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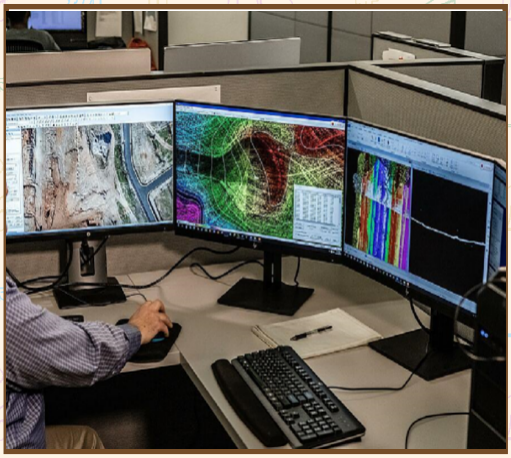
Telecom Sector Skill Council

# Facilitator Guide





Sector
**Telecom Sector Skill Council**

Sub-Sector
**Network Managed Services**

Occupation
**Network Operation and Maintenance**

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**NSQF Level 5**

# Drone Data Processor

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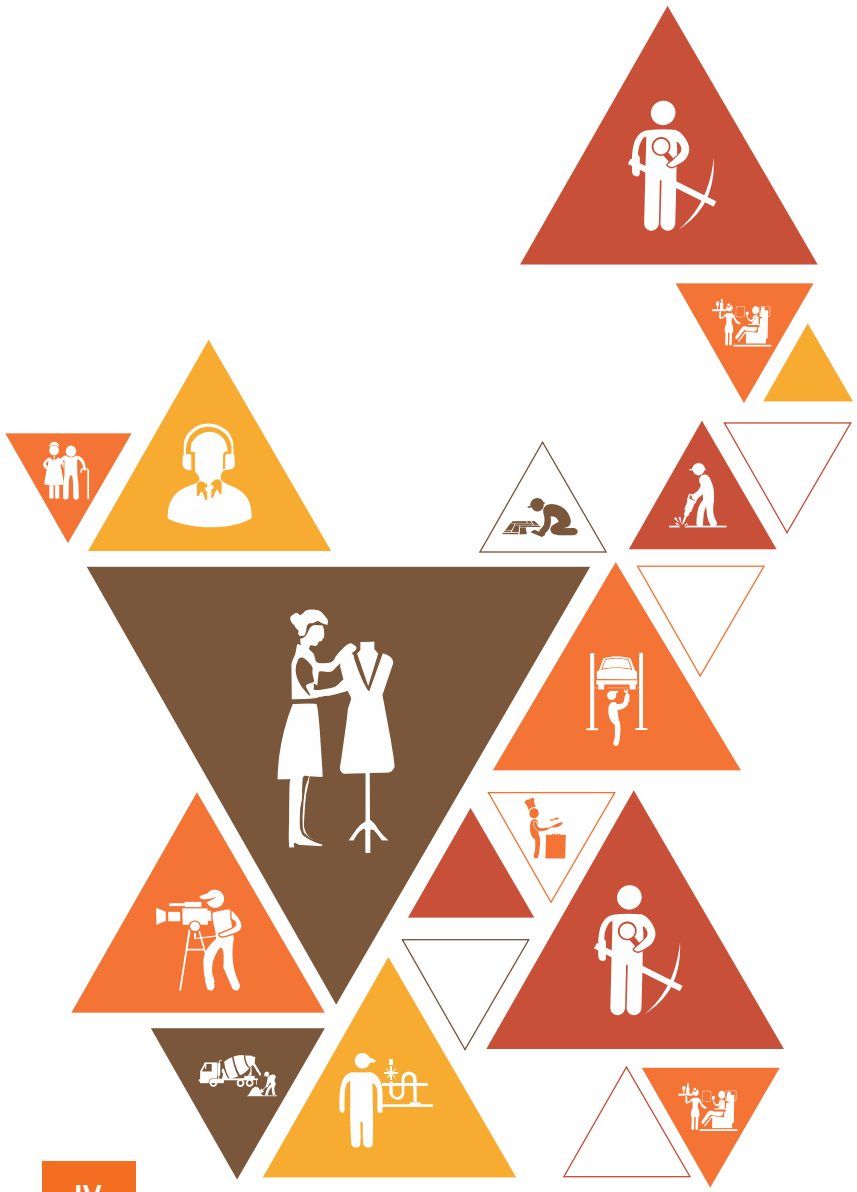
"Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission"

**Shri Narendra Modi**

Prime Minister of India



## Acknowledgement

We are thankful to all organizations and individuals who have helped us in the preparation of this Facilitator Guide. We also wish to extend our gratitude to all those who reviewed the content and provided valuable inputs for improving the quality, coherence and content presentation of chapters. This Facilitator Guide will lead to the successful rollout of the skill development initiatives, helping greatly our stakeholders particularly trainees, trainers and assessors etc. We are thankful to our Subject Matter Expert for the content and for helping us in the preparation of this Facilitator Guide.

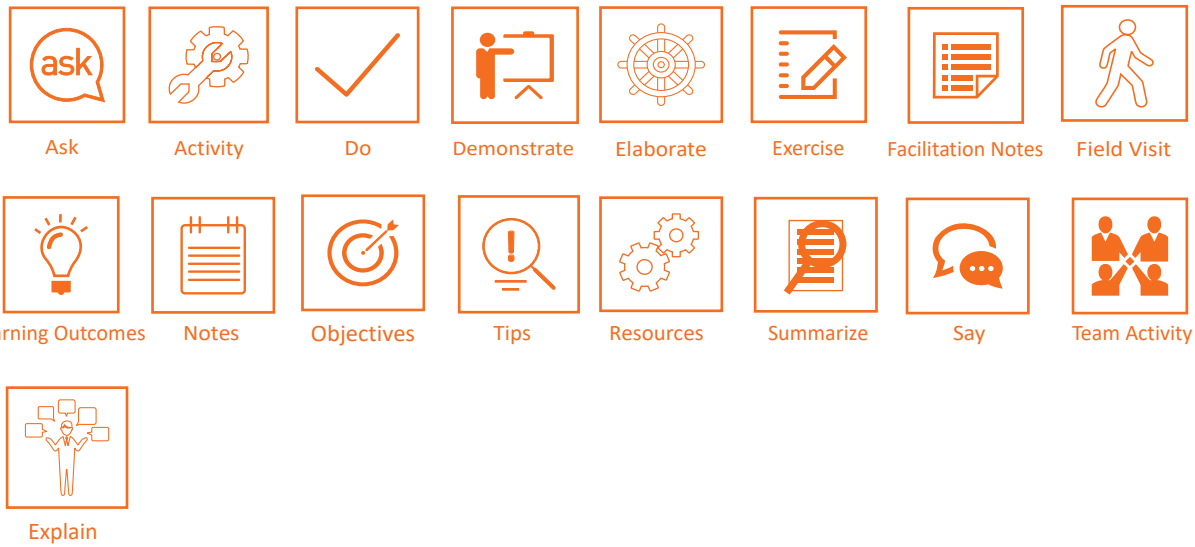
It is expected that this publication would meet the complete requirements of QP/NOS based training delivery. We welcome suggestions from users, industry experts and other stakeholders for any improvement in future.

## About the Book

The objective of the guide is to provide an approach map for interacting with the trainees undergoing training in this job role. The course aims to provide both theoretical and practical knowledge to the trainees and also to guide them about Drone Data Processor. The guide is neither a substitute nor a complete road map, but an aid to help to pass on the knowledge on all the aspects to the trainees in a systematic manner. It is expected that the trainer is fully conversant with all the contents of the guide. The guide is just to indicate how to proceed in covering a topic and includes some additional information that may be necessary for the trainer to develop better comprehension of the following aspects:

- **Knowledge and Understanding:** Satisfactory operational learning and comprehension to play out the required chore.
- **Performance Criteria:** Pick up the required aptitudes through hands-on preparation and play out the required operations inside the predetermined measures.
- **Professional Skills:** Capacity to settle on operational choices relating to the zone of work. The job will also include judging comprehension and also help them learn more through hands-on training. But it has to be ensured that these are following the knowledge imparted and time spent on each unit. It is expected that irrespective of the region, knowledge of all aspects will be imparted to trainees

## Symbols Used



# Table of Contents



It is recommended that all trainings include the appropriate Employability skills Module. Content for the same can be accessed https://www.skillindiadigital.gov.in/content/list

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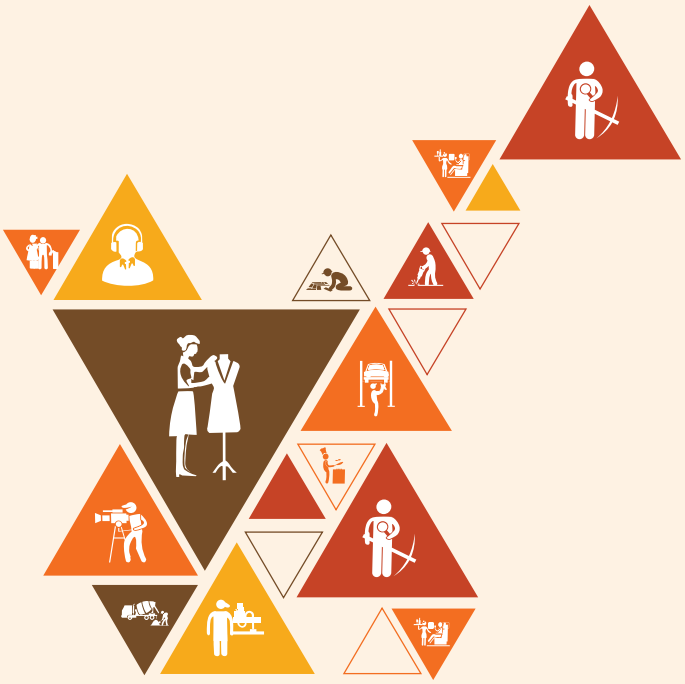
# 1. Introduction to Telecom Sector and about Drone Data Processor

Unit 1.1 - Introduction to Drone Market and the Need for Drone Data Processing

Unit 1.2 - Role and Responsibilities of a Drone Data Processor



Bridge Module

# Key Learning Outcomes

**After the end of this module, participants will be able to:**

1. Explain the size and scope of the telecom industry and its sub-sectors.
2. Discuss the need of Drone Data Processing in Telecom Sector.
3. Explain the role and responsibilities of a Drone Data Processor.

# Unit 1.1: Introduction to the Telecom Sector and need of Drone Data Processing

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the size and scope of the telecom industry and its sub-sectors.
2. Discuss the need of Drone Data Processing in Telecom Sector.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Presentations, Whiteboard, Marker, Projector, Laptop, Videos.
  - Charts on telecom market size and sub-sectors, case studies of drone use in telecom, and examples of processed drone data.
- **Practical**
  - Sample drone-generated data, network infrastructure diagrams, and telecom industry case studies showcasing the role of drones.

## Notes

In this unit, we will discuss the telecom industry's structure, its sub-sectors, and how drone data processing plays a pivotal role in addressing specific challenges in this sector.

## Say

- Good morning and welcome to the training program on "Drone Data Processor."
- Let us start with an ice-breaking session to get to know each other better.
- In this session, we will discuss the telecom industry, its subsectors, and the critical role drone data processing plays in telecommunication.
- Icebreaker:
  - **Purpose:** This activity aims to familiarise the participants in the group with one another.
  - **Tentative Duration:** 15 minutes

- Procedure:
    - Ask participants to introduce themselves with an adjective that begins with the initial letter of their name (e.g., “Astronomer Nakul, Scientist Nimisha”).
    - Request that they additionally share their interest in the telecom sector.
- Expected Outcome: The outcome of this activity is that the Participants build camaraderie, creating a collaborative learning environment.

## Ask

Ask the participants the following questions to initiate the session:

- What do you know about the telecom industry in India?
- Can you share examples of where drones are used in industries today?

Write down the answers on the whiteboard/flipchart. Use the responses as cues to introduce the session topics.

## Explain

In this session, we will cover the following points:

- **Telecom Industry in India:**
    - The telecom sector is among the largest industries in India, enabling digital connectivity for millions.
    - Discuss its rapid expansion due to the adoption of 5G, mobile data growth, and enhanced broadband services.
- **Sub-Sectors of the Telecom Industry:**
    - Highlight key sub-sectors such as mobile networks, broadband services, infrastructure providers (e.g., telecom towers), and managed services.
- **Drone Market:**
    - Overview of the drone market’s growth in India, emphasizing regulatory changes and technological advancements.
- **Industry Use Cases for Drones:**
    - Examples include tower inspections, mapping, and monitoring infrastructure in remote locations.

- **Need for Drone Data Processing in the Telecom Sector:**
  - Drones generate raw data such as images, videos, and maps.
  - Processing this data into actionable insights like damage reports or geographical maps is crucial for improving efficiency and decision-making.

## Activity-1

**Activity 1: Identify Sub-Sectors of the Telecom Industry**

- Name: Mapping Telecom Sub-Sectors
- Objectives:
  - Familiarize participants with the telecom industry's sub-sectors.
- Materials Needed:
  - Whiteboard, markers, and reference charts on the telecom sector.
- Procedure:
  - Divide participants into small groups.
  - Ask each group to list as many sub-sectors of the telecom industry as they can within 10 minutes.
  - Consolidate their answers on a whiteboard.
  - Briefly elaborate on how these sub-sectors contribute to the telecom ecosystem.
- Expected Outcome: Participants will gain a clear understanding of the structure of the telecom industry.

## Activity-2

**Activity 2: Understanding Drone Applications in Telecom**

- Name: Brainstorm Drone Use Cases
- Objectives:
  - Help participants relate drone applications to telecom operations.
- Materials Needed:
  - Charts or visuals showing drones and telecom towers.

- Procedure:
  - Present an image or video of a telecom tower inspection by a drone.
  - Ask participants to brainstorm possible drone use cases for the telecom sector (e.g., inspecting towers, capturing terrain data).
  - Write their responses on a flipchart and explain how drone data processing adds value (e.g., creating actionable reports).
- Expected Outcome: Participants will understand how drones are utilized in the telecom industry and the importance of data processing.

## Notes for facilitation

- Use the **Telecom Sector Overview** section in the participant handbook (PHB) to discuss the telecom industry's size, sub-sectors, and trends.
- Refer to drone industry case studies to explain real-world applications and benefits.
- Highlight the importance of drone data processing in enabling faster, data-driven decisions for telecom operations.

## Notes

# Unit 1.2: Roles & Responsibilities of a Drone Data Processor

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the role and responsibilities of a Drone Data Processor

## Resources to be used

- **Theory:**
    - Trainer Guide & Participant Handbook, Presentations, Whiteboard, Marker, Projector, Laptop.
- **Practical:**
    - Visual aids illustrating drone data processing workflows and charts explaining the key responsibilities of a Drone Data Processor.

## Say

- Good morning and welcome back to the training program.
- In this session, we will focus on understanding the specific roles and responsibilities of a Drone Data Processor.

## Ask

- What do you think are the key responsibilities of a Drone Data Processor?
- Have you come across scenarios where raw data needed significant processing? What challenges did you notice?
- Write responses on a whiteboard or flipchart to connect them with the session content.

## Elaborate

In this session, we will cover the following points:

1. Role of a Drone Data Processor:
    a) Converts raw data captured by drones into meaningful insights.
    b) Processes various types of data, including images, videos, geospatial data, and 3D models.
2. Responsibilities of a Drone Data Processor:
    a) Data Collection & Validation: Ensuring the data received is accurate and complete.
    b) Data Cleaning & Preprocessing: Removing noise, correcting distortions, and preparing data for analysis.
    c) Analysis & Interpretation: Using software to extract key insights (e.g., identifying damage on telecom towers, generating heatmaps).
    d) Reporting: Presenting processed data in a format suitable for stakeholders, such as detailed reports or interactive visuals.
    e) Maintaining Data Security: Ensuring data is stored securely and adhering to privacy guidelines.

## Activity-1

**Activity 1: Brainstorm Responsibilities of a Drone Data Processor**

- Name: Identifying Key Responsibilities
- Objectives:
    - Familiarize participants with the critical tasks involved in drone data processing.
- Materials Needed:
    - Whiteboard, markers, and a reference chart outlining responsibilities.
- Procedure:
    - Divide participants into small groups.
    - Ask each group to brainstorm tasks they believe are part of a Drone Data Processor's role.
    - Consolidate their responses and introduce any additional responsibilities using a prepared chart.

- Expected Outcome: Participants will gain a clear understanding of the various responsibilities of a Drone Data Processor.

## Activity-2

**Activity 2: Role Play – Drone Data Processing Workflow**

- Name: Simulating the Workflow
- Objectives:
  - Help participants understand the step-by-step workflow of a Drone Data Processor.
- Materials Needed:
  - Participant handbook, visual aids, and a simple dataset (e.g., drone-captured images).
- Procedure:
  - Assign participants specific steps in the data processing workflow (e.g., validating data, cleaning data, generating insights).
  - Ask them to explain their assigned step in the workflow to the group.
  - Encourage questions and discussions to clarify each step.
- Expected Outcome: Participants will understand how each responsibility fits into the overall data processing workflow.

## Notes for facilitation

- Use real-life examples to demonstrate the responsibilities.
- Simplify complex concepts and focus only on the basics, as advanced topics will be covered later.
- Encourage active participation and provide feedback on their ideas and role-play presentations.
- Summarize the session with key takeaways and address any questions.

## Exercise

**Short Answer Questions:**

1. **What is the primary responsibility of a Drone Data Processor in the telecom sector?**

   The primary responsibility of a Drone Data Processor in the telecom sector is to process and analyze data collected by drones to support network planning, maintenance, and optimization.

2. **What types of data do Drone Data Processors typically work with?**

   Drone Data Processors typically work with aerial imagery, LiDAR data, 3D models, and geographic information system (GIS) data.

3. **How does drone data processing aid in improving network planning and deployment?**

   Drone data processing aids in improving network planning and deployment by providing accurate, up-to-date aerial data for site surveys, topographical analysis, and network coverage optimization.

4. **What are some personal attributes necessary for a Drone Data Processor to be successful in their role?**

   The personal attributes necessary for a Drone Data Processor are attention to detail, analytical thinking, technical proficiency, problem-solving ability, adaptability and communication skills

5. **Describe one potential career progression path for a Drone Data Processor.**

   Drone Data Scientist

**Fill in the Blanks:**

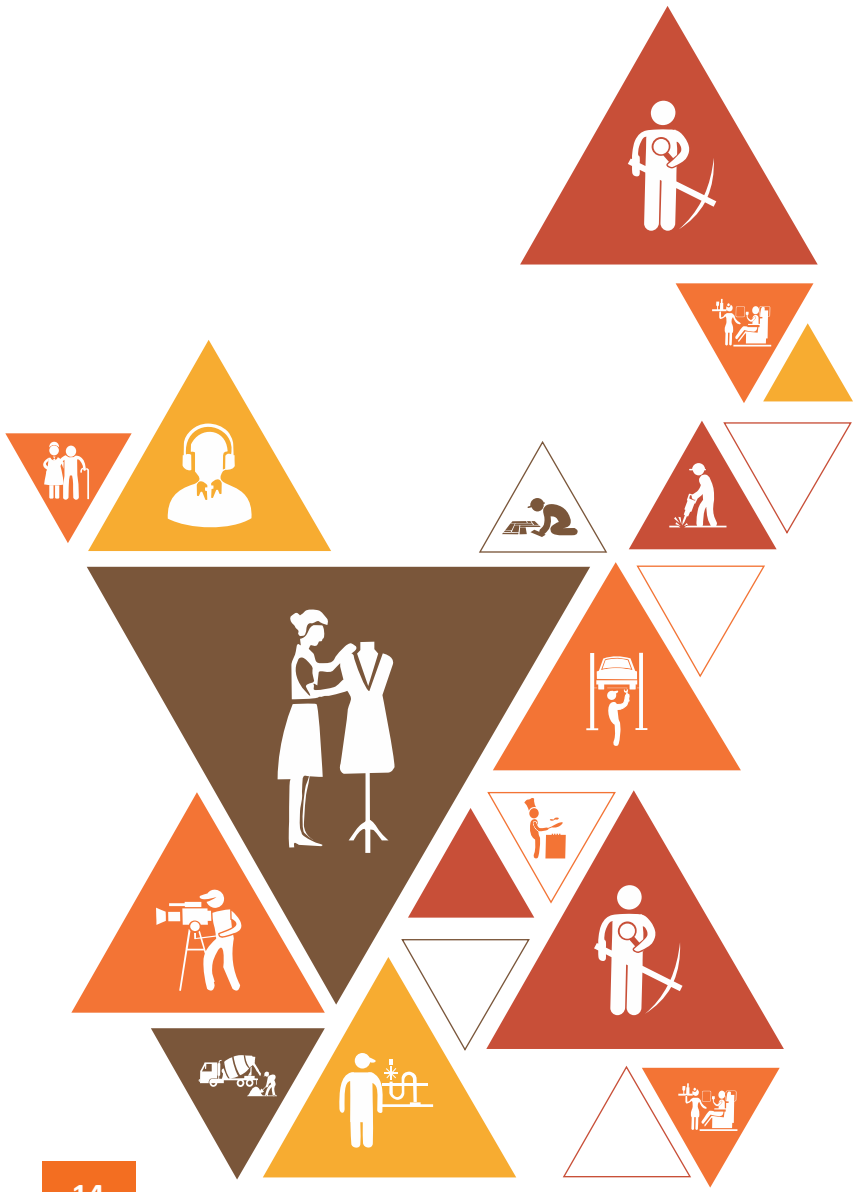
1. The Indian drone market is projected to grow at a CAGR of **15%,** reaching $5 billion by 2030.
2. The introduction of the Drone Rules 2021 has significantly boosted the drone industry in India.
3. Drone Data Processors are responsible for generating precise 3D Point Clouds in **.xyz** and **.las** formats.
4. 3D **models** are created in urban planning to guide infrastructure development and restoration work.
5. The career of a Drone Data Processor can progress to roles like **Entrepreneur** or Consultant, offering niche services to industries.

