

General Requirement Specification High-End Electronic Total Station

April 2010

1 Introduction

This specification describes the requirements for an electronic total station (ELTS) which can operate directly with an industry standard CF Type on-board data collection unit (ODCU). Other required features are described that will enhance productivity and ensure compatibility with existing or anticipated related equipment. Additionally, the instrument and software shall be fully upgradable and compatible with existing equipment.

ELTS:	Electronic Total Station
ODCU:	Onboard Data Collection Unit
GPS:	Global Position System
Existing Equipment:	Leica TCRP1205(ELTS), Leica ATX 1260 Series(GPS)
Existing Office Software:	Leica GEO Office

2 General

2.1 Quality Control

The manufacturer shall adhere to industry standards for quality control in manufacture and performance of the instrument.

- 2.1.1 The manufacturer of the ELTS shall be in compliance with ISO9001.
- 2.1.2 On request, the manufacturer shall provide, at the customers' expense, a certificate of compliance, calibration, or both, in accordance with the recognized ISO standard for the instrument type.
- 2.1.3 The supplier shall maintain repair parts and service for the ELTS for a period of five years after instrument production stops.

2.2 Construction

- 2.2.1 To assure long-term accuracy and reliability, the instrument body shall be one piece metallic construction, with high-strength fiber-reinforced plastic cover plates. The design emphasis shall be on ruggedness, stability and light weight.
- 2.2.2 To minimize setup time and eliminate maintenance-prone cables, the unit shall be fully self-contained with integral keyboards, displays, battery and ODC.
- 2.2.3 A rugged carrying handle shall be an integral part of the unit and shall be removable.

2.3 Transport Case

- 2.3.1 The ELTS shall be delivered in a rugged transport case, suitable for shipment via common carrier.
- 2.3.2 The transport case shall contain the following:
Instrument, with tribrach attached; spare internal battery; toolkit for minor field adjustments; cable or Bluetooth device to connect ELTS to computer; CF card; ODCU; sunshade; rain cover; and user manual.

2.4 Human Factors

- 2.4.1 Buttons, focusing ring, and other controls shall be designed to provide a high level of comfort and convenience for the operator.
- 2.4.2 Face I position of the instrument shall be configurable via the instrument software.
- 2.4.3 Horizontal and vertical motion controls shall be "endless fine drive". Horizontal and vertical coarse positioning shall be performed using mechanical friction couplings; there shall be no clamping mechanism.

2.5 Tribrach

- 2.5.1 To maximize flexibility and compatibility with work performed by conventional opto-mechanical theodolites, the unit shall mount to the industry standard WILD/LEICA forced-centering tribrach system, and be fully compatible with current WILD/LEICA theodolite accessories.
- 2.5.2 The ELTS tilting axis height shall be 196mm above the tribrach dish.
- 2.5.3 The ELTS shall be equipped with a laser plummet. An option to use a tribrach with optical plummet shall be available. This optional tribrach shall include an optical plummet with 2X magnification, focusing range from 0.5 meters to infinity and field-of-view of 5.7°.

2.6 Leveling & Plummet

- 2.6.1 The ELTS shall use a liquid-filled dual-axis electronic compensator.
- 2.6.2 The compensator shall be switchable ON/OFF from the keyboard or RS232 interface.
- 2.6.3 The ELTS shall use a graphical electronic display for fine-leveling the instrument.
- 2.6.4 For efficient plumbing above survey marks, the ELTS shall be equipped with a laser plummet located in the alidade. The plummet shall automatically be switched on whenever the user invokes the electronic level display.
- 2.6.5 For speed and convenience in rough leveling, the ELTS shall have a liquid-filled circular "bull's-eye" level with a range of 4'.

