राष्ट्रीय भू-सूचना विज्ञान
एवं प्रौद्योगिकी संस्थान
भारतीय सर्वेक्षण विभाग
विज्ञान और प्रौद्योगिकी विभाग

National Institute for Geo-Informatics
Science & Technology
Survey of India
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Standards for Transmission Line Survey

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Session Objectives

- **Understand the Role of Surveys:** Explain the importance of transmission line surveys in **planning, design and construction** of overhead power lines.
- **Familiarize with Standards & Regulations:** Introduce the **statutory framework and BIS standards (IS 5613)** governing transmission line surveys in India.
- **Explain Survey Stages:** Describe the **systematic stages** of transmission line surveying from walk-over survey to check survey.
- **Introduce Modern Technologies:** Highlight the application of **GNSS, ETS, GIS, satellite imagery and digital terrain models** in modern surveys.
- **Link Survey Data to Design & Construction:** Demonstrate how survey outputs support **alignment optimization, tower spotting, foundation design and statutory clearances**.
- **Build Professional Competence:** Enable participants to **interpret survey charts, profiles and schedules** for effective engineering decision-making.

Transmission Line Surveys

- **Foundation of Power Transmission Planning**
  Transmission line surveys form the first and most critical engineering activity for overhead power lines, governing alignment, safety, cost, and constructability.
- **Electrical & Statutory Compliance**
  Ensures statutory ground clearances, right-of-way (RoW), conductor sag–tension limits and safe crossings over roads, railways, rivers and habitations.
- **Optimized Alignment & Tower Spotting**
  Integrates terrain, span length, tower type, soil conditions and access to achieve minimum cost with maximum reliability.
- **Multidisciplinary Engineering Input**
  Combines surveying, geodesy, geotechnical evaluation, environmental considerations and construction logistics.
- **Modern Survey Technologies**
  Utilizes GNSS, ETS, UAV/LiDAR, GIS and digital terrain models for high accuracy and efficient decision-making.
- **Key Survey Deliverables**
  Plan & profile drawings, tower schedule, clearance checks, crossing details and RoW maps—forming the backbone of power line design and execution

BIS Standard for Transmission Line Surveys(India)

- Governing Code: IS 5613 – Code of Practice for Design, Installation and Maintenance of Overhead Power Lines, issued by the Bureau of Indian Standards (BIS).
- **Voltage-wise Applicability:**
  - Part 1: Lines up to and including 11 kV
  - Part 2: Lines above 11 kV up to and including 220 kV
  - Part 3: Lines above 220 kV
- **Survey-Relevant Provisions:**
  - IS 5613 (Part 2, Section 2) specifically covers walk-over survey, route alignment, detailed survey, survey charts, and check survey.
- **Engineering Significance:**
  - Provides a standardized framework ensuring accurate survey data, safe electrical clearances, reliable design inputs and compliance with statutory requirements.

Statutory and Regulatory Framework

- **Statutory Basis:** Transmission line surveys are carried out under the **Indian Electricity Act, 2003**, which provides legal authority for survey, right-of-way, construction and operation of overhead power lines.
- **Technical Safety Regulations:** Compliance with **CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010** is mandatory, governing ground clearances, safety distances and performance requirements.
- **Multi-Agency Clearances:** Survey data must satisfy requirements of **Railways, Airports Authority of India (AAI), Defence Authorities, Forest Department**, and **PTCC** for crossings, height restrictions, protected areas and interference issues.
- **Mandatory Compliance:** Adherence to statutory and regulatory provisions is compulsory at **survey, design and construction stages**.
- **Role of Survey Data:** Accurate, reliable, and well-documented survey outputs form the **technical foundation for statutory approvals**, alignment finalization and safe execution of power transmission projects.

Personnel and Responsibility Requirements – IS 5613

- **Mandatory Competence: IS 5613** requires that transmission line surveys be carried out by **authorized, trained, and experienced personnel**.
- **Technical Supervision:** Survey operations shall be **supervised by technically qualified engineers**, competent under applicable **State and Central regulations**.
- **Accountability:** Clear assignment of responsibility ensures **traceability, professional accountability, and compliance** with statutory and safety requirements.
- **Integrity of Survey Outputs:** Competent execution and supervision safeguard the **accuracy, reliability, and engineering validity** of survey data used for design, statutory clearances, and construction.

Right-of-Way (ROW) Standards

- **Critical Planning Element:** Right-of-Way (RoW) is fundamental to transmission line planning, ensuring **electrical safety, statutory clearances, maintenance access and vegetation control**.
- **BIS Guidance:** As per **IS 5613** of the **Bureau of Indian Standards (BIS)**, recommended minimum RoW widths vary with voltage level.
- **Recommended Minimum RoW Widths**

Voltage Level	RoW Width
33 kV	15 m
66 kV	18 m
110 kV	22 m
132 kV	27 m
220 kV	35 m

- **Survey Prerequisite:** RoW clearing shall be completed **before detailed survey**, both in **legal terms (permissions, consent)** and **physical terms (access and visibility)**.
- **Compensation Documentation:** Assessment of **crop damage and land-use impact** must be recorded during survey to support compensation and statutory processes.