**True/False Questions:**

1. The primary responsibility of a Drone Data Processor is to capture data from drones. (True/False)
   - **False** (*They process and analyze the data, not capture it*.)
2. The role of a Drone Data Processor only involves basic image stitching and data collection. (True/False)
   - **False** (*It involves advanced data processing and analysis*.)
3. A career as a Drone Data Processor can include roles like Project Manager or Team Lead. (True/False)
   - True

4. Drone Data Processing is only used in agriculture and urban planning. (True/False)
    - **False** *(It is used in various sectors, including telecom, infrastructure, and mining.)*
5. Adaptability is an essential personal attribute for a Drone Data Processor, as they need to keep up with technological advancements. (True/False)
    - True

## Notes



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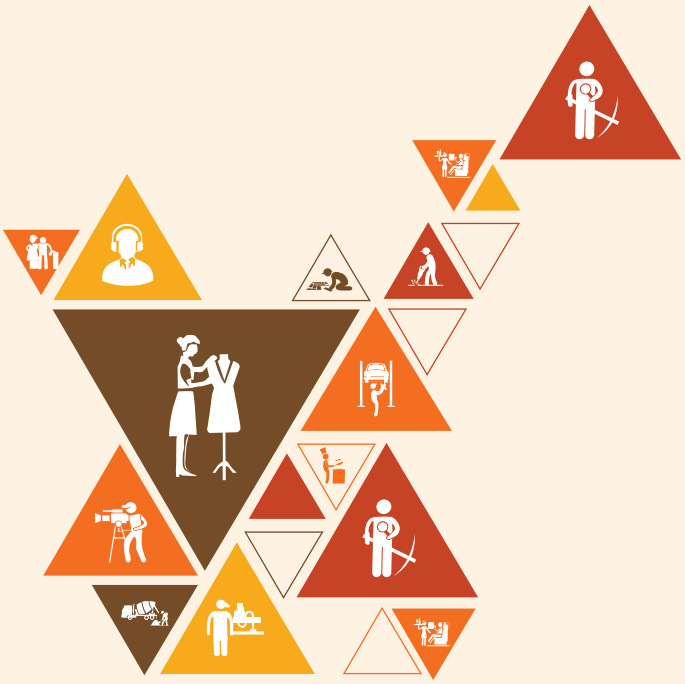
# 2. Data Extraction/ Collection

Unit 2.1 - Drone Components and Calibration

Unit 2.2 - Flight Planning and Data Collection

Unit 2.3 - Data Processing and Analysis



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# Key Learning Outcomes

**After the end of this module, participants will be able to:**

1. Explain the size and scope of the telecom industry and its sub-sectors.
2. Describe the components of drones and associated sensors involved in calibration.
3. Explain the importance of accurate data measurements in drone calibration.
4. Elucidate the significance of data compatibility with downstream processing tools in drone data extraction.
5. Demonstrate software interfaces for inputting parameters and executing calibration processes effectively.
6. Identify and calibrate various sensors on drones for accurate data measurements.
7. Show how to adjust sensor settings based on environmental conditions and data collection requirements.
8. Demonstrate the calibration process effectively using software interfaces.
9. Enlist the factors influencing the optimal overlap between images in drone flight planning.
10. Explain the process of data extraction and collection using drones.
11. Discuss how to plan drone flights to ensure optimal overlap between images.
12. Show how to apply techniques to adjust sensor settings based on environmental conditions.
13. Analyze selected data formats to ensure they meet project specifications and industry standards.
14. Discuss the effectiveness of ground control points (GCPs) in enhancing calibration precision.
15. Discuss how to report findings derived from 2D DEM processing.
16. Evaluate elevation data discrepancies and rectify anomalies in DEMs derived from drone data.
17. Demonstrate how to create 2D orthomosaics from individual images using principles of photogrammetry.
18. Demonstrate how to perform accuracy assessments of orthomosaics and identify artifacts or irrelevant data.
19. Describe how to apply filtering and smoothing techniques to enhance 2D DEM quality.

# Unit 2.1: Drone Components and Calibration

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the size and scope of the Telecom industry and its subsectors.
2. Define the components of drones and associated sensors involved in calibration.
3. Explain the importance of accurate data measurements in drone calibration.
4. Describe the significance of data compatibility with downstream processing tools in drone data extraction.
5. Show the use of software interfaces for inputting parameters and executing calibration processes effectively.
6. Show how to identify and calibrate various sensors on drones for accurate data measurements.
7. Explain how to adjust sensor settings based on environmental conditions and data collection requirements.
8. Demonstrate application of techniques to adjust sensor settings based on environmental conditions.
9. Explain the calibration process effectively using software interfaces.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, and Presentations.
- **Practical**
  - Drone model or simulator, visual aids highlighting drone components and calibration steps, and software interface for sensor calibration.

## Say

Good morning, everyone! In today's session, we will explore the components of drones, understand the calibration process, and its importance for obtaining accurate data.

## Ask

- What components of a drone are most critical for its operation?
- Why do you think sensor calibration is essential?
- How do environmental conditions affect drone sensors?
- Write responses on a whiteboard and connect them to the session topics.

## Elaborate

After the end of this unit, participants will be able to:

1. Give an overview of the construction sector.
2. Drone Components and Sensors:
    a) Key drone parts: Frame, propulsion system, flight controller, GPS, IMU, and gimbals.
    b) Associated sensors: Camera, LIDAR, infrared, and ultrasonic sensors.
3. Importance of Accurate Calibration:
    a) Ensures precise data collection.
    b) Reduces errors caused by environmental factors.
4. Data Compatibility:
    a) Importance of sensor settings aligning with software tools for downstream processing.
5. Calibration Techniques:
    a) Using software interfaces to input parameters and calibrate sensors.
    b) Adjusting sensor settings for environmental conditions such as temperature and humidity.

## Activity-1

**Activity 1: Drone Component Identification Objectives:**

- Name: Recognizing Key Drone Components
    - Help participants familiarize themselves with drone components and sensors.
- Materials Needed:
    - Drone model or diagram, marker, and reference charts of drone parts.
- Procedure:
    - Divide participants into pairs.
    - Provide each pair with a diagram or model of a drone.
    - Ask them to label the components (e.g., GPS, IMU, gimbal) and briefly discuss their functions.
    - After 10 minutes, review the labels and explain each component.
- Expected Outcome: Participants will be able to identify key drone components and understand their roles.

## Activity-2

**Activity 2: Sensor Calibration Demonstration**

- Name: Calibrating a Drone Sensor
- Objectives:
    - Introduce participants to the process of sensor calibration using software interfaces.
- Materials Needed:
    - Laptop, drone calibration software, and a simulated drone setup.
- Procedure:
    - Open the calibration software on the projector.
    - Demonstrate step-by-step how to calibrate one sensor (e.g., IMU or camera).
    - Explain the parameters being adjusted and their importance.
    - Let participants individually try the steps on their laptops using the simulator.
- Expected Outcome: Participants will gain hands-on experience with the calibration process using software interfaces.

## Notes for facilitation

- Use visual aids to simplify explanations of drone components and sensors.
- Ensure all participants can access the calibration software or simulator for practice.
- Keep the activities focused on basics; advanced calibration topics will be covered in later units.
- Address questions by demonstrating concepts with the drone model or simulator.
- Summarize the session with a quick recap of the calibration process and its importance.

## Notes

# Unit 2.2: Flight Planning and Data Collection

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Elucidate the factors influencing the optimal overlap between images in drone flight planning.
2. Explain the process of data extraction and collection using drones.
3. Show how to plan drone flights to ensure optimal overlap between images.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, and Presentations.
- **Practical:**
  - Drone flight simulator, visual aids on image overlap and flight paths, and drone mission planning software.

## Say

Good morning, everyone! Today, we will explore how to effectively plan drone flights for optimal data collection and image overlap. By the end of this session, you'll be able to plan flight missions for accurate and reliable data collection.

## Ask

- Why is image overlap important in drone flight planning?
- What factors do you think affect the overlap between images?
- What steps would you take to ensure accurate data collection using a drone?
- Write responses on a whiteboard and connect them to the session objectives.

## Elaborate

After the end of this unit, participants will be able to:

1. Factors Influencing Image Overlap:
    a) Altitude, camera settings, terrain type, and drone speed.
    b) Differences between forward and side overlap.
2. Process of Data Extraction and Collection:
    a) Capturing images and videos.
    b) Downloading data to a computer or cloud storage.
3. Flight Planning for Optimal Overlap:
    a) Using flight planning software to define waypoints and adjust settings.
    b) Practical considerations: battery life, weather, and terrain obstacles.

## Activity-1

**Activity 1: Simulating Drone Flight Paths**

- Name: Planning a Drone Flight for Optimal Overlap
- Objectives:
    - Familiarize participants with flight planning software and image overlap principles.
- Materials Needed:
    - Laptops with mission planning software, projector, and visual aids on image overlap.
- Procedure:
    - Demonstrate on the projector how to set up a flight path using mission planning software.
    - Highlight key settings such as altitude, overlap percentage, and speed.
    - Allow participants to practice creating their own flight paths in pairs using laptops.
- Expected Outcome: Participants will understand how to plan drone flights with optimal image overlap for accurate data collection.

## Activity-2

**Activity 2: Analyzing Image Overlap**

- Name: Evaluating Image Overlap from a Sample Dataset
- Objectives:
  - Help participants visualize the importance of overlap in data collection.
- Materials Needed:
  - Sample image sets with varying overlap percentages, projector, and chart paper.
- Procedure:
  - Show a dataset of drone images with high and low overlap percentages.
  - Discuss the impact of insufficient overlap on data accuracy and processing.
  - Ask participants to work in small groups to list observations and recommendations for ensuring proper overlap.
  - Expected Outcome: Participants will be able to identify the importance of proper overlap in achieving reliable data.

## Notes for facilitation

- Arrange the relevant handouts and leaflets for a better understanding of the topics
- Ensure all participants have access to the flight planning software or observe the demonstration closely.
- Keep the explanation of overlap factors basic and relatable; advanced topics will follow in later units.
- Encourage active participation during both activities to reinforce learning.
- Conclude the session with a quick summary of key takeaways from flight planning and data collection.

## Notes

# Unit 2.3: Data Processing and Analysis

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain how to analyze selected data formats to ensure they meet project specifications and industry standards.
2. Evaluate the effectiveness of ground control points (GCPs) in enhancing calibration precision.
3. Generate comprehensive reports detailing findings derived from 2D DEM processing.
4. Evaluate elevation data discrepancies and rectify anomalies in DEMs derived from drone data.
5. Demonstrate how to create 2D orthomosaics from individual images using principles of photogrammetry.
6. Perform accuracy assessments of orthomosaics and identify artifacts or irrelevant data.
7. Generate 2D DEMs and apply filtering and smoothing techniques to enhance quality.

## Resources to be used

- **Theory**
    - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, and Photogrammetry principles presentations.
- **Practical**
    - Laptops with processing software (e.g., Pix4D, Agisoft Metashape), drone datasets, visual aids, and charts showcasing DEM generation steps.

## Say

Good morning, everyone! Today, we will dive into the exciting world of data processing and analysis in drone operations. We'll explore the methods of analyzing data, generating orthomosaics, and creating precise 2D Digital Elevation Models (DEMs).

## Ask

- What are the common data formats generated by drones?

- How do GCPs improve calibration and accuracy?
- What challenges do you foresee when generating DEMs or orthomosaics?What challenges do you foresee when generating DEMs or orthomosaics?

  Write down responses and build on them during the session.

## Elaborate

After the end of this unit, participants will be able to:

1. Analyzing Data Formats:
   a) Key drone data formats (e.g., GeoTIFF, LAS, CSV).
   b) Checking for compatibility with project specifications and industry standards.
2. Ground Control Points (GCPs):
   a) Importance in calibration and enhancing accuracy.
   b) Placement strategies and evaluation techniques.
3. Orthomosaic Creation:
   a) Basics of photogrammetry.
   b) Aligning and stitching images for seamless 2D mapping.
4. Digital Elevation Models (DEMs):
   a) Generating and refining 2D DEMs.
   b) Techniques for filtering and smoothing elevation data.
5. Accuracy Assessments:
   a) Identifying artifacts or irrelevant data in processed outputs.
   b) Steps for anomaly rectification.

## Activity-1

**Activity 1: DEM Quality Puzzle**

- Name: Elevation Data Refinement Challenge
- Objectives:
  - Help participants identify elevation data anomalies and practice smoothing techniques.
- Materials Needed:
  - Pre-processed DEMs with intentional errors, laptops with processing software.
- Procedure:
  - Provide each participant with a DEM containing elevation discrepancies.
  - Task them with identifying anomalies and rectifying them using filtering tools in the software.
  - Participants will share their final results and discuss the steps they took.
- Expected Outcome: Participants learn to identify and rectify DEM discrepancies to ensure accurate outputs.

## Activity-2

**Activity 2: Orthomosaic Assembly Relay**

- Name: Team-Based Photogrammetry Race
- Objectives:
  - Reinforce understanding of orthomosaic creation while encouraging teamwork.
- Materials Needed:
  - Laptops with software, pre-loaded datasets of individual drone images.
- Procedure:
  - Divide participants into teams and assign each team a drone dataset.
  - Teams must align and stitch the images to create a seamless orthomosaic.
  - Once completed, teams evaluate their orthomosaics for artifacts or errors.
  - The first team to generate an accurate orthomosaic wins a small prize (optional).
- Expected Outcome: Participants will understand the process of creating orthomosaics and identifying potential artifacts in a fun and collaborative manner.

## Notes for facilitation

- Keep instructions simple and encourage creativity during activities.
- Monitor participants closely during the relay activity to ensure fair play and learning.
- Conclude by summarizing the importance of accurate data analysis and the role of GCPs, DEMs, and orthomosaics in real-world applications.

## Exercise

**Short Answer Questions:**

1. **What are the primary components of drones involved in calibration?**

   The primary components of drones involved in calibration include the GPS system, IMU (Inertial Measurement Unit), and camera sensors.

2. **Why is it important to ensure data compatibility with downstream processing tools in drone data extraction?**

   It is important to ensure data compatibility with downstream processing tools in drone data extraction to maintain data integrity, facilitate accurate analysis, and avoid errors in processing.

3. **How can environmental conditions influence sensor settings on drones?**

   Environmental conditions such as temperature, humidity, and wind can influence sensor settings on drones by affecting their performance and data accuracy.

4. **What role do ground control points (GCPs) play in enhancing calibration precision?**

   Ground control points (GCPs) enhance calibration precision by providing known reference coordinates that improve georeferencing accuracy in drone data.

5. **What is the significance of evaluating elevation data discrepancies in DEMs derived from drone data?**

   Evaluating elevation data discrepancies in DEMs derived from drone data is significant as it helps identify errors and refine the model for accurate topographical representation.

**Fill-in-the-Blanks**

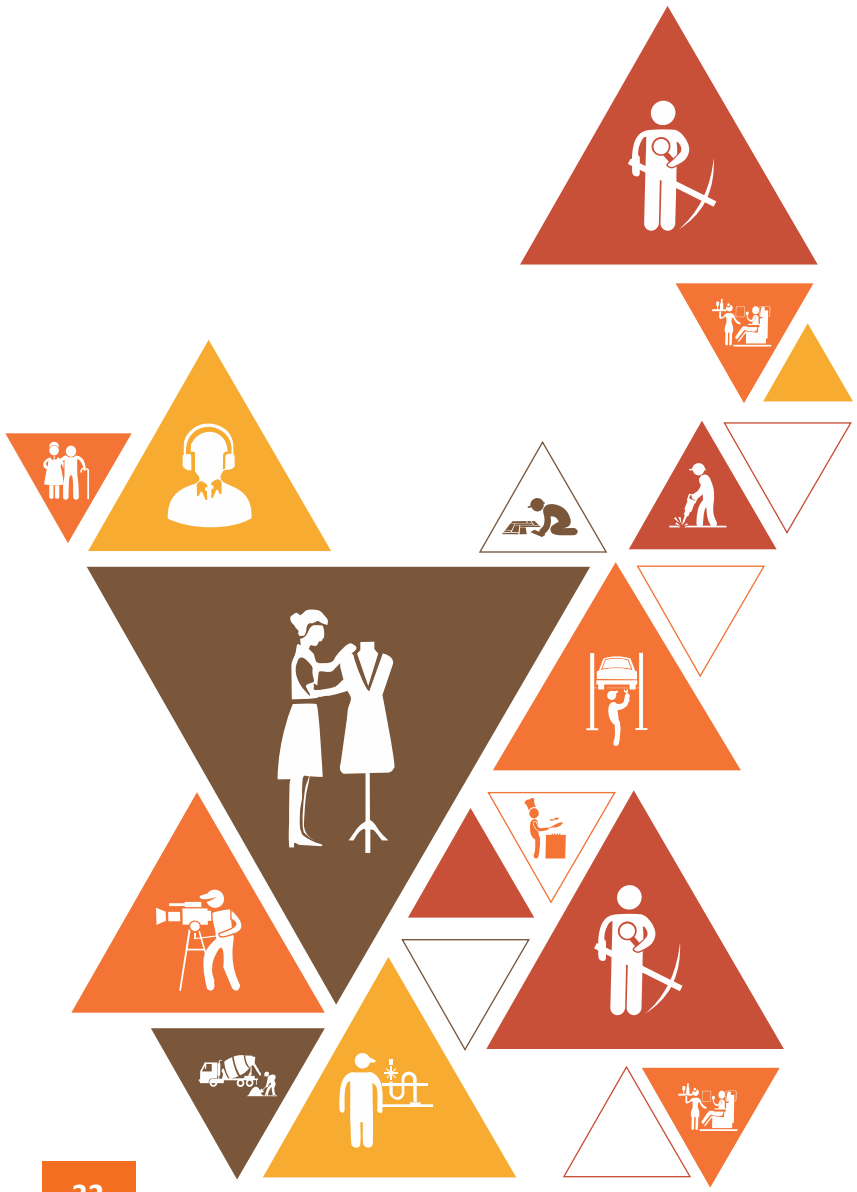
1. The process of **calibration** is essential for ensuring accurate data measurements in drone operations.
2. Data compatibility with software tools is vital for successful downstream processing in drone data extraction.

3. Adjusting **sensor** settings is necessary to accommodate environmental conditions during data collection.
4. **Processing** reports provide detailed findings from 2D DEM processing.
5. In drone flight planning, optimal **overlap** between images ensures better data quality.

**True/False Questions**

1. Accurate data measurements are not necessary for effective drone calibration. (True/False)
    - **False** (*Accurate data measurements are critical for drone calibration to ensure that the sensor data is reliable)*
2. Sensor settings on drones must remain constant regardless of environmental conditions. (True/False)
    - **False** (*Environmental conditions such as temperature, humidity, and wind can affect the performance of sensors)*
3. Ground control points (GCPs) enhance the precision of drone calibration processes. (True/False)
    - True
4. The creation of 2D orthomosaics is based on principles of photogrammetry. (True/False)
    - True
5. Data formats used in drone projects do not need to meet industry standards. (True/False)
    - **False** (*Data formats must meet industry standards to ensure compatibility with various processing tools)*

## Notes



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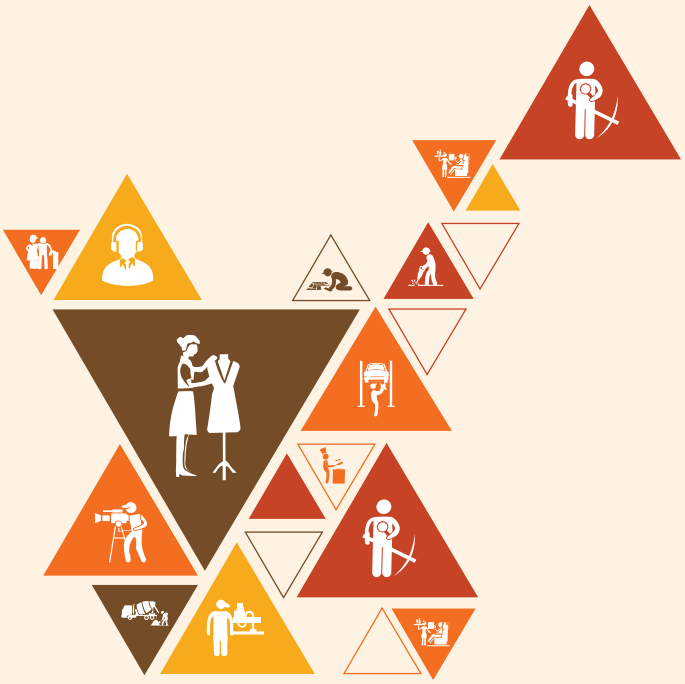
# 3. Data Processing and Integration

Unit 3.1: Drone Data Acquisition & Processing Fundamentals
Unit 3.2: Advanced Data Processing & Analysis



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# Key Learning Outcomes

**After the end of this module, participants will be able to:**

1. Explain the components of drones and associated sensors used for accurate data measurements.
2. Demonstrate how to calibrate drones and associated sensors to ensure accurate data measurements.
3. Describe the importance of optimal flight planning for drone operations.
4. Show how to plan drone flights with optimal overlap for accurate data extraction.
5. Define various types of drone data and their significance in data processing.
6. Discuss the necessity of sensor calibration for ensuring accurate data measurements.
7. Explain the process of adjusting sensor settings based on environmental conditions.
8. Demonstrate the implementation of accurate Ground Control Points (GCPs) for precise calibration.
9. Interpret the importance of compatibility of data formats with downstream processing tools.
10. Analyze project specifications and industry standards to verify selected data formats.
11. Demonstrate how to process raw drone imagery efficiently for 3D reconstruction.
12. Apply principles of photogrammetry and image acquisition for capturing drone data.
13. Show how to apply georeferencing techniques to ensure spatial accuracy in orthomosaic creation.
14. Demonstrate filtering and smoothing techniques to enhance the quality of 2D DEMs.
15. Analyze drone imagery to filter out artifacts and irrelevant data from orthomosaics.
16. Evaluate elevation data to identify anomalies and discrepancies for rectification.
17. Perform accuracy assessments by comparing orthomosaics with ground truth data.
18. Describe how to extract 2D DEM data files from external memory sources.
19. Demonstrate the integration of drone-acquired elevation data with existing 2D DEMs.
20. Show how to generate realistic and detailed textures on 3D meshes using original images.
21. Discuss comprehensive reports detailing findings from DEM processing for stakeholders.
22. Evaluate the quality of orthomosaics and DEMs based on project requirements.

