GEAR :: INSPECT
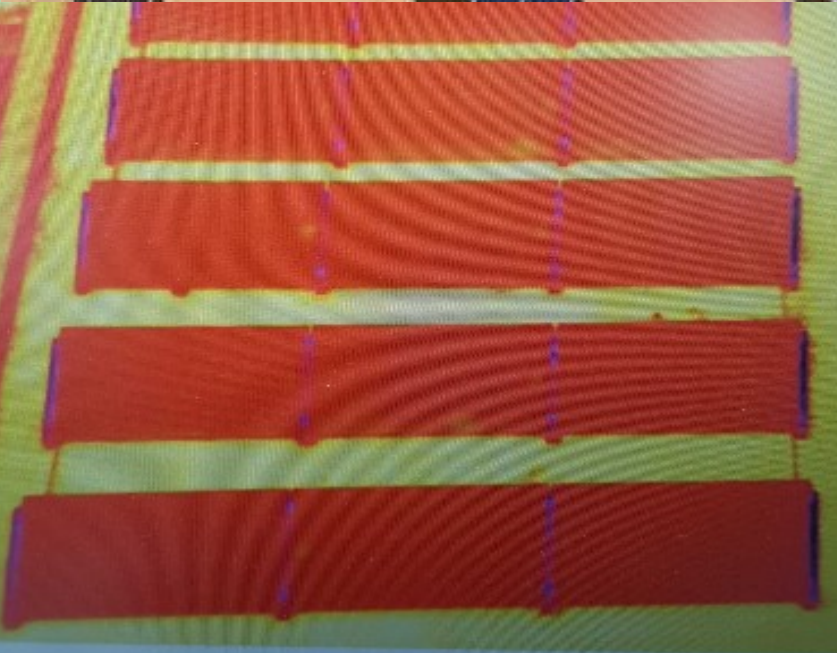Solar / Photovoltaic

INFORMATIONAL REVIEW

AUTOMATIC AERIAL INSPECTIONS USING UAV / DRONES
USE CASE: **SOLAR / PHOTOVOLTAIC**

GEAR INSPECTION

GEAR provides comprehensive drone-based photo, photo thermal and video inspections for your buildings or sites.

VALUE OF GEAR INSPECTION AS A SERVICE (GIAS) SUBSCRIPTION

Subscribing to GEAR to constantly inspect your organization's sites and infrastructure offers perfectly tailored customization that will always be up to date and the ability to try out new developments (concepts).

We are a fast growing start-up developing new innovative features for solar panel inspections and associated automation.

