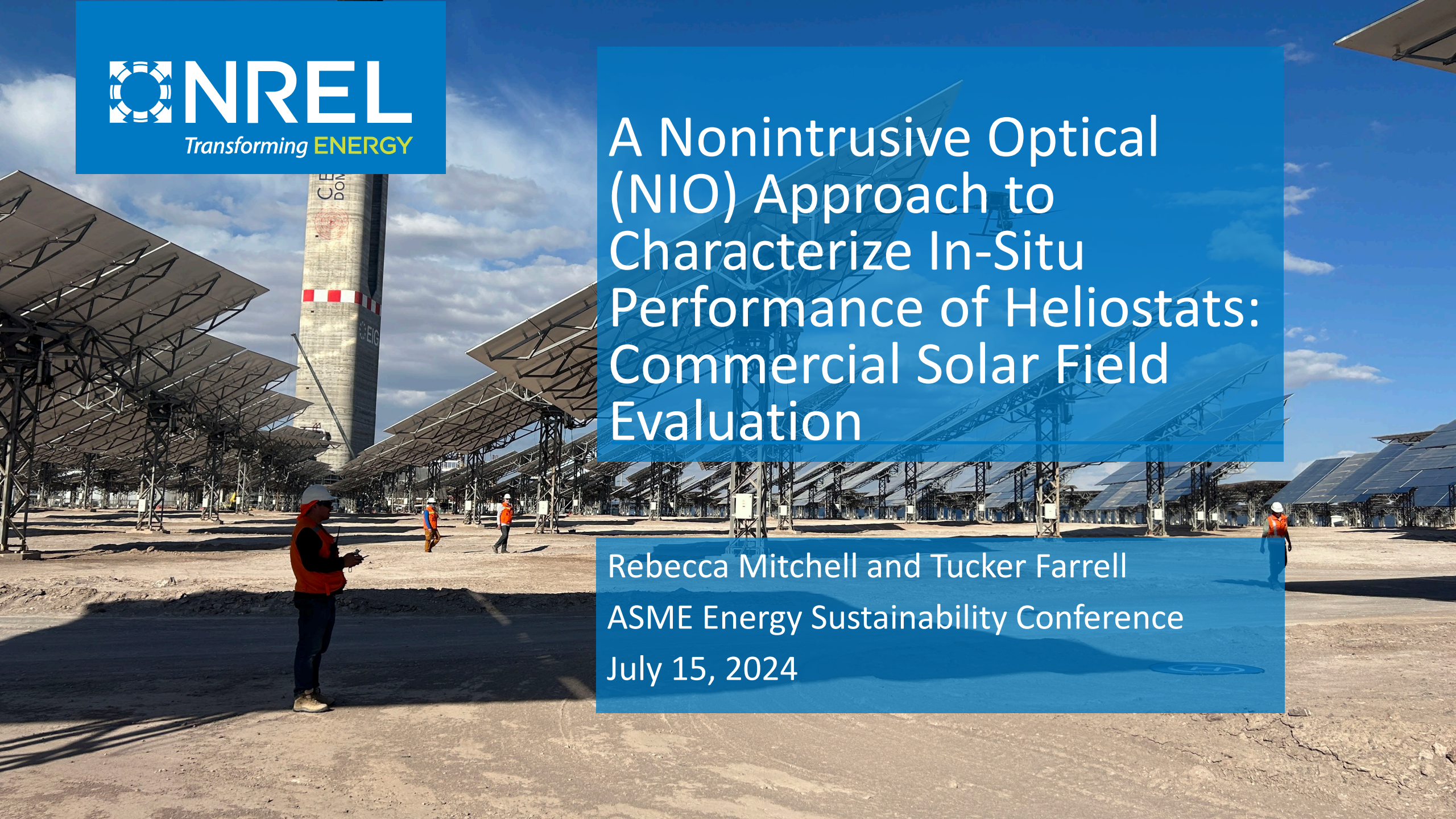


A Nonintrusive Optical (NIO) Approach to Characterize In-Situ Performance of Heliostats: Commercial Solar Field Evaluation

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ASME Energy Sustainability Conference

