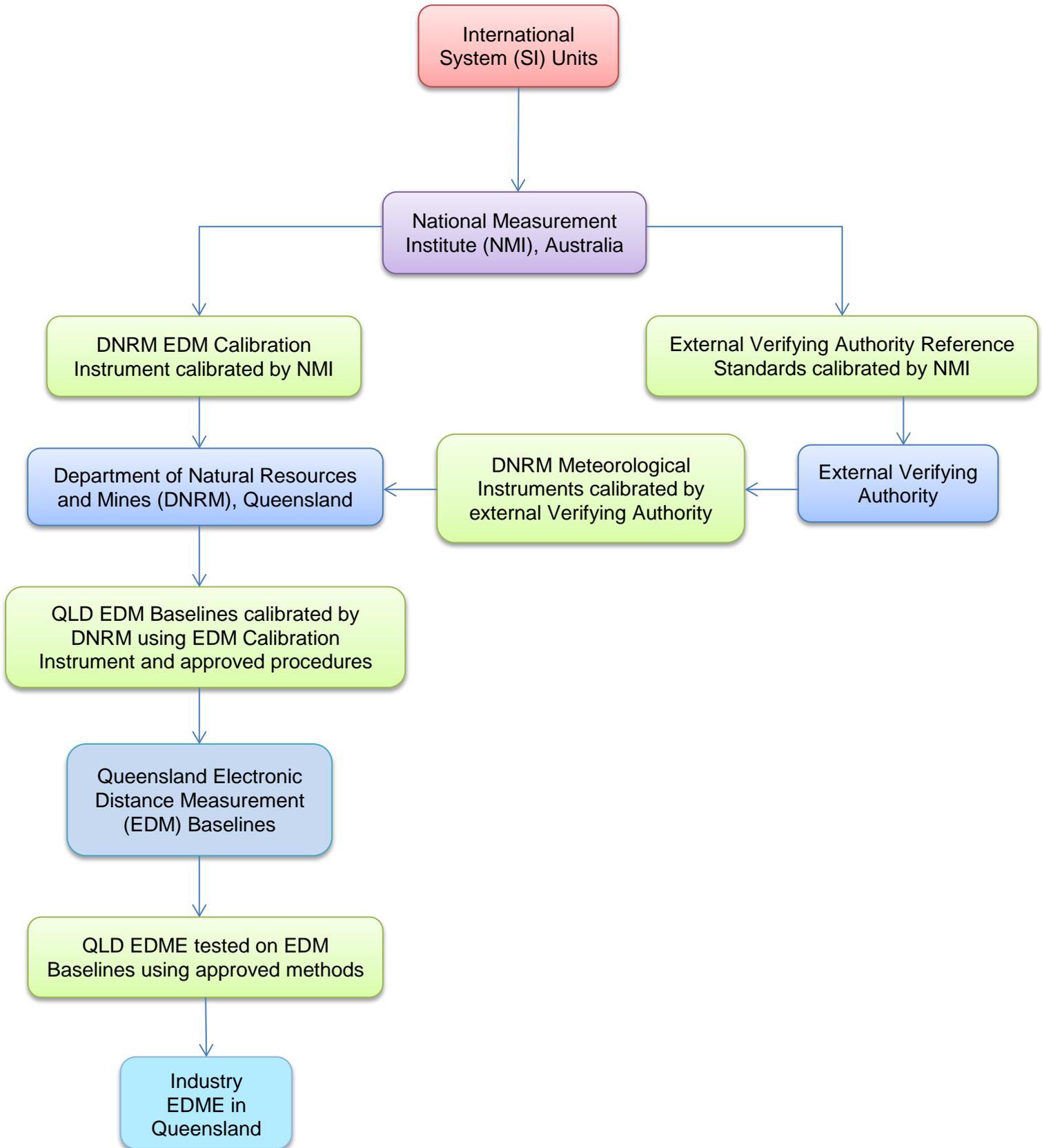
### **National Association of Testing Authorities**

#### **Measurement Science & Technology**

**Samer Al-Shami**                      Senior Client Coordinator  
PH: (07) 3721 7300                      F: (07) 3848 3660  
628 Ipswich Road, Annerley, QLD, 4103  
E: [samer.al-shami@nata.com.au](mailto:samer.al-shami@nata.com.au)

*Contact this officer for all NATA related enquiries (including audits)*

## Appendix D Traceability Link Diagram



## Appendix E Document Referrals and Links

| Item | Item Name                                      | Link / Location   |
|------|--|---|
| 1    | Verifying Authority Appointment                | <a href="\\chgfile9\geodata\GAP\LTOLE\CBD.041230_Management\NMI">\\chgfile9\geodata\GAP\LTOLE\CBD.041230_Management\NMI</a>   |
| 2    | NMI Website                                    | <a href="http://www.measurement.gov.au">http://www.measurement.gov.au</a>   |
| 3    | NATA Website                                   | <a href="http://www.nata.com.au/nata/">http://www.nata.com.au/nata/</a>   |
| 4    | Departmental LTOLE webpage                     | <a href="http://www.business.qld.gov.au/industry/property-construction-trades-engineering/surveying/calibration-equipment">http://www.business.qld.gov.au/industry/property-construction-trades-engineering/surveying/calibration-equipment</a> |
| 5    | CBD.041230.LTOLE_Master_Document_List          | <a href="\\chgfile9\geodata\GAP\LTOLE\CBD.041230_Management">\\chgfile9\geodata\GAP\LTOLE\CBD.041230_Management</a>   |
| 6    | Departmental Shared Server Directory for LTOLE | <a href="\\chgfile9\geodata\GAP\LTOLE">\\chgfile9\geodata\GAP\LTOLE</a>   |