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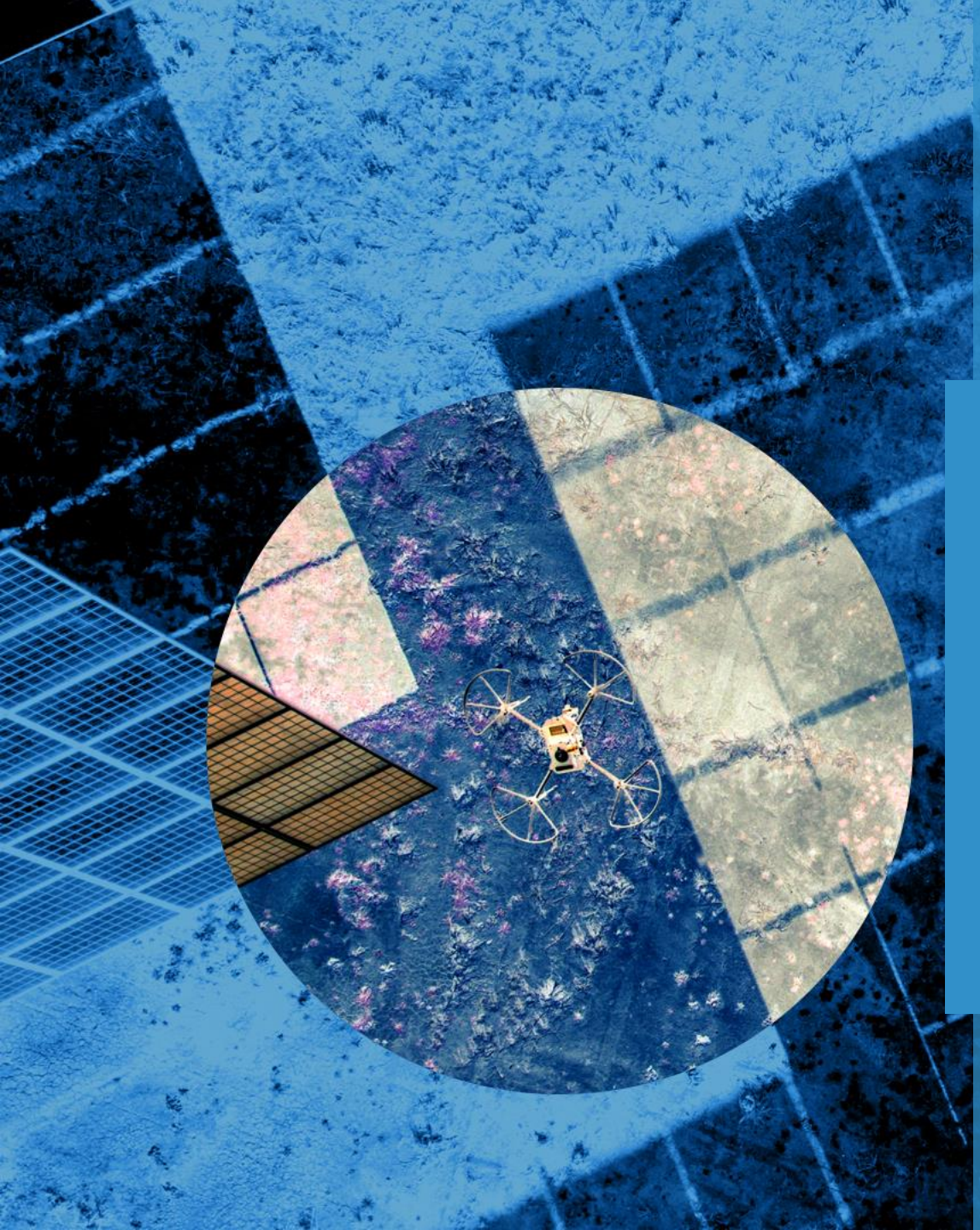
TECHNOLOGIES



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9th PVPMC Workshop
12/6/2017
Weihai, China

Agenda

- The Unmanned Aerial System (UAS)
- Value of UAV (or drones) in PV Lifecycle
- About Aerospec Technologies
- Company Vision - Robot Corps

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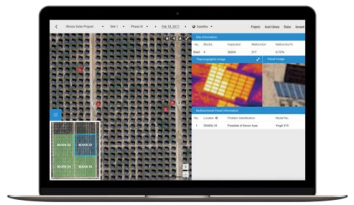
UAS Ecosystem

- Flight Planning
- Data Communication
- Sense and Avoid
- Swarming
- Remote Control?

