**Step 7: Testing and Refinement**

***Test Cases***

**Test Case 1: Train Approaching – Gates Should Close**

* **Inputs:**
  + Train proximity sensor = **Active (Train detected)**
  + Gate status = **Open**
  + Timing verification = **Valid (Sufficient time to close gates before train arrives)**
  + Cross-verification (secondary sensor) = **Consistent (Confirms train is approaching)**
* **Expected Output:**
  + Gates **close** immediately.
  + Red warning lights & alarms **activate**.
* **Actual Output:**
  + (Should match expected; if not, timing or sensor logic may be faulty.)

**Test Case 2: False Alarm (Sensor Malfunction) – Gates Should Remain Open**

* **Inputs:**
  + Train proximity sensor = **Active (False detection)**
  + Gate status = **Open**
  + Timing verification = **Invalid (No train expected per schedule)**
  + Cross-verification = **Inconsistent (Secondary sensor does not detect train)**
* **Expected Output:**
  + Gates **remain open** (system ignores false alarm).
  + Logs error for maintenance.
* **Actual Output:**
  + If gates close unnecessarily, cross-verification logic needs improvement.

**Test Case 3: Train Departing – Gates Should Open After Safe Delay**

* **Inputs:**
  + Train proximity sensor = **Inactive (Train has passed)**
  + Gate status = **Closed**
  + Timing verification = **Valid (Delay ensures train is fully clear)**
  + Cross-verification = **Consistent (Track clear)**
* **Expected Output:**
  + Gates **open after a safe delay**.
  + Warning signals **deactivate**.
* **Actual Output:**
  + If gates open too early, timing logic needs adjustment.

**Test Case 4: Emergency Override (Manual Control)**

* **Inputs:**
  + Manual override = **Activated (Maintenance mode)**
  + Train proximity sensor = **Active**
  + Gate status = **Open**
* **Expected Output:**
  + Gates **remain open despite train detection** (allowing maintenance).
  + System logs override event.
* **Actual Output:**
  + If gates close during override, safety logic must prioritize manual control.

***Improvements & Refinements***

1. **Redundant Sensor Checks:**
   * Add a third sensor to minimize false positives/negatives.
2. **Dynamic Timing Adjustment:**
   * Adjust gate closure timing based on train speed (if variable).
3. **Fail-Safe Defaults:**
   * If conflicting inputs occur, default to **"gates closed"** for maximum safety.
4. **Self-Testing Mode:**
   * Automatically test sensor consistency periodically and alert if discrepancies are found.
5. **Backup Power Handling:**
   * Ensure gates close if power fails (battery backup + mechanical fallback).

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