Scope of Transmission Line Survey

- **Standard Reference:** As per **IS 5613** issued by the **Bureau of Indian Standards (BIS)**, transmission line surveys are conducted in defined sequential stages.
- **Survey Components:**
  - **Walk-over Survey** – Preliminary reconnaissance of the proposed corridor
  - **Route Alignment Survey** – Finalization of alignment and preparation of alignment maps
  - **Detailed Survey (Plan & Profile)** – Accurate horizontal and vertical control for design
  - **Survey Charts Preparation** – Engineering drawings for tower spotting and clearance checks
  - **Check Survey** – Verification of survey data prior to construction
- **Engineering Rationale:**
  - Each stage progressively refines **alignment accuracy and engineering detail**, forming a reliable basis for design, statutory approvals, and construction of overhead power transmission lines.

Walk-Over Survey

- **Purpose:** The walk-over survey is the **initial reconnaissance stage** of transmission line surveying, carried out before detailed alignment and profiling.
- **Primary Objectives:**
  - Identification of **feasible transmission corridors** between terminal substations
  - Preliminary assessment of **terrain conditions, accessibility, and land use**
  - Identification of major constraints such as **forests, habitations, rivers, highways, railways, and existing power lines**
- **Mapping Basis:**
  - Multiple alternative routes are identified and marked on **Survey of India (SOI)** toposheets for comparative study.
- **Engineering Significance:**
  - Forms the **basis for route optimization and comparative evaluation**, enabling selection of the most technically feasible, economical, and environmentally acceptable alignment.

Preparation of Route Alignment Map

- **Purpose:** Following the walk-over survey, route alignment maps are prepared to depict the proposed transmission line corridor for comparative evaluation and approvals.
- **Map Scales**
  - Standard alignment maps: 1 : 50,000
  - Urban / complex terrain: 1 : 10,000
  - Key / index maps (where required): 1 : 200,000
- **Data Sources**
  - Survey of India (SOI) toposheets (baseline reference)
  - High-resolution satellite imagery, GNSS-based field data, and GIS platforms
  - UAV photogrammetry / LiDAR in complex or inaccessible terrain
- **Engineering Significance:**
  - Enables accurate corridor visualization, faster route optimization, and robust inputs for statutory clearances and detailed survey planning, while remaining compliant with IS 5613.

Modern Tools in Transmission Line Surveys

- **High-Resolution Satellite Imagery:** Provides up-to-date ground information for **corridor visualization, land-use assessment, and constraint identification**.
- **GNSS / DGPS Observations:** Enable **precise horizontal and vertical control**, supporting accurate alignment, profiling, and geo-referencing.
- **GIS Platforms:** Facilitate **integration, analysis, and visualization** of spatial, environmental, and engineering data within a single framework.
- **Engineering Advantages:**
  - Rapid updating of **legacy toposheets and alignment maps**
  - Accurate **corridor analysis and route optimization**
  - Early identification of **environmental and social constraints**, reducing redesign and approval delays

Route Selection and Optimization Criteria

- **Planning Objective:** Selection of an optimized route is governed by **engineering, economic, environmental and social considerations**.
- **Key Criteria:**
  - **Minimum total line length**
  - **Minimum number of angle points**
  - **Avoidance of forests, wildlife sanctuaries and eco-sensitive zones**
  - **Avoidance of dense habitations and restricted areas**
  - **Minimum crossings** of rivers, highways, railways and existing **EHV lines**
  - **Year-round accessibility** for construction and maintenance
- **Alternative Route Evaluation:**
  - Typically **three alternative routes (Alt-I, Alt-II, Alt-III)** are identified.
  - Comparative assessment is carried out using **quantitative parameters** (length, towers, cost) and **qualitative parameters** (environmental and social impact).

Detailed Survey – Transmission Line

- **Purpose:** After approval of the optimized route, a **detailed survey** is conducted to fix the precise **centre line** and collect all **engineering data** required for design and construction.
- **Survey Instruments:**
  - **Electronic Total Stations (ETS)**
  - **Differential GNSS (DGPS)**
  - **Digital Levels**
- **Plan Survey:**
  - Establishes **horizontal control**, traverse alignment, angle points and locations of **crossings and topographic features**.
- **Profile Levelling:**
  - Carried out along the **centre line** to determine ground elevations.
  - Levelling must **start and close on approved benchmarks**.

Height Systems and GNSS Integration

- **GNSS Height Output:** GNSS observations provide **ellipsoidal heights (h)** referenced to a mathematical ellipsoid.
- **Engineering Requirement:** Transmission line design requires **orthometric heights (H)** referenced to mean sea level.
- **Height Conversion Relationship:**
  - $H = h - N$, where **N** is the **geoid undulation**.
- **Role of Geoid Models:**
  - Accurate geoid models are essential to convert GNSS heights reliably.
  - Ensures **consistent vertical control**, accurate ground profiles and safe electrical clearances.
- **Engineering Significance:**
  - Enables effective **integration of GNSS data** with levelling results in transmission line design and construction.