Flight Control Systems and Data Centers



- 2D/3D Model Orthomosaic
- GIS Data Processing
- Multi-spectrum Data Processing
- Object Tracking
- Object Measure and analysis

Aerial Platforms

Payloads

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Value of UAS in PV Lifecycle

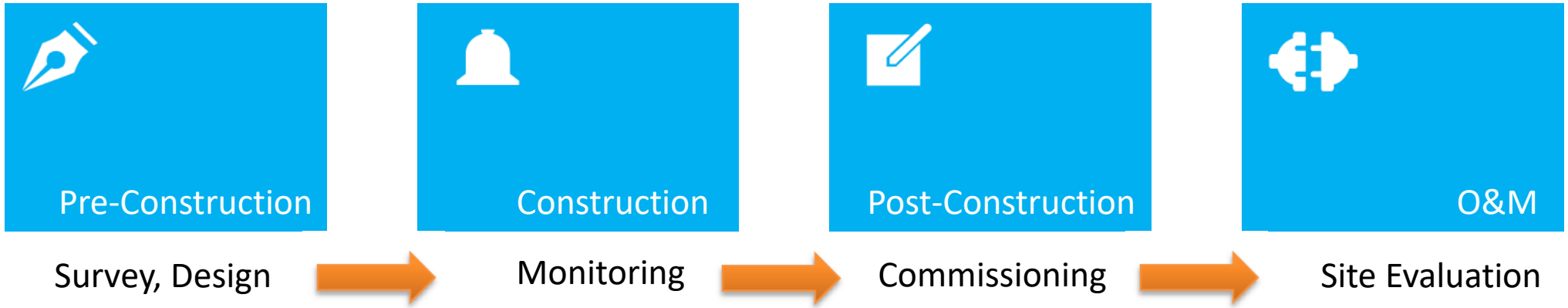
UAS Technology is useful in every phase of PV Lifecycle

Phase 1. Aerial survey can be used during pre-construction to select solar site using high resolution 2D map and CAD output.

Phase 2. During construction phase, frequent fly over can monitor construction progress to prevent project delays.

Phase 3. Conduct thorough site scans that covers 100% of PV modules and accurately assess module conditions.

Phase 4. Quarterly aerial inspections to check for hot spots, data can be integrated into existing SCADA or other monitoring system as part of O&M.



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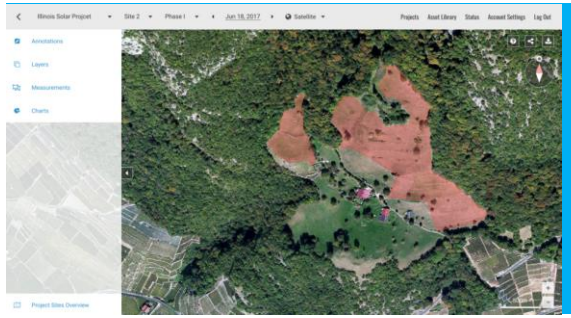
Phase 1. Pre-Construction Survey

Use UAV to acquire aerial data, construct 2D/3D models, perform data analysis

3D Model



2D Model

- Data acquired from UAV gets uploaded to the cloud, 2D/3D model can be created automatically via software, CAD output can be integrated with GIS data and layered with various satellite images.
- Pre-construction site selection with 2D/3D model, data can be exported to solar site design tool such as Helioscope for further processing.
- Various measurement can be done on the cloud including dimensions, area, volumetric, even annotations.

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Phase 2. Construction Monitoring

- Aerial flight can be done as often as weekly to monitor construction progress
- Project progress can be compared to track delays, flag anomalies, and allow annotations
- Aerial flight data is transmitted to cloud in real time and allow simultaneous access to multiple users regardless of physical location

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Phase 3. Post-construction Commissioning

Aerial inspection can replace ground crew I-V Curving to be more efficient and cost-effective

UAV Aerial Inspection

Automated flight plan allows UAV to scan 2MW in about 10 minutes.

Perfectly safe operation in low attitude flight (<200 ft.)

Data is automatically recorded and can be further analyzed to generate insights.