# Unit 3.1: Drone Data Acquisition & Processing Fundamentals

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the size and scope of the Telecom industry and its subsectors.
2. Describe the components of drones and associated sensors used for accurate data measurements.
3. Demonstrate calibration of drones and associated sensors to ensure accurate data measurements.
4. Explain the importance of optimal flight planning for drone operations.
5. Show how to plan drone flights with optimal overlap for accurate data extraction.
6. Define various types of drone data and their significance in data processing.
7. Discuss the necessity of sensor calibration for ensuring accurate data measurements.
8. Explain the process of adjusting sensor settings based on environmental conditions.
9. Demonstrate how to implement accurate Ground Control Points (GCPs) for precise calibration.
10. Show interpretation the importance of compatibility of data formats with downstream processing tools.
11. Show how to analyze project specifications and industry standards to verify selected data formats.
12. Describe how to process raw drone imagery efficiently for 3D reconstruction.

## Resources to be used

- **Theory**
    - Trainer Guide & Participant Handbook, Presentations, Whiteboard, Marker, Projector, Laptop, Video Films.
- **Practical**
    - Charts on drone components and calibration steps, visual aids on flight planning and data formats, software interfaces for imagery processing, and GCP demonstration tools.

## Say

- "Good morning and welcome to the training session on 'Drone Data Acquisition & Processing Fundamentals.' In this session, we will explore how to acquire and process data from drones effectively."

- "We will begin with an overview of drone components and progress towards data processing fundamentals for achieving accurate project outcomes."

## Ask

- "Can you name the main components of a drone and their functions?"
- "Why is calibration important for drone sensors?"
- "How does flight planning impact the accuracy of data extraction?"

Record responses on the whiteboard to introduce the session topics.

## Elaborate

After the end of this unit, participants will be able to:

1. Drone Components and Sensors:
    a) Key parts like GPS modules, cameras, and sensors for accurate measurements.
    b) Overview of their integration in data acquisition.
2. Calibration and Environmental Adjustments:
    a) Ensuring precision through proper calibration techniques.
    b) Adjusting settings for optimal performance in varying conditions.
3. Flight Planning and Overlap:
    a) Importance of planning flights with sufficient overlap for seamless data integration.
4. Ground Control Points (GCPs):
    a) Role of GCPs in enhancing calibration accuracy.
5. Data Processing Fundamentals:
    a) Processing raw imagery into 3D reconstructions.
    b) Verifying data formats against industry standards.

## Activity-1

**Activity 1: Drone Anatomy Puzzle**

- Name: Identify Drone Components
- Objective: To help trainees learn about the key components of drones and their functions.
- Materials Needed:
  - Printable cutouts of drone components, labels, and a blank drone outline.
- Procedure:
  - Divide participants into small groups.
  - Provide each group with a set of cutouts and labels.
  - Ask them to assemble the drone by placing components in the correct locations and matching labels.
  - Discuss the roles of each component after the activity.
- Outcome: Participants gain a solid understanding of drone components and their functions.

## Activity-2

**Activity 2: Simulated Calibration Exercise**

- Name: Sensor Calibration Demonstration
- Objective: To demonstrate how to calibrate drone sensors effectively.
- Materials Needed:
  - A drone calibration simulator or software interface, projector, and mock datasets.
- Procedure:
  - Use the simulator to show the step-by-step process of calibrating sensors.
  - Ask participants to replicate the steps on their laptops.
  - Conduct a short quiz to reinforce the learning.
- Outcome: Participants will be able to perform basic calibration tasks and understand their importance in data accuracy.

## Notes for facilitation

- Use simple and clear language to explain technical concepts.
- Ensure that all participants are actively engaged during hands-on activities.
- Encourage questions and provide real-world examples for better understanding.
- Summarize each topic and reiterate the importance of accurate data acquisition and processing.

## Notes

# Unit 3.2: Advanced Data Processing & Analysis

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the size and scope of the Telecom industry and its subsectors.
2. Explain the principles of photogrammetry and image acquisition for capturing drone data.
3. Explain georeferencing techniques to ensure spatial accuracy in orthomosaic creation.
4. Demonstrate filtering and smoothing techniques to enhance the quality of 2D DEMs.
5. Show how to analyze drone imagery to filter out artifacts and irrelevant data from orthomosaics.
6. Show how to analyze elevation data to identify anomalies and discrepancies for rectification.
7. Discuss the accuracy assessments by comparing orthomosaics with ground truth data.
8. Explain how to extract 2D DEM data files from external memory sources.
9. Describe how to integrate drone-acquired elevation data with existing 2D DEMs.
10. Demonstrate how to generate realistic and detailed textures on 3D meshes using original images.
11. Explain generation of comprehensive reports detailing findings from DEM processing for stakeholders.
12. Show how to evaluate the quality of orthomosaics and DEMs based on project requirements.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Presentations, Projector, Laptop, Videos, and Technical Papers.
- **Practical**
  - Drone data sets, software for photogrammetry and georeferencing, sample DEM files, and tools for 3D modeling and texture creation.

## Say

- "Today, we will delve into the advanced methods of processing and analyzing drone-acquired data, focusing on creating high-quality outputs like orthomosaics and 2D DEMs."

- "We will explore techniques to filter out irrelevant data, analyze elevation discrepancies, and integrate data with existing resources."

## Ask

- "Can anyone describe what photogrammetry involves and why it's crucial for drone data processing?"
- "What challenges have you faced while working with elevation data or orthomosaics in past projects?"

Record responses to guide the discussion on advanced data processing techniques.

## Elaborate

After the end of this unit, participants will be able to:

1. Photogrammetry and Georeferencing:
    a) Principles of photogrammetry for accurate data acquisition.
    b) Georeferencing techniques to ensure spatial alignment in outputs.
2. Data Enhancement Techniques:
    a) Filtering and smoothing methods to improve DEM quality.
    b) Artifact removal and anomaly detection in elevation data.
3. Integration and Analysis:
    a) Combining drone-acquired data with existing datasets.
    b) Detailed texture creation for 3D models.
4. Report Generation:
    a) Presenting findings in a structured manner to stakeholders.
    b) Assessing data quality against project standards.

## Activity-1

**Activity 1: Photogrammetry Mapping Challenge**

- Name: Align the Imagery
- Objective: To practice georeferencing and understand its importance.
- Materials Needed:
    - Sample drone images and mapping software.
- Procedure:
    - Provide participants with drone images of a specific area.
    - Ask them to align these images using georeferencing techniques.
    - Review the accuracy of their alignment and discuss improvements.
- Outcome: Participants understand how to ensure spatial accuracy in orthomosaics.

## Activity-2

**Activity 2: DEM Enhancement Workshop**

- Name: Smoothing the Terrain
    - Objective: To apply filtering and smoothing techniques to DEMs.
- Materials Needed:
    - Sample DEM files, filtering tools, and software.
- Procedure:
    - Provide participants with raw DEM files containing noise.
    - Guide them through the process of applying filters to enhance the quality.
    - Compare their results to demonstrate the impact of proper techniques.
- Outcome: Participants gain hands-on experience in improving DEM quality.

## Notes for facilitation

- Use case studies to show real-world applications of these techniques.
- Encourage participants to share their approaches and compare results during activities.
- Provide step-by-step guidance during practical tasks for clarity and confidence building.

## Exercise

**Short Answer Questions:**

1. **What are the key components of drones and sensors used for accurate data measurements?**

   The key components of drones and sensors used for accurate data measurements include the GPS system, IMU (Inertial Measurement Unit), camera or LiDAR sensors, and the flight control system.

2. **Why is calibrating drones and sensors necessary for accurate data collection?**

   Calibrating drones and sensors is necessary for accurate data collection because it ensures that measurements are precise, georeferencing is accurate, and the data aligns with real-world coordinates.

3. **How does optimal flight planning contribute to effective drone operations?**

   Optimal flight planning contributes to effective drone operations by ensuring the correct altitude, overlap, and flight path, which improves data quality, coverage, and accuracy.

4. **What is the significance of Ground Control Points (GCPs) in ensuring precise calibration?**

   Ground Control Points (GCPs) are significant in ensuring precise calibration by providing known reference coordinates that improve the accuracy of georeferencing and spatial data alignment.

5. **How can filtering and smoothing techniques enhance the quality of 2D DEMs?**

   Filtering and smoothing techniques enhance the quality of 2D DEMs by removing noise, correcting errors, and ensuring the data accurately represents the terrain without irrelevant artifacts.

**Fill in the blanks**

1. **Georeferencing techniques** is necessary to ensure spatial accuracy in orthomosaic creation.
2. The compatibility of **data formats** with downstream processing tools is crucial for effective data processing.
3. Optimal flight planning involves ensuring sufficient **overlap** between images for accurate data extraction.
4. **Filtering** techniques help remove artifacts and irrelevant data from orthomosaics.
5. Comprehensive **processing** detail findings from DEM processing for stakeholders.

**True/False Questions**

1. Calibrating drone sensors is optional for accurate data measurements. (True/False)

- **False** (Calibration is essential for ensuring accurate and reliable data collection.)

2. Georeferencing techniques are used to ensure spatial accuracy in orthomosaic creation. (True/False)
   - True
3. Filtering and smoothing techniques are irrelevant to the quality of 2D DEMs. (True/False)
   - **False** (These techniques are important for improving the quality and accuracy of 2D DEMs by removing errors and noise.)
4. Drone-acquired elevation data can be integrated with existing 2D DEMs. (True/False)
   - True
5. Project specifications and industry standards are not important for verifying selected data formats. (True/False)
   - **False** (Project specifications and industry standards are critical for ensuring data compatibility and quality.)

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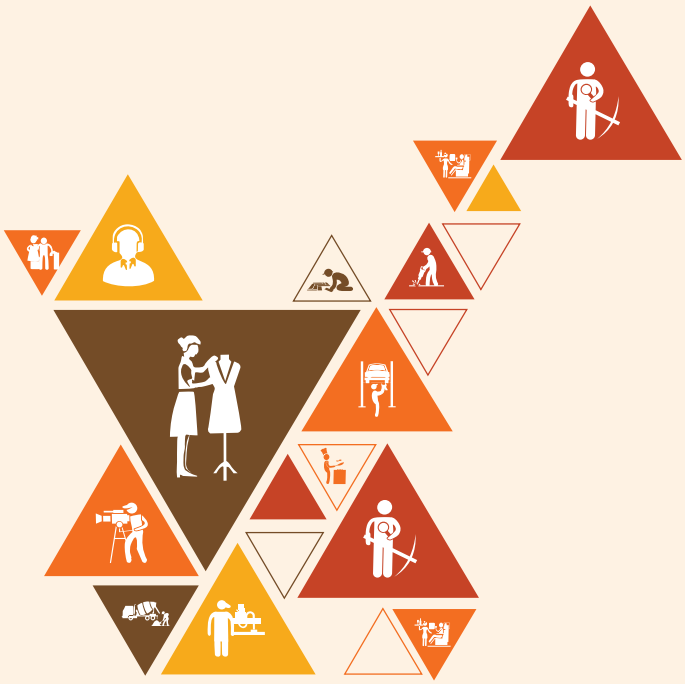
# 4. Data Analysis and Projection Techniques

Unit 4.1: Spatial Data Acquisition and Preprocessing
Unit 4.2: GIS Analysis and Integration
Unit 4.3: Advanced Modeling and Output Evaluation



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## Key Learning Outcomes

**After the end of this module, participants will be able to:**

1. Explain the size and scope of the telecom industry and its sub-sectors.
2. Describe the process of extracting spatial data from drone sensors and ensuring georeferencing.
3. Identify the fundamental principles of remote sensing technologies and their applications in GIS.
4. Understand the necessity of data alignment and coordinate projections for spatial consistency in GIS.
5. Explain the process of image processing algorithms and their role in feature extraction from drone-collected data.
6. Interpret the steps involved in creating orthomosaics, including image registration and color balancing.
7. Extract spatial data from drone sensors and align it with the desired coordinate system.
8. Apply georeferencing techniques to ensure spatial accuracy in drone data integration.
9. Apply quality control checks and preprocessing steps for accurate data preparation in 3D modeling.
10. Analyze drone imagery to identify artifacts and irrelevant data for filtration.
11. Generate comprehensive metadata for spatial datasets, documenting key information for effective communication with stakeholders.
12. Explain the importance of integrating diverse datasets into GIS environments for comprehensive analysis.
13. Define various GIS analysis methods such as spatial queries, overlay analysis, and buffer analysis.
14. Analyze project specifications and industry standards to verify selected data formats.
15. Integrate diverse datasets into GIS environments for comprehensive spatial analysis.
16. Utilize GIS software to perform spatial queries and overlay analysis for specific information extraction.
17. Perform spatial queries and overlay analysis using GIS software to extract specific information.
18. Analyze elevation data to identify anomalies and discrepancies for rectification.
19. Comprehend the principles of 3D modeling techniques, including point cloud generation and mesh creation.
20. Explain the steps for creating orthomosaics, including image overlap adjustments and stitching algorithms.

21. Apply image processing algorithms to enhance and manipulate raw drone imagery for feature extraction.
22. Generate 3D models from drone-collected data, including point cloud generation and mesh creation.
23. Create orthomosaics by registering individual images, adjusting image overlap, and applying image stitching algorithms.
24. Synthesize visual information onto 3D meshes to enhance realism and detail in the generated models.
25. Evaluate the quality of orthomosaics and DEMs based on project requirements.
26. Evaluate the accuracy and reliability of processed spatial data for 3D modeling and feature extraction.
27. Evaluate the completeness and fidelity of generated 3D models and orthomosaics.

# Unit 4.1: Spatial Data Acquisition and Preprocessing

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Describe the process of extracting spatial data from drone sensors and ensuring georeferencing.
2. Identify the fundamental principles of remote sensing technologies and their applications in GIS.
3. Explain the importance of data alignment and coordinate projections for spatial consistency in GIS.
4. Explain the process of image processing algorithms and their role in feature extraction from drone-collected data.
5. Show how to interpret the steps involved in creating orthomosaics, including image registration and color balancing.
6. Show how to extract spatial data from drone sensors and align it with the desired coordinate system.
7. Demonstrate application of georeferencing techniques to ensure spatial accuracy in drone data integration.
8. Show the application of quality control checks and preprocessing steps for accurate data preparation in 3D modeling.
9. Show how to analyze drone imagery to identify artifacts and irrelevant data for filtration.
10. Explain how to generate comprehensive metadata for spatial datasets, documenting key information for effective communication with stakeholders.

## Resources to be used

- **Theory**
    - Trainer Guide, Presentations, GIS software documentation, Participant Handbook, and sample metadata templates.
- **Practical**
    - Sample drone sensor data, GIS software for georeferencing, preprocessing tools, and metadata creation templates.

## Say

- "Today, we will explore the critical steps in acquiring and preprocessing spatial data for GIS applications."
- "We'll focus on ensuring georeferencing accuracy, preparing data for modeling, and creating metadata for stakeholder communication."

## Ask

- "Why do you think spatial accuracy is essential in GIS data integration?"
- "Have you encountered challenges in aligning drone imagery with coordinate systems? If yes, what were they?"

## Elaborate

After the end of this unit, participants will be able to:

1. The process of extracting spatial data and ensuring alignment with coordinate systems.
2. Principles of remote sensing and their relevance in GIS applications.
3. Techniques for preprocessing data to meet project requirements.
4. Steps for generating metadata that effectively communicates dataset details.

## Activity-1

**Activity 1: Coordinate Projection Game**

- Name: Align the Map
- Objective: To practice aligning spatial data with the correct coordinate system.
- Materials Needed:
    - Pre-mapped drone data, GIS software.
- Procedure:
    - Provide participants with mismatched coordinate datasets.
    - Challenge them to align the data with the desired projection system.

- Discuss the challenges they faced and the strategies they used.

- Outcome: Participants learn the importance of accurate coordinate alignment.

## Activity-2

**Activity 2: Feature Extraction Puzzle**

- Name: Hidden Features
- Objective: To identify and extract features from drone imagery.
- Materials Needed:
  - Drone imagery, image processing software.
- Procedure:
  - Provide participants with raw drone imagery.
  - Ask them to use image processing tools to extract specific features (e.g., buildings, vegetation).
  - Compare extracted features and discuss precision techniques.
- Outcome: Participants enhance their understanding of image processing algorithms.

## Notes for facilitation

- Use real-world examples to illustrate the importance of preprocessing steps.
- Encourage participants to collaborate and share strategies during activities.
- Provide feedback after practical tasks to ensure continuous improvement.

# Unit 4.2: GIS Analysis and Integration

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the size and scope of the Telecom industry and its subsectors.
2. Explain the importance of integrating diverse datasets into GIS environments for comprehensive analysis.
3. Define various GIS analysis methods such as spatial queries, overlay analysis, and buffer analysis.
4. Show how to analyze project specifications and industry standards to verify selected data formats.
5. Explain how to integrate diverse datasets into GIS environments for comprehensive spatial analysis.
6. Show the use of GIS software to perform spatial queries and overlay analysis for specific information extraction.
7. Explain how to perform spatial queries and overlay analysis using GIS software to extract specific information.
8. Demonstrate how to analyze elevation data to identify anomalies and discrepancies for rectification.

## Resources to be used

- **Theory**
  - Trainer Guide, GIS software documentation, Project Specification Guidelines, GIS Tutorial.
- **Practical**
  - Sample datasets for spatial queries, GIS software, and analysis tools for overlay and buffer analysis.

## Say

- "In this unit, we will focus on how GIS integrates various datasets and how we can use GIS analysis tools effectively."
- "Understanding spatial queries, overlay analysis, and how to handle elevation data will improve your spatial data analysis skills."

## Ask

- "How do you think integrating diverse datasets into GIS enhances spatial analysis?"
- "Can anyone share an example where GIS integration helped uncover valuable insights in a project?"

## Elaborate

After the end of this unit, participants will be able to:

1. Look at the different GIS analysis methods, such as spatial queries, buffer analysis, and overlay analysis, and how to apply them.
2. Explore the importance of verifying data formats against project specifications to ensure accurate analysis.
3. Work with GIS software tools to perform specific spatial queries and analyze elevation data for discrepancies.

## Activity-1

**Activity 1: Data Integration Challenge**

- Name: Merge the Maps
- Objective: To integrate diverse datasets into a GIS environment for a comprehensive spatial analysis.
- Materials Needed:
    - Sample spatial datasets in different formats (shapefiles, rasters, etc.), GIS software.
- Procedure:
    - Provide participants with different datasets (e.g., land use, elevation, road networks).
    - Challenge them to integrate these datasets into a single GIS project.
    - Ask them to perform a spatial analysis based on the integrated data (e.g., identifying areas with high elevation near roads).
- Outcome: Participants learn the importance of combining datasets for comprehensive spatial analysis.

## Activity-2

**Activity 2: Spatial Query Exploration**

- Name: Query the Data
- Objective: To demonstrate how to perform spatial queries to extract specific information from a GIS environment.
- Materials Needed:
  - Sample GIS project with various layers of spatial data, GIS software.
- Procedure:
  - Provide participants with a GIS project containing multiple layers (e.g., land-use data, water bodies, infrastructure).
  - Instruct them to use spatial queries to extract specific information (e.g., querying land-use data for industrial zones within a certain radius of water bodies).
  - Discuss the results and potential uses for these queries in real-world scenarios.
- Outcome: Participants gain practical experience with spatial query tools.

## Notes for facilitation

- Encourage participants to collaborate and share their thought processes during analysis activities.
- Offer examples of practical applications for GIS analysis methods in different industries (e.g., urban planning, agriculture).
- Ensure that participants understand how to use GIS tools effectively before starting activities.