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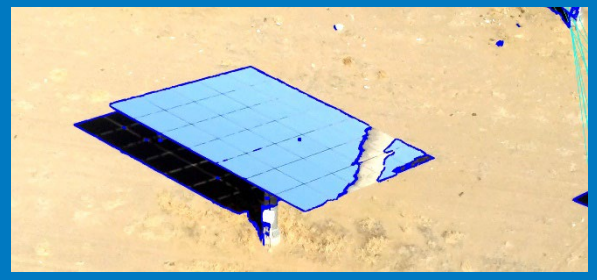
What is NIO

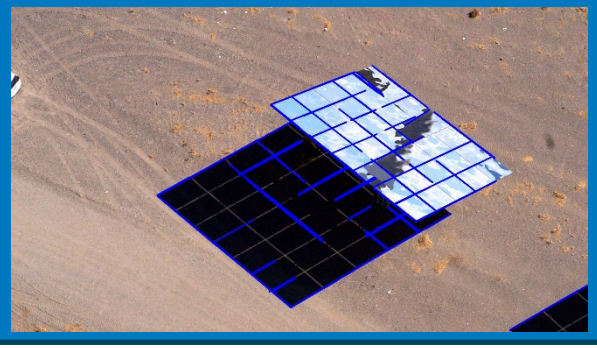
- NIO allows for the efficient optical assessment of a commercial-scale CSP solar field.
- Heliostats are scanned in seconds using Unmanned Aircraft Systems (UAS) imaging.
- The method produces detailed optical characterization data over the full mirror surface for every heliostat (slope, canting, and tracking error).