Ground crew with handheld thermal IR camera will take about 3 days to inspect 2MW

Some site conditions are hard for human access, such as hills.
Manual data recording takes a long time and gives sparse analytics

Ground Crew Truck Roll

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Phase 3. Post-construction Commissioning

2D Mapping + GIS Data Integration + Inspection Result + Post Inspection Analytics

- Measure hot spot temperature differences vs. average temp.
- Accurate display hot spot location on 2D map
- Provide hot spot analysis and statistics of the entire site

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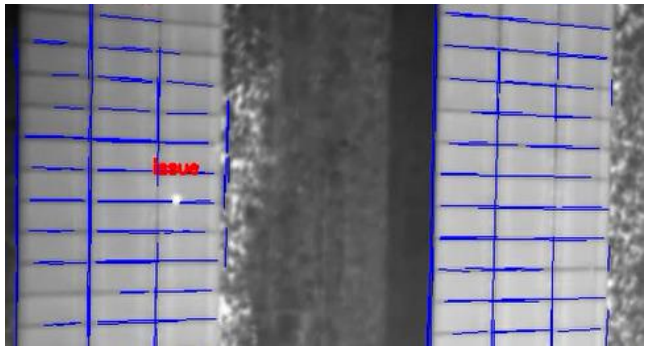
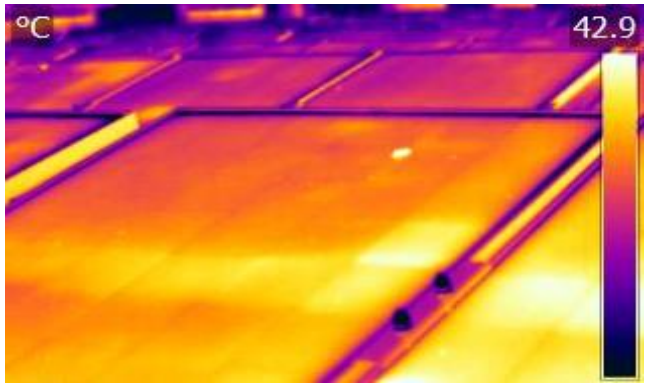
Phase 3. Post-construction Commissioning



UAV Aerial Inspection equipped with thermal IR sensor can detect and pinpoint hot spots.



Result and location can be verified using a handheld thermal IR camera and accurately measure panel temperature.

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Phase 3. Post-construction Commissioning

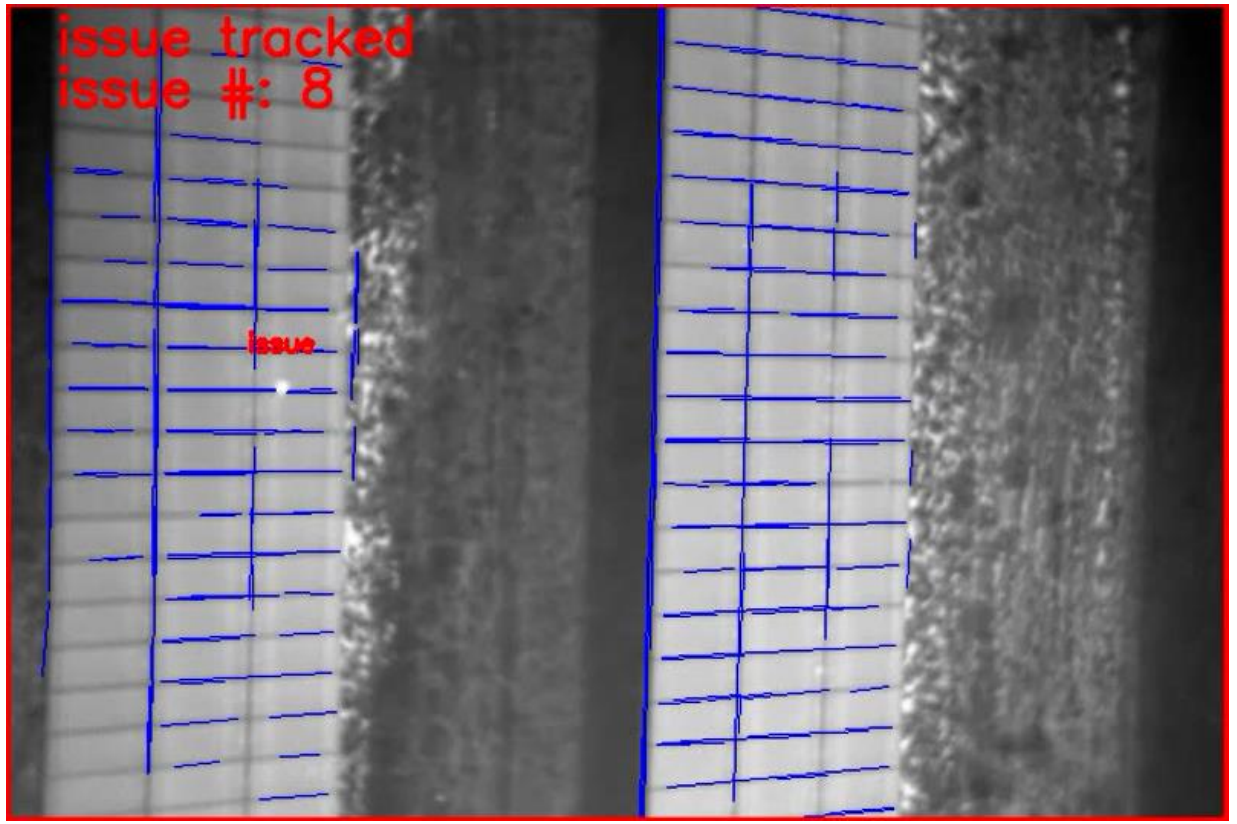
Advantages using UAV during commissioning

