**Introduction**

Thermographic inspections are an essential part of preventive maintenance for solar panel installations. By detecting defects early, operators can minimize downtime and maximize energy output. Spectral Scan Solutions offers a structured inspection program, carried out with thermal drones, to systematically monitor installations and optimize maintenance strategies.

**1. Preparation**

**1.1 Project Planning & Risk Analysis**

* **Project Name:** (Not specified)
* **Location:** (Not specified)
* **Date:** (Not specified)
* **Project Manager:** (Not specified)

|  |  |  |
| --- | --- | --- |
| **Risk** | **Impact (High/Medium/Low)** | **Measures** |
| Unstable weather | High | Schedule a backup inspection day |
| GPS signal loss | Medium | Provide manual control |
| Hazardous zone | High | Adjust flight route |

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**1.2 Pre-Inspection Checklist**

* **Date:** (Not specified)
* **Inspector:** (Not specified)

✅ Weather check (wind, rain, temperature) ✅ Drone and battery status verified ✅ Thermal camera calibrated ✅ Flight plan loaded ✅ Safety procedures reviewed

**2. Inspection Execution**

**2.1 Thermographic Inspection Report**

* **Project Name:** (Not specified)
* **Date:** (Not specified)
* **Inspector:** (Not specified)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Part** | **Recorded Temperature** | **Deviation? (Yes/No)** | **Visual Damage? (Yes/No)** | **Comments** |
| PV module A1 | 95°C | Yes | No | Overheating |

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✅ Thermographic images attached ✅ Reference values compared with factory values

**2.2 Drone Inspection Flight Report**

* **Project Name:** (Not specified)
* **Date:** (Not specified)
* **Drone Type:** (Not specified)
* **Pilot:** (Not specified)

|  |  |
| --- | --- |
| **Flight Data** | **Value** |
| Number of flights | X |
| Total flight time | X min |
| Max. flight altitude | X m |
| GPS signal strength | Good/Moderate/Poor |
| Weather conditions | Sunny/Windy/Cloudy |

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**3. Analysis & Action**

**3.1 Client Advisory Report (post-inspection)**

* **Client:** (Not specified)
* **Location:** (Not specified)
* **Date:** (Not specified)
* **Inspection Summary:**
  + ✅ X defects found
  + ✅ X high-priority defects
  + ✅ Recommended actions within X days
* **Key Recommendations:**
  + Immediate repair of ...
  + Preventive maintenance ...
  + Optimization of inspection frequency ...

**3.2 Generating Work Orders**

* Documentation of identified defects.
* Creation of work orders in the maintenance management system.
* Assignment to responsible maintenance teams.
* Scheduling of repairs within priority levels.

**4. Re-inspection & Optimization**

**4.1 Checking Repairs**

* Thermographic check within 24-48 hours after repair.
* Evaluation of repairs and possible further adjustment of maintenance strategy.

**4.2 Documenting Cost Savings**

* Recording of repaired defects and impact on energy yield.
* Analysis of avoided costs through early detection and repair.
* Generating reports for investors and operators.

**4.3 Root Cause Failure Analysis (RCFA)**

* Analysis of recurring defects to identify structural problems.
* Improving installation practices and maintenance procedures.
* Recommendations for future optimizations and technological upgrades.

**5. Implementation Timeline**

|  |  |  |
| --- | --- | --- |
| **Phase** | **Duration** | **Activity** |
| Preparation | 1 month | Inventory and route planning |
| First Inspection | 2 weeks | Drone inspection and data processing |
| Analysis & Action | 1 month | Reporting and work order creation |
| Re-inspection | 2 weeks | Post-repair check |
| Optimization | Ongoing | Adjusting inspection frequencies |

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With this structured inspection program, Spectral Scan Solutions offers a reliable and efficient solution for the management and maintenance of solar panel installations. Through systematic thermographic analyses, we minimize energy losses and maximize the lifespan of installations.