UAS data collection

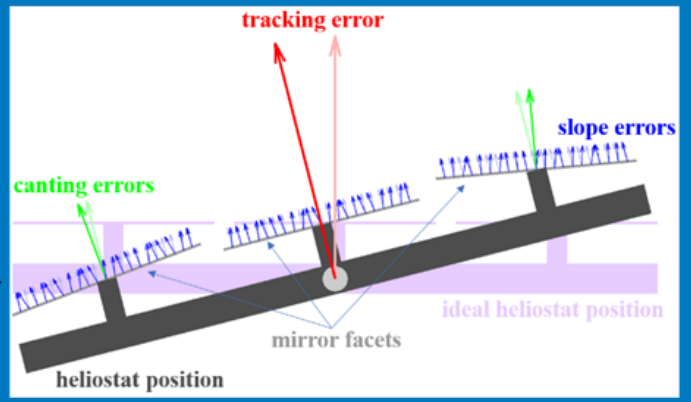


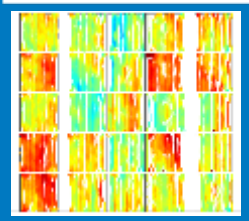
Computer vision and ML image processing





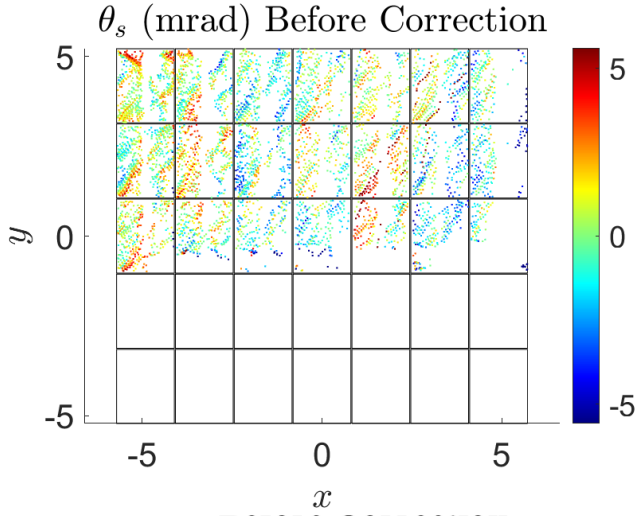
Optical error characterization







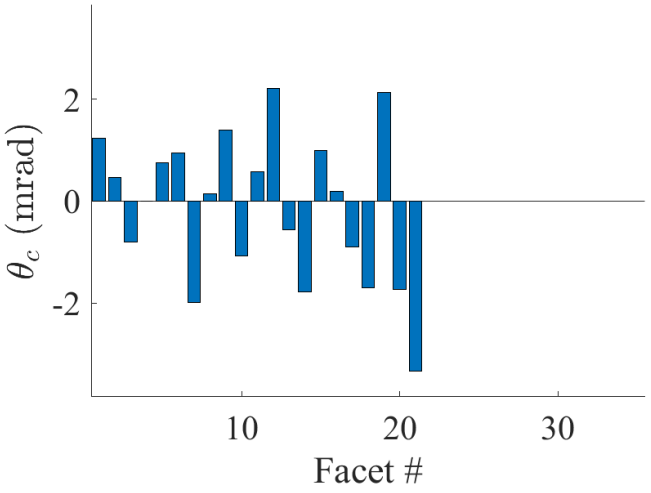
Applying NIO at Crescent Dunes

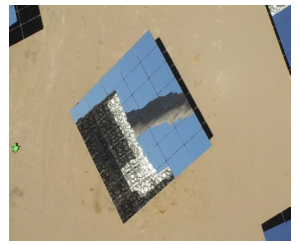












Applying NIO at Cerro Dominador



- ***Largest UAS Scan to date: 10% of the field, over 1100 heliostats***
- ***Scanning 100 heliostats per flight***
- ***Contracted two commercial partners for tool operation***

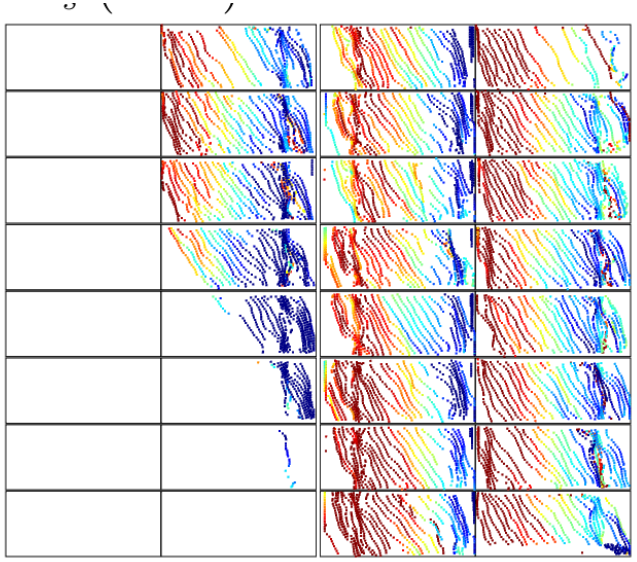
TIETRONIX aerodyne

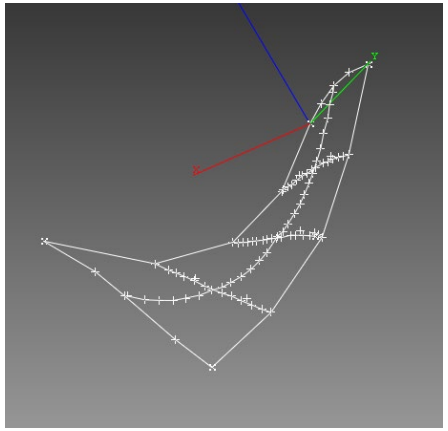
Why Measure Heliostats in the Solar Field?

