U.S. Department of Energy
HelioCon
Heliostat Consortium for Concentrating Solar-Thermal Power

An International Heliostat Consortium (HelioCon): Progress Highlight in 2023

Guangdong Zhu, NREL

On behalf of HelioCon team

October 11th, 2023 • SolarPACES 2023 • Sydney, AU

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HelioCon: Team

- Leadership team:
  - NREL researchers and administrative support
    - Lead: Guangdong Zhu, Ph. D.
  - Sandia researchers
    - Lead: by Margaret Gordon, Ph.D.
- Non-voting members:
  - ASTRI: Australian Solar Thermal Research Institute
- Board of Advisors
  - Utility, developers, plant owners, component suppliers, EPCs, Academia, standards and international advisors
- Members
  - RFP awarded project performers
  - Other Consortium funded project performers and cost-share providers.
- Non-consortium stake-holders
  - Subject-matter experts; U.S. and international institutions.

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE

NREL Transforming ENERGY

Sandia National Laboratories

ASTRI Australian Solar Thermal Research Institute

CSIRO

Australian National University

THE UNIVERSITY of ADELAIDE

QUT

SolarDynamics

THE UNIVERSITY OF NEW MEXICO

THE UNIVERSITY OF ARIZONA

Northeastern University

SARCOS

TIETRONIX

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A Glance of Sub-Team at NREL


Chad Augustine


Raven Barnes


Miriam Coron


Jack deBloois

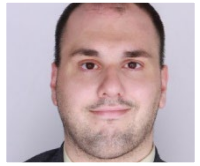

Mackenzie Dennis


Rebekah Durand


Ulrike Egerer

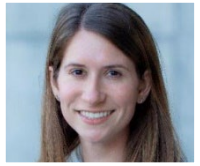

Tucker Farrell


Cindy Gerk


Mike Grabel

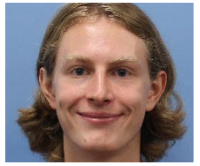

Patrick Hayes


Kyle Heinzman


Maggie Kautz


Mojo Keshiro


Devon Kesseli


Louis King


Parthiv Kurup


Dylan Mayes


Mark Mehos


Rebecca Mitchell

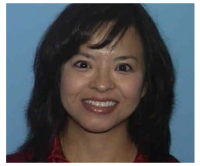

Matt Muller


Jessica Roe

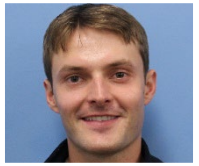

Gabriel Shuster


Katelyn Spadavecchia


Brooke Stanislawski


Linh Truong


Daniel Tsvankin


Evan Westphal


Shashank Yellapantula


Guangdong Zhu


Alex Zolan

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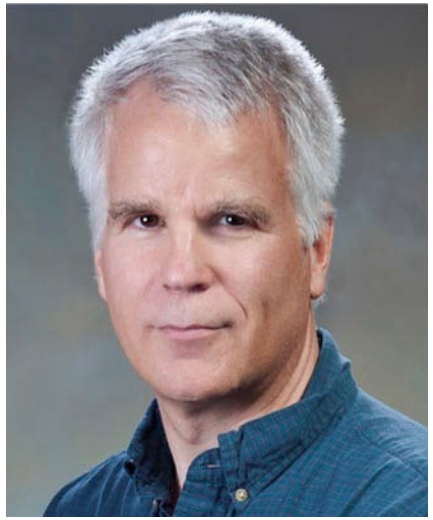
A Glance of Sub-Team at Sandia

Jeremy Sment

Margaret Gordon



Randy Brost

Kenneth Armijo

Braden Smith

Rebecca Schaller

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A Glance of Sub-Team at ASTRI

Mike Collins - CSIRO

Joseph Coventry - ANU

Matthew Emes - Adelaide

Michael Cholette - QUT

Dominic Zaal - ASTRI

Giovanni Picotti - QUT

John Pye - ANU

Michael Rae - CSIRO

Maziar Arjomandi - Adelaide

Ye Wang - ANU

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A Glance of Sub-Team from RFP Projects

Kyle Kattke – SD SunRing

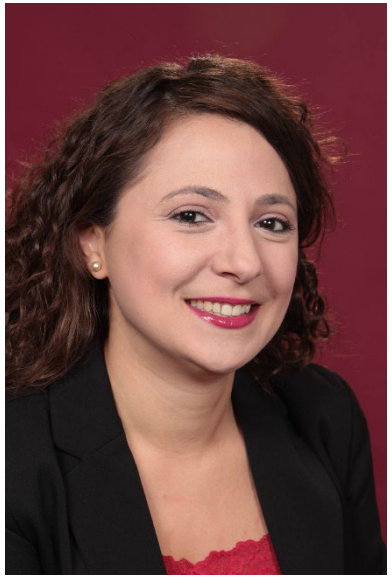
Rick Sommers – SD Wireless

Roger Angel - UAz

Hank Price – SD SunRing

Eric Belski - Sarcos

Hameed Metghalchi - Northeastern



Eirini Eleni Tsiropoulou - UNM

Michel Izygon - Tietronix

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Outline

- HelioCon management
- **Metrology & standards**
- **Components & controls**
- **Field deployment**
- **Techno-economic analysis**
- **Resources, Training and Education**
- RFP projects
- Not HelioCon, but related

Outline

- **HelioCon management**
  - **HelioCon website**
  - **HelioCon seminars**
- Metrology & standards
- Components & controls
- Field deployment
- Techno-economic analysis
- Resources, Training and Education
- RFP projects
- Not HelioCon, but related

Project: HelioCon Website

- **Objectives**
  - Create a place to promote the heliostat technology and its application
  - Create a place to share the resources with the public
- **Approaches**
  - An independent website with prompt updates
- **Status**
  - Fully developed website framework
  - Timely update the contents
  - increasing visits
- **Leads:** Cindy Gerk, Patrick Hayes, NREL

HelioCon.org

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Project: HelioCon Seminars

- **Objectives**
  - Share the knowledge and insights of top-notch experts to the whole communities
- **Approaches**
  - Host, record and share seminars with the public
- **Status**
  - 16 expert seminars
  - 2 training seminars
- **Lead:** Rebecca Mitchell, NREL

HelioCon Seminar Videos

Date	Title	Instructor	Video Link	Training Documents
April 10, 2023	CSP Tower Technology: 10+ Years of Innovation and 35+ Years of Mature Prior Innovation	Yoel Gilon	video	Slides, Flyer
March 1, 2023	Introduction of the 2022 CSP Blue Book of China	Zhifeng Wang	video	Slides, Flyer
February 1, 2023	Solar Field for CSP Tower Technology: Best Practices and Lessons Learned in Operational Commercial Projects	Raul Gonzalez Marcelo	video	Slides, Flyer
November 9, 2022	Mitigating Unconscious Bias in Work Teams	Anelisa Simons SNL	video	Slides, Flyer
October 19, 2022	Transferring Photovoltaic lessons learned to Concentrating Solar Power	Dr. Matthew Muller, NREL	video	Slides, Flyer
August 11, 2022	Advanced Manufacturing for Heliostats – What We Can Learn from Automotive Joining Technologies, Materials, and Automation	Wagon Wills, Gonzalez Group Dr. Randy Brost, Sandia	video	Slides, Flyer
August 1, 2022	13 HelioCon Interns, NREL/SNL/DOE	13 HelioCon Interns, NREL/SNL/DOE	video	Slides, Flyer
July 13, 2022	Heliostat Aerodynamics and Wind Load: Characterization and Prediction in Atmospheric Boundary Layer	Matthew Emes, University of Adelaide	video	Slides, Flyer
June 29, 2022	Soiling Losses for Concentrating Solar Power – Prediction, Assessment, and Mitigation	Dr. Michael Cholette, Queensland University of Technology	video	Slides, Flyer
June 8, 2022	Bottom-up Analyses for Two Heliostat Collectors and an Initial Heliostat Supply Chain	Parthiv Kurup, NREL	video	Slides, Flyer
May 18, 2022	Heliostat Components and Controls	Dr. Ken Armijo, Sandia	video	Slides, Flyer
April 13, 2022	Economies of Scale – Field Deployment Considerations to Accommodate Evolving Energy Markets	Dr. Jeremy Sment, Sandia	video	Slides, Flyer
March 30, 2022	What's Looking Up Down Under? Progress of Australian Solar Thermal Research Institute (ASTRI) Heliostat Activities	Mike Collins, CSIRO Energy	video	Slides, Flyer
March 16, 2022	Resources, Training, and Education for the Heliostat Workforce	Dr. Rebecca Mitchell, NREL	video	Slides, Flyer
February 16, 2022	An Undervalued Foundation for Heliostat Technologies - Optical Characterization, Modeling, and Measurement	Dr. Guangdong Zhu, NREL	video	Slides, Flyer
February 3, 2022	Technoeconomic Analysis of Heliostat Technologies	Dr. Chad Augustine, NREL	video	Slides, Flyer
January 12, 2022	CSP Capabilities at the National Renewable Energy Laboratory	Mark Mehos, NREL	video	Slides, Flyer
December 8, 2021	CSP Capabilities at Sandia National Labs	Dr. Margaret Gordon, Sandia	video	Slides, Flyer

HelioCon Training Videos

Date	Title	Speakers	Video Link	Seminar Documents
May 19, 2022	HelioCon SolTrace Tutorial Session I: A Beginner's Overview	Al Lewandowski	video	Files
August 1, 2022	HelioCon SolTrace Tutorial Session II: Implementing Advanced Geometries	Al Lewandowski	video	Files

Outline

- HelioCon management
- **Metrology & standards**
  - **OpenCSP**
  - **SOFAST**
  - **NIO technology**
  - **ReTNA technology**
  - **NREL third-party platform development**
  - **Slope error data reporting**
  - **Slope error conversation from photogrammetry**
  - **Soiling measurement**
  - **Heliostat shape estimation**
  - **Mirror soiling**
- Components & controls
- Field deployment
- Techno-economic analysis
- Resources, Training and Education
- RFP projects
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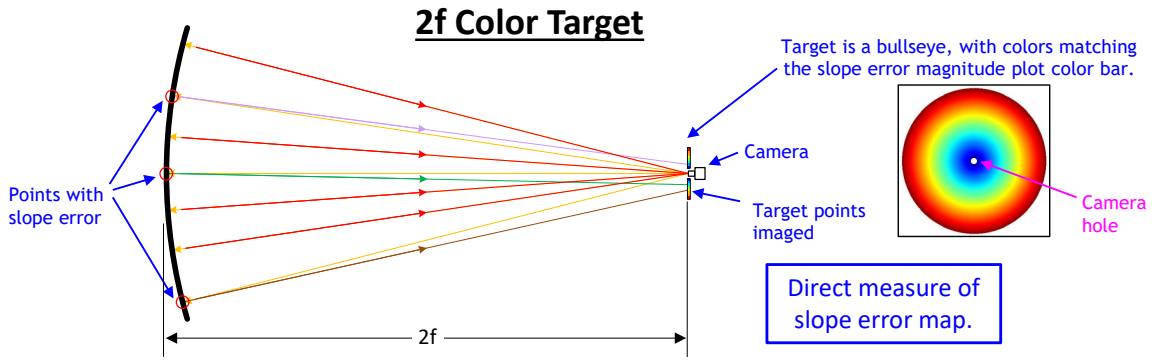
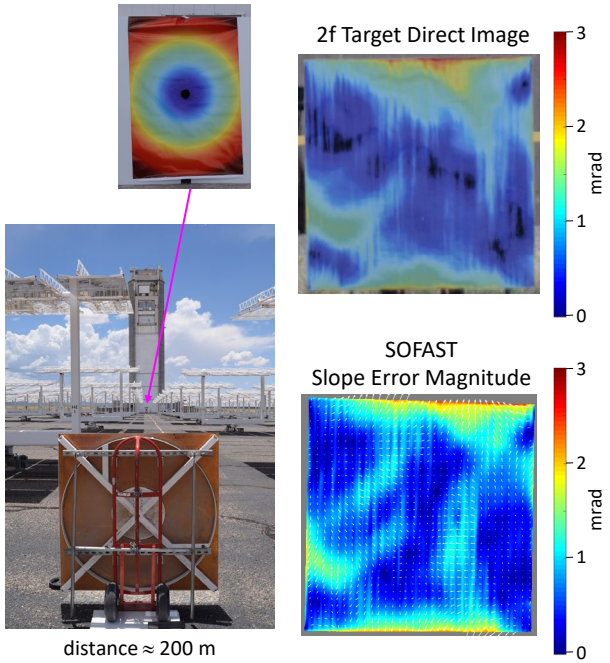
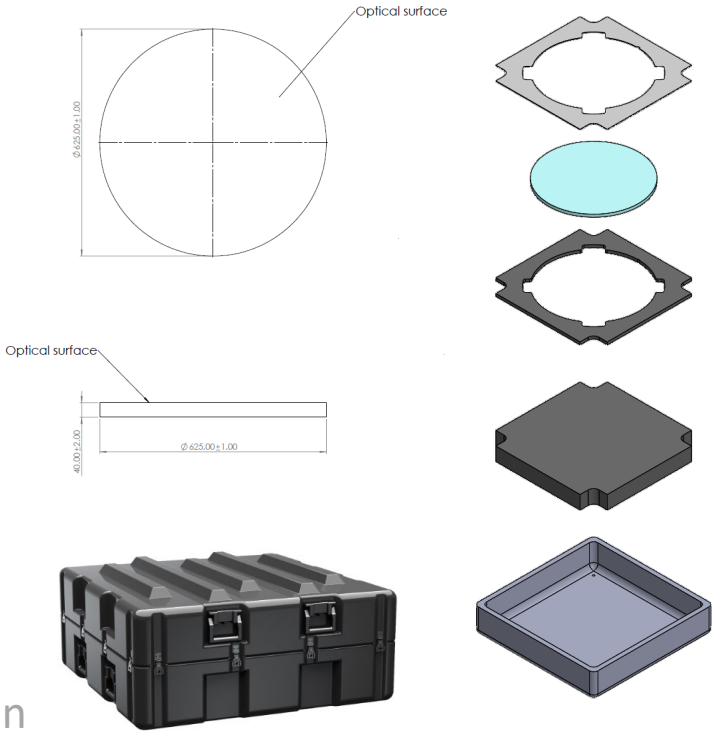
Project: OpenCSP

- **Objectives:**
  - Establish a community library of CSP foundation classes, algorithms and applications
- **Approach:**
  - Develop the coding standards
  - Establish foundation classes, core algorithms and automated tests
  - Promote community collaboration to develop and, when ready, release new applications to the whole CSP community
- **Status:**
  - Established foundation for OpenCSP diagnostics
  - In next year, to release first version of OpenCSP and ground truth for wide use
- **Lead:** Randy Brost, Sandia





f = 100 m Calibration Mirror Design



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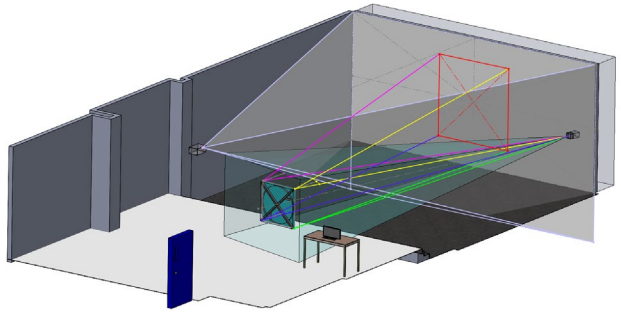
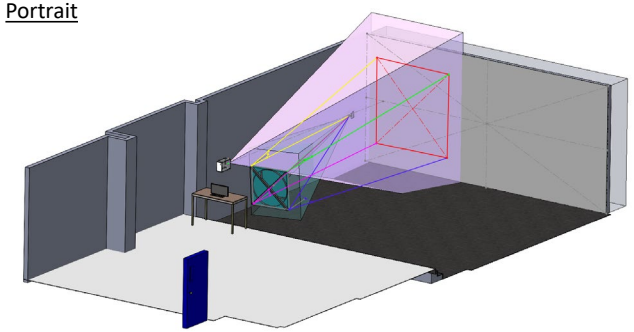
Project: SOFAST Upgrades

- **Objectives**
  - High-resolution, fast, slope measurement for both facets and full heliostats.
  - Suitable for:
    - Prototype development
    - Manufacturing process development
    - High-volume factory production
  - Multiple improvements in code quality, extensibility, flexibility, ease of use, application to key new problems.
- **Approach**
  - Deflectometry.
  - High-quality code, simplify calibration.
  - Check against ground truth.
- **Status**
  - Version 1 in commercial use.
  - Version 2 nearing completion.
- **Lead:** Randy Brost, Sandia

Landscape



Portrait



Ideal Design

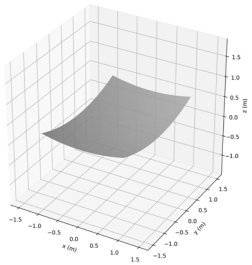
$$z = \frac{x^2}{4f_x} + \frac{y^2}{4f_y}$$

$f_x = 100$ m

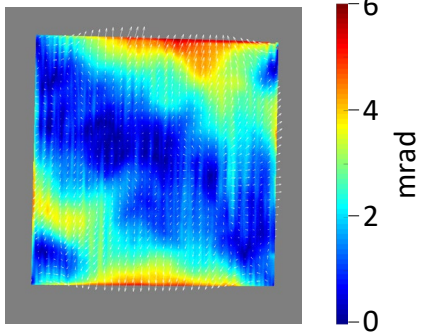
$f_y = 100$ m

$l_x = 1.22$ m

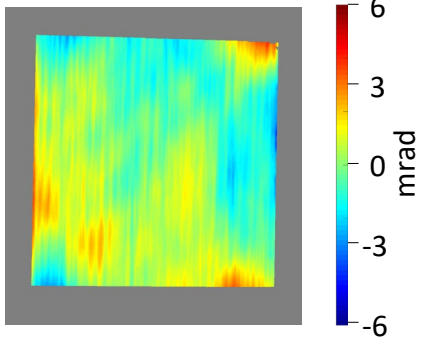
$l_y = 1.22$ m



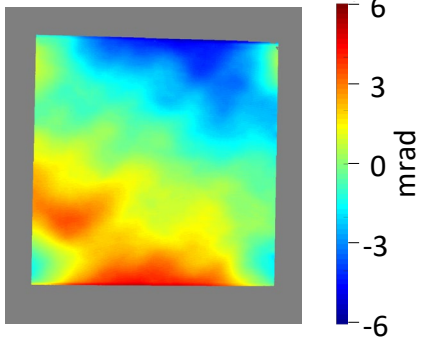
Slope Error Magnitude



X Slope Error

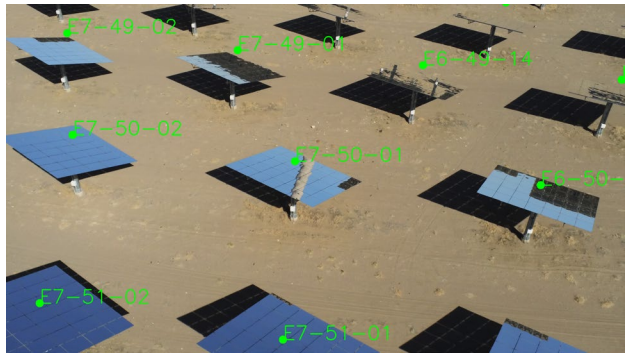


Y Slope Error



Project: NIO Technology

- **Objectives**
  - In-situ technology suitable for utility-scale heliostat fields
  - Measure slope error, canting error and tracking error
- **Approach**
  - Drone-driven camera
  - Reflectometry
  - Automated image-processing through computer vision and machine learning
- **Status**
  - Entering into demonstration stage
    - NSTFF (done)
    - Crescent Dunes (done)
    - Cerror Dominador (planned)
- **Leads:** Tucker Farrell, Rebecca Mitchell, NREL



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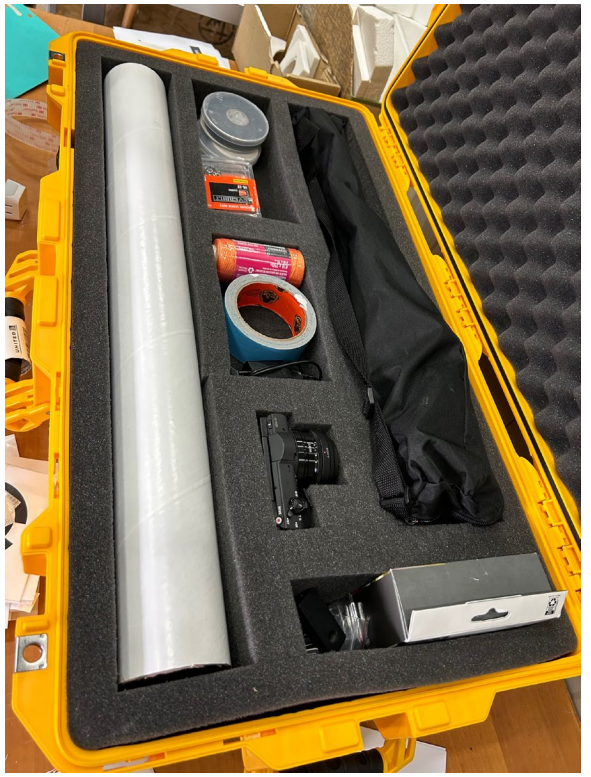
Project: ReTNA Technology

- **Objectives**
  - Laboratory technology suitable for single heliostat prototype
  - Portable, efficient and automatic
  - Measure slope error, canting error
    - Varying orientation
    - Varying load
- **Approach**
  - Deflectometry & photogrammetry
  - Automated image-processing through computer vision and machine learning
- **Status**
  - Completed concept-proof stage
  - Building a prototype at NREL
- **Lead**: Devon Kesseli, NREL



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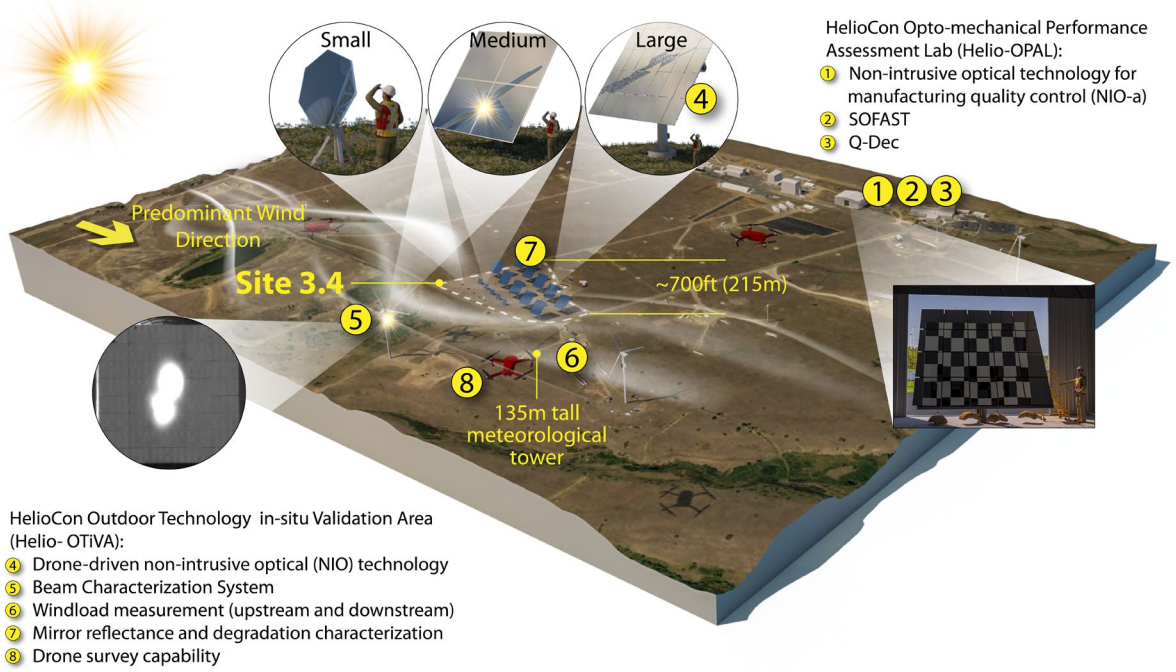
Project: Third-Party Evaluation Platform at NREL's Flatirons Campus

- **Objectives**
  - Make available third-party heliostat performance assessment capabilities to serve CSP industry.
    - evaluation of heliostat designs under indoor and outdoor conditions
    - validation of newly developed metrology technologies by others
- **Approach**
  - Develop/acquire, install and calibrate most-advanced metrology technologies within HelioCon
  - Demonstrate the test capability with a case study
  - Call for test services on commercial heliostat designs
- **Status**
  - Developing new techniques
- **Lead**: Rebecca Mitchell



Project: Slope Error Data Processing & Reporting

Objectives

- Standardise methods for slope error data processing and reporting

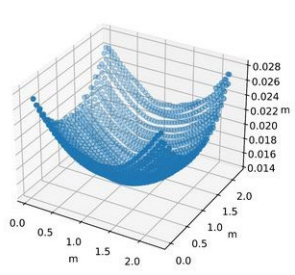
Approach

- Develop software tools for data processing and reporting
- Test against shared data sets
- Release library as open source (pending approval)

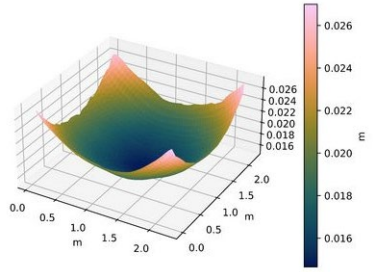
Status

- Software tools developed and tested on CSIRO point cloud surface data. Initial results shared with Heliocon

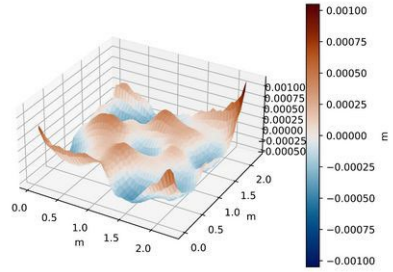
Leads: Mike Collins, Calum Acutt, CSIRO



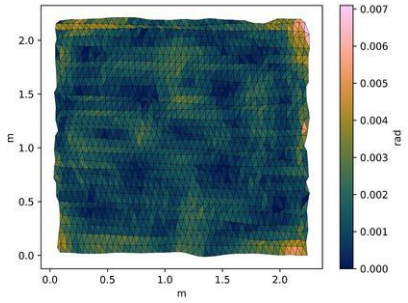
Raw Points



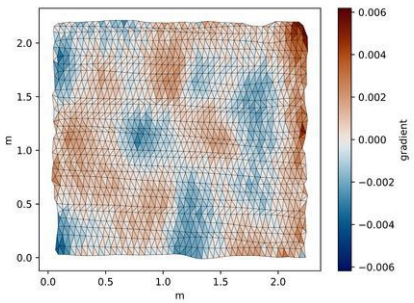
Mesh of Raw Data



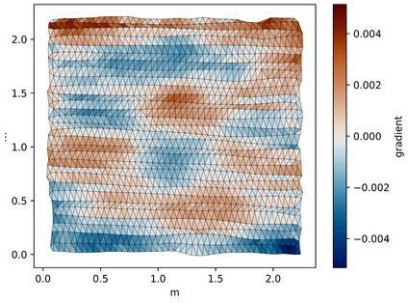
Z error (circular best fit paraboloid)



Slope error 2d



Slope error x direction



Slope error y direction

Project: Slope errors from photogrammetry

Australian National University

Objective

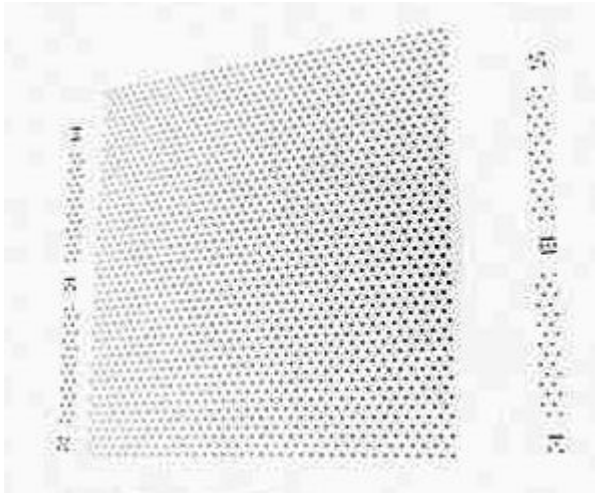
- To implement, as open source code, a method for converting photogrammetry point-cloud data to equivalent slope error values.

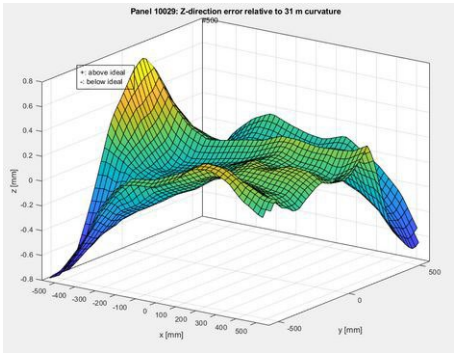
Approach

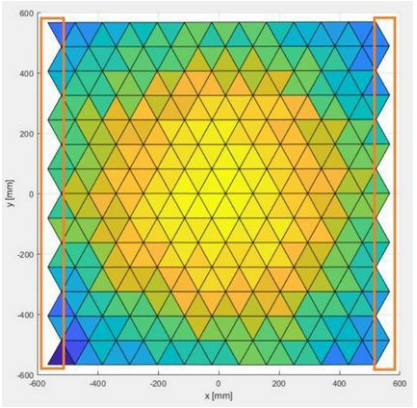
- Acquire point-clouds from images using projected or adhered dots and process using commercial “VMS” photogrammetry tool.
- Implement a new Python script based on previous IDL/Matlab ANU code: Delauney triangulation, axis alignment, paraboloid fitting, residual fitting to Rayleigh and Normal distributions.

Status

- Initial code developed and shared at https://github.com/anustg/Solar_concentrator_optics.git
- Next: close the loop also by cross-checking flux mapping and ray tracing.



