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ETS Specifications

Instrument Specifications, Data Structures, Configuration & User Interface

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Session Objectives

- **Understand the concept and components of an ETS**, including angle measurement, EDM, onboard processing, and data storage.
- **Interpret key ETS specifications** related to angular accuracy, distance measurement, compensators, measurement modes, and IP ratings.
- **Explain the working principles of dual-axis and quad-axis compensators** and their impact on measurement accuracy.
- **Understand ETS data structures and configuration settings** for reliable data capture, QA/QC, and error minimization.
- **Develop the ability to select and operate an ETS appropriately** based on project requirements and field conditions.

What is an ETS?

- Integrated instrument combining:
  - Electronic theodolite (angles)
  - EDM (distances)
  - Microprocessor & data storage
- Measures:
  - Horizontal angle
  - Vertical angle
  - Slope distance
- Computes coordinates in real time
- Replaces separate theodolite + EDM + field book

ETS Instrument Specifications

- Specifications define **capability and accuracy**
- Main categories:
  - Angular measurement
  - Distance (EDM) measurement
  - Optical & mechanical
  - Environmental & power
- Must match **project accuracy requirements**

Angular Measurement Specifications

- Angular accuracy: 1″, 2″, 5″, 7″
- Smaller value → higher precision
- Display resolution (e.g., 0.1″)
- Dual / Quad-axis compensator
- Compensator range (±4′ to ±6′)

- **Impact:**
- Controls traverse angular misclosure
- Influences positional accuracy at distance

Quad-Axis (Quadruple) Compensator

- Extends dual-axis compensation using **four internal observation states**
- Combines:
  - **Dual-axis tilt sensing**
  - **Face-left / face-right normalization**
- Automatically corrects:
  - Instrument tilt (X & Y)
  - **Collimation error**
  - **Vertical index (circle zero) error**
- Provides **higher angular accuracy and stability**
- Designed for **high-precision control and engineering surveys**

Dual-Axis Compensator

- An electronic tilt-sensing system that detects inclination of the instrument about **two mutually perpendicular horizontal axes** (commonly referred to as **X and Y axes**) and automatically corrects angular observations.
- **Axes of Measurement**
- **X-axis (longitudinal axis)** – tilt in the direction of telescope sighting
- **Y-axis (transverse axis)** – tilt perpendicular to the telescope direction
- **Function**
- Measures small deviations from perfect leveling
- Computes correction values in real time
- Applies corrections to:
  - **Horizontal angle (Hz)**
  - **Vertical angle (V)**

Characteristics

Compensation range: typically a **few arcminutes**

Corrects **random and systematic tilt errors** caused by:

Imperfect leveling
Ground settlement
Tripod instability

Limitation

Does **not inherently correct**:

Collimation error
Vertical circle index error

Error Types and Compensation

Error Type	Dual-Axis	Quad-Axis
Leveling tilt	✔ Corrected	✔ Corrected
Horizontal axis tilt	✔	✔
Collimation error	✖ Not corrected	✔ Automatically corrected
Vertical index error	✖ Not corrected	✔ Automatically corrected
Face-dependent errors	✖	✔ Eliminated

Distance (EDM) Specifications

- Accuracy format:
  ±(a mm + b ppm)
- Prism mode:
  - High accuracy, long range
- Reflectorless mode:
  - Lower accuracy
  - Useful for inaccessible points
- Measurement time: fine / rapid / tracking

Measurement time

- **Fine Mode**
  - Longest measurement time
  - Maximum signal averaging
  - **Highest accuracy**
  - Used for **control and precision surveys**
- **Rapid Mode**
  - Moderate measurement time
  - Balanced averaging
  - **High accuracy with faster results**
  - Used for **general engineering and topographic surveys**
- **Tracking Mode**
  - Very short, continuous measurement
  - Minimal averaging
  - **Fast real-time distance updates** (lower precision)
  - Used for **setting out and stake-out work**

Typical IP(Ingress Protection) Ratings for ETS

- **IP54**
  - Suitable for normal site conditions
  - Limited protection in rain and dusty environments
- **IP65**
  - Dust tight, protected against water jets
  - Suitable for most engineering and construction surveys
- **IP66**
  - Dust tight, protected against heavy rain
  - Suitable for harsh weather and long outdoor operations

ETS Data Structures

- Data stored in **JOB / PROJECT**
- Hierarchical structure:
  - Control points
  - Station setups
  - Observations (angles, distances)
  - Computed coordinates
- Raw observations preserved
- Computed values derived, not overwritten

Point & Observation Records

- **Point Data**
  - Point ID
  - X, Y, Z coordinates
  - Code & description
  - Measured / computed status
- **Observation Data**
  - Hz angle, V angle
  - Slope distance
  - HI & HT
  - Face (FL / FR)
  - Time & mode
- **Importance:** QA/QC and traceability

