

Advanced Data Sensing in Construction

Ruoxin Xiong, Ph.D.

Assistant Professor of Construction Management

rxiong3@kent.edu

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Learning Objectives

- Understand the importance of advanced data sensing in modern construction.
- Explore key technologies, such as IoT sensors, drones, and LiDAR.
- Discuss practical applications in construction projects.
- Identify challenges in data security and propose mitigation strategies.

Construction Management Objectives: Five Pillars

- Everything we do, everything we manage, everything we discuss is relative to one of these topics
- In most cases, as a manager/owner/architect/subcontractor will pick one that is most important to them, and therefore will try and make you manage their most important item
- Safety
- Cost
- Quality
- Schedule
- Sustainability

How to Evaluate A Construction Project?

- Safety
- Cost
- Quality
- Schedule
- Sustainability

Playhouse Square - The Lumen
1600 Euclid Ave, Cleveland, OH 44115



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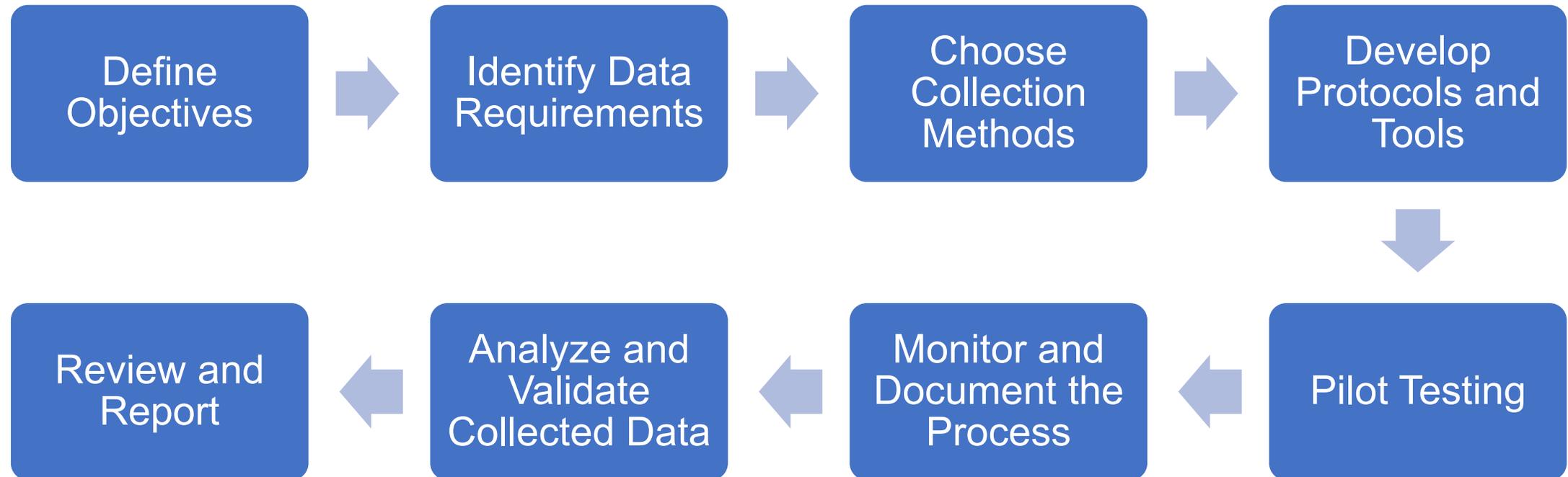


All Answers Can Be Found Within The Data...

- Data Analysis can uncover the truth in Construction
- Data Capture, Storage and Analysis uncovers variances to estimates
- The more you study your data, the more you know about your project
- Data can be used “Retrospectively” to settle disputes on historical impacts
- Data can be used “Prospectively” to avoid future cost overruns and delays through “Predictive Analytics”

...

Data Collection Plans for Practical Applications



Step 1: Define Objectives

- **Clearly articulate the purpose of data collection**
 - Five pillars
- **Identify specific questions or hypotheses to address**
 - What are the (major) factors influencing the performance?
- **Determine how the data will support decision-making or analysis**

Example: What Impacts Cost and Schedule (Performance) in Construction?