Geotechnical and Terrain Data Collection

- **Objective:** To obtain soil and terrain information essential for **safe and economical tower foundation design**.
- **Data Collected During Survey:**
  - **Soil bearing capacity**
  - **Soil type and stratification**
  - **Angle of repose**
  - **Flooding and erosion potential**
- **Engineering Impact:**
  - Governs **foundation type selection**, depth, and construction methodology.
  - Critical in **river crossings, marshy areas, and hilly terrain** to ensure long-term stability.

Preparation of Survey Charts

- **Primary Construction Document:** Survey charts constitute the **core engineering drawings** used for tower spotting, clearance checks and construction execution.
- **Standard Scales:**
  - **Horizontal scale: 1 : 2000**
  - **Vertical scale: 1 : 200**
- **Sag Template Application:**
  Sag templates are superimposed on longitudinal profiles to determine:
  - **Maximum conductor sag** at highest operating temperature
  - **Uplift conditions** under wind loading
  - **Minimum statutory ground and crossing clearances**
- **Engineering Outcome:**
  - **Final tower locations and span lengths** are fixed based on sag–clearance analysis, ensuring electrical safety and constructability.

Tower Scheduling and Crossing Details

- **Tower Schedule in Survey Charts:**
  Survey charts incorporate a detailed **tower schedule** specifying:
  - **Tower number and type**
  - **Span lengths** between adjacent towers
  - **Angle of deviation** at angle locations
  - **Special crossings** such as railway, highway, river and existing power lines
- **Crossing Details:**
  - Separate **crossing schedules and drawings** are prepared for each major crossing.
  - Ensure compliance with **statutory electrical clearances** and requirements of concerned authorities.
- **Engineering Significance:**
  - Provides precise inputs for **tower design, foundation planning, safety clearance verification, and construction execution**.

Check Survey

- **Timing:** The check survey is carried out **immediately prior to construction** to validate all survey data on the ground.
- **Primary Objectives:**
  - **Peg marking** of approved tower locations
  - **Verification of ground levels and offsets** with respect to survey charts
  - **Marking of pit centres** for tower foundations
- **Special Consideration in Sloping Ground:**
  - **Relative levels of individual pit centres** are measured.
  - Determines the requirement for **leg extensions, stepped foundations or benching**.
- **Engineering Significance:**
  - Ensures alignment accuracy, foundation correctness, and eliminates discrepancies before construction commencement.

Accuracy, Tolerances, and Construction Interface

- **Critical Requirement:** Stub setting and foundation geometry demand **high survey precision** to ensure correct tower erection.
- **Level Tolerances:**
  - Differences in level between **corresponding stub points** must remain within **prescribed construction tolerances**.
- **Survey–Construction Interface:**
  - Accurate transfer of survey data to site controls **foundation alignment, verticality and geometry**.
- **Engineering Impact:**
  - Survey inaccuracies at this stage can lead to **tower distortion, erection difficulties, uneven load distribution, and reduced long-term stability**.

Conclusion

- **Integrated Engineering Process:** Transmission line surveying is a **systematic, multi-stage engineering activity** integrating surveying science, geospatial technologies, statutory compliance and construction practicality.
- **Standards-Based Practice:** Adherence to **IS 5613** of the **Bureau of Indian Standards (BIS)** ensures **uniformity, safety and reliability** of transmission infrastructure.
- **Evolving Methodologies:** Modern surveys combine **classical surveying principles** with **GNSS, GIS, remote sensing and digital tools**.
- **Future Focus:** Increasing emphasis on **environmental protection, social responsibility and infrastructure optimization** continues to shape advanced transmission line survey practices.

Exercise

Problem 1: Sag–Clearance and Tower Spotting

A **220 kV** transmission line is proposed over undulating terrain.
The horizontal distance between two tentative tower locations is **420 m**.
The reduced levels (RL) of ground at the two tower locations are **RL = 102.40 m** and **RL = 98.10 m**.
The lowest ground point between the towers has **RL = 94.60 m**.

Given:

Maximum conductor sag at highest temperature = **9.8 m**

Minimum statutory ground clearance required = **7.0 m**

Conductor attachment point at tower = **+18.0 m above ground level at each tower**

Tasks:

Determine the **lowest point of the conductor** between the towers.

Check whether the **minimum ground clearance** is satisfied.

If clearance is inadequate, determine the **minimum additional tower height** required.

Exercise

Problem 2: Combined GNSS–Levelling Accuracy Assessment

A detailed survey for a transmission line corridor uses GNSS and third-order levelling over a length of **16 km**.

GNSS observations give ellipsoidal heights with a standard deviation of **±0.030 m**.
The geoid undulation model has an accuracy of **±0.020 m**.
The observed levelling closing error is **0.060 m**.

Tasks:

Compute the **permissible closing error** for third-order levelling using $e \leq 0.0125\sqrt{K}$

Assess whether the **levelling results are acceptable**.

Compute the **combined uncertainty in orthometric height (H)** at a tower location.

Comment on the **implications for sag–clearance design**.

Summary

End of Session – Thank You!