1. Autonomous/pilot guided flight, automatic data recording
2. UAV Swarming for large site scan to reduce time required
3. Accurately detect hot spots down to module level regardless of plant size
4. Thermal IR inspection data can overlay on 2D site map for better analysis
5. Automatically detect module hot spots using computer vision algorithms
6. Safe operations without ground crew in the field

Aerial Inspection – Case Study

2MW site – 7 minutes

Computer Vision + Machine Learning Automatically Identify Photovoltaic Panels



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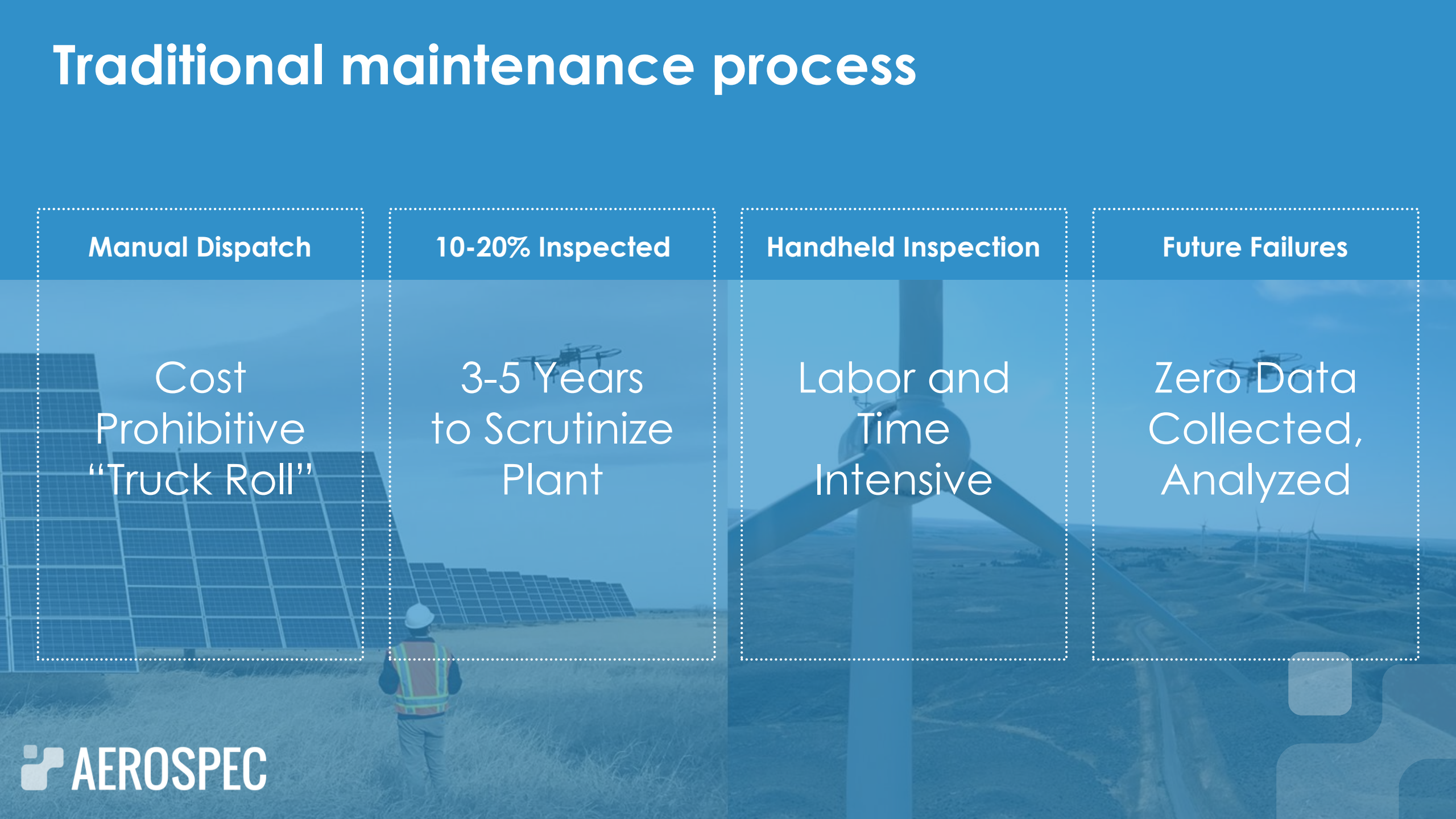
Traditional maintenance process