ENGINEERS & ARCHITECTS	OWNERS	CONSTRUCTION MANAGERS	CONTRACTORS	OTHER
<ul style="list-style-type: none"> • Poor Design • Incomplete Design • Slow Response Time 	<ul style="list-style-type: none"> • Excessive Changes • Delayed Approvals/ Permits • Prolonged Planning • Delayed Payment 	<ul style="list-style-type: none"> • Poor Planning/ Scheduling • Coordination Issues • Unachievable Schedule • Mismanagement of Resources 	<ul style="list-style-type: none"> • Unachievable Bid • Poor Productivity/ Performance • Mismanagement of resources • Labor Shortages 	<ul style="list-style-type: none"> • Unanticipated Weather • Changing Market Conditions

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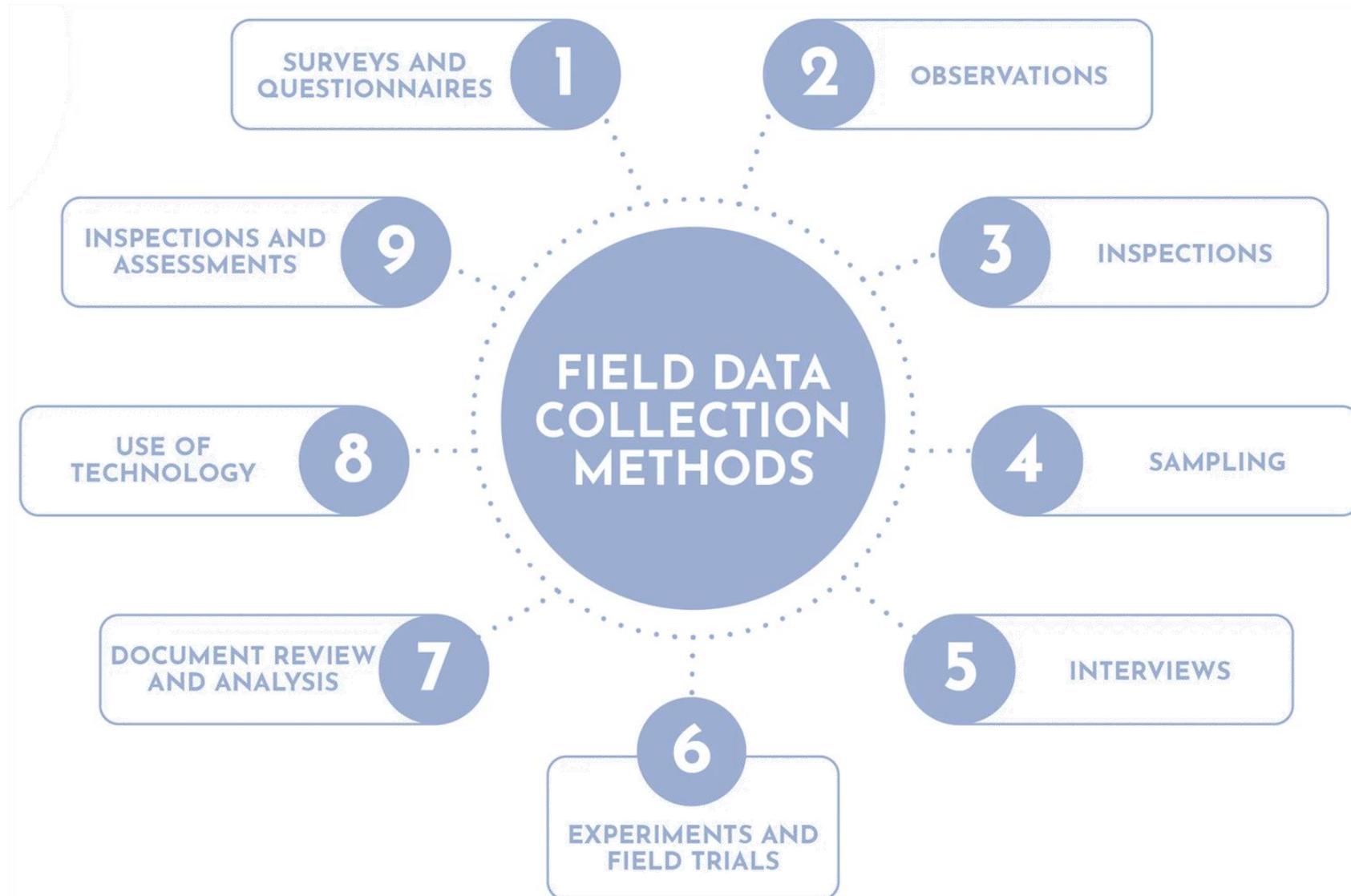
Step 2: Identify Data Requirements

- **Determine data sources (e.g., sensors, surveys, historical records, experiments)**

- **Assess the variables and metrics to be measured**

Can you share field data collection methods you have used or are familiar with in practical applications?