2.7 Power Supply

The ELTS is powered by an onboard battery, or by connection to external battery or power supplies:

- 2.7.1 The ELTS shall be supplied with a battery mounted internally in the standard of the instrument. The battery shall be easily replaceable without the use of any tools.
- 2.7.2 The onboard battery shall be rechargeable Lithium Ion, 7.4V, 3.8Ah.
- 2.7.3 Battery capacity: Under normal conditions, a single battery, fully charged, shall be capable of providing at least 400 angle and distance measurements (motorized instrument) or 600 angle and distance measurements (non-motorized instrument).
- 2.7.4 A battery charger shall be supplied with the ELTS. Typical charging time shall be 90 minutes. A cable to allow the charger to be connected to a car battery (via cigarette lighter) shall be supplied.
- 2.7.5 External power supply:
 - 2.7.5.1 The ELTS shall be compatible with 12V external power supplies or batteries. External power is supplied to the ELTS via the data-interface connection described herein.
 - 2.7.5.2 The ELTS shall be fully compatible with Leica GEB211 and GEB221 batteries. Batteries shall be able to be swapped between existing ALDOT instrumentation which they already have.
- 2.7.6 To maximize battery life in the field, provisions shall be incorporated to automatically shut down: (a) the EDM immediately after completing a measurement and; (b) the ELTS after a predefined time.

2.8 Documentation

The ELTS shall be supplied with complete user documentation including manuals for applications and technical data. The documentation shall be supplied as follows:

- 2.8.1 Small-format user manual. To ensure that the manual is readily accessible by field personnel, this manual shall fit inside the Transport Case.
- 2.8.2 Field Manuals for instrument operation and the use of onboard applications.
- 2.8.3 A CD-ROM shall be supplied with the ELTS, and shall contain the following information:
 - 2.8.3.1 Complete technical documentation (Technical Reference Manual) shall be supplied in PDF format.
 - 2.8.3.2 PDF files of the user and field manuals described above.
 - 2.8.3.3 Current (as of ELTS delivery date) version of instrument firmware and onboard applications.

- 2.8.4 Additional technical documentation shall not be included with the ELTS, but may be obtained from the manufacturer:
 - 2.8.4.1 Data formats
 - 2.8.4.2 Interfacing information and external commands

3 Instrument Operation

3.1 Keyboard Display

- 3.1.1 The ELTS shall be configured with a display/keyboard unit in each face. The display shall be fixed to the instrument.
- 3.1.2 The display shall be LCD, illuminatable.
- 3.1.3 The display shall be graphics-capable, with resolution of 320x240 pixels (¼ VGA).
- 3.1.4 The display brightness, illumination, and contrast shall be controllable from the keyboard.
- 3.1.5 The keyboard shall use weatherproof keys that are illuminatable.
- 3.1.6 The key illumination shall be controllable from the keyboard.
- 3.1.7 The keyboard shall use color-coded keys. The keys shall be sectionalized into groups for:
 - 3.1.7.1 Entry of numerical information, one key per number
 - 3.1.7.2 Control and selection of menus using multi-function 'hotkeys', cursor control, and 'Enter' key.
- 3.1.8 To promote ease of use and maximize initial productivity, all functions supported by the ELTS shall be selectable from displayed menu selection numbers and prompts ("Menu Driven.").
- 3.1.9 To promote maximum productivity as operator familiarity with the ELTS develops, all functions supported by the ELTS shall be selectable by numeric keystrokes corresponding to the displayed menu selection numbers ("Command Driven.").
- 3.1.10 Keyboard functions shall include at least the following:
 - 3.1.10.1 Single-keystroke to invoke measure and recording of distance and angles.
 - 3.1.10.2 Single-key distance measurement.
 - 3.1.10.3 Single-key initiation of manual code entry.
 - 3.1.10.4 Single-key control of ESC function, CE, and ENTER.
 - 3.1.10.5 Single-key access to menu onboard applications programs. This menu shall be accessible at all times.
 - 3.1.10.6 Single-key access to commonly or often-accessed functions, including:
 - 3.1.10.6.1 EDM parameters for ppm and prism selection
 - 3.1.10.6.2 EDM measure modes
 - 3.1.10.6.3 Electronic level and compensator
 - 3.1.10.6.4 Atmospheric corrections
 - 3.1.10.6.5 Offsets configuration
- 3.1.11 To prevent accidental switching off, a paired keystroke, with confirmation, shall be employed to switch off the ELTS.
- 3.1.12 Alphanumeric input shall supported and be handled in one of two user-selectable ways:
 - 3.1.10.6 Via function keys. Upper and lower case characters and special symbols shall be supported.
 - 3.1.10.6 Via the numeric keypad in a manner similar to programmable cellular telephones.
- 3.1.13 Language. Standard language shall be English, with Spanish, French, Swedish, Finnish, Danish, Italian, Portuguese, Norwegian, Japanese, Chinese and German available.