# Unit 4.3: Advanced Modeling and Output Evaluation

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the principles of 3D modeling techniques, including point cloud generation and mesh creation.
2. Demonstrate how to generate 3D models from drone-collected data, including point cloud generation and mesh creation.
3. Describe the steps for creating orthomosaics, including image overlap adjustments and stitching algorithms.
4. Show how to create orthomosaics by registering individual images, adjusting image overlap, and applying image stitching algorithms.
5. Show how to apply image processing algorithms to enhance and manipulate raw drone imagery for feature extraction.
6. Demonstrate how to synthesize visual information onto 3D meshes to enhance realism and detail in the generated models.
7. Explain how to evaluate the quality of orthomosaics and DEMs based on project requirements.
8. Discuss how to evaluate the accuracy and reliability of processed spatial data for 3D modeling and feature extraction.
9. Elucidate how to evaluate the completeness and fidelity of generated 3D models and orthomosaics.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - Drone imagery, 3D modeling software, GIS tools, sample raw images for orthomosaic creation, and software for point cloud generation

## Say

Good morning, everyone! In today's session, we will explore 3D modeling techniques, focusing on point cloud generation and mesh creation. We will also cover the process of creating orthomosaics, image stitching, and how to synthesize visual information onto 3D meshes for realistic results.

## Ask

- What is the role of point cloud data in 3D modeling?
- How do you think image overlap affects the quality of an orthomosaic?
- Why is it important to ensure that the 3D model and orthomosaic are accurate?
- Write responses on a whiteboard and connect them to the session topics.

## Elaborate

After the end of this unit, participants will be able to:

1. 3D Modeling Techniques:
    a) Point cloud generation and mesh creation.
    b) Techniques for improving the accuracy of 3D models.
2. Creating Orthomosaics:
    a) Image overlap adjustments.
    b) Stitching algorithms for seamless image registration.
3. Image Processing:
    a) Applying image processing algorithms for feature extraction.
4. Synthesizing Visual Information on 3D Meshes:
    a) Enhancing realism and detail.
5. Evaluating the Output:
    a) Quality checks on orthomosaics and DEMs.
    b) Accuracy of 3D models and orthomosaics in relation to project requirements.

## Activity-1

**Activity 1: Point Cloud to 3D Model Creation**

- Name: From Point Cloud to 3D Model
- Objectives:
  - To demonstrate the process of generating a 3D model from drone-collected data, focusing on point cloud generation and mesh creation.
- Materials Needed:
  - Drone imagery, 3D modeling software (e.g., Pix4D, Agisoft Metashape), sample point cloud data.
- Procedure:
  - Provide participants with a set of drone-collected point cloud data.
  - Guide participants through the process of generating a 3D model by first creating the point cloud and then generating the mesh.
  - Show how to refine the model by applying quality control measures (e.g., mesh smoothing, refinement).
  - Ask participants to assess the model for completeness and accuracy.
- Expected Outcome:
  - Participants will understand how point cloud generation and mesh creation work together to build a 3D model and how to assess its quality.

## Activity-2

**Activity 2: Orthomosaic Stitching Challenge**

- Name: Creating Orthomosaics
- Objectives:
  - To teach participants how to register individual images, adjust image overlap, and apply stitching algorithms to create seamless orthomosaics.
- Materials Needed:
  - Sample drone images with partial overlap, orthomosaic software (e.g., QGIS, ArcGIS).
- Procedure:
  - Provide participants with individual images taken from a drone, ensuring they have overlap between them.

- Ask them to use the software to register the images, adjusting the overlap for the best stitching.
- Demonstrate how to apply stitching algorithms to ensure smooth transitions between images.
- Have participants evaluate the orthomosaic for any inconsistencies or stitching errors.

- Expected Outcome:
  - Participants will gain hands-on experience in creating and evaluating orthomosaics and understand how image overlap and stitching contribute to the quality of the final product.

## Notes for facilitation

- Ensure that participants have access to 3D modeling and orthomosaic software for hands-on practice.
- Encourage participants to ask questions and share any challenges they face during the activities.
- Remind participants that creating accurate models and orthomosaics requires careful attention to detail, especially with image overlap and mesh refinement.
- Provide additional resources for those interested in exploring advanced features in the software.

## Exercise

**Short Answer Questions:**

1. **What are the fundamental principles of remote sensing technologies and their applications in GIS?**

   The fundamental principles of remote sensing technologies involve the collection of data from a distance, often using satellite or drone sensors, and analyzing the data to extract valuable information.Applications in GIS (Geographic Information Systems) include land use mapping, environmental monitoring, and urban planning.

2. **How does georeferencing ensure spatial accuracy in drone data integration?**

   Georeferencing ensures spatial accuracy in drone data integration by aligning the collected data with real-world coordinates, ensuring that the data can be correctly overlaid with other spatial datasets.

3. **What role do image processing algorithms play in feature extraction from drone-collected data?**

Image processing algorithms play a crucial role in feature extraction from drone-collected data by enhancing images, identifying key features (such as buildings, roads, or vegetation), and converting raw imagery into usable data for analysis.

4. **What are the key steps involved in creating orthomosaics from drone imagery?**

   The key steps involved in creating orthomosaics from drone imagery include image acquisition, image alignment, image stitching, and georeferencing to produce a seamless and accurate map representation of the area.

5. **How can the quality of orthomosaics and DEMs be evaluated based on project requirements?**

   The quality of orthomosaics and DEMs (Digital Elevation Models) can be evaluated based on project requirements by assessing the accuracy, resolution, and alignment of the data, and ensuring it meets the standards for the intended use.

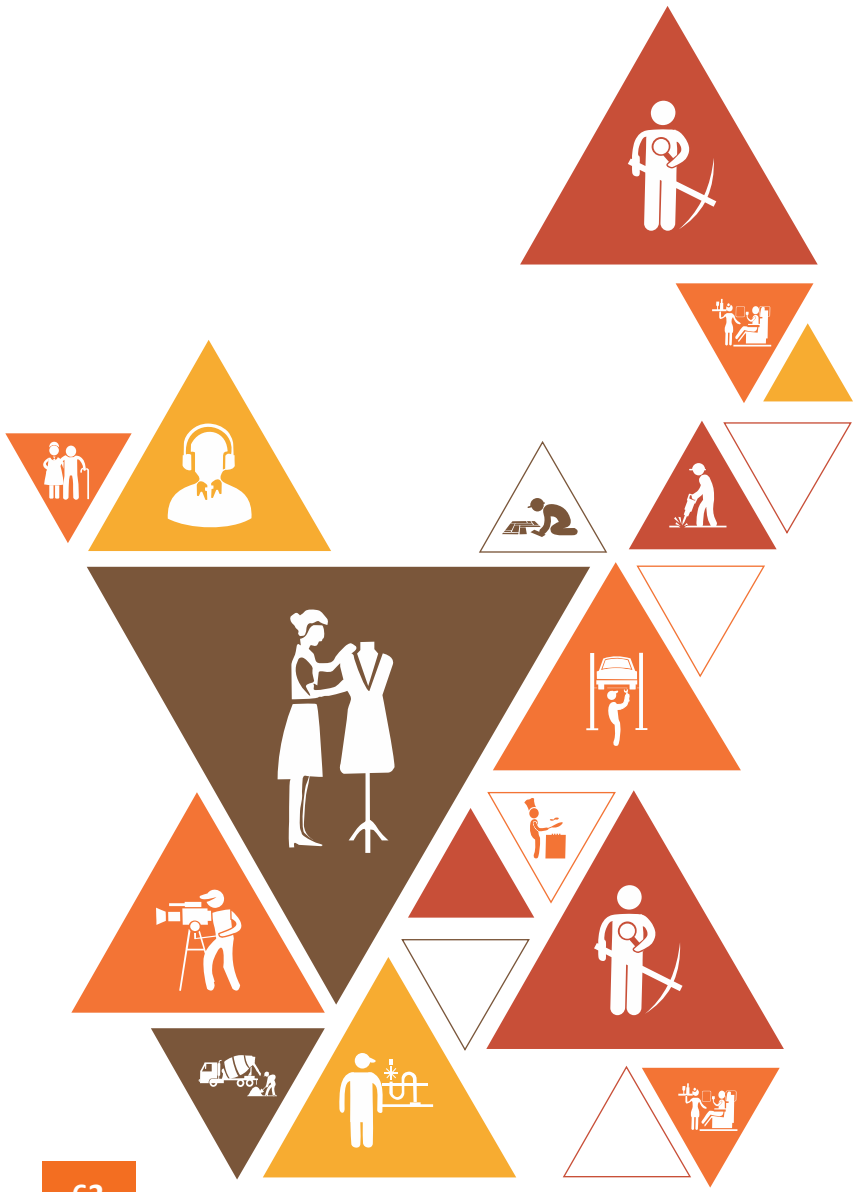
**Fill in the blanks**

1. Georeferencing techniques ensure **spatial** accuracy in drone data integration.
2. Image processing algorithms are used to **enhance** and manipulate raw drone imagery for feature extraction.
3. **Comprehensive** metadata for spatial datasets documents key information for stakeholders.
4. Diverse datasets can be integrated into **GIS** environments for comprehensive spatial analysis.
5. The process of **georeferencing** ensures spatial consistency by aligning data with coordinate projections.

**True/False Questions**

1. Coordinate projections are unnecessary for ensuring spatial consistency in GIS. (True/False)
   - **False** *(Coordinate projections are crucial for aligning data with real-world locations and ensuring spatial consistency.)*
2. Image stitching algorithms are used in the creation of orthomosaics from drone imagery. (True/False)
   - True
3. Comprehensive metadata is irrelevant when documenting spatial datasets. (True/False)
   - **False** (*Comprehensive metadata is essential for understanding the data and ensuring its proper use and interpretation*.)

4. GIS analysis methods include spatial queries, overlay analysis, and buffer analysis. (True/False)
    - True
5. The fidelity of generated 3D models should be evaluated to ensure accuracy. (True/False)
    - True



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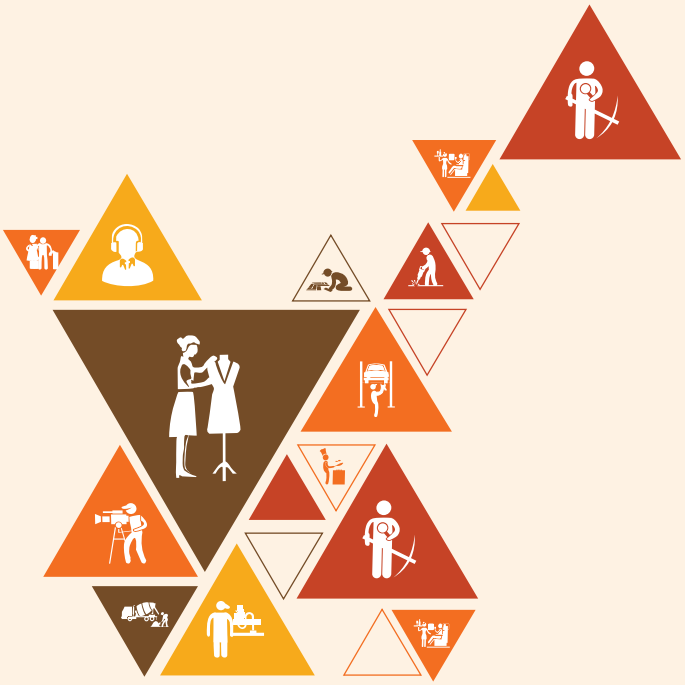
# 5. Remote Sensing Data Analysis and Interpretation

Unit 5.1: Thermal and Infrared (TIR) Data Calibration and Analysis
Unit 5.2: RF Data Analysis and Integration
Unit 5.3: Automated Analysis and Machine Learning in Spatial Data Processing



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# Key Learning Outcomes

**After the end of this module, participants will be able to:**

1. Describe the process of calibrating TIR sensors for accurate thermal imagery.
2. Define temperature calibration techniques for converting raw thermal data into meaningful temperature values.
3. Explain methods for analyzing thermal and infrared data to detect anomalies and patterns.
4. Identify techniques for quantifying thermal variations across landscapes and interpreting temperature distributions.
5. Calibrate TIR sensors to ensure accurate thermal measurements.
6. Apply temperature calibration techniques to convert raw thermal data into temperature values.
7. Analyze thermal and infrared data to detect anomalies and patterns.
8. Generate thermal maps and visualizations to represent temperature distributions spatially.
9. Analyze thermal variations across landscapes and interpret temperature distributions.
10. Define frequency analysis and pattern recognition algorithms used in analyzing RF data.
11. Understand the importance of integrating diverse datasets for comprehensive spatial analysis.
12. Retrieve and analyze RF data collected from drone storage systems.
13. Conduct frequency analysis and identify trends or anomalies in collected RF signals.
14. Develop systematic approaches for categorizing Thermal, Infrared, and RF data based on parameters such as location and time.
15. Explain the necessity of metadata tagging and database organization for efficient data management.
16. Interpret the principles behind automated analysis of Thermal, Infrared, and RF data.
17. Comprehend the role of machine learning in automating data analysis and pattern recognition.
18. Implement metadata tagging and database management for organizing Thermal, Infrared, and RF data.
19. Utilize industry-standard software tools for automated analysis of Thermal, Infrared, and RF data.
20. Develop streamlined processing workflows and implement validation procedures for automated analysis.
21. Compare automated analysis results with manual or ground truth assessments to ensure consistency.

22. Design automated reporting mechanisms to present analysis results effectively.
23. Customize or develop algorithms as needed to address specific requirements or challenges posed by the dataset.
24. Incorporate machine learning models and techniques to automate identification of patterns and anomalies within the data.
25. Design automated processing workflows and incorporate parallel processing or distributed computing solutions for efficient analysis.

# Unit 5.1: Thermal and Infrared (TIR) Data Calibration and Analysis

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Describe the process of calibrating TIR sensors for accurate thermal imagery.
2. Explain how to calibrate TIR sensors to ensure accurate thermal measurements.
3. Define temperature calibration techniques for converting raw thermal data into meaningful temperature values.
4. Explain the temperature calibration techniques to convert raw thermal data into temperature values.
5. Explain the methods for analyzing thermal and infrared data to detect anomalies and patterns.
6. Show how to analyze thermal and infrared data to detect anomalies and patterns.
7. Identify techniques for quantifying thermal variations across landscapes and interpreting temperature distributions.
8. Show how to generate thermal maps and visualizations to represent temperature distributions spatially.
9. Demonstrate analysis of thermal variations across landscapes and interpret temperature distributions.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - Thermal Infrared (TIR) sensor or thermal imaging camera, GIS software, thermal data sets, and temperature calibration tools.

## Say

Good morning, everyone! In today's session, we will explore thermal infrared (TIR) data calibration and analysis. We will focus on how to calibrate TIR sensors, analyze thermal data, and generate meaningful insights from temperature distributions across landscapes.

## Ask

- What is the importance of accurate thermal data in environmental and agricultural studies?
- How does thermal calibration affect the quality of the data we collect?
- What patterns in temperature distribution might indicate potential environmental issues?

Write responses on the whiteboard and connect them to the session topics.

## Elaborate

After the end of this unit, participants will be able to:

1. Thermal Data Calibration:
    a) . Understanding the calibration process for TIR sensors.
    b) . Techniques for ensuring accurate thermal measurements.
2. 2. Temperature Calibration:
    a) . Converting raw thermal data into meaningful temperature values.
    b) . The role of temperature calibration in data analysis.
3. 3. Analyzing Thermal Data:
    a) . Methods for detecting anomalies and patterns.
    b) . Identifying techniques for quantifying thermal variations.
4. 4. Thermal Mapping and Visualization:
    a) . Generating thermal maps and visualizations for temperature distribution.
    b) . Analyzing and interpreting thermal variations across landscapes.

## Activity-1

**Activity 1: TIR Sensor Calibration Demonstration**

- Name: Calibrating a Thermal Infrared Sensor

- Objectives:
  - To demonstrate how to calibrate a TIR sensor for accurate thermal measurements.
- Materials Needed:
  - Thermal infrared sensor, calibration software, sample thermal data set.
- Procedure:
  - Provide a brief overview of the sensor calibration process.
  - Demonstrate step-by-step how to calibrate the TIR sensor using calibration software.
  - Show how to adjust for environmental factors like temperature, humidity, and angle of view.
  - Allow participants to practice calibrating the TIR sensor using sample data.
- Expected Outcome:
  - Participants will gain hands-on experience calibrating TIR sensors, ensuring accurate thermal data collection.

## Activity-2

**Activity 2: Thermal Data Analysis and Visualization**

- Name: Analyzing and Visualizing Thermal Data
- Objectives:
  - To teach participants how to analyze thermal and infrared data to detect anomalies and generate thermal maps.
- Materials Needed:
  - Thermal data sets, GIS software (e.g., QGIS, ArcGIS), temperature visualization tools.
- Procedure:
  - Provide participants with a set of thermal data that includes temperature variations across a landscape.
  - Guide participants through the process of analyzing the data to identify anomalies such as heat spots or cold areas.
  - Demonstrate how to use GIS software to create thermal maps and visualize temperature distributions.
  - Have participants create their own thermal maps and interpret the temperature patterns across the landscape.

- Expected Outcome:
    - Participants will develop the skills to analyze thermal data and generate thermal maps that reflect temperature variations and help in pattern detection.

## Notes for facilitation

- Use real-world examples to explain the practical applications of thermal data calibration and analysis, such as in agriculture or environmental monitoring.
- Ensure that participants have access to the necessary software and data sets for hands-on practice.
- Offer guidance as participants work through the analysis of thermal data and visualization exercises.
- Emphasize the importance of calibration for the accuracy and reliability of thermal imagery in real-world applications.

# Unit 5.2: RF Data Analysis and Integration

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Define frequency analysis and pattern recognition algorithms used in analyzing RF data.
2. Show how to retrieve and analyze RF data collected from drone storage systems.
3. Demonstrate how to conduct frequency analysis and identify trends or anomalies in collected RF signals.
4. Explain the importance of integrating diverse datasets for comprehensive spatial analysis.
5. Discuss how to develop systematic approaches for categorizing Thermal, Infrared, and RF data based on parameters such as location and time.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - RF data sets, frequency analysis software (e.g., MATLAB, Python), drone storage system data retrieval tools, GIS software for data integration, signal processing tools

## Say

Good morning, everyone! Today, we will explore RF data analysis and how to integrate it with other data sources like Thermal and Infrared data. We will focus on frequency analysis, identifying trends or anomalies in RF signals, and categorizing RF data to support comprehensive spatial analysis.

## Ask

- What are some real-world applications of RF data in drone operations?
- Why is it important to identify patterns or anomalies in RF signals?
- How might integrating RF data with thermal and infrared data enhance data analysis?

Write responses on the whiteboard and connect them to the session topics.

## Elaborate

After the end of this unit, participants will be able to:

1. Frequency Analysis and Pattern Recognition Algorithms:
    a) Understanding frequency analysis and its importance in RF data.
    b) Overview of pattern recognition techniques used for RF data analysis.
2. Retrieving RF Data from Drone Storage Systems:
    a) Methods for retrieving RF data from drone storage systems.
    b) Handling and processing raw RF data for analysis.
3. Conducting Frequency Analysis:
    a) Techniques for conducting frequency analysis on RF signals.
    b) Identifying trends, anomalies, and signal patterns in RF data.
4. Data Integration:
    a) The importance of integrating RF data with other spatial data types for a comprehensive analysis.
5. Categorizing RF, Thermal, and Infrared Data:
    a) Developing systematic approaches for categorizing data based on location, time, and other parameters.

## Activity-1

**Activity 1: Frequency Analysis and Pattern Recognition**

- Name: Conducting RF Frequency Analysis
- Objectives:
    - To demonstrate how to conduct frequency analysis and identify anomalies or trends in RF data.
- Materials Needed:
    - RF data sets, frequency analysis software (MATLAB or Python), signal processing tools.

- Procedure:
    - Provide participants with a sample RF data set from a drone's storage system.
    - Introduce frequency analysis concepts and tools available in MATLAB or Python.
    - Demonstrate how to conduct frequency analysis and apply pattern recognition algorithms to identify trends or anomalies in the data.
    - Allow participants to analyze the RF data set using the software, identifying key patterns or anomalies.
- Expected Outcome:
    - Participants will be able to perform frequency analysis on RF data and recognize trends or anomalies using relevant algorithms.

## Activity-2

**Activity 2: Data Integration and Categorization**

- Name: Integrating and Categorizing RF, Thermal, and Infrared Data
- Objectives:
    - To teach participants how to integrate RF data with other datasets and categorize it based on parameters such as time and location.
- Materials Needed:
    - GIS software (e.g., QGIS, ArcGIS), RF, Thermal, and Infrared data sets.
- Procedure:
    - Provide participants with a combination of RF, Thermal, and Infrared data sets.
    - Demonstrate how to integrate these datasets into a GIS software environment for spatial analysis.
    - Teach participants how to categorize the data based on parameters like location, time, and sensor type.
    - Guide participants through the process of creating a spatial analysis model that integrates these data types for enhanced decision-making.
- Expected Outcome:
    - Participants will gain the ability to integrate and categorize multiple data types, enabling them to perform comprehensive spatial analysis.

## Notes for facilitation

- Ensure participants are familiar with the software tools (MATLAB, Python, GIS software) prior to activities.
- Offer individual support to participants as they conduct frequency analysis and data integration exercises.
- Emphasize the real-world importance of integrating diverse datasets in decision-making and problem-solving scenarios.
- Provide additional resources or reading materials on RF data analysis and pattern recognition algorithms for deeper learning.