Manual Dispatch	10-20% Inspected	Handheld Inspection	Future Failures
Cost Prohibitive “Truck Roll”	3-5 Years to Scrutinize Plant	Labor and Time Intensive	Zero Data Collected, Analyzed



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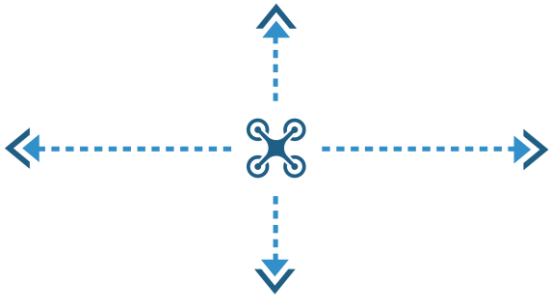
With our technology, we are more efficient in every step of the maintenance process

Rapid Deployment	Entire Plant	Scalable	Big Data
MANUAL WORK REPLACED BY MACHINE 	100% COVERED 	10X FASTER 	PREDICTIVE ANALYTICS 

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Core Technologies

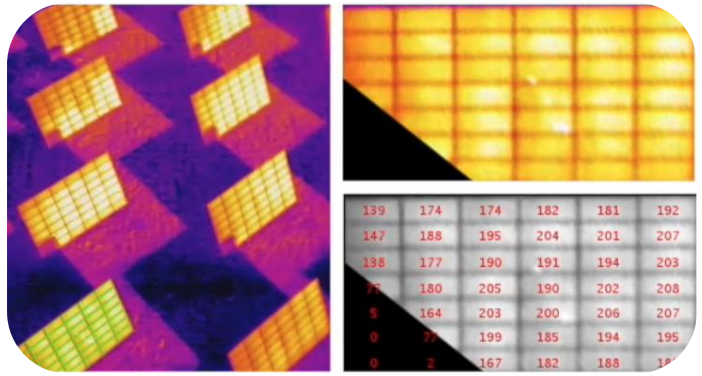
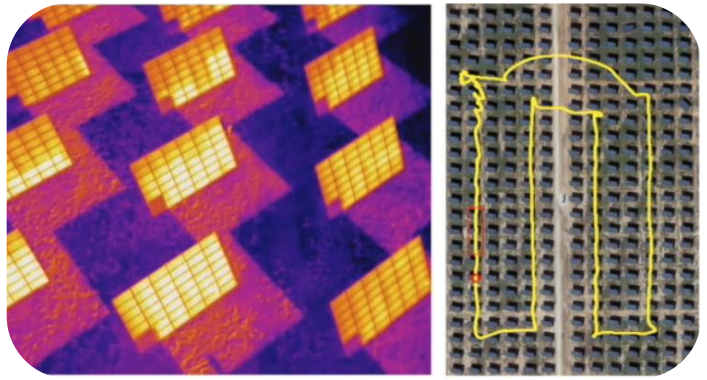
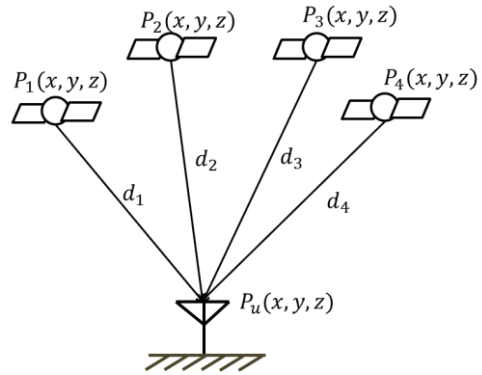