3.2 Electronic Guide Light

To assist the prism operator in determining the direction in which the ELTS is pointing (i.e. to find 'line') the manufacturer shall provide an Electronic Guide Light System (EGLS).

- 3.2.1 The EGLS shall consist of blinking two light sources, one red and one yellow, mounted above the objective lens of the telescope. When the prism operator is to one side or the other of line, he or she will see that one light source is more prominent than the other. When on line, the operator is in the 'null zone' between the lights, and will see neither source.
- 3.2.2 The EGLS shall be operable in either Face I or Face II. To eliminate difficulty due to color-blindness or other constraints, the light sources shall blink at different rates.
- 3.2.3 The operator shall be able to switch the EGLS On or Off and control the intensity of the lights from a menu that is always available via a single keystroke from any operation of the ELTS.
- 3.2.4 The range of the EGLS shall be 150m in average conditions.
- 3.2.5 The positioning accuracy of the EGLS should be 5cm at 100m.

3.3 Graphical User Interface (GUI)

The ELTS shall have a graphical user interface with simple icons displaying instrument status, including:

- 3.3.1 Battery charge level
- 3.3.2 Compensator status
- 3.3.3 Status of EDM
- 3.3.4 Prism selected
- 3.3.5 Status of Target Recognition System

3.4 Configuration Settings

It shall be possible to set and retain indefinitely the following configuration settings into the ELTS via the keyboard:

- 3.4.1 Units & Formats
 - 3.4.1.1 Distance units and significant digits displayed
 - 3.4.1.2 Angle units and significant digits displayed
 - 3.4.1.3 Units for temperature and pressure
 - 3.4.1.4 Coordinate display format: NE or EN
 - 3.4.1.5 Angles clockwise or counter-clockwise
 - 3.4.1.6 ELTS face I position
 - 3.4.1.7 Time and time display format
 - 3.4.1.8 Date and date display format
- 3.4.2 Interfaces and Devices
 - 3.4.2.1 Baud rate
 - 3.4.2.2 Parity
 - 3.4.2.3 Data Bits
 - 3.4.2.4 Stop bit
- 3.4.3 General Settings
 - 3.4.3.1 PIN Code setting at instrument startup
 - 3.4.3.2 Start Screen application selection
 - 3.4.3.3 Definable user menu with most important functions
 - 3.4.3.4 Definable hotkeys with most important functions
- 3.4.4 Survey Settings

- 3.4.4.1 Definable Point ID templates with numeric or alphanumeric incrementation.
- 3.4.4.2 Definable data display on standard measurement screen.
- 3.4.4.3 It shall be possible to store measured data into one job, and access a second job to obtain points for setup, stakeout and reference line. In this case, measured data does not affect the information stored in the 2nd job.
- 3.4.4.4 Prism constant
- 3.4.4.4 Atmospheric and geometric PPM values
- 3.4.5 Station Data
 - 3.4.5.1 Station coordinates
 - 3.4.5.2 Instrument height
 - 3.4.5.3 Horizontal orientation
- 3.4.6 Calibration
 - 3.4.6.1 Compensator index, longitudinal and transverse errors
 - 3.4.6.2 Vertical index error
 - 3.4.6.3 Horizontal and vertical collimation error
 - 3.4.6.4 Tilting axis error
 - 3.4.6.5 Calibration for Target Recognition System, if applicable
- 3.4.7 Storing of Configuration Settings
 - To allow rapid and consistent configuration, ELTS shall be able to read and write the stored configuration settings to a data file residing on the ODCU.