## Notes

# Unit 5.3: Automated Analysis and Machine Learning in Spatial Data Processing

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the necessity of metadata tagging and database organization for efficient data management.
2. Explain the principles behind automated analysis of Thermal, Infrared, and RF data.
3. Elucidate the role of machine learning in automating data analysis and pattern recognition.
4. Demonstrate how to implement metadata tagging and database management for organizing Thermal, Infrared, and RF data.
5. Show how to utilize industry-standard software tools for automated analysis of Thermal, Infrared, and RF data.
6. Describe streamlined processing workflows and validation procedures for automated analysis.
7. Discuss the comparison of automated analysis results with manual or ground truth assessments to ensure consistency.
8. Design automated reporting mechanisms to present analysis results effectively.
9. Explain how to customize or develop algorithms to address specific requirements or challenges posed by the dataset.
10. Elucidate how to incorporate machine learning models and techniques to automate the identification of patterns and anomalies within the data.
11. Show how to design automated processing workflows and incorporate parallel processing or distributed computing solutions for efficient analysis.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - Software tools for automated analysis (e.g., Python, TensorFlow, MATLAB, GIS software), Machine Learning models, metadata tagging tools, spatial data sets (Thermal, Infrared, RF), and database management tools.

## Say

Good morning, everyone! Today, we will dive into the exciting world of automated analysis and machine learning in spatial data processing. We will explore how metadata tagging and machine learning can streamline data management, enhance pattern recognition, and automate analysis workflows.

## Ask

- Why is metadata tagging critical for spatial data management?
- What do you think are the benefits of automating data analysis compared to manual analysis?
- How can machine learning models help us recognize patterns in large datasets?

Write responses on the whiteboard and connect them to the session topics.

## Elaborate

After the end of this unit, participants will be able to:

1. Metadata Tagging and Database Organization:
    a) The importance of metadata in data management.
    b) How database organization aids in efficient spatial data handling.
2. Automated Analysis of Thermal, Infrared, and RF Data:
    a) Introduction to principles and software tools for automated analysis.
    b) The role of automated workflows in data processing.
3. Machine Learning for Data Analysis:
    a) How machine learning models can automate pattern recognition and anomaly detection in spatial data.
    b) Examples of machine learning applications in Thermal, Infrared, and RF data.
4. Streamlined Processing Workflows:
    a) The design of automated workflows and validation procedures.
    b) Integration of parallel computing for efficiency.

5. Automated Reporting Mechanisms:

    a) How to design and implement automated reporting systems for analysis results.

6. Customizing Algorithms:

    a) Modifying algorithms to address dataset-specific challenges and requirements.

## Activity-1

**Activity 1: Metadata Tagging and Database Management**

- Name: Implementing Metadata Tagging and Organizing Data
- Objectives:
    - To demonstrate how to implement metadata tagging and organize spatial data in a database for efficient access and management.
- Materials Needed:
    - Spatial data sets (Thermal, Infrared, RF), Database management software (e.g., MySQL, MongoDB), metadata tagging tools.
- Procedure:
    - Provide participants with sample spatial data files (Thermal, Infrared, RF).
    - Show participants how to apply metadata tagging to the data (e.g., including location, time, sensor type, etc.).
    - Demonstrate how to organize the tagged data within a database for efficient query and retrieval.
    - Have participants practice tagging and organizing their own sample data files.
- Expected Outcome:
    - Participants will learn how to efficiently tag metadata and organize spatial data for easy access and management.

## Activity-2

**Activity 2: Machine Learning for Pattern Recognition**

- Name: Using Machine Learning to Recognize Patterns in Spatial Data

- Objectives:
    - To demonstrate how machine learning models can automate the recognition of patterns or anomalies in Thermal, Infrared, and RF data.
- Materials Needed:
    - Machine Learning software (e.g., Python, TensorFlow), sample datasets (Thermal, Infrared, RF), Jupyter Notebooks.
- Procedure:
    - Introduce participants to basic machine learning models for pattern recognition (e.g., supervised learning algorithms like decision trees, SVM).
    - Provide a sample dataset (e.g., RF signals with identified anomalies) and guide participants through the process of training a machine learning model.
    - Demonstrate how to evaluate the model's performance in recognizing patterns and anomalies.
    - Allow participants to train and test their own models on sample datasets.
- Expected Outcome:
    - Participants will understand the role of machine learning in automating pattern recognition and gain hands-on experience in training models on spatial data.

## Notes for facilitation

- Ensure all participants have access to the necessary software tools (Python, TensorFlow, etc.) for machine learning and database management.
- Walk participants through the steps of tagging metadata and organizing data, ensuring they understand the importance of these processes in spatial data management.
- Provide additional resources or documentation on machine learning models and algorithms for further learning.
- Emphasize the real-world applicability of automating data analysis and pattern recognition in industries such as environmental monitoring, agriculture, and urban planning.

## Exercise

**Short Answer Questions:**

1. **What are the key steps in calibrating TIR sensors for accurate thermal imagery?**

   The key steps in calibrating TIR (Thermal Infrared) sensors for accurate thermal imagery include performing pre-flight and post-flight calibration, applying temperature references, and ensuring proper sensor alignment with the imaging system.

2. **How can temperature calibration techniques convert raw thermal data into meaningful temperature values?**

   Temperature calibration techniques convert raw thermal data into meaningful temperature values by applying a calibration factor or correction equation that accounts for sensor errors and environmental conditions.

3. **What methods can be used to analyze thermal and infrared data for detecting anomalies and patterns?**

   Methods used to analyze thermal and infrared data for detecting anomalies and patterns include using algorithms like thresholding, edge detection, and clustering, as well as visualizing temperature anomalies through heat maps.

4. **Why is metadata tagging and database organization essential for efficient data management?**

   Metadata tagging and database organization are essential for efficient data management because they provide context for data interpretation, ensure proper storage, and allow easy retrieval and analysis of large datasets.

5. **How does machine learning facilitate the automation of data analysis and pattern recognition?**

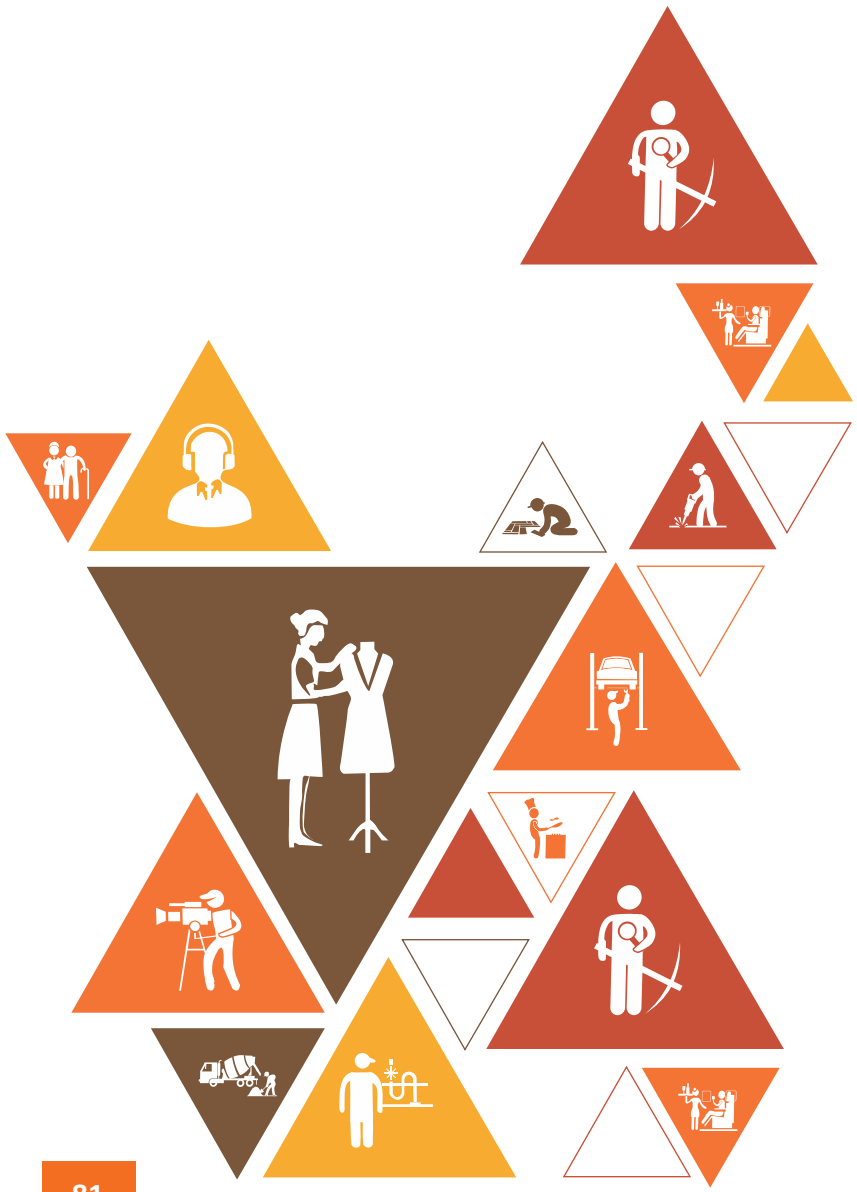
   Machine learning facilitates the automation of data analysis and pattern recognition by training models to identify patterns in large datasets, detect anomalies, and predict outcomes without manual intervention

**Fill in the blanks**

1. **Temperature** calibration techniques are used to convert raw thermal data into meaningful temperature values.
2. The process of **calibrating** TIR sensors ensures accurate thermal measurements.
3. Frequency analysis and **pattern** recognition algorithms are crucial for analyzing RF data.
4. Generating **thermal** maps helps represent temperature distributions spatially across landscapes.
5. Machine learning models can automate the identification of patterns and anomalies within datasets.

**True/False Questions**

1. TIR sensors do not require calibration for accurate thermal measurements. (True/False)
    - **False** (*Calibration is crucial for accurate thermal measurements, as sensors can have inherent inaccuracies.)*
2. Thermal maps are essential for spatial representation of temperature distributions. (True/False)
    - True
3. Metadata tagging and database management are unnecessary for organizing Thermal, Infrared, and RF data. (True/False)
    - **False** (*Metadata and database management are essential for organizing and managing large datasets effectively.)*
4. Automated analysis of Thermal, Infrared, and RF data can incorporate machine learning models. (True/False)
    - True
5. Parallel processing and distributed computing solutions enhance the efficiency of automated processing workflows. (True/False)
    - True



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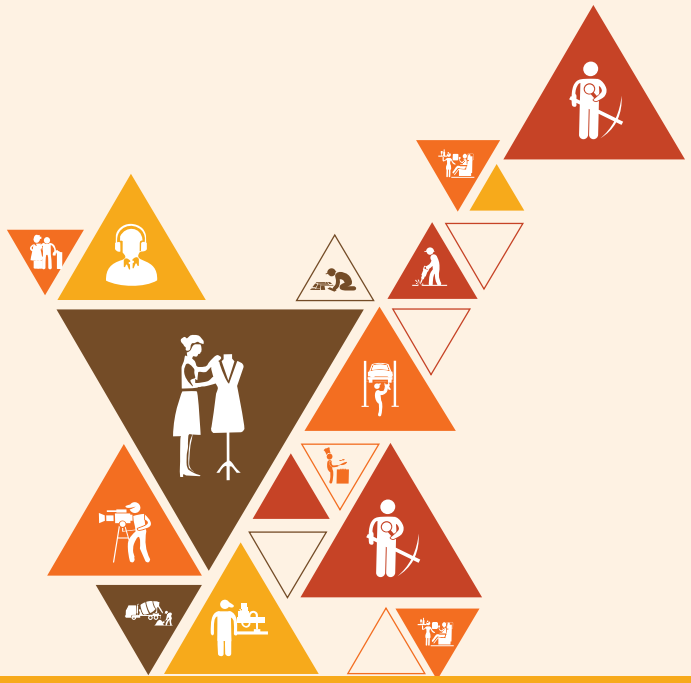
# 6. Fault Identification and Analysis in Equipment and Infrastructure

Unit 6.1: Principles of Drone Flight Path Planning and Data Collection

Unit 6.2: Thermal Imaging and Data Integration

Unit 6.3: Fault Detection Using Advanced Tools and Techniques



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# Key Learning Outcomes

**After the end of this module, participants will be able to:**

1. Explain the principles behind planning drone flight paths for telecom equipment inspection.
2. Define normal operating temperatures for various types of telecom equipment.
3. Demonstrate the integration of acquired geospatial data with existing maps or infrastructure layouts of telecom equipment.

# Unit 6.1: Principles of Drone Flight Path Planning and Data Collection

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Define the purpose and importance of telecom equipment inspections using drones.
2. Explain the fundamental principles behind designing efficient drone flight paths for equipment inspections.
3. Identify the key factors influencing flight path planning, including coverage, altitude, and obstacles.
4. Describe the functionality of software tools such as Pix4D and DroneDeploy for optimizing drone flight paths.
5. Show how to develop and plan drone flight paths to ensure comprehensive coverage of telecom infrastructure.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - Drone model or simulator, Pix4D and DroneDeploy software, telecom equipment maps, flight planning tools, and sample terrain data.

## Say

Good morning, everyone! In today's session, we will explore how drones are used for telecom equipment inspections, focusing on the principles of flight path planning and data collection. We will also learn about the role of software tools like Pix4D and DroneDeploy in optimizing flight paths.

## Ask

- Why do you think drones are used for telecom equipment inspections instead of traditional methods?
- What factors do you think are essential for designing an effective drone flight path?

- How can flight path planning help in collecting the most useful data?
- Write responses on the whiteboard and connect them to the session topics.

## Elaborate

After the end of this unit, participants will be able to:

1. Purpose of Telecom Equipment Inspections Using Drones:
    a) Faster and more efficient inspections.
    b) Reduced risk to personnel in hazardous environments.
2. Principles of Drone Flight Path Planning:
    a) Factors to consider in flight path design: coverage, altitude, obstacles, and environmental conditions.
    b) Efficiency in data collection and flight duration.
3. Software Tools for Flight Path Optimization:
    a) Overview of Pix4D and DroneDeploy for creating optimized flight paths.
    b) How to use these tools to automate flight planning and ensure comprehensive coverage.
4. Developing Flight Paths for Telecom Infrastructure Inspections:
    a) Planning paths for inspecting towers, antennas, and other equipment.
    b) Ensuring that the flight paths cover all critical areas while avoiding obstacles.

## Activity-1

**Activity 1: Drone Flight Path Design Exercise**

- Name: Designing Efficient Drone Flight Paths
- Objectives:
    - To practice designing drone flight paths for telecom equipment inspections.
- Materials Needed:

- Maps or diagrams of telecom equipment, laptop with Pix4D or DroneDeploy installed, flight planning software.

- Procedure:
  - Provide participants with a map of telecom infrastructure (e.g., telecom tower or antenna location).
  - Have them use Pix4D or DroneDeploy to create a flight path for a drone inspection.
  - Instruct them to consider key factors such as coverage area, altitude, and obstacles (e.g., trees, buildings).
  - Afterward, review the flight paths designed by participants and discuss the pros and cons of different approaches.

- Expected Outcome:
  - Participants will gain hands-on experience in using flight planning software and learn how to create efficient drone flight paths for telecom inspections.

## Activity-2

**Activity 2: Flight Path Simulation and Optimization**

- Name: Optimizing Drone Flight Path for Telecom Inspections
- Objectives:
  - To demonstrate how software tools like Pix4D and DroneDeploy can be used to optimize flight paths.
- Materials Needed:
  - Laptop, Pix4D or DroneDeploy software, flight path data from the previous activity.
- Procedure:
  - Show participants how to upload their flight paths to Pix4D or DroneDeploy.
  - Demonstrate how to use the optimization features of the software, such as adjusting altitude and modifying paths to avoid obstacles.
  - Let participants apply the optimization techniques to their own flight paths and compare the results.
  - Discuss how the optimized flight paths can improve efficiency and data coverage during the inspection.
- Expected Outcome:
  - Participants will learn how to use optimization features in flight planning software to improve the effectiveness of drone inspections.

## Notes for facilitation

- Ensure all participants have access to the necessary software tools (Pix4D, DroneDeploy) and are familiar with the interface.
- Provide additional resources on the principles of flight path planning and data collection for telecom inspections.
- Encourage participants to consider the specific needs of telecom infrastructure when designing flight paths, such as the height and positioning of antennas.
- Highlight real-world applications of optimized flight paths in telecom infrastructure inspections to demonstrate the relevance of the skills being learned.

## Notes

# Unit 6.2: Thermal Imaging and Data Integration

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the role of thermal imaging in detecting faults in telecom equipment.
2. Define the normal operating temperature ranges for various telecom equipment.
3. Identify and analyze abnormal heat signatures in thermal images to pinpoint potential malfunctions.
4. Show how to apply temperature calibration techniques to convert raw thermal data into actionable information.
5. Demonstrate how to integrate thermal and geospatial data with existing maps and infrastructure layouts for analysis.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - Thermal camera or thermal imaging software, telecom equipment layouts, thermal data from drone inspections, geospatial software (e.g., GIS), and sample maps.

## Say

Good morning, everyone! In today's session, we will explore the power of thermal imaging for detecting faults in telecom equipment, learn how to interpret thermal data, and understand how to integrate this information with geospatial data for effective analysis.

## Ask

- How do you think thermal imaging can help in identifying faults in telecom equipment?
- What do you think could happen if a telecom component operates above its normal temperature range?
- How would you integrate thermal data into existing telecom infrastructure maps for better analysis?

Write responses on the whiteboard and discuss them as a group.

## Elaborate

After the end of this unit, participants will be able to:

1. Role of Thermal Imaging in Detecting Faults:
    a) How thermal imaging can reveal overheating or malfunctioning components in telecom equipment.
    b) The importance of early detection of faults to prevent costly downtime.
2. Normal Operating Temperature Ranges:
    a) Understanding the typical temperature ranges for telecom equipment such as antennas, routers, and power supplies.
    b) Identifying what constitutes normal vs. abnormal temperature readings.
3. Identifying and Analyzing Abnormal Heat Signatures:
    a) Techniques to analyze thermal images for irregularities, such as hot spots or temperature gradients.
    b) How to interpret the data to pinpoint potential malfunctions.
4. Temperature Calibration Techniques:
    a) Converting raw thermal data into actionable temperature values.
    b) Adjusting for environmental conditions that may affect thermal readings.
5. Integrating Thermal and Geospatial Data:
    a) Combining thermal data with geospatial information, like infrastructure maps, to get a clearer picture of equipment status.
    b) Visualizing thermal anomalies on maps to aid in troubleshooting.

## Activity-1

**Activity 2: Flight Path Simulation and Optimization**

- Name: Optimizing Drone Flight Path for Telecom Inspections
- Objectives:

- To practice identifying abnormal heat signatures in thermal images and correlating them with potential faults.

- Materials Needed:
  - Thermal images of telecom equipment, laptop, thermal imaging software.
- Procedure:
  - Provide participants with thermal images showing telecom equipment.
  - Ask participants to identify any heat anomalies, such as unusual temperature increases or irregular patterns in the images.
  - Have them discuss possible causes for the heat signatures they identified.
  - Review and explain the findings as a group, emphasizing the importance of early fault detection.
- Expected Outcome:
  - Participants will be able to identify abnormal heat patterns in thermal images and understand their implications for telecom equipment malfunctions.

## Activity-2

**Activity 2: Thermal Data Integration with Geospatial Information**

- Name: Integrating Thermal Data into Geospatial Maps
- Objectives:
  - To demonstrate how to combine thermal data with geospatial data for comprehensive analysis of telecom infrastructure.
- Materials Needed:
  - Thermal data (e.g., heat signatures), GIS software, telecom infrastructure maps.
- Procedure:
  - Show how to upload thermal data into GIS software alongside telecom infrastructure maps.
  - Demonstrate how to overlay thermal data onto the maps and visualize temperature variations across the network.
  - Guide participants through the process of linking thermal hotspots with specific equipment on the map for targeted analysis.
  - Discuss how this integration can assist in prioritizing maintenance or troubleshooting efforts.

- Expected Outcome:
    - Participants will gain hands-on experience integrating thermal data with geospatial maps, allowing for a more detailed and accurate analysis of telecom equipment.

## Notes for facilitation

- Ensure all participants have access to the necessary software and thermal imaging data.
- Encourage participants to consider the real-world application of these techniques, such as identifying failing components before they cause service outages.
- Emphasize the importance of temperature calibration for ensuring that thermal data is accurate and reliable.
- Discuss how the integration of thermal and geospatial data can be a powerful tool for maintaining telecom infrastructure.

## Notes

# Unit 6.3: Fault Detection Using Advanced Tools and Techniques

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain how to utilize machine learning models to automate fault detection in telecom equipment.
2. Demonstrate spatial analysis to identify equipment irregularities using advanced tools.
3. Show how to generate thermal maps and 3D models of telecom infrastructure for visualization and analysis.
4. Show how to evaluate the accuracy and reliability of detection methods for fault analysis.
5. Describe how to apply learned techniques to analyze real-world case studies in telecom infrastructure fault detection.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - Machine learning software (e.g., TensorFlow, Scikit-learn), GIS software, thermal camera data, 3D modeling software (e.g., Blender, SketchUp), telecom infrastructure datasets.

## Say

Good morning, everyone! In today's session, we will dive into advanced techniques for fault detection in telecom infrastructure. We will explore how machine learning can automate fault detection, learn how to use spatial analysis tools, and understand how to generate 3D models and thermal maps to visualize and analyze telecom equipment.

## Ask

- How do you think machine learning can assist in detecting faults in telecom equipment?
- What are some common faults in telecom equipment that may be difficult to identify manually?
- How can spatial analysis improve our ability to detect faults across large telecom networks?
- What challenges do you think may arise when using advanced tools for fault detection?
- Write responses on the whiteboard and discuss them as a group.