info@gear-systems.com
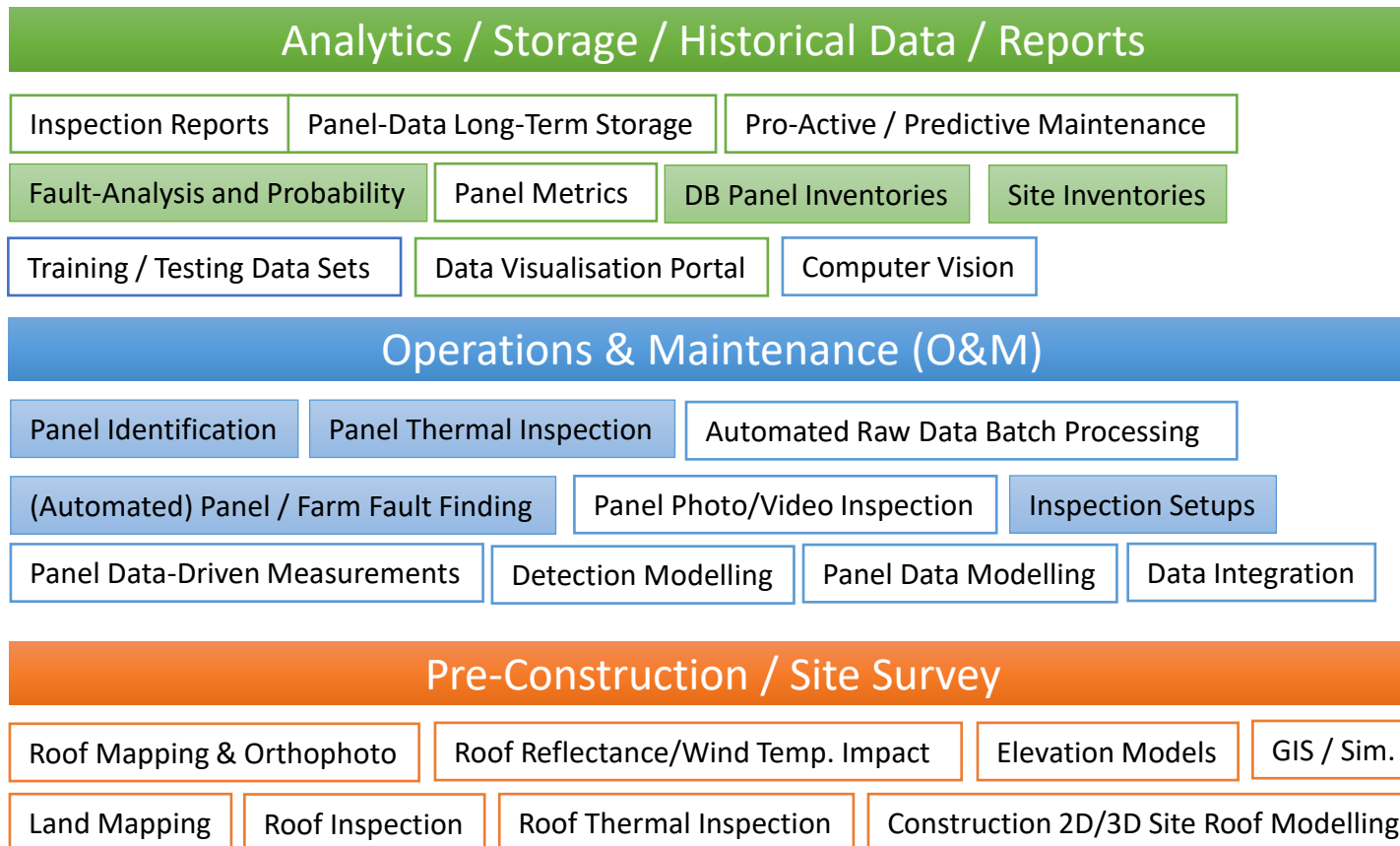linkedin.com/company/gear-bv
www.gear-systems.com

Solar / Photovoltaic Panel Inspection (2021)

GEAR drone automated inspections can support multiple types fault finding in residential or industrial panel installations

There are three main stages where panel-data and solar-panel inspections are valuable

- Pre-Construction Phase
- O&M Phase
- Continuous Data Analytics

Using GEAR drone inspections for the solar / photovoltaic renewables solar/photovoltaic sector can reveal valuable information in all project stages.

Analytics / Storage / Historical Data / Reports

| Inspection Reports | Panel-Data Long-Term Storage | Pro-Active / Predictive Maintenance |

| Fault-Analysis and Probability | Panel Metrics | DB Panel Inventories | Site Inventories |

| Training / Testing Data Sets | Data Visualisation Portal | Computer Vision |

Operations & Maintenance (O&M)

| Panel Identification | Panel Thermal Inspection | Automated Raw Data Batch Processing |

| (Automated) Panel / Farm Fault Finding | Panel Photo/Video Inspection | Inspection Setups |

| Panel Data-Driven Measurements | Detection Modelling | Panel Data Modelling | Data Integration |

Pre-Construction / Site Survey

| Roof Mapping & Orthophoto | Roof Reflectance/Wind Temp. Impact | Elevation Models | GIS / Sim. |

| Land Mapping | Roof Inspection | Roof Thermal Inspection | Construction 2D/3D Site Roof Modelling |

Register a Site Once, refer it every other time after. This process saves time in providing inputs for inspections.