NREL Transforming ENERGY

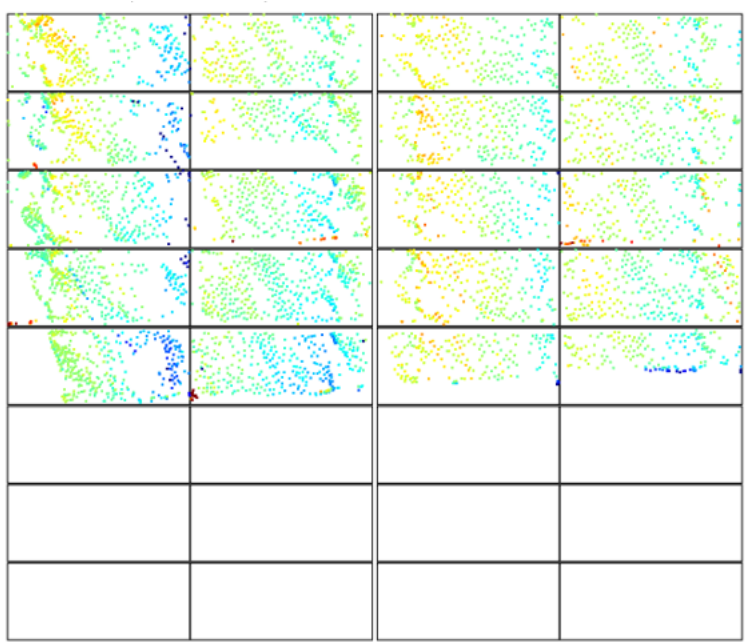
Heliostat warehouse performance ≠ solar field performance