## Elaborate

After the end of this unit, participants will be able to:

1. Utilizing Machine Learning Models for Fault Detection:

    a) Overview of how machine learning can automate the process of detecting faults in telecom equipment.

    b) Types of machine learning models (e.g., supervised, unsupervised) used for fault detection.

    c) Benefits of automation, including faster fault detection and reduced human error.

2. Spatial Analysis for Identifying Irregularities:

    a) How spatial analysis techniques can identify patterns in telecom infrastructure that may indicate faults.

    b) Tools for spatial analysis, such as GIS software and spatial statistics.

3. Generating Thermal Maps and 3D Models for Visualization:

    a) The process of creating thermal maps to visualize temperature anomalies in telecom equipment.

    b) Using 3D models to visualize the entire telecom infrastructure and pinpoint problematic areas.

4. Evaluating Accuracy and Reliability of Detection Methods:

    a) Assessing the accuracy and reliability of fault detection tools and techniques.

    b) Methods for validating detection results, including ground truth comparisons and error analysis.

5. Real-World Case Studies:

    a) Analyzing real-world telecom infrastructure case studies to see how advanced detection techniques are applied.

    b) Discussing lessons learned and best practices for fault detection in the field.

## Activity-1

**Activity 1: Machine Learning Model for Fault Detection**

- Name: Automating Fault Detection with Machine Learning
- Objectives:
  - To demonstrate how machine learning models can be used to detect faults in telecom equipment.
- Materials Needed:
  - Laptop with machine learning software (e.g., TensorFlow or Scikit-learn), telecom equipment dataset with fault labels.
- Procedure:
  - Explain the basic concept of training a machine learning model for fault detection.
  - Provide participants with a sample dataset of telecom equipment data (including faults).
  - Guide them through the process of training a simple machine learning model to classify faults.
  - Discuss the results and how well the model detects faults.
- Expected Outcome:
  - Participants will gain hands-on experience in using machine learning to identify faults in telecom infrastructure and understand how to improve model accuracy.

## Activity-2

**Activity 2: Generating Thermal Maps and 3D Models**

- Name: Creating Visualizations for Fault Analysis
- Objectives:
  - To demonstrate how to generate thermal maps and 3D models of telecom infrastructure for visualization.
- Materials Needed:
  - Thermal images, GIS software, 3D modeling software (e.g., Blender), telecom infrastructure data.
- Procedure:
  - Show how to import thermal images and telecom infrastructure data into GIS software.
  - Demonstrate how to overlay thermal data onto infrastructure maps to identify anomalies.

- Guide participants in creating simple 3D models of telecom infrastructure using thermal data for analysis.
- Discuss how these visualizations can help in identifying potential fault zones.

- Expected Outcome:
  - Participants will understand how to use thermal data and 3D modeling tools to create visualizations that can help identify faults in telecom infrastructure.

## Notes for facilitation

- Ensure all participants are familiar with the machine learning tools and software needed for the activities.
- Emphasize the importance of evaluating the accuracy and reliability of detection methods to avoid false positives or missed faults.
- Encourage collaboration during case study analysis to enhance learning and problem-solving skills.
- Provide real-world examples to illustrate how these advanced tools and techniques can improve fault detection and infrastructure maintenance in telecom networks.

## Exercise

**Short Answer Questions:**

1. **What is the purpose of using drones for telecom equipment inspections?**

   The purpose of using drones for telecom equipment inspections is to provide efficient, safe, and accurate monitoring of hard-to-reach equipment, such as antennas, towers, and cables, without the need for manual inspection or scaffolding.

2. **How do software tools like Pix4D and DroneDeploy optimize drone flight paths?**

   Software tools like Pix4D and DroneDeploy optimize drone flight paths by automating flight planning, adjusting for factors like altitude, overlap, and terrain, and ensuring that the drone collects the necessary data while minimizing flight time.

3. **What are the key factors that influence flight path planning for drone inspections?**

   Key factors that influence flight path planning for drone inspections include coverage area, flight altitude, terrain or obstacles, weather conditions, and the equipment being inspected.

4. **How does thermal imaging help in detecting faults in telecom equipment?**

   Thermal imaging helps in detecting faults in telecom equipment by identifying abnormal heat patterns, such as hotspots, which may indicate malfunctioning equipment like overheating cables or damaged components.

5. **What techniques are used to integrate thermal and geospatial data with existing maps?**

   Techniques used to integrate thermal and geospatial data with existing maps include georeferencing the thermal data and aligning it with geographic information systems (GIS) using GPS coordinates and map overlays.

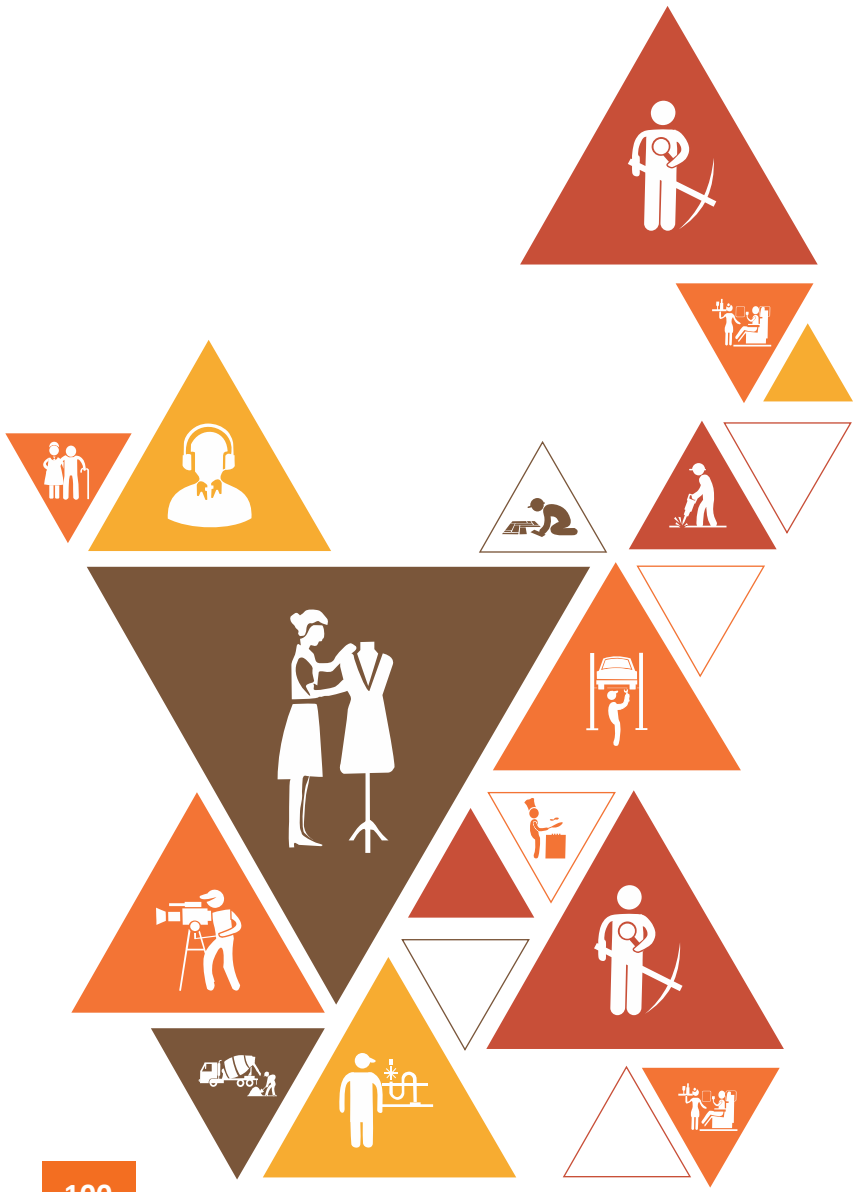
**Fill in the blanks**

1. **Drone** inspections using drones help identify faults in telecom equipment efficiently.
2. The functionality of tools like **Pix4D** and DroneDeploy optimizes drone flight paths.
3. Key factors influencing flight path planning include **coverage area**,, altitude, and obstacles.
4. Thermal imaging helps detect **heat** signatures that indicate potential malfunctions.
5. **Temperature** calibration techniques convert raw thermal data into actionable information.

**True/False Questions**

1. Thermal imaging is not useful for identifying faults in telecom equipment. (True/False)
   - **False** *(Thermal imaging is useful for detecting faults by identifying abnormal heat patterns that may indicate equipment failure.)*
2. Flight path planning for drone inspections should account for coverage, altitude, and obstacles. (True/False)
   - True
3. Pix4D and DroneDeploy are software tools used to optimize drone flight paths. (True/False)
   - True
4. Abnormal heat signatures in thermal images always indicate normal functioning. (True/False)
   - **False** *(Abnormal heat signatures often indicate potential faults or malfunctions in telecom equipment.)*
5. Integrating thermal data with geospatial maps helps in analyzing telecom infrastructure layouts. (True/False)
   - True

## Notes



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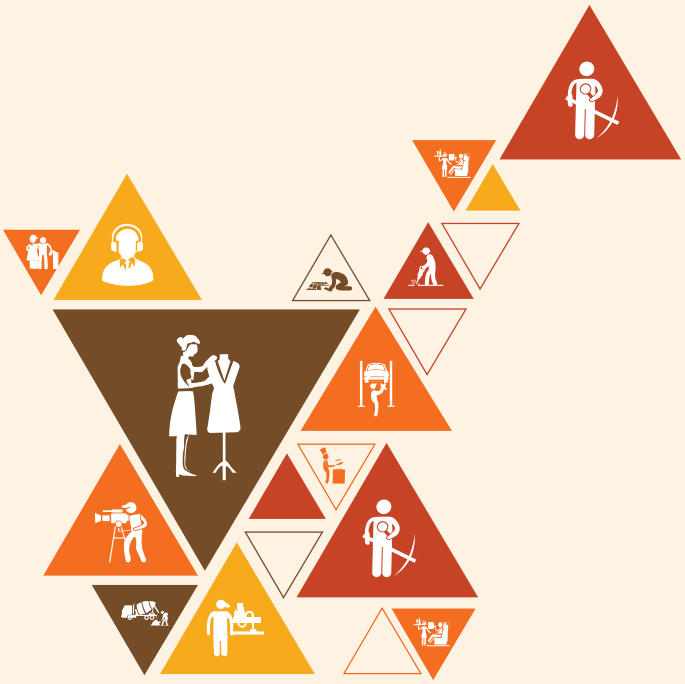
# 7. RF Signal Mapping and Optimization Fundamentals

Unit 7.1: Fundamentals of GIS, Spatial Data, and Remote Sensing
Unit 7.2: GIS Analysis Methods and Spatial Data Processing
Unit 7.3: Advanced Modeling, Orthomosaics, and Data Integration



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## Key Learning Outcomes

**After the end of this module, participants will be able to:**

1. Explain the fundamental principles of spatial data, GIS concepts, and coordinate systems.
2. Describe image processing algorithms used in spatial data analysis.
3. Define 3D modeling techniques, including point cloud generation, surface reconstruction, mesh creation, and quality assessment.
4. Conduct terrain analysis to derive information about elevation, slope, aspect, and other terrain characteristics.

# Unit 7.1: Fundamentals of GIS, Spatial Data, and Remote Sensing

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Explain the fundamental principles of spatial data, GIS concepts, and coordinate systems.
2. Define remote sensing technologies and their applications in feature extraction, GIS analysis, and 3D modeling.
3. Describe image processing algorithms used in spatial data analysis.
4. Define the application of TIR sensors, temperature calibration techniques, and the analysis of thermal and infrared data in GIS platforms.
5. Show how to extract spatial data from drone sensors and ensure georeferencing and alignment with the desired coordinate system.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - GIS software (e.g., ArcGIS, QGIS), remote sensing data, drone sensor data, image processing software, TIR sensor data, coordinate system reference materials.

## Say

- Good morning, everyone! Today, we will explore the fundamentals of Geographic Information Systems (GIS), spatial data, and remote sensing. We'll cover the key concepts of spatial data, GIS, and coordinate systems, as well as the role of remote sensing technologies in GIS analysis.
- We will also dive into how to apply temperature calibration techniques for thermal data analysis and how drone sensors can be used to extract and georeference spatial data.

## Ask

- What is GIS, and how does it help in spatial data analysis?

- Can you think of examples of how remote sensing technologies are used in real-world applications?
- How do you think image processing plays a role in improving the quality of spatial data?
- What challenges might arise when extracting and aligning spatial data from drone sensors?
- Write responses on the whiteboard and discuss them as a group.

## Elaborate

After the end of this unit, participants will be able to:

1. Fundamental Principles of Spatial Data, GIS Concepts, and Coordinate Systems:
    a) The basics of spatial data, its types, and formats (e.g., vector and raster data).
    b) Key GIS concepts such as layers, attributes, and spatial relationships.
    c) The importance of coordinate systems (e.g., WGS84, UTM) for accurate spatial analysis.
2. Remote Sensing Technologies and Their Applications:
    a) Definition and types of remote sensing (e.g., satellite imagery, LiDAR, thermal infrared).
    b) Applications of remote sensing in feature extraction, GIS analysis, and 3D modeling.
3. Image Processing Algorithms for Spatial Data Analysis:
    a) Introduction to image processing techniques such as enhancement, classification, and filtering.
    b) How image processing algorithms are used to improve spatial data quality and extract useful information.
4. Thermal and Infrared Data in GIS Platforms:
    a) Introduction to TIR sensors and their role in collecting thermal data.
    b) Temperature calibration techniques to convert raw thermal data into meaningful information.
    c) Analyzing thermal and infrared data within GIS platforms for spatial analysis.
5. Extracting Spatial Data from Drone Sensors:
    a) How to extract spatial data from drone sensors, including thermal and RGB imagery.

b) Ensuring georeferencing and alignment of drone-collected data with the desired coordinate system.

## Activity-1

**Activity 1: GIS Concepts and Coordinate Systems**

- Name: Understanding Spatial Data and Coordinate Systems
- Objectives:
  - To introduce participants to the fundamentals of spatial data, GIS concepts, and coordinate systems.
- Materials Needed:
  - GIS software (e.g., QGIS or ArcGIS), coordinate system reference materials.
- Procedure:
  - Introduce the key concepts of spatial data (vector and raster formats) and GIS layers.
  - Show how GIS can be used to visualize and analyze spatial data.
  - Guide participants in using GIS software to load sample spatial data and explore its attributes.
  - Demonstrate how to set the coordinate system in GIS software to match the data's reference system.
- Expected Outcome:
  - Participants will gain hands-on experience in GIS and coordinate systems, understanding how spatial data is managed and visualized.

## Activity-2

**Activity 2: Thermal Data Analysis in GIS**

- Name: Temperature Calibration and Analysis in GIS
- Objectives:
  - To demonstrate how to use thermal data in GIS platforms and apply temperature calibration techniques.
- Materials Needed:
  - Thermal infrared imagery, GIS software, temperature calibration formulas.

- Procedure:
    - Explain the basics of TIR sensors and how they collect thermal data.
    - Demonstrate how to calibrate raw thermal data using temperature calibration techniques.
    - Show how to integrate the calibrated thermal data into GIS software for analysis.
    - Guide participants through analyzing temperature variations in infrastructure using thermal maps.
- Expected Outcome:
    - Participants will understand how to calibrate and analyze thermal data within GIS platforms to detect temperature anomalies and features of interest.

## Notes for facilitation

- Ensure participants are comfortable using GIS software and understand the basic concepts of spatial data and coordinate systems.
- Emphasize the importance of accurate georeferencing and calibration techniques for reliable spatial analysis.
- Highlight real-world applications of remote sensing, such as in agriculture, urban planning, and disaster management.
- Provide troubleshooting guidance for common issues in georeferencing and data alignment.
- Encourage participants to experiment with different types of remote sensing data and image processing techniques for deeper learning.

## Notes

# Unit 7.2: GIS Analysis Methods and Spatial Data Processing

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Define various GIS analysis methods such as spatial queries, overlay analysis, buffer analysis, network analysis, and terrain analysis.
2. Explain quality control checks, preprocessing steps, and data organization techniques for spatial data processing.
3. Show how to conduct overlay analysis, buffer analysis, and network analysis using GIS software.
4. Demonstrate how to integrate diverse datasets into GIS environments and perform spatial queries and analyses.
5. Show how to perform image processing to enhance and manipulate raw drone imagery for feature extraction.
6. Explain how to conduct terrain analysis to derive information about elevation, slope, aspect, and other terrain characteristics.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - GIS software (e.g., ArcGIS, QGIS), raw drone imagery, spatial datasets, overlay analysis tools, network analysis tools.

## Say

Welcome! In this session, we will explore the various GIS analysis methods and spatial data processing techniques. These methods are essential for performing advanced analyses like overlay analysis, buffer analysis, and network analysis, which can help you gain deep insights from geospatial data. We will also cover preprocessing techniques to prepare data for analysis and look at how terrain analysis can provide valuable information on topography and elevation.

## Ask

- What are some common GIS analysis methods you've encountered so far?
- What are some common GIS analysis methods you've encountered so far?
- Can you think of real-world scenarios where spatial queries and overlay analysis would be used?
- How do you think terrain analysis can help in decision-making for environmental or urban planning?

## Elaborate

After the end of this unit, participants will be able to:

1. GIS Analysis Methods:
    a) Spatial Queries: Identifying specific locations or features within a dataset based on defined conditions.
    b) Overlay Analysis: Combining multiple spatial datasets to analyze relationships between them.
    c) Buffer Analysis: Creating buffer zones around features to analyze proximity.
    d) Network Analysis: Analyzing networks (e.g., transportation, utilities) to find optimal paths or routes.
    e) Terrain Analysis: Understanding elevation, slope, aspect, and other terrain characteristics for environmental and engineering purposes.
2. Quality Control and Preprocessing:
    a) Techniques for cleaning and preparing raw data for analysis.
    b) Organizing spatial data to ensure consistency and accuracy during analysis.
3. Image Processing for Feature Extraction:
    a) Enhancing and manipulating drone imagery to extract features and prepare data for analysis.
4. Integrating Diverse Datasets in GIS:
    a) Combining datasets from different sources (e.g., satellite, drone, surveys) for comprehensive analysis.

## Activity-1

**Activity 1: Conducting Overlay and Buffer Analysis**

- Name: Practical Application of Overlay and Buffer Analysis
- Objectives:
    - To demonstrate how to conduct overlay and buffer analysis using GIS software.
    - Materials Needed:
    - GIS software (e.g., QGIS or ArcGIS), spatial datasets (e.g., land use, transportation, utilities).
- Procedure:
    - Introduce overlay analysis and buffer analysis as tools for analyzing relationships between spatial features.
    - Show how to load multiple datasets into GIS software.
    - Walk participants through the steps of performing overlay analysis to identify areas of intersection or relationships between features.
- Demonstrate how to create buffer zones around features (e.g., roads, rivers) to assess proximity impacts.
    - Guide participants through performing these analyses on a sample dataset.
- Expected Outcome:
    - Participants will gain hands-on experience in performing overlay and buffer analysis, helping them analyze spatial relationships and proximity impacts.

## Activity-2

**Activity 2: Terrain Analysis and Image Processing**

- Name: Analyzing Terrain and Enhancing Drone Imagery
- Objectives:
    - To demonstrate terrain analysis techniques and image processing for feature extraction from drone imagery.
- Materials Needed:
    - GIS software, raw drone imagery (e.g., elevation data, imagery of terrain).
- Procedure:
    - Introduce terrain analysis and explain how elevation, slope, and aspect provide useful information for environmental and planning purposes.

- Demonstrate how to analyze terrain using elevation data in GIS software to derive slope and aspect maps.
- Show how to perform image processing on raw drone imagery to enhance the data for feature extraction.
- Guide participants through using image processing techniques (e.g., filtering, classification) to extract meaningful features from the drone imagery.

- Expected Outcome:
  - Participants will understand how terrain analysis can provide insights into topography and will gain experience enhancing drone imagery for feature extraction.

## Notes for facilitation

- Emphasize the importance of preprocessing and quality control to ensure the reliability of analysis results.
- Ensure participants understand the different analysis methods and when to use them in real-world scenarios.
- Provide examples of how GIS analysis methods, like overlay analysis and terrain analysis, are used in urban planning, disaster management, and environmental studies.
- Encourage participants to experiment with different types of spatial data and analysis methods for deeper understanding.
- Offer support for common challenges, such as managing large datasets or interpreting the results of complex analyses.

## Notes

# Unit 7.3: Advanced Modeling, Orthomosaics, and Data Integration

## Unit Objectives

**By the end of this unit, the trainees will be able to:**

1. Define 3D modeling techniques, including point cloud generation, surface reconstruction, mesh creation, and quality assessment.
2. Describe the steps involved in creating orthomosaics, including image registration, adjustment of image overlap, colour balancing, image stitching algorithms, and orthorectification techniques.
3. Show the process to generate 3D models from drone-collected data and perform quality assessment.
4. Show how to create orthomosaics by registering individual images, adjusting image overlap, and applying image stitching algorithms.
5. Demonstrate how to apply temperature calibration techniques to convert raw thermal data into meaningful temperature values.
6. Describe how to implement preprocessing steps to clean and prepare data for 3D modeling.

## Resources to be used

- **Theory**
  - Trainer Guide & Participant Handbook, Whiteboard, Marker, Projector, Laptop, Presentations
- **Practical**
  - 3D modeling software (e.g., Autodesk ReCap, Agisoft Metashape), GIS software (e.g., ArcGIS, QGIS), thermal imagery, drone imagery, software for image stitching and orthorectification.