Panel Identification is done based on GEO reference following first inspection. The exact location is further linked to an unique DB Identifier used throughout the lifecycle of the respective panel

Inventories
- Site Inventories
- Panel Inventories

INVENTORIES

- **Site** Registration allows referring same site for several inspection or searching / filtering options
- Site Panels **Identification is kept unique** throughout panel lifecycle once recorded in the system
- A **site-map** along with any other information such as site-model, orthophoto, elevations can be recorded for the ease of operations
- **Panels** linked to a site and made searchable in a hierarchical manner
- **Sub-sites** (e.g. building within a larger site) can be represented and modelled
- **Panel identification** can be done by manually linkage to a site and ID allocation or automatically based on its location within the site or subsite **geo-markups**
- **A WEB interface** makes any interaction and data-input easy and fast
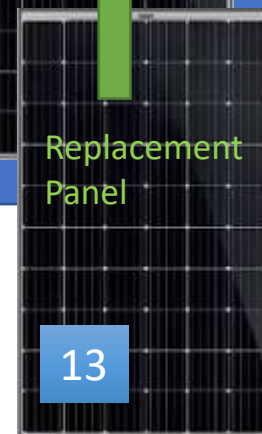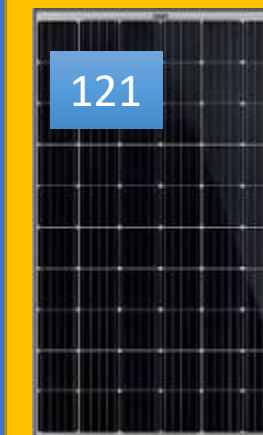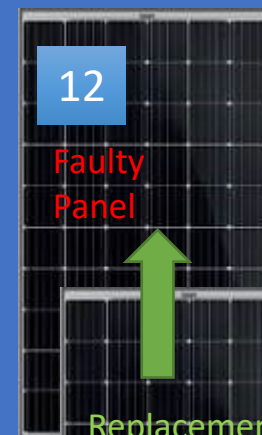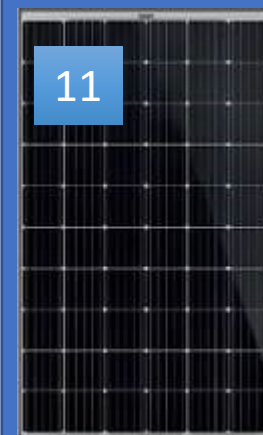
DB Panel Inventories

Site Inventories

Panel Identification

SITE 1 (e.g. house/factory/plan/farm/etc.)
Geography, Positioning, Address, Site-Details, Site Access and other information can be stored in relation to a site

SITE 12
Unlimited number of sub-sites is possible with options to logically group and linking elements

11

12

Faulty Panel

121

Replacement Panel

13

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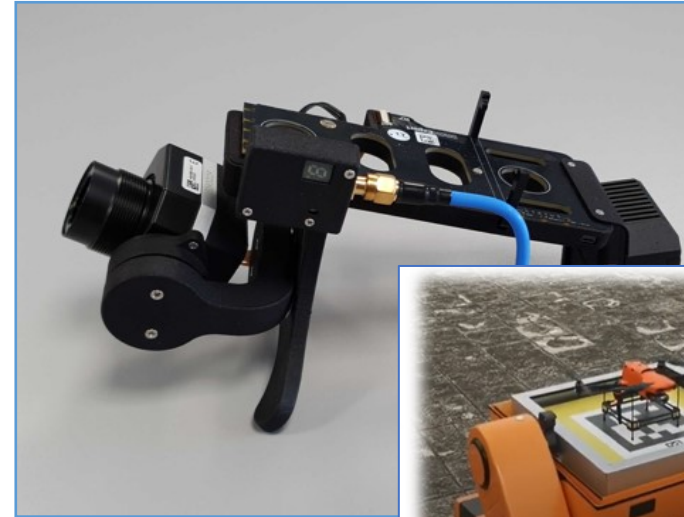
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Drone Aerial Inspections