**Inspection Program Step-by-Step Plan**

**Step 1 – Defining Components to be Inspected**

* Identifying critical components in solar panel installations:
  + Solar panels and cell defects (hotspots, microcracks, PID)
  + Inverters and electrical connections
  + Bypass diodes and cabling
* Prioritizing based on failure sensitivity and impact on energy production.

**Step 2 – Creating an Inventory List**

* Mapping the solar panel installations with GPS coordinates.
* Drawing up inspection routes for drones based on installation layouts.
* Grouping installations by location or type for efficient inspections.

**Step 3 – Determining Inspection Frequencies**

* Annual inspections for standard installations.
* Semi-annual inspections for installations with previous defects or in extreme climatic conditions.
* Ad-hoc inspections in case of performance degradation or damage after weather conditions.

**Step 4 – Setting Temperature Limits**

* Using reference data and factory specifications to establish temperature limits.
* Recording deviating temperature patterns (>10°C difference between cells as an indication of defects).
* Analyzing historical data to improve trend and pattern recognition.

**Step 5 – Performing Inspections**

* Selection and training of drone pilots and thermographers.
* Using advanced thermal drones such as the DJI Mavic 3 Enterprise, DJI M30T and DJI M350.
* Capturing thermal images and visual photos under standardized conditions.

**Step 6 – Generating Work Orders**

* Integrating inspection results into maintenance software.
* Automatic generation of work orders for repair actions.
* Assigning repair work to specialized technicians.

**Step 7 – Re-inspecting Repairs**

* Thermographic check within 24-48 hours after repair.
* Evaluating repairs and possibly further adjusting the maintenance strategy.

**Step 8 – Documenting Cost Savings**

* Recording repaired defects and impact on energy yield.
* Analyzing avoided costs through early detection and repair.
* Generating reports for investors and operators.

**Step 9 – Root Cause Failure Analysis (RCFA)**

* Analyzing recurring defects to identify structural problems.
* Improving installation practices and maintenance procedures.
* Recommendations for future optimizations and technological upgrades.

**Implementation Timeline**

|  |  |  |
| --- | --- | --- |
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**1. Preparation Documents**

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* **Date:** (Not specified)
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| --- | --- | --- |
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**1.2 Pre-Inspection Checklist**

* **Date:** (Not specified)
* **Inspector:** (Not specified)

✅ Weather check (wind, rain, temperature) ✅ Drone and battery status verified ✅ Thermal camera calibrated ✅ Flight plan loaded ✅ Safety procedures reviewed

**2. Inspection Documents**

**2.1 Thermographic Inspection Report**

* **Project Name:** (Not specified)
* **Date:** (Not specified)
* **Inspector:** (Not specified)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Part** | **Recorded Temperature** | **Deviation? (Yes/No)** | **Visual Damage? (Yes/No)** | **Comments** |
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**2.2 Drone Inspection Flight Report**

* **Project Name:** (Not specified)
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* **Drone Type:** (Not specified)
* **Pilot:** (Not specified)

|  |  |
| --- | --- |
| **Flight Data** | **Value** |
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| Total flight time | X min |
| Max. flight altitude | X m |
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| Weather conditions | Sunny/Windy/Cloudy |

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**3. Documents for Communication and Action**

**3.1 Client Advisory Report (post-inspection)**

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* **Location:** (Not specified)
* **Date:** (Not specified)
* **Inspection Summary:**
  + ✅ X defects found
  + ✅ X high-priority defects
  + ✅ Recommended actions within X days
* **Key Recommendations:**
  + Immediate repair of ...
  + Preventive maintenance ...
  + Optimization of inspection frequency ...

**3.2 Maintenance Plan for Recurring Defects**

* **Project Name:** (Not specified)
* **Location:** (Not specified)
* **Date:** (Not specified)

| Defect Category | Inspection Frequency | Recommended Action | |---|---|