## Say

- In this unit, we will explore advanced modeling techniques and the creation of orthomosaics using drone-collected data. We'll also cover the integration of thermal data and how to preprocess data to create high-quality 3D models and orthomosaics.
- You will learn how to generate point clouds, perform surface reconstruction, and use various algorithms to create accurate orthomosaics. These techniques are fundamental in applications such as environmental monitoring, urban planning, and infrastructure analysis.

## Ask

- Have you ever worked with 3D models or orthomosaics before? What software or methods did you use?
- Why do you think it is important to have accurate orthomosaics and 3D models in geospatial analysis?
- Write responses on the whiteboard and discuss them as a group.

## Elaborate

After the end of this unit, participants will be able to:

1. 3D Modeling Techniques:
    a) Point Cloud Generation: The process of converting raw data (e.g., LiDAR, drone imagery) into 3D point clouds.
    b) Surface Reconstruction: Creating surfaces from point clouds to represent real-world objects or terrain.
    c) Mesh Creation: Generating 3D models (meshes) from reconstructed surfaces.
    d) Quality Assessment: Ensuring the accuracy and precision of the models through checks and validation.
2. Creating Orthomosaics:
    a) Image Registration: Aligning multiple images to create a coherent dataset.
    b) Image Overlap Adjustment: Managing the overlap between images to ensure smooth transitions.
    c) Image Stitching Algorithms: Merging multiple images seamlessly to create a large, continuous image.
    d) Orthorectification: Correcting for distortions due to sensor angles or terrain variations.
3. Temperature Calibration:
    a) Applying techniques to convert raw thermal data into temperature values for accurate analysis.

4. Data Preprocessing:

   a) Cleaning and preparing data to ensure accuracy in 3D modeling, orthomosaic creation, and thermal analysis.

## Activity-1

**Activity 1: Generating 3D Models from Drone Data**

- Name: 3D Modeling Workflow with Drone Data
- Objectives:
  - To demonstrate the process of generating 3D models (point clouds, surfaces, meshes) from drone data.
- Materials Needed:
  - 3D modeling software (e.g., Agisoft Metashape), drone imagery, point cloud data.
- Procedure:
  - Introduce the concept of point clouds and how they are generated from drone imagery.
  - Demonstrate the process of creating a surface from point cloud data.
  - Show how to refine the surface into a 3D mesh, highlighting the importance of mesh resolution and quality.
  - Perform quality checks on the generated model to ensure it meets the required standards (e.g., accuracy, resolution).
  - Guide participants through these steps on a sample dataset, ensuring hands-on experience.
- Expected Outcome:
  - Participants will understand how to process drone-collected data to create 3D models, including generating point clouds, surface reconstruction, and mesh creation.

## Activity-2

**Activity 2: Creating Orthomosaics and Image Stitching**

- Name: Orthomosaic Creation and Image Stitching
- Objectives:
  - To demonstrate the steps involved in creating orthomosaics, including image registration, overlap adjustment, and image stitching.

- Materials Needed:
    - Drone imagery, image stitching software (e.g., Pix4D, Agisoft Metashape), GIS software (e.g., QGIS).
- Procedure:
    - Introduce the concept of orthomosaics and explain the importance of image registration and overlap.
    - Demonstrate how to align individual images to create a seamless mosaic using image stitching software.
    - Show how to adjust image overlap for better alignment and smoother transitions between images.
    - Walk participants through the process of applying orthorectification techniques to correct any distortions in the final orthomosaic.
    - Allow participants to apply these steps to create an orthomosaic from sample drone imagery.
- Expected Outcome:
    - Participants will gain practical experience in creating orthomosaics and will understand the key steps involved in stitching images, correcting distortions, and ensuring accuracy.

## Notes for facilitation

- Emphasize the importance of data quality in 3D modeling and orthomosaic creation.
- Ensure participants understand how the quality of drone imagery and sensor calibration impacts the accuracy of the final models and mosaics.
- Provide support for technical challenges, such as managing large datasets or adjusting parameters for optimal results.
- Offer real-world examples where 3D models and orthomosaics are used, such as in infrastructure inspections, land surveys, and environmental studies.
- Encourage participants to experiment with different data types and settings to refine their understanding of the processes.

## Exercise

**Short Answer Questions:**

1. **What are the fundamental principles of spatial data and GIS concepts?**

   The fundamental principles of spatial data and GIS concepts involve the representation, analysis, and visualization of geographic data, which includes both vector and raster data types. GIS uses spatial reference systems, coordinate systems, and data models to store, manipulate, and analyze spatial information for decision-making processes.

2. **How are remote sensing technologies applied in feature extraction and 3D modeling?**

   Remote sensing technologies are applied in feature extraction and 3D modeling by capturing data from sensors (like LiDAR, radar, and cameras) mounted on satellites, drones, or aircraft.

3. **What is the purpose of image processing algorithms in spatial data analysis?**

   Image processing algorithms in spatial data analysis help improve image quality, extract meaningful features, and enhance the accuracy of analysis by applying techniques like filtering, segmentation, classification, and feature extraction.

4. **What are the key steps involved in creating orthomosaics from drone images?**

   The key steps involved in creating orthomosaics from drone images are:
   1. Image Registration
   2. Adjustment of Image Overlap
   3. Color Balancing
   4. Image Stitching Algorithms
   5. Orthorectification

5. **How does temperature calibration help in converting raw thermal data into meaningful values?**

   Temperature calibration helps in converting raw thermal data into meaningful values by applying correction factors to account for sensor inaccuracies, environmental conditions, and measurement inconsistencies.

**Fill in the blanks**

1. GIS analysis methods include spatial queries, overlay analysis, buffer analysis, **surface analysis,** and terrain analysis.
2. **Thermal** sensors are used for capturing thermal and infrared data for GIS platforms.
3. Image stitching algorithms and orthorectification techniques are essential for creating **orthomosaics** from drone images.

4. Quality control checks and preprocessing steps ensure **accurate** data preparation for 3D modeling.
5. **3D modelling** techniques include point cloud generation, surface reconstruction, and mesh creation.

**True/False Questions**

1. Thermal imaging is not useful for identifying faults in telecom equipment. (True/False)
   - **False** *(Thermal imaging is useful for detecting faults by identifying abnormal heat patterns that may indicate equipment failure.)*
2. Georeferencing ensures spatial data is aligned with the desired coordinate system. (True/False)
   - True
3. Overlay analysis cannot be conducted using GIS software. (True/False)
   - **False** *(Overlay analysis is a fundamental GIS function for analyzing spatial relationships between layers.)*
4. Remote sensing technologies have no applications in GIS or 3D modeling. (True/False)
   - **False** *(Remote sensing technologies are essential in GIS and 3D modeling for capturing and analyzing spatial data.)*
5. Preprocessing steps are not necessary for cleaning and preparing data for 3D modeling. (True/False)
   - **False** *(Preprocessing is crucial for ensuring accurate, clean data for modeling.)*
6. Temperature calibration techniques are used to convert raw thermal data into actionable temperature values. (True/False)
   - True

## Notes

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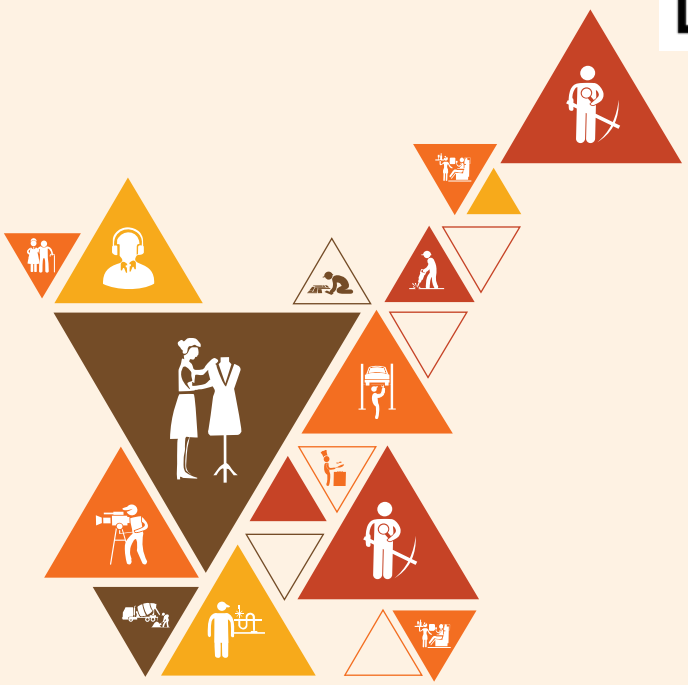
# 8. Employability Skills (60 Hours)

It is recommended that all trainings include the appropriate Employability Skills Module. Content for the same can be accessed

**Scan the QR code below to access the ebook**



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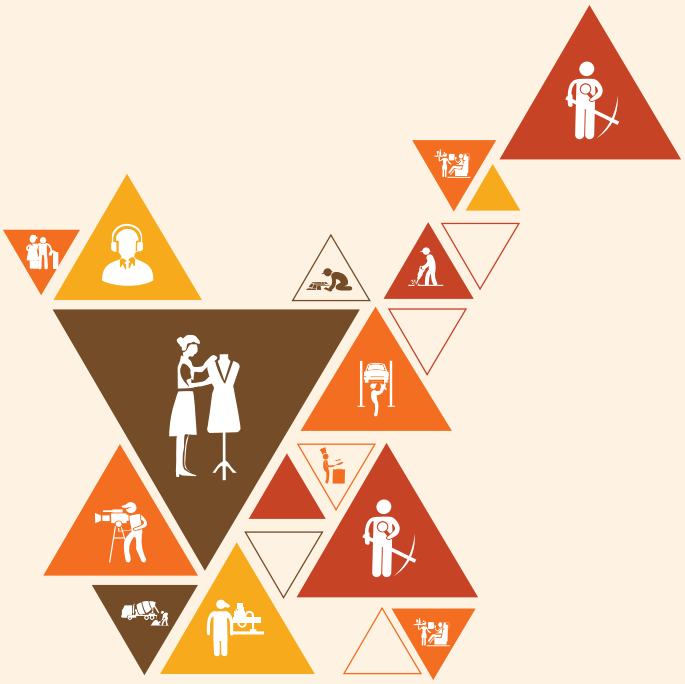
# 9. Annexures

Annexure I - Training Delivery Plan

Annexure II - Assessment Criteria

Annexure III - QR Codes –Video Links



# Annexure I

## Training Delivery Plan

| Training Delivery Plan | | | |
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| **Program Name:** | Drone Data Processor | | |
| **Qualification Pack Name & Ref. ID** | Drone Data Processor, TEL/Q6223 | | |
| **Version No.** | 1.0 | **Version Update Date** | - |
| **Prerequisites to Training (if any)** | Graduate (Completed 2ndYear of 3year/4year (Electronics/Telecom/CS)) with NA of experience<br>OR<br>Graduate (Completed 1st Year of 3year/4year (Electronics/Telecom/CS)) with 1 Year of experience and 6 months in relevant experience<br>OR<br>Completed 3-year diploma after 10th with 1 Year of experience and 6 months in relevant experience<br>OR<br>Previous relevant Qualification of NSQF Level (NSQF Level 4.5) with 1 Year of experience and 6 months in relevant experience<br>OR<br>Previous relevant Qualification of NSQF Level (NSQF Level 4) with 3 Years of experience in relevant experience | | |
| **Training Outcomes** | **After completing this program, participants will be able to:**<br>• Demonstrate proficiency in importing, pre-processing, and synthesizing drone and remote sensing data, including 3D point cloud spatial data, aerial imagery, and remote sensing data such as thermal, infrared, and RF data. Signal Analysis, Ground Station Maintenance, and Security Implementation<br>• Develop the ability to perform thorough analysis of GIS data, extract relevant features, and generate 3D models and orthomosaics for further analysis and decision-making processes.Incident management or PM Activity<br>• Acquire the skills necessary to identify equipment and infrastructure faults using thermal imaging analysis, RF signal strength analysis, and geospatial mapping techniques.Manage Work, Resources and Safety at workplace<br>• Learn to collect RF signal data, analyze signal strength, detect interference, and conduct frequency analysis to optimize RF mapping and enhance communication infrastructure performance.<br>• Understand the importance of data organization for quality checks and will be able to perform automated analysis of accurate data, ensuring data integrity and efficiency in processing large datasets.<br>• Employability Skills (60 Hours) | | |

| Sl. No. | Module | Unit | Session Name | Session Objectives | NOS Reference | Method -ology | Training Tools / Aids | Duration (hours) |
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| 1 | Chapter 1: Introduction to Telecom Sector and about Drone Data Processor<br>T- 05:00<br>P- 08:00<br>(HH: MM) | Unit 1.1: Introduction to the Telecom Sector and need of Drone Data Processing | Telecom Industry and its sub-sectors | Explain the size & scope of the Telecom industry and its sub-sectors | TEL/N6273, PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15. PC16, PC17, PC18, PC19, PC20, PC21, PC22, PC23.KU1, KU2, KU3, KU4, KU5, KU6, KU7, KU8, KU9, KU10, KU11, KU12, KU13, KU14.GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8. | Classroom lecture, games, group participation, group activity | Training Kit – Trainer Guide, Presentations, Whiteboard, Marker, Projector, Laptop, Video Films, Computer with internet facility | T- 01:00<br>P- 02:30 |
| | | | Drone Market and Drone Data Processing | Discuss the need of Drone Data Processing in Telecom Sector | | Classroom lecture, games, group participation, group activity | | T- 01:30<br>P- 02:30 |
| | | Unit 1.2: Workplace Practices and Operational Preparedness | Role, Responsibilities of a Drone Data Processor | Explain the role and responsibilities of a Drone Data Processor. | | Classroom lecture, games, group participation, group activity | | T- 01:30<br>P- 02:00 |
| | | | Career opportunities for a Drone Data Processor | Identify the career opportunities for a Drone Data Processor. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br>P- 01:00 |
| 2 | Chapter 2: Data Extraction/ Collection (TEL/N6273)<br>T- 15:00<br>P- 32:00<br>(HH: MM) | Unit 2.1 - Drone Components and Calibration | Fundamentals of Drone Calibration | Understand the components of drones and the basics of calibration for accurate data measurements. | TEL/N6273, PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15. PC16, PC17, PC18, PC19, PC20, | Classroom lecture, games, group participation, group activity | Training Kit – Trainer Guide, Presentations, Whiteboard, Marker, Projector, Laptop, | T- 01:30<br>P- 04:00 |

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| | | | Data Compatibility and Software Interfaces | Learn to identify, calibrate, and adjust sensors for accurate data collection under varying environmental conditions. | PC21, PC22, PC23. KU1, KU2, KU3, KU4, KU5, KU6, KU7, KU8, KU9, KU10, KU11, KU12, KU13, KU14. GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8. | Classroom lecture, games, group participation, group activity | Video Films, Computer with internet facility | T-02:00<br>P-04:00 |
| | | | Sensor Calibration and Adjustments | Develop skills to execute advanced calibration processes and ensure high data accuracy using software tools. | | Classroom lecture, games, group participation, group activity | | T-01:30<br>P-04:00 |
| | | Unit 2.2 - Flight Planning and Data Collection | Basics of Flight Planning and Image Overlap | Understand the factors influencing image overlap and its role in flight planning for accurate data collection. | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |
| | | | Data Collection Techniques and Processes | Learn to collect data effectively by planning and executing drone flights with precision. | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |
| | | | Optimizing Flight Plans for Various Applications | Develop the ability to create customized flight plans based on project requirements. | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |
| | | Unit 2.3 - Data Processing and Analysis | Data Validation and Ground Control Points (GCPs) | Understand the role of data formats and GCPs in ensuring project accuracy. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-05:00 |

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| | | | 2D Orthomosaics and Digital Elevation Models (DEMs) | Learn to create and refine 2D orthomosaics and DEMs for quality outputs | | Classroom lecture, games, group participation, group activity | | T- 01:00<br><br>P- 05:00 |
| | | | Accuracy Assessment and Report Generation | Explain techniques for evaluating data accuracy and producing comprehensive reports. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br><br>P- 04:00 |
| | | | | Understand the factors influencing image overlap and its role in flight planning for accurate data collection. | | Classroom lecture, games, group participation, group activity | | T- 02:00<br><br>P- 04:00 |
| 3 | Chapter 3: Data Processing and Integration (TEL/ N6274)<br>T- 20:00<br>P- 40:00<br>(HH: MM) | Unit 3.1: Drone Data Acquisition & Processing | Drone Components and Sensors for Data Accuracy | Learn about the components of drones and the sensors used for accurate data collection. | TEL/N6274, PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15. PC16, PC17, PC18, PC19, PC20, PC21, PC22, PC23, PC24.KU1, KU2, KU3, KU4, KU5, KU6, KU7, KU8, KU9, KU10. GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8, GS9, GS10, GS11, GS12, GS13. | Classroom lecture, games, group participation, group activity | Training Kit – Trainer Guide, Presentations, Whiteboard, Marker, Projector, Laptop, Video Films, Computer with internet facility, Field visit to the nearby | T- 02:00<br><br>P- 04:00 |
| | | | Calibration of Drones and Sensors | Understand and apply drone and sensor calibration techniques to ensure accurate data collection. | | Classroom lecture, games, group participation, group activity | | T- 02:00<br><br>P- 04:00 |

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| | | | Optimal Flight Planning for Accurate Data Acquisition | Learn the principles of flight planning for drone operations to ensure optimal data collection. | | handloom unit for Project work/ Case Study | | T-02:00<br>P-04:00 |
| | | | Planning for Optimal Overlap and Accurate Data Extraction | Show the process of planning drone flights to ensure optimal image overlap for accurate data extraction. | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |
| | | | Sensor Calibration Based on Environmental Conditions | Learn how to adjust drone sensor settings based on environmental conditions for precise data collection. | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |
| | | Unit 3.2: Advanced Data Processing & Analysis | Photogrammetry and Image Acquisition | Understand the principles of photogrammetry and how to capture drone data accurately. | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |
| | | | Georeferencing and Spatial Accuracy | Learn how to apply georeferencing techniques to ensure spatial accuracy in orthomosaic creation. | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |
| | | | Filtering and Smoothing Techniques for 2D DEMs | Demonstrate the use of filtering and smoothing techniques to enhance the quality of 2D DEMs | | Classroom lecture, games, group participation, group activity | | T-02:00<br>P-04:00 |

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| | | | Analyzing and Rectifying Data Discrepancies | Learn to analyze elevation data and rectify discrepancies in DEMs and orthomosaics. | | Classroom lecture, games, group participation, group activity | | T- 02:00<br>P- 04:00 |
| | | | Accuracy Assessment and Report Generation | Discuss accuracy assessment techniques and generate comprehensive reports from DEM processing. | | Classroom lecture, games, group participation, group activity | | T- 02:00<br>P- 04:00 |
| 4 | Chapter 4: Data Analysis and Projection Techniques (TEL/N6275)<br>T- 15:00<br>P- 45:00<br>(HH: MM | Unit 4.1: Spatial Data Acquisition and Preprocessing | Extracting Spatial Data from Drone Sensors and Ensuring Georeferencing | Understand the process of extracting spatial data from drone sensors and ensure georeferencing accuracy. | TEL/N6275, PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15. PC16, PC17, PC18, PC19, PC20, PC21, PC22, PC23, PC24, PC25, PC26, PC27, PC28, PC29, PC30, PC31, PC32, PC33, PC34, PC35. KU1,KU2, KU3, KU4, KU5, KU6, KU7, KU8. GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8, GS9, GS10, GS11, GS12, GS13. | Classroom lecture, games, group participation, group activity | Laptop, white board, marker, projector, charts, Flow chart, Computer with internet facility, Field visit to the nearby handloom unit and the textile testing facility for Project work/ Case Study | T- 00:30<br>P- 01:30 |
| | | | Remote Sensing Technologies and Their Applications in GIS | Gain an understanding of remote sensing technologies and their application in GIS. | | Classroom lecture, games, group participation, group activity | | T- 00:30<br>P- 01:30 |

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| | | | Data Alignment and Coordinate Projections for Spatial Consistency | Understand the significance of data alignment and coordinate projections for spatial consistency in GIS. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Image Processing Algorithms and Feature Extraction from Drone Data | Learn the process of applying image processing algorithms for feature extraction from drone-collected data. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Creating Orthomosaics: Image Registration and Color Balancing | Understand the process of creating orthomosaics, focusing on image registration and color balancing. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Extracting Spatial Data and Aligning with Coordinate Systems | Learn how to extract spatial data from drone sensors and align it with the desired coordinate system. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Georeferencing Techniques for Spatial Accuracy in Drone Data Integration | Master georeferencing techniques to ensure spatial accuracy in the integration of drone data. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |

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| | | | Quality Control and Preprocessing for Accurate 3D Modeling | Learn the importance of quality control and preprocessing steps for preparing data for 3D modeling. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Analyzing Drone Imagery for Artifacts and Irrelevant Data | Identify and filter out artifacts and irrelevant data from drone imagery for improved analysis. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Generating Comprehensive Metadata for Spatial Datasets | Learn how to generate comprehensive metadata for spatial datasets to ensure effective communication with stakeholders. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | Unit 4.2: GIS Analysis and Integration | Data Integration in GIS | Understand the importance and methods of integrating diverse datasets into GIS for spatial analysis. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-03:00 |
| | | | GIS Analysis Techniques | Explore GIS analysis techniques like spatial queries, overlay, and buffer analysis. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-03:00 |
| | | | Verifying Data Formats | Learn to verify data formats based on project specifications and industry standards. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-03:00 |