- Flight Setups
- Hardware

INSPECTION PREPARATION

- **Thermal** inspection require a particular setup of drone flight plan along with specific O&M thermal camera settings
- Either radiometric (**RJPG**) or **tif** is possible with FLIR cameras
- A dual-camera system (thermal and visual) is used for better fault identification
- For small sites non-zoomed inspections custom built drones are used
- For particular zooming options to finds particular faults larger drones are used (e.g. DJI Matrice or similar)
- Depending on weather / site restrictions & limitation and other settings, flight can take longer or shorter times to produce required deliverables

INFORMATIONAL REVIEW GEAR UAV automatic inspections

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Thermal and Visual Panel Inspections
- Thermal
- Fault Detection

FAULT DETECTION & VISUALISATION

- **Thermal imaging** is used to detect common faults with solar panels
- **Visual** inspections is complementary and used as way to increase fault detection accuracy rate
- Typically **computer-vision** in a form of object/form detection **is** deployed to process large batches of panels and perform automatic fault-detection (provided an accuracy level is expected too alongside)
- Faults are linked to their respective recorded Panel IDs for further correlations and documentation
- **Historical tracking** can be later deployed on panel-basis
- Explore the common Faults that can be identified with drones aerial inspections next

Panel Thermal Inspection

(Automated) Panel / Farm Fault Finding
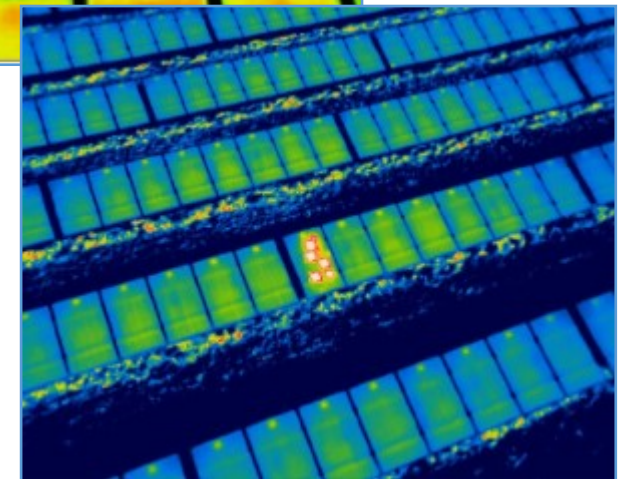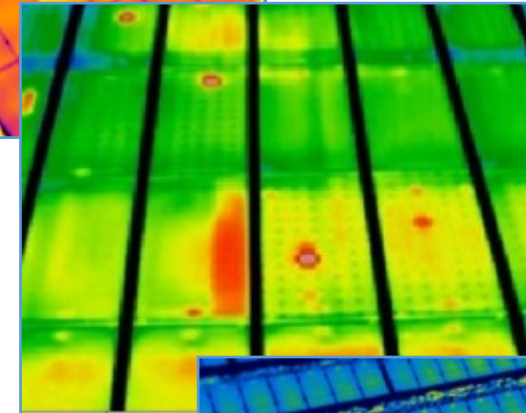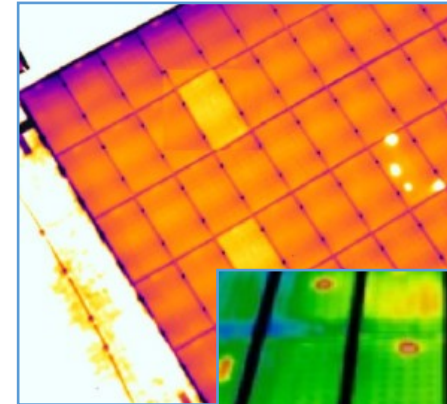
INFORMATIONAL REVIEW GEAR UAV automatic inspections

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## Fault Detection and Probability
- Common Faults
- Detection Methods

Solar Panel Fault List

- Hot Spots / Cluster of Thermal Anomalies (variant)
- Micro Cracks
- Snail trail contamination
- PID Effect
- Internal corrosion
- Dirt & Birds
- Overheated Components
- Bypass Diode Fault
- Faulty Interconnection
- Electrical & Inverter Issues isolation
- Delamination
- Shattering
- Ingress
- Deformation
- Discoloration
- Fire