Step 2: Identify Data Requirements



Step 2: Identify Data Requirements

Typical sensors used in the field

- **IoT Sensors:** Embedded in materials for temperature, humidity, and stress
- **LiDAR:** High-resolution 3D mapping and as-built verification
- **Drones:** Aerial surveys, photogrammetry, and site monitoring
- **Wearables:** Monitoring worker health and safety

Step 2: Identify Data Requirements

Internet of Things (IoT) sensor

a specialized electronic device within the Internet of Things (IoT) that detects and measures various **physical parameters** like *temperature, light, motion, or sound in the environment*

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Alcohol Sensor



Ultrasonic Sensor



IR optical Sensor



LDR Sensor



Gas Sensor



Gyroscope Sensor



Rain Sensor



Sense Hat



Photo Diode



IR proximity
Sensor



Proximity Sensor



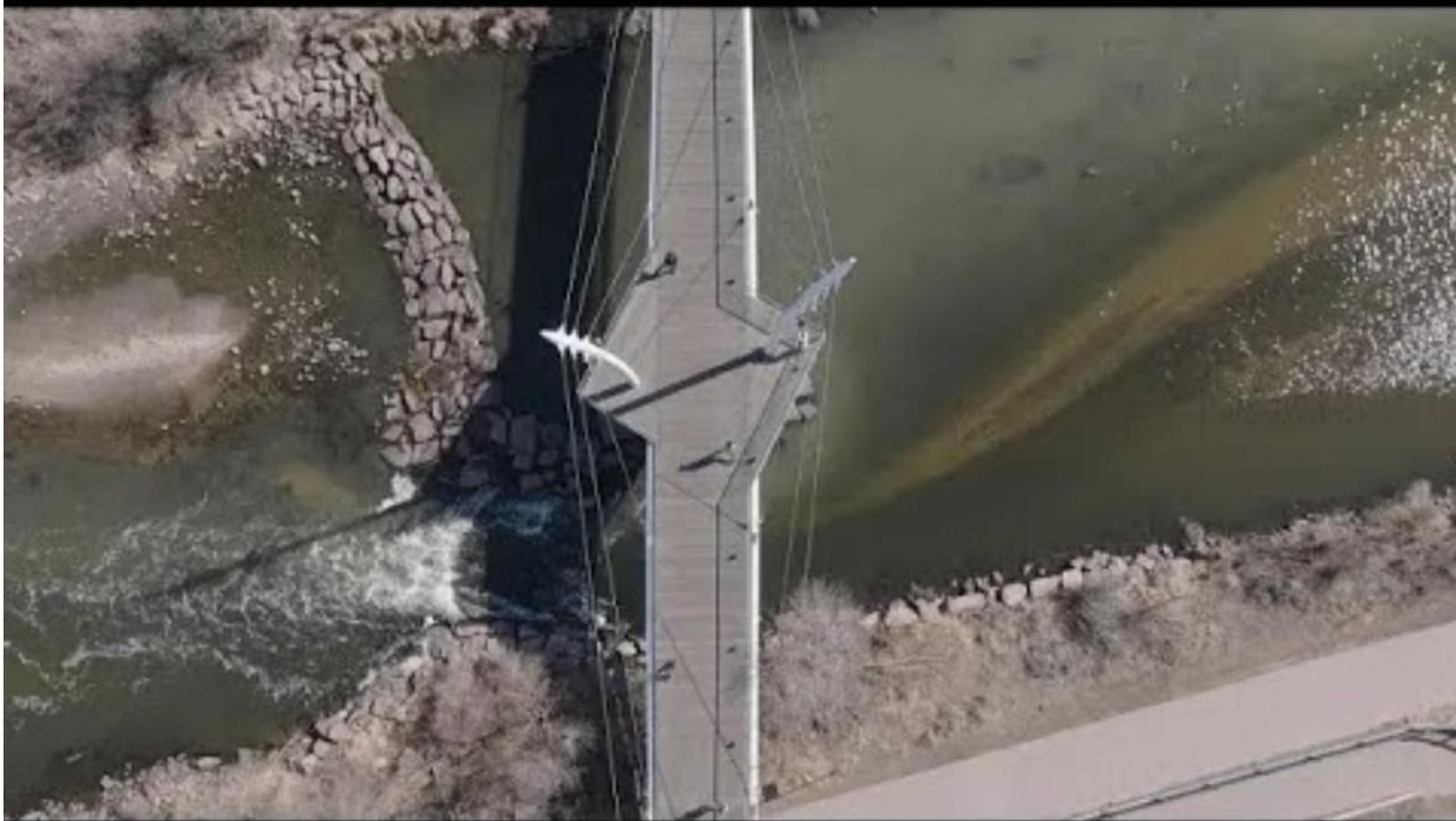
PIR Sensor

Step 2: Identify Data Requirements

Internet of Things (IoT) sensor

- Monitoring concrete curing (e.g., temperature, humidity sensors)
- Structural health analysis (e.g., strain gauges, accelerometers)
- Equipment usage and predictive maintenance

Step 2: Identify Data Requirements



IoT Sensor Data Used for Bridge Monitoring

Step 2: Identify Data Requirements

LiDAR (Light Detection and Ranging)

- **How It Works:**
 - Emitting laser pulses to measure distances.
- **Data Types:**
 - Dense point clouds used for 3D modeling.
- **Applications:**
 - Creating accurate as-built models.
 - Identifying clashes during prefabrication.
 - Inspecting bridges and roadways for structural integrity.



Step 2: Identify Data Requirements