4 Angular Measurement

4.1 General

- 4.1.1 The angle measurement system shall use absolute encoders, preventing the need for manual indexing or electronic reorientation of circles upon power-up, even though instrument orientation may have been changed during power off.
- 4.1.2 To reduce errors associated with circle eccentricity, the ELTS shall employ diametrically opposed sensors for reading the encoders.
- 4.1.3 The angle measurement system shall be configurable for angles left or right from the keyboard or via the interface.
- 4.1.4 Accuracy and resolution. The ELTS shall provide horizontal and vertical an angle measurement accuracies shown in the tables below measured in accordance with ISO 17123-3.

4.2 Speed of Measurement

- 4.2.1 The angle measurement system shall measure continuously and provide instantaneous output while the instrument is at rest.
- 4.2.2 The angle measurement system shall measure continuously and be capable of providing time-tagged measurements within 0.2 second while the instrument is moving at any rotational speed below 45 degrees (50 gons) per second.

4.3 Automatic Corrections

- 4.3.1 Corrections to horizontal and vertical circle readings for minor instrument mis-leveling (< 4') shall be applied automatically by use of a liquid-filled electronic dual-axis compensator system.
- 4.3.2 To eliminate the requirement for manual adjustment of data due to reticule misalignment and axis errors, the ELTS shall automatically compensate circle readings by user-determined and stored correction values for vertical index error and horizontal collimation error.

4.4 Units and Resolution

- 4.4.1 The ELTS subsystem shall support the following angular units:
 - 4.4.1.1 360 Decimal Degrees, resolution 2, 3 or 4 decimals.
 - 4.4.1.2 360 Hexagecimal (Degrees, Minutes, Seconds), resolution 60", 10", 5", 1" or 0.1".
 - 4.4.1.3 400 Gons, resolution 2, 3 or 4 decimals.
 - 4.4.1.4 6400 mils, resolution 1, 2 or 3 decimals

5 Distance Measurement

5.1 General

- 5.1.1 The ELTS shall use a coaxial infrared distance meter.
- 5.1.2 As an option, the ELTS shall be equipped with a reflectorless EDM using a visible red laser beam.
- 5.1.3 The ELTS shall provide the following features:
 - 5.1.3.1 Operator entry of ambient temperature and pressure for calculation and storage of atmospheric ppm factor.
 - 5.1.3.2 Entry and storage of geometric ppm (in 0.1ppm steps) and additive constant for prism (in 0.1mm steps) directly from the ELTS keyboard.
 - 5.1.3.3 Automatic correction of distances for earth curvature and refraction.

5.2 Units and Resolution

- 5.2.1 The ELTS shall support the following units for display of distances and coordinates:
 - 5.2.1.1 Meters, resolution 0, 1, 2, 3 or 4 decimals.
 - 5.2.1.2 INT Feet, resolution 0, 1, 2, 3 or 4 decimals.
 - 5.2.1.3 INT Feet / Inch
 - 5.2.1.4 US Feet, resolution 0, 1, 2, 3 or 4 decimals.
 - 5.2.1.5 US Feet / Inch

6 Data Collection and Management

6.1 Onboard Data Storage

- 6.1.1 The ODCU shall be industry standard CompactFlash (CF) data storage card.
- 6.1.2 The ODCU shall be operable over the temperature range of -20°C to +50°C.
- 6.1.3 The ODCU shall be storable over the temperature range of -40°C to +70°C.
- 6.1.4 The ODCU shall be available in several capacities, 32 MB, 256 MB.
- 6.1.5 To ensure complete measurement data the ODCU shall store all information to a comprehensive database file.
- 6.1.6 To maximize productivity, the ODCU shall allow converting measurement data into user defined ASCII formats including WILD/LEICA GSI8 and GSI16.
- 6.1.7 Additional information, including applications log files, text data, and configuration sets may be stored on the ODCU.
- 6.1.8 The ODCU shall be accessible for reading and writing from the ELTS keyboard and from the RS232 port.
- 6.1.9 The system shall permit editing of data stored on the ODCU. This includes the following:
 - 6.1.9.1 Input, editing, and deletion of Coordinate Points.
 - 6.1.9.2 Input and editing of Code information.
 - 6.1.9.3 Editing of point numbers.
 - 6.1.9.4 Editing of measured data is not permitted.