Image Recognition
Machine Learning



UAV autonomous navigation
Computer Vision



Multi-dimensional precision positioning (Not affected by the terrain)

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Case Study – 100MW site in Texas

$8.8MM More Lifetime Production

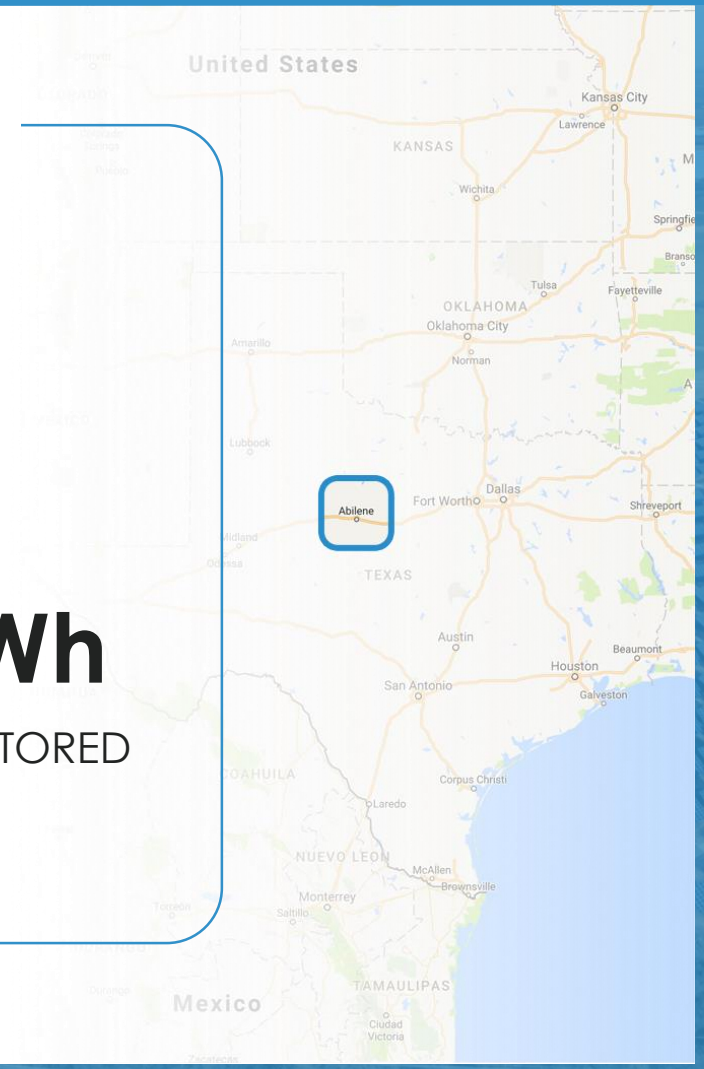
24 HOURS
INSPECTION TIME

3,500
ANOMALIES

423,000
PV MODULES

3.0GWh
ENERGY RESTORED

Based on 100MW Site



"We found problems that may have otherwise have been overlooked for years."

– Jesus, Site Operator

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Vision - Robot Corps

- Robot
- Robot Monkey (MIT Robot Lab)


Mechanical control system
Big data center

- Ultrasonic testing
- Geographic location information calculation
- Multispectral data fusion
- Target recognition and tracking
- Goal Measurement and Analysis

- Driverless Vehicle

Autopilot control system
Big data center

- Mechanical brake module
- Geographic location information calculation
- Positioning: GPS, radar, computer vision


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