Mirror shape warping



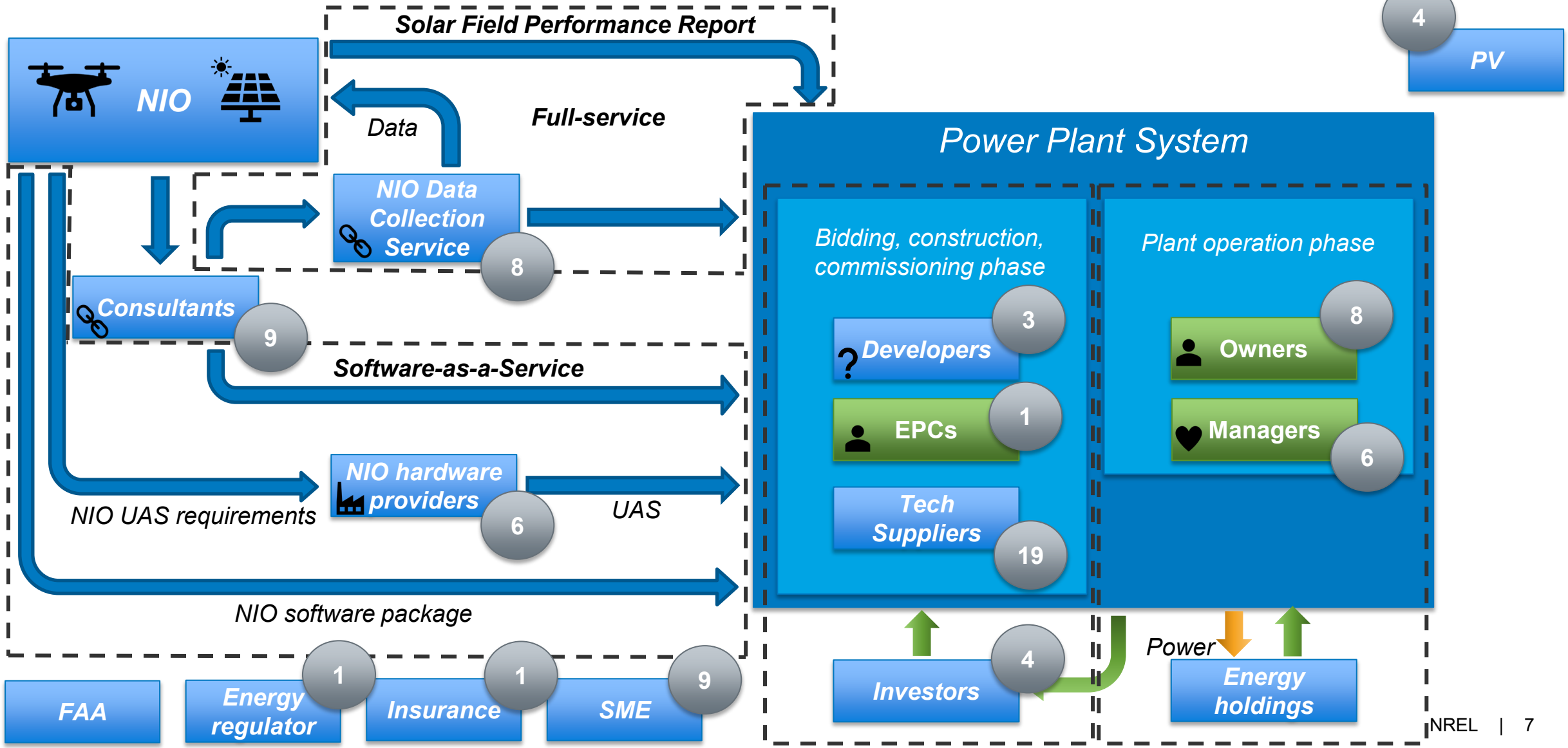


Canting calibration differing from design



Industry Attitudes Toward Solar Field Evaluation

CSP Power Tower Ecosystem



Plant Owners, Managers, and Leaders



Identified Uses of NIO

Solar Field Diagnostics

- Plants have invested heavily in optical performance
- Control system upgrades over multi-million-dollar heliostat adjustment plan.
- Calibration system upgrades to improve heliostat pointing
- BCS calibrations have issues addressing far-field mirrors due to spillage intrusion on target and weak beam at long distance

Solar Field Monitoring

- Not all plants report issues calibrating, but can't measure mirror shape
- Fields are appropriately oversized for losses
- To an extent, consistency is more important than meeting modeled output
- Emphasized reliance on models
- Plants have expressed interest in "knowing the state of the field"



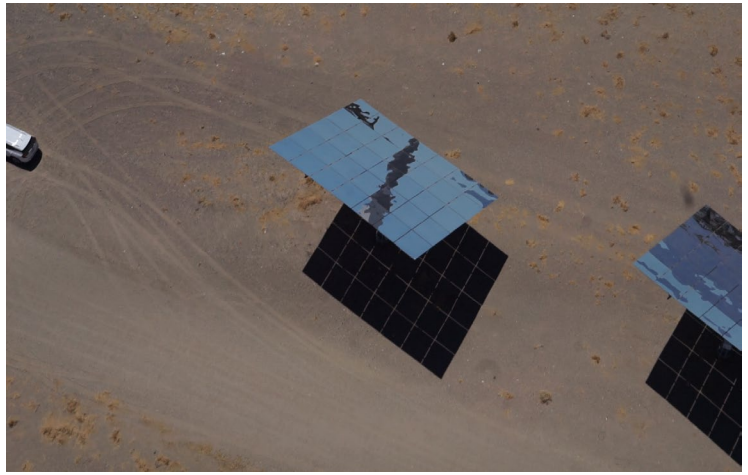
Technology Suppliers



Key Points

Heliostat designers

- 3rd party assessment of optics is highly recommended
- Plants haven't requested in-field validation from the designer
- All design parameters are developed internally (0.5-2 mrad common)
- Not every heliostat is adjustable in the field
- A good heliostat is in the design. In-field adjustments are costly. If they're needed, you're in trouble.



Contractors and Consultants



Key Points

Consultants/Contractors

- Solar field losses are not explicitly characterized, strictly expected vs received power.
- But, models often include itemized loss-budgets based on specs from heliostat designer
- Strong models are crucial for optimization and performance monitoring
- Plants can be overwhelmed with technical issues, must help identify which ones matter
- Performance guarantees are used for commissioning, must hit % of design power.
- Disputes occur when actual watts don't meet design watts – whose component is at fault?
- Contracts are not written with enough technical detail/requirements for optical performance



Main Takeaways for NIO

- Can perform scans of at high-volume and provide detailed optomechanical error data of heliostats in a commercial solar field environment
- Need to convince plant managers/owners of the value of heliostat evaluation
- Next steps for NIO:
  - Comparison of NIO results with commercial field calibration/measurement systems
  - Comparison testing with new BCS target at NREL's Flatirons campus

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Thank You

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United States

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Next Seminar September 27th!

HelioCon Seminar Series: Challenges and Solutions in Heliostat Optical Metrology
Speaker: Dr. Randy Brost, SNL
When: 1-2 pm MDT Wednesday September 27th
Zoom: https://nrel.zoomgov.com/j/1613394621