6.2 Coding and Point Descriptions

- 6.2.1 Thematic Coding and Free Coding
 - 6.2.1.1 The ELTS shall support a thematic coding for points, lines and areas and a free coding system, in which a descriptor code may be modified with additional attributes. The values of these attributes may be preset or input from the keyboard.
 - 6.2.1.2 Attributes may be designated as Normal (i.e. Optional), Fixed (i.e. not editable) or Mandatory. If a code with a Mandatory attribute is selected, the operator will not be allowed to record the code until a suitable value for the Mandatory attribute has been entered or selected.
- 6.2.2 It shall be possible to create new thematic and free codes onboard the instrument or with the Office Support Tools described below.
- 6.2.3 QuickCoding: The ELTS shall support numerical or alphanumerical QuickCodes for thematic or free codes. Upon entry of QuickCode the ELTS shall take and store a measurement together with the thematic or free code.
 - 6.2.3.1 The QuickCoding shall be available in the Surveying screens.
 - 6.2.3.2 QuickCodes shall be defined by use of the Office Support Tools described below.

6.3 Office Software Support Tools

- 6.3.1 Office Support Software: An integrated set of software tools shall be available to enable the user to perform the following:
 - 6.3.1.1 Creation and editing of code lists, including thematics, data prompts, and QuickCode designations.

- 6.3.1.2 Import of ASCII coordinate data, using a Coordinate Import Wizard similar in operation to MS-Excel.
- 6.3.1.3 Loading firmware and applications to the ELTS.
- 6.3.1.4 Transfer data to and from the ODCU.
- 6.3.1.5 Reformatting and post processing of ELTS data.
- 6.3.2 Office Simulation
 - An office simulation of the onboard software shall be available for training and educational purposes.

6.4 Accuracy

The TRS shall produce a positioning accuracy of 2 mm. If desired, the pointing accuracy of the TRS may be reduced to produce faster operation in conjunction with the EDM in tracking mode.

6.5 360° Degree Prism

- 8.5.1 To eliminate the need for the operator to always keep the prism pointed towards the ELTS, there shall be available a single prism assembly that will reflect the EDM and TRS signals back to the ELTS, regardless of the horizontal orientation of the prism.
- 8.5.2 The prism shall be constructed of six high quality glass corner cube reflectors with a durable rubber mounting to absorb shocks, and in such a manner that the prism will not roll if leaned against a wall or other surface.
- 8.5.3 The prism is attached to the pole or carrier via a quick-release bayonet mount.

7 Onboard Applications

The ELTS shall offer an extensive library of onboard applications software. This software shall reside in the internal memory of the instrument.

7.1 General

The following applications shall be available as standard delivery:

- 11.1.1 Setup (Set Azimuth, Known Backsight Point, Resection, Orientation & Height transfer)
- 11.1.2 Survey (incl. automatic measurement of points, height to remote object).
- 11.1.3 2-D and 3-D Stakeout, with graphical guidance.
- 11.1.4 COGO (Calculation of inverse, traverse, intersections, line and arc calculations, shift, rotate & scale).

7.2 Optional Applications

Additional applications shall include, but not be limited to:

- 11.2.1 Building Stakeout via Reference Lines
- 11.2.2 Road Stakeout
- 11.2.3 Stakeout to Digital Terrain Model
- 11.2.4 Sets of Angles
- 11.2.5 Monitoring
- 11.2.6 Area Division
- 11.2.7 Traversing
- 11.2.8 Automated Face Scanning
- 11.2.9 Hidden Points
- 11.3.0 Seamlessly transfer of data between existing ALDOT instrumentation with no need of converting format to match what they already are using.