ETS Configuration Settings

- Measurement settings:
  - Angle units (deg / gon)
  - Distance units (m / ft)
- EDM parameters:
  - Prism constant
  - Temperature & pressure
- Coordinate system:
  - Local / Grid
  - Orientation method
- Incorrect settings → systematic errors

ETS User Interface (UI)

- LCD / touch screen
- Keypad & trigger key
- Status indicators:
  - Battery
  - Compensator
  - EDM mode
- Functional menus:
  - Survey
  - Stakeout
  - Traverse / Resection
  - Job & data management

Check list for procurement of ETS

Requirement	Specification Needed	Pass/Fail
Project accuracy	??? mm	✔ / ✘
Longest distance	??? m	✔ / ✘
EDM accuracy	mm + ppm	✔ / ✘
Angular accuracy	1"/2"/5"	✔ / ✘
Combined error	< required	✔ / ✘
Reflectorless needs	Y/N	✔ / ✘
Compensator	dual/quad	✔ / ✘
Software features	✓	✔ / ✘
IP rating	IP65/66	✔ / ✘
Battery life	Hours	✔ / ✘
Weight	kg	✔ / ✘

SUMMARY TABLE: CHOOSING ETS BASED ON PROJECT NEEDS

Project Type	Recommended ETS Distance Accuracy	Recommended Angular Accuracy
Cadastral survey	2 mm + 2 ppm	1″–3″
Building construction	2–3 mm + 2–3 ppm	2″–5″
Topographic survey	3–5 mm + 3–5 ppm	5″–10″
Engineering projects (bridges, metro)	1–2 mm + <2 ppm	1″
Long alignments	<3 mm + <2 ppm	2″–5″
Geodetic control	<1 mm + <1 ppm	<1″

Typical ETS Specifications

ANGULAR MEASUREMENT			
Accuracy Hz and V	Absolute, continuous, diametrical[1]	2'' / 3'' / 5"	1" / 2" / 3" / 5" / 7"
	■ Display resolution: 0.1'' (0.1 mgon) ■ Quadruple axis compensation ■ Compensator setting accuracy[2]: 0.5'' / 1''/ 1.5" / 2" ■ Compensator range: +/- 4' ■ Electronic level resolution: 2" ■ Circular level sensitivity: 6` / 2 mm	✔	✔
DISTANCE MEASUREMENT			
Range	■ Prism (GPR1, GPH1P): 0.9 m to 3,500 m ■ Prism GPR1 (Long Range mode) > 10,000 m	✔	✔
	Non-Prism / Any surface ■ R500[3] ■ R1000[4]	✔ ✗	✔ •
Accuracy / Measurement time	Single prism ■ Precise+ / Once: 1 mm + 1.5 ppm (typical 2.4 s) ■ Precise&Fast / Once&Fast: 2 mm + 1.5 ppm (typical 2 s) ■ Tracking / Continously: 3 mm + 1.5 ppm (typical < 0.15 s) ■ Averaging: 1 mm + 1.5 ppm ■ Long Range mode / > 4 km: 5 mm + 2 ppm (typical 2.5 s)	✔	✔
	Non-Prism / Any surface ■ 0 m - 500 m: 2 mm + 2 ppm (typical 2.4 s[5]) ■ > 500 m: 4 mm + 2 ppm	✔	✔
Laser dot size	■ At 30 m: 7 mm x 10 mm ■ At 50 m: 8 mm x 20 mm ■ At 100 m: 16 mm x 25 mm	✔	✔
Telescope	■ Magnification: 30x ■ Resolving power: 3" ■ Focusing range: 1.55 m / 5.08 ft to infinity ■ Field of view: 1°30' / 1.66 gon / 2.7 m at 100 m	✔	✔

Summary

- Specifications define **what the ETS can achieve**
- Data structures ensure **reliability & verification**
- Configuration controls **systematic errors**
- User interface affects **speed & blunder prevention**
- Accurate results require:
  - Correct instrument
  - Correct settings
  - Correct operation
- **Well-configured ETS = Reliable survey results**

Exercise

Exercise 1: Understanding ETS Specifications

You are provided with the specifications of an Electronic Total Station, including:

Angular accuracy

Compensator type (dual-axis / quad-axis)

EDM measurement modes (fine / rapid / tracking)

IP rating

Tasks:

Identify which specifications directly affect **angular accuracy** and **distance accuracy**.

Explain how the compensator type influences measurement reliability.

State whether the instrument is more suitable for **control surveying** or **construction work**, with reasons.

Exercise 2: Field Use and Configuration Awareness

During a field survey, an ETS is used under the following conditions:

Slightly uneven ground

Light rain and dust

Combination of detail survey and setting out

Tasks:

Select the appropriate:

- Measurement mode (fine / rapid / tracking)
- Minimum IP rating

List two configuration settings that must be checked before observations.

Explain the possible errors if the compensator or settings are ignored.

End of Session – Thank You!