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| | | | Advanced Spatial Queries and Overlay | Master performing spatial queries and overlay analysis to extract information. | | Classroom lecture, games, group participation, group activity | | T-01:00<br><br>P-03:00 |
| | | | Elevation Data Analysis | Analyze elevation data to identify anomalies and apply rectification techniques. | | Classroom lecture, games, group participation, group activity | | T-01:00<br><br>P-03:00 |
| | | Unit 4.3: Advanced Modeling and Output Evaluation | 3D Modeling Techniques | Understand the principles of 3D modeling, including point cloud generation and mesh creation. | | Classroom lecture, games, group participation, group activity | | T-00:45<br><br>P-02:00 |
| | | | Generating 3D Models | Learn how to generate 3D models from drone data, focusing on point clouds and mesh creation. | | Classroom lecture, games, group participation, group activity | | T-00:45<br><br>P-02:00 |
| | | | Orthomosaic Creation | Master creating orthomosaics through image overlap adjustments and stitching algorithms. | | Classroom lecture, games, group participation, group activity | | T-00:45<br><br>P-02:00 |

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| | | | Image Processing for Feature Extraction | Apply image processing algorithms to enhance and manipulate raw drone imagery for feature extraction. | | Classroom lecture, games, group participation, group activity | | T- 00:45<br><br>P- 02:00 |
| | | | Enhancing 3D Models | Synthesize visual information onto 3D meshes to enhance the realism and detail of generated models. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br><br>P- 02:30 |
| | | | Output Quality Evaluation | Evaluate the quality of orthomosaics, DEMs, and 3D models based on project requirements. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br><br>P- 02:30 |
| 5 | Chapter 5: Remote Sensing Data Analysis and Interpretation (TEL/N6276)<br>T- 15:00<br>P- 45:00<br>(HH: MM) | Unit 5.1: Thermal and Infrared (TIR) Data Calibration and Analysis | TIR Sensor Calibration | Understand and apply calibration techniques for accurate thermal imagery from TIR sensors. | TEL/N6276, PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15. PC16, PC17, PC18, PC19, PC20, PC21, PC22, PC23, PC24, PC25, PC26, PC27, PC28, PC29, PC30, PC31, PC32, PC33, PC34, PC35. | Classroom lecture, games, group participation, group activity | Training Kit – Trainer Guide, Presentations, Whiteboard, Marker, Projector, Laptop, Video Films, Sun simulator, EL tester, multi meter ,clamp meter. | T- 01:00<br><br>P- 03:00 |
| | | | Temperature Calibration Techniques | Learn how to convert raw thermal data into meaningful temperature values using calibration techniques. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br><br>P- 03:00 |

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| | | | Thermal Data Analysis | Analyze thermal and infrared data to detect anomalies, patterns, and variations across landscapes. | KU1, KU2, KU3, KU4, KU5, KU6, KU7, KU8, KU9, KU10.GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8, GS9, GS10, GS11, GS12, GS13. | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-03:00 |
| | | | Thermal Mapping | Generate thermal maps and visualizations to represent temperature distributions spatially. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-03:00 |
| | | Unit 5.2: RF Data Analysis and Integration | Frequency Analysis in RF Data | Understand and apply frequency analysis and pattern recognition in RF data. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-03:00 |
| | | | RF Data Retrieval and Analysis | Retrieve and analyze RF data to detect trends and anomalies in drone-collected signals. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-03:00 |
| | | | Data Integration for Spatial Analysis | Learn how to integrate diverse datasets, including RF, Thermal, and Infrared, for comprehensive spatial analysis. | | Classroom lecture, games, group participation, group activity | | T-00:45<br>P-02:00 |
| | | Unit 5.3: Automated Analysis and Machine Learning in Spatial Data Processing | Metadata and Database Organization | Understand the importance of metadata tagging and database management for efficient data handling. | | Classroom lecture, games, group participation, group activity | | T-00:45<br>P-02:00 |

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| | | | Automated Data Analysis | Learn the principles and tools used in the automated analysis of Thermal, Infrared, and RF data. | | Classroom lecture, games, group participation, group activity | | T-01:00<br><br>P-03:00 |
| | | | Machine Learning for Data Analysis | Explore how machine learning can automate data analysis and pattern recognition in thermal, infrared, and RF data. | | Classroom lecture, games, group participation, group activity | | T-01:00<br><br>P-03:00 |
| | | | Streamlined Workflows and Validation | Understand streamlined workflows and validation procedures for automated analysis and comparing results with ground truth data. | | Classroom lecture, games, group participation, group activity | | T-01:00<br><br>P-03:00 |
| | | | Automated Reporting and Algorithm | Learn how to design automated reporting mechanisms and develop customized algorithms to address dataset-specific challenges. | | Classroom lecture, games, group participation, group activity | | T-01:00<br><br>P-03:00 |
| | | | Parallel Processing and Efficient Analysis | Implement parallel processing and distributed computing solutions for efficient automated analysis. | | Classroom lecture, games, group participation, group activity | | T-01:00<br><br>P-03:00 |

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| 6 | Chapter 6: Remote Fault Identification and Analysis in Equipment and Infrastructure (TEL/N6277)<br>T- 10:00<br>P- 20:00<br>(HH: MM) | Unit 6.1: Principles of Drone Flight Path Planning and Data Collection | Introduction to Telecom Equipment Inspections Using Drones | Understand the purpose and significance of using drones for telecom equipment inspections. | TEL/N6277 PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15. PC16, PC17, PC18, PC19, PC20, PC21, PC22, PC23, PC24, PC25, PC26, PC27, PC28, PC29.KU1, KU2, KU3, KU4, KU5, KU6, KU7, KU8, KU9, KU10.GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8, GS9, GS10, GS11, GS12, GS13. | Classroom lecture, games, group participation, group activity | Training Kit – Trainer Guide, Presentations, Whiteboard, Marker, Projector, Laptop, Video Films, Site Visit for Practical Learning. | T- 00:30<br>P- 01:00 |
| | | | Fundamentals of Drone Flight Path Design | Learn the fundamental principles behind designing efficient flight paths for telecom equipment inspections. | | Classroom lecture, games, group participation, group activity | | T- 00:30<br>P- 01:30 |
| | | | Factors Influencing Flight Path Planning | Identify key factors such as coverage, altitude, and obstacles that impact flight path planning. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br>P- 01:30 |
| | | | Software Tools for Optimizing Flight Paths | Learn to use software tools like Pix4D and DroneDeploy for flight path optimization. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br>P- 02:00 |
| | | | Planning Drone Flight Paths for Telecom Infrastructure | Develop and plan drone flight paths to ensure comprehensive coverage of telecom equipment. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br>P- 02:00 |

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| | | Unit 6.2: Thermal Imaging and Data Integration | Role of Thermal Imaging in Telecom Inspections | Understand the role of thermal imaging in identifying faults in telecom equipment. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:00 |
| | | | Identifying Normal and Abnormal Heat Signatures | Learn to identify and analyze abnormal heat signatures to detect potential malfunctions. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Temperature Calibration for Actionable Data | Apply temperature calibration techniques to convert raw thermal data into useful information. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-01:30 |
| | | | Integrating Thermal and Geospatial Data | Integrate thermal and geospatial data with infrastructure layouts for comprehensive analysis. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-01:30 |
| | | Unit 6.3: Fault Detection Using Advanced Tools and Techniques | Machine Learning for Fault Detection | Learn how to utilize machine learning models to automate fault detection in telecom equipment. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Spatial Analysis for Identifying Equipment Irregularities | Use spatial analysis tools to identify equipment irregularities in telecom infrastructure. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |

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| | | | Generating Thermal Maps and 3D Models | Learn how to generate thermal maps and 3D models for telecom infrastructure analysis. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P- 01:30 |
| | | | Evaluating Detection Methods for Fault Analysis | Evaluate the accuracy and reliability of fault detection methods used in telecom equipment inspections. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br>P- 01:30 |
| 7 | Chapter 7: RF Signal Mapping and Optimization Fundamentals (TEL/N6278)<br>T- 10:00<br>P- 20:00<br>(HH: MM) | Unit 7.1: Fundamentals of GIS, Spatial Data, and Remote Sensing | Introduction to Spatial Data and GIS Concepts | Understand the fundamental principles of spatial data, GIS concepts, and coordinate systems. | TEL/N6278, PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15. PC16, PC17, PC18, PC19, PC20, PC21, PC22, PC23.KU1, KU2, KU3, KU4, KU5, KU6, KU7, KU8, KU9, KU10, KU11, KU12.GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8, GS9, GS10, GS11, GS12, GS13. | Classroom lecture, games, group participation, group activity | Training Kit – Trainer Guide, Presentations, Whiteboard, Marker, Projector, Laptop, Video Films, Site Visit for Practical Learning. | T- 00:30<br>P- 01:00 |
| | | | Remote Sensing Technologies and Applications | Learn about remote sensing technologies and their applications in GIS, feature extraction, and 3D modeling. | | Classroom lecture, games, group participation, group activity | | T- 00:30<br>P- 01:30 |
| | | | Image Processing Algorithms for Spatial Data | Describe image processing algorithms used in spatial data analysis. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br>P- 01:30 |

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| | | | TIR Sensors and Thermal Data in GIS | Understand the application of TIR sensors, temperature calibration techniques, and thermal data analysis in GIS platforms. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-02:00 |
| | | | Georeferencing and Alignment of Spatial Data | Show how to extract spatial data from drone sensors and ensure georeferencing and alignment with the desired coordinate system. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-02:00 |
| | | Unit 7.2: GIS Analysis Methods and Spatial Data Processing | GIS Analysis Methods | Define GIS analysis methods such as spatial queries, overlay analysis, buffer analysis, network analysis, and terrain analysis. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Quality Control and Data Organization | Learn about quality control checks, preprocessing steps, and data organization techniques for spatial data processing. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-01:30 |
| | | | Conducting GIS Analysis | Show how to conduct overlay analysis, buffer analysis, and network analysis using GIS software. | | Classroom lecture, games, group participation, group activity | | T-00:30<br>P-01:30 |
| | | | Image Processing and Feature Extraction | Demonstrate how to integrate diverse datasets into GIS environments and perform spatial queries, image processing, and feature extraction. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P-01:30 |

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| | | Unit 7.3: Advanced Modeling, Orthomosaics, and Data Integration | 3D Modeling Techniques | Define 3D modeling techniques, including point cloud generation, surface reconstruction, mesh creation, and quality assessment. | | Classroom lecture, games, group participation, group activity | | T- 00:30<br>P- 01:30 |
| | | | Creating Orthomosaics | Describe the steps involved in creating orthomosaics, including image registration, overlap adjustments, color balancing, and stitching algorithms. | | Classroom lecture, games, group participation, group activity | | T- 00:30<br>P- 01:30 |
| | | | Generating 3D Models from Drone Data | Show the process of generating 3D models from drone-collected data and performing quality assessment. | | Classroom lecture, games, group participation, group activity | | T-01:00<br>P- 01:30 |
| | | | Applying Temperature Calibration for Thermal Data | Demonstrate how to apply temperature calibration techniques and perform preprocessing steps to clean and prepare data for 3D modeling. | | Classroom lecture, games, group participation, group activity | | T- 01:00<br>P- 01:30 |
| 8 | DGT/VSQ/ N0102: Employability Skills (60 Hours) | Unit 8.1: Employability Skills | 1. Introduction to Employability Skills | Discuss the Employability Skills required for jobs in various industries.<br>List different learning and employability related GOI and private portals and their usage. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 2 |

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| | | | 2. Constitutional values - Citizenship | Explain the constitutional values, including civic rights and duties, citizenship, responsibility towards society and personal values and ethics such as honesty, integrity, caring and respecting others that are required to become a responsible citizen.<br>Show how to practice different environmentally sustainable practices. | DGT/VSQ/N0102, PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14, PC15, PC16, PC17, PC18, PC19, PC20, PC21, PC22, PC23, PC24, PC25, PC26, PC27, PC28, PC29, PC30, PC31, PC32, PC33.KU1, KU2, KU3, KU4, KU5, KU6, KU7, KU8, KU9, KU10, KU11, KU12, KU13, KU14, KU15, KU16, KU17, KU18, KU19.GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8, GS9. | Classroom lecture, games, group participation, group activity, field visit | Handbook | 2 |
| | | | 3. Becoming a Professional in the 21st Century | Discuss importance of relevant 21st century skills.<br>Exhibit 21st century skills like Self-Awareness, Behavior Skills, time management, critical and adaptive thinking, problem-solving, creative thinking, social and cultural awareness, emotional awareness, learning to learn etc. in personal or professional life.<br>Describe the benefits of continuous learning. | | Classroom lecture, games, group participation, group activity | Handbook | 2 |

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| | | | 4. Basic English Skills | Show how to use basic English sentences for everyday conversation in different contexts, in person and over the telephone.<br>Read and interpret text written in basic English.<br>Write a short note/paragraph / letter/e -mail using basic English. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 4 |
| | | | 5. Career Development & Goal Setting | By the end of this course, participants will have the knowledge and skills to set clear, achievable career goals and develop a structured career development plan, enabling them to advance in their chosen career path and make informed decisions about their professional future. | | Classroom lecture, games, group participation, group activity | Handbook | 4 |
| | | | 6. Communication Skills | Demonstrate how to communicate effectively using verbal and nonverbal communication etiquette.<br>Explain the importance of active listening for effective communication.<br>Discuss the significance of working collaboratively with others in a team. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 4 |

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| | | | 7. Diversity & Inclusion | Demonstrate how to behave, communicate, and conduct oneself appropriately with all genders and PwD.<br>Discuss the significance of escalating sexual harassment issues as per POSH act. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 2 |
| | | | 8. Financial and Legal Literacy | Outline the importance of selecting the right financial institution, product, and service.<br>Demonstrate how to carry out offline and online financial transactions, safely and securely.<br>List the common components of salary and compute income, expenditure, taxes, investments etc.<br>Discuss the legal rights, laws, and aids. | | Classroom lecture, games, group participation, group activity | Handbook | 8 |

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| | | | 9. Essential Digital Skills | Describe the role of digital technology in today's life.<br>Demonstrate how to operate digital devices and use the associated applications and features, safely and securely.<br>Discuss the significance of displaying responsible online behavior while browsing, using various social media platforms, e-mails, etc., safely and securely.<br>Create sample word documents, excel sheets and presentations using basic features utilize virtual collaboration tools to work effectively. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 6 |
| | | | 10. Entrepreneurship | Explain the types of entrepreneurship and enterprises.<br>Discuss how to identify opportunities for potential business, sources of funding and associated financial and legal risks with its mitigation plan.<br>Describe the 4Ps of Marketing-Product, Price, Place and Promotion and apply them as per requirement.<br>Create a sample business plan, for the selected business opportunity. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 14 |

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| | | | 11. Customer Service | Describe the significance of analysing different types and needs of customers. Explain the significance of identifying customer needs and responding to them in a professional manner. Discuss the significance of maintaining hygiene and dressing appropriately. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 8 |
| | | | 12. Getting Ready for apprenticeship & Jobs | Create a professional Curriculum Vitae (CV). Use various offline and online job search sources such as employment exchanges, recruitment agencies, and job portals respectively. Discuss the significance of maintaining hygiene and confidence during an interview. Perform a mock interview. List the steps for searching and registering for apprenticeship opportunities. | | Classroom lecture, games, group participation, group activity, field visit | Handbook | 4 |

# Annexure - II

| Assessment Guidelines and Assessment Weightage | |
|---|---|
| **Job Role** | **Drone Data Processor** |
| **Qualification Pack** | TSC/Q6223 |
| **Sector Skill Council** | Telecom |

| Sr. No. | Guidelines for Assessment |
|---|---|
| 1 | Criteria for assessment for each Qualification Pack will be created by the Sector Skill Council. Each Element/ Performance Criteria (PC) will be assigned marks proportional to its importance in NOS. SSC will also lay down proportion of marks for Theory and Skills Practical for each Element/ PC. |
| 2 | The assessment for the theory part will be based on knowledge bank of questions created by the SSC. |
| 3 | Assessment will be conducted for all compulsory NOS, and where applicable, on the selected elective/option NOS/set of NOS. |
| 4 | Individual assessment agencies will create unique question papers for theory part for each candidate at each examination/training center (as per assessment criteria below). |
| 5 | Individual assessment agencies will create unique evaluations for skill practical for every student at each examination/ training center based on these criteria. |
| 6 | To pass the Qualification Pack assessment, every trainee should score the Recommended Pass % aggregate for the QP |
| 7 | In case of unsuccessful completion, the trainee may seek reassessment on the Qualification Pack. |

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| TEL/N6267: Install of Antenna at remote end and establish link | 30 | 60 | - | 10 | 100 | 20 |
| TEL/N6268: Set up and Operate Ground Station | 30 | 60 | - | 10 | 100 | 15 |
| TEL/N6269: Signal Analysis, Ground Station Maintenance, and Security Implementation | 30 | 60 | - | 10 | 100 | 15 |
| TEL/N6270: Manage Network Operation Centre (NOC) or Hub | 30 | 60 | - | 10 | 100 | 10 |
| TEL/N6271: Incident management or PM Activity | 30 | 60 | - | 10 | 100 | 10 |
| TEL/N6272: Network Management, Performance Optimization and Testing | 30 | 60 | - | 10 | 100 | 10 |
| TEL/N9104: Manage Work, Resources and Safety at workplace | 40 | 50 | - | 10 | 100 | 10 |
| DGT/VSQ/N0102: Employability Skills (60 Hours) | 20 | 30 | - | - | 50 | 10 |
| **Total** | **240** | **440** | **0** | **70** | **750** | **100** |

# Annexure-III

| Chapter Name | Unit Name | Topic Name | URL | QR Code | Video Duration |
|---|---|---|---|---|---|
| Chapter 1: Introduction to Telecom Sector and about Drone Data Processor | Unit 1.1: Introduction to the Telecom Sector and need of Drone Data Processing | Telecom Industry-Size and Scope | https://youtu.be/5wlF17PNt-0?feature=shared | | 05:57 |
| | Unit 1.2: Roles & Responsibilities of a Drone Data Processor | Drone Data Processing Industry | https://youtu.be/5wlF17PNt-0?feature=shared | | 03:06 |
| Chapter 2: Data Extraction/ Collection | Unit 2.1: Drone Components and Calibration | Calibration \| Drone Flight Basics | https://youtu.be/n8X1REkt7Go?si=nmka15WhZZEivQgO | | 00:54 |
| | Unit 2.2: Flight Planning and Data Collection | Flight Planning | https://www.youtube.com/watch?v=2aLiWjMSNGE | | 40:47 |
| | Unit 2.3: Data Processing and Analysis | Digital Elevation Model | https://youtu.be/fvzNkdmoy48?feature=shared | | 01:32 |

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| Chapter 3: Processing of Collected Data | Unit 3.1: Drone Data Acquisition & Processing Fundamental | Drone Data Processing | https://www.youtube.com/watch?v=dCAmkDvvZCM |  | 01:09 |
| | Unit 3.2: Advanced Data Processing & Analysis | ArcGIS for Drone Data Processing and Analysis | https://www.youtube.com/watch?v=fI-IKTj6r4E |  | 44:07 |
| Chapter 4: Analyze and Project the Collected Data | Unit 4.1: Spatial Data Acquisition and Preprocessing | Pre-processing of spatial datasets | https://www.youtube.com/watch?v=k5rPHofBJXc |  | 26:50 |
| | Unit 4.2: GIS Analysis and Integration | GIS, Spatial Analysis, and Statistics | https://www.youtube.com/watch?v=ytijQl3EDG0 |  | 54:15 |
| Chapter 5: Analise Remote Sensing Data | Unit 5.1: Thermal and Infrared (TIR) Data Calibration and Analysis | Aerial Thermal Imaging Fundamentals | https://www.youtube.com/watch?v=hMv2POnZHyo |  | 50:25 |

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|---|---|---|---|---|---|
| | Unit 5.2: RF Data Analysis and Integration | Testing RF interference from drone transmitters | https://www.youtube.com/watch?v=hB9g5PA6dng |  | 41:02 |
| | Unit 5.3: Automated Analysis and Machine Learning in Spatial Data Processing | Machine learning in drone remote sensing | https://www.youtube.com/watch?v=k1U_vowlHiI |  | 47:07 |
| Chapter 6: Fault Identification and Analysis in Equipment and Infrastructure | Unit 6.1: Principles of Drone Flight Path Planning and Data Collection | Drone Flight Path Planning | https://youtu.be/Zj8XEP8uS8o?feature=shared |  | 01:31 |
| | Unit 6.2: Thermal Imaging and Data Integration | Thermal Imaging | https://youtu.be/EoDFUQsUeN4?feature=shared |  | 10:00 |
| | Unit 6.3: Fault Detection Using Advanced Tools and Techniques | Basic Spatial Analysis | https://youtu.be/XiND8vDyAB4?feature=shared |  | 26:43 |

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| Chapter 7: RF Signal Mapping and Optimization | Unit 7.1: Fundamentals of GIS, Spatial Data, and Remote Sensing | Fundamentals of GIS | https://youtu.be/vJAQHA5XQWI?feature=shared |  | 35:22 |
| | Unit 7.2: GIS Analysis Methods and Spatial Data Processing | GIS Analysis | https://youtu.be/FuIRA-9aZqA?feature=shared |  | 26:00 |
| | Unit 7.3: Advanced Modeling, Orthomosaics, and Data Integration | Point Cloud Generation | https://youtu.be/yXCkyuo8bcs?feature=shared |  | 03:01 |

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

Telecom
Sector
Skill
Council

Telecom Sector Skill Council of India
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