8 Tables

8.1 Physical

Dimensions:	203 x 226 x 328 mm
Weight:	
- Instrument (non-motorized):	4.8 kg
- Instrument (motorized with TRS):	5.5 kg
- Tribrach:	0.8 kg
- Battery:	0.2 kg

8.2 Environmental

Operating temperature range:	-4°F to +122°F (-20°C to +50°C)
Storage temperature range:	-40°F to +158°F (-40°C to +70°)
Humidity:	Max 95 % non condensing
Dust, Water and Sand:	IP54 (IEC 60529)

8.3 Telescope

Magnification:	30x
Field-of-view:	1°30' (1.66 gon) 2.7m at 100m
Clear objective diameter:	40mm
Focusing:	1.7m (5.6ft) to infinity
Reticule illumination:	selectable from keyboard
Fully transiting:	yes

8.4 Angle Measurement 3"

Accuracy (ISO 17123-3)	
- Horizontal:	3" (1.0mgon)
- Vertical:	3" (1.0mgon)
Display least count:	0.1" (0.5mgon)
Compensator	
- Type:	Centralized dual-axis compensator
- Setting Range:	4' (0.07gon)
- Setting Accuracy:	1" (0.3mgon)

8.5 Angle Measurement 5"

Accuracy (ISO 17123-3)	
- Horizontal:	5" (1.5mgon)
- Vertical:	5" (1.5mgon)
Display least count:	0.1" (0.5mgon)
Compensator	
- Type:	Centralized dual-axis compensator
- Setting Range:	4' (0.07gon)
- Setting Accuracy:	5" (1.5mgon)

8.6 Distance Measuring System (Infrared)

8.6.1 General

Type:	Infrared, coaxial
Carrier Wave:	780nm

8.6.2 Accuracy

Measurement Mode:	Accuracy:
Standard (prism):	2mm + 2ppm
Fast (prism):	5mm + 2ppm
Tracking (prism):	5mm + 2ppm

8.6.3 Measurement Time

Measurement Mode:	Measurement Time:
Standard (prism):	1.5sec
Fast (prism):	0.8sec
Tracking (prism):	<0.15sec

8.6.4 Range

Target Type:	Range (average conditions, 20km visibility):
Reflective tape target:	800 ft (250m) (60 x 60mm target)
Circular prism:	10,000ft (3000m)
360 Prism:	5,000ft (1500m)
Mini Prism:	4,000ft (1200m)

8.7 Distance Measuring System (Reflectorless / Long Range)

8.7.1 General

Type:	Red laser, coaxial
Laser:	Visible red laser, can also be used as pointer
Carrier Wave:	670nm

8.7.2 Accuracy

Measurement Mode:	Accuracy:
Standard (RL) 1.5 – 500 m:	3mm + 2ppm
Standard (RL) > 500 m:	5mm + 2ppm
Long range (prism):	5mm + 2ppm

8.7.3 Measurement Time

Measurement Mode:	Measurement Time:
Standard (RL) 1.5 – 500 m:	Typ. 3-6sec
Standard (RL) > 500 m:	Typ. 3-6sec
Long range (prism):	Typ. 2.5sec

8.7.4 Range

Target Type:	Range (Avg conditions, 20km visibility)
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Reflectorless (Kodak Grey Card, white side, 90% reflective):	1640ft (500m)
Reflectorless (Kodak Grey Card, grey side, 18% reflective):	990ft (300m)
Long Range to circular prism:	24,600ft (>7500m)

8.8 Units and Resolution

8.8.1 Angular Units

360 decimal degree:	0.0001 deg
360 sexagesimal:	0.1"
6400 mil:	0.001
400 gon:	0.0001 gon

8.8.2 Distance Units

Meters:	0.0001m
International feet:	0.0001ft
US Feet:	0.0001ft
US Feet and Inches:	0.0001 gon

8.9 Plummet

Type:	Laser
Intensity:	10 levels, user selectable
Accuracy:	Deviation from plumbline: 1.5 mm at 1.5 m instrument height
Spot size:	2.5 mm at 1.5 m instrument height

8.9.1 Physical

Weight, including battery:	0.753 kg / 1.660 Lb
Dimensions:	218 x 123 x 47 mm
Environmental:	IP67 (IEC60529) Dusttight Waterproof to 1 m temporary immersion
Operating Temperature:	-30°C to +65°C
Storage Temperature:	-40°C to +70°
Operating Time with one battery:	10 hours
Interface:	RS232