The goal of the aerial inspection is to provide the most probable fault cause in shortest time possible on all panels inspected in most automated way possible. To do that training sets and test sets are used based on installation specifics (angles, formats, vendor, etc.) Once a reliable fault detection & matching probability is reached, the model is further applied to following inspections saving time in fault-analysis

Fault-Analysis and Probability

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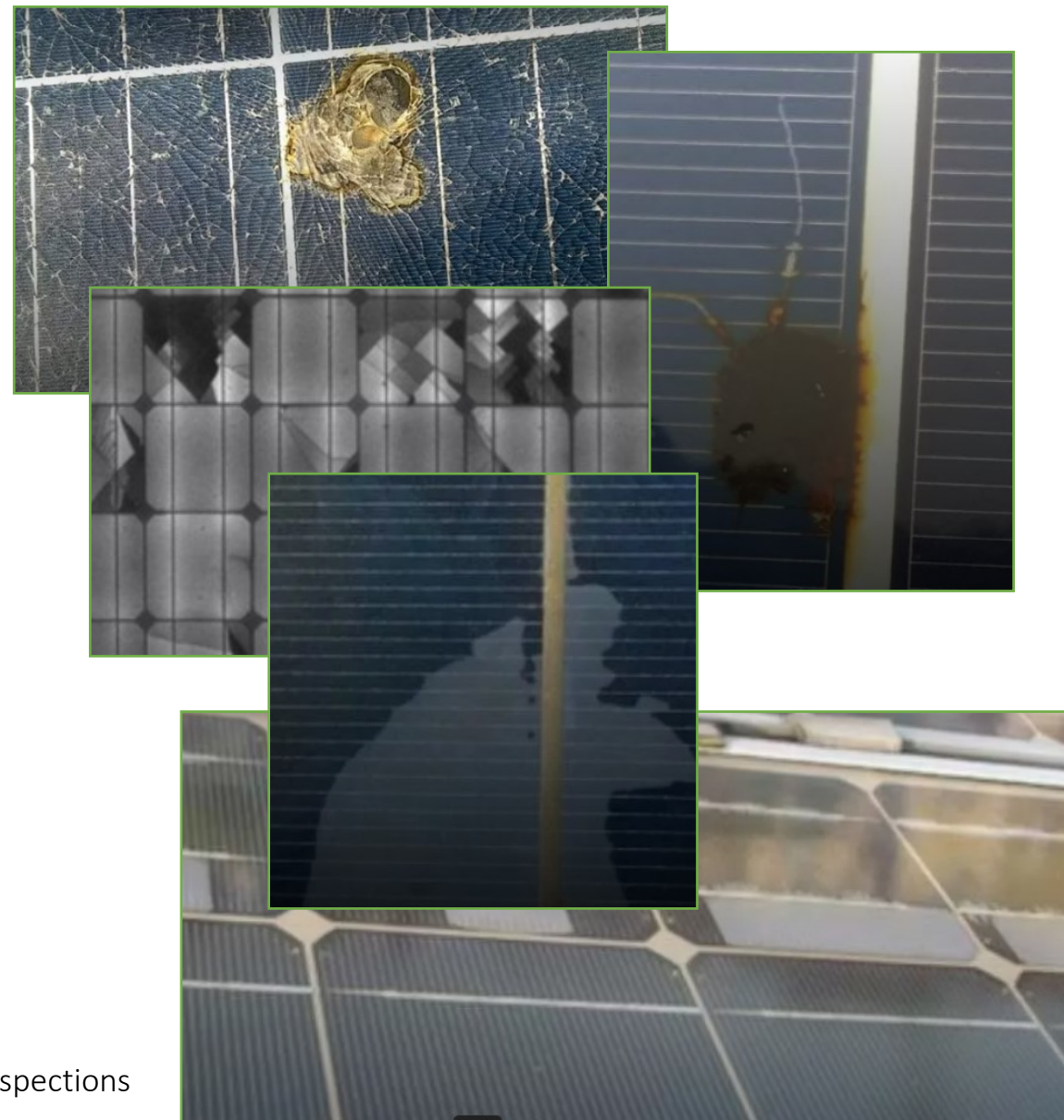
A docking and charging station is deployed on site permanently in case of remote inspection. The station can accommodate several type of drones and can be setup in various configurations in case of multiple boxes are deployed to cover a large area/site.