Digitizing Construction Site With LiDAR Data

Step 2: Identify Data Requirements

Drone Technology

- **Data Outputs (depend on the sensors equipped):**
 - Example: photos, point clouds, and thermal images

- **Advantages:**
 - Enhanced Accessibility
 - Speed and Efficiency
 - High-Resolution Data
 - ...

- **Challenges:**
 - Regulatory constraints
 - Limited Battery Life
 - Weather Dependency
 - ...



Step 2: Identify Data Requirements

Drone Technology

- **Applications:**
 - Progress monitoring with high-resolution imagery
 - Hazard detection using thermal sensors
 - Earthwork volume calculation for grading efficiency

Step 2: Identify Data Requirements

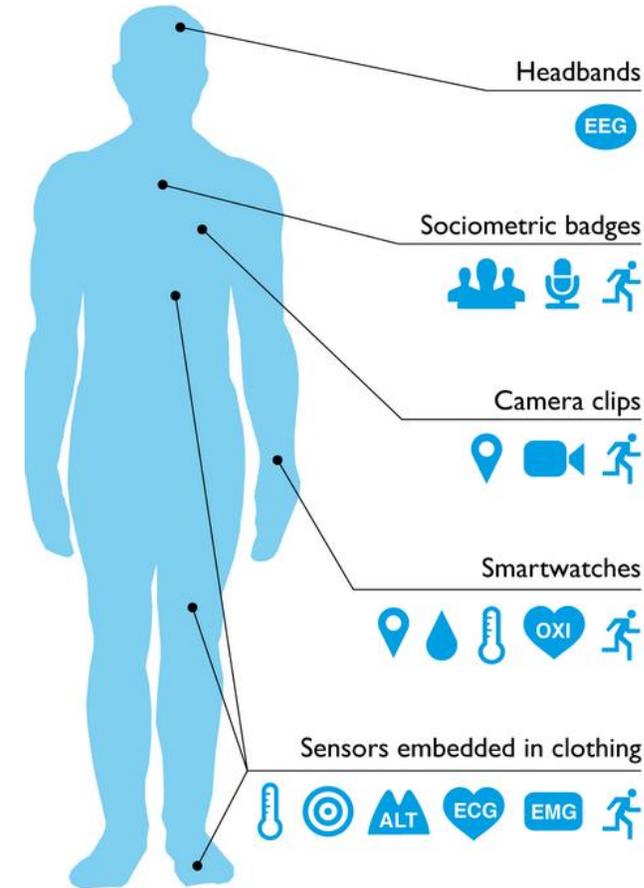


Drone Surveying for Construction - Photogrammetry & Mapping

Step 2: Identify Data Requirements

Wearable Sensors

- Capture different types of signals such as activity, physiological and environmental signals
- Monitoring worker health and safety



-  Accelerometer
-  Altimeter
-  Digital camera
-  Electrocardiogram
-  Electromyograph
-  Electroencephalogram
-  Electrodermograph
-  Location GPS
-  Microphone
-  Oximeter
-  Bluetooth proximity
-  Pressure
-  Thermometer

Step 2: Identify Data Requirements



Improving construction worker safety with wearable sensors

Step 3: Choose Collection Methods

- **Select appropriate methods (e.g., observation, surveys, interviews, IoT devices)**
 - Data collection costs and efficiency
- **Ensure methods are suitable for the type of data and context**
- **Consider using a combination of methods for comprehensive data coverage**

Step 3: Choose Collection Methods

Ethical and Legal Considerations !!!

- Obtain necessary permissions or approvals (e.g., IRB for human subjects research)
- Ensure data privacy and security
- Provide informed consent for participants, where applicable

Step 4: Develop Protocols and Tools



Create standardized forms, templates, or software tools for **consistency**.



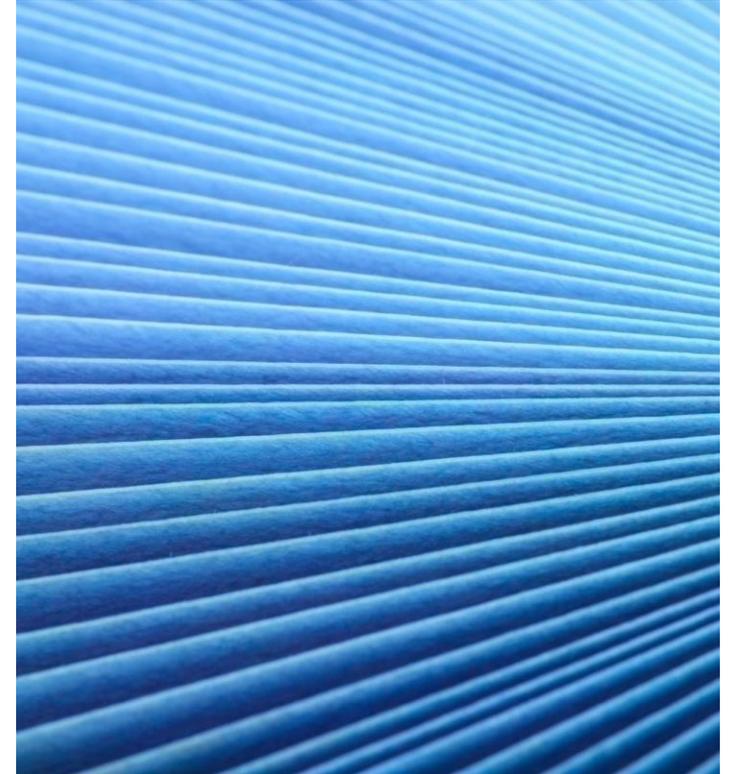
Define protocols for **data recording, labeling, and storage**.



Train team members to ensure **uniformity** in data collection practices.



Define backup and recovery protocols to **prevent data loss**.



Step 5: Pilot Testing

- Conduct a trial run to identify potential issues in methods or tools.
- Make necessary adjustments based on feedback from the pilot.
- Define quality control checks to identify missing, inconsistent, or erroneous data.

Step 6: Monitor and Document the Process

- Monitor ongoing collection to address any deviations or challenges
- Document each step of the process to maintain transparency and reproducibility

Step 7: Analyze and Validate Collected Data

- Perform initial analysis to identify trends or errors
- Validate the data against predefined criteria or benchmarks.

Step 8: Review and Report

- Evaluate the effectiveness of the data collection plan
- Summarize findings and lessons learned to improve future plans

Any Questions?

Breakout Activity: Evaluate and Improve Thermal Comfort of Occupants In the CAED Building

Background:

- Maintain optimal indoor environment conditions such as air quality, temperature and humidity levels improves occupant satisfaction and productivity
- Identify problem areas can address complaints such as "too hot" or "too cold" spaces
- Environmental data helps optimize HVAC (Heating, Ventilation, and Air Conditioning) operations
- Reduce unnecessary energy consumption leads to cost savings and sustainability



Breakout Activity: Evaluate and Improve Thermal Comfort of Occupants In the CAED Building (4 groups)

Instructions:

- 4-6 participants in a group and assign one team leader to facilitate coordination and present findings
- The goal is to **monitor environmental conditions, improve occupant comfort, and save energy consumption** in CAED
- Some Standards: <https://comfort.cbe.berkeley.edu/>
- Please develop a **data collection plan**
 - What data to capture and monitor
 - What sensors for data collection
 - What specific locations in CAED building for data collection and why
 - What data recording frequency and duration
 - Consider any challenges, such as sensor placement or access to power
 - ...

Review

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Thank You!