Remote Drone Inspection
- Drone on site
- Docking & Weather Station
- Remote Flying & Planning Software

REMOTE INSPECTION

- **Remote Drone Flight** BVLOS
- **24/7 on site** inspections assuring a dedicated on-site drone + box
- Live streaming of the inspection
- Automated flight plan assuring autonomous inspection
- Remote pilot (using 4G/5G coverage)
- On site local weather station
- Mission Planning (for 1 drone or fleet) including waypoints, calendar, pre-scheduler, waypoints actions and mission logs

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Remote Drone Inspection

- Mission Templates
- Real-Time inspections and Weather parameter check
- Integration in larger Enterprise ecosystem

Features

- Management of multiple drones (**permutation**) with one box
- **Station Hopping** in order to cover a larger area using more boxes
- Smart Phone Control & Integration
- Asset Management / Inventory Management
- Incident Response & defined Actions →

  - Send drones to a location on demand
  - Control drones with joypad, joystick, keyboard
  - Geofences to demarcate fly zones
  - Configure fail-safe features for inspection operations
  - Control settings on drone +/- payloads

Using a local weather station can give best indication of flight conditions.

drone A

drone B

1
2
3
4

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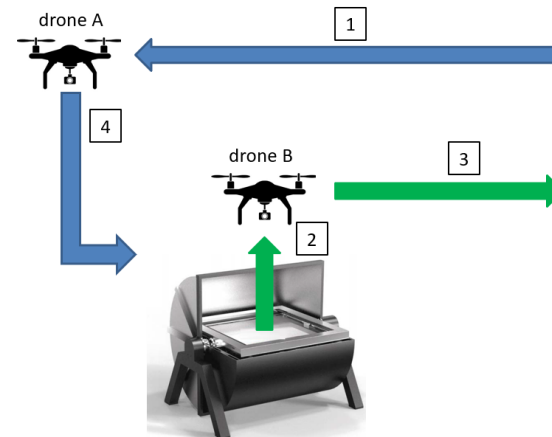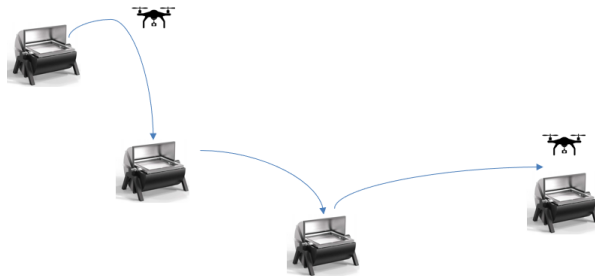
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Automatically identifying a common-fault is a deep-learning process. The larger the example sets used the better the fault-matching probability
Factors include weather, vendor specifics, installation specifics, successful correlations between thermal and vision cameras and correct flight setups

Key value to using this process
- Batch processing in fault-finding serves good speed of delivery
- Assure a standard list of faults and implement O&M procedures
- Understanding of particular faults can trigger preventive maintenance or realistic predictions about the panel
- Modelling and data abstraction give powerful options in analytics and historical fault-tracking on panel-basis
- Using a diverse fleet of drones and imagery systems covers several types of installations (e.g. residential, industrial)
- Using GEAR's subscription to store all the data saves processing, transfer and storage costs
- Continuously training fault-detection models keeps reliability of fault-detection high
- Using a one-stop web-interface for all install-base across several end-customers and sites simplifies interactions
- Other Panel Related data can be integrated in the database (DB) along to provide better identification and control
- Using centralized inventories assures a solid path to panel life-cycle management
- Combination of thermal and photographic imagery gives best results

ABOUT GEAR
We are a fast growing start-up developing new innovative features for inspections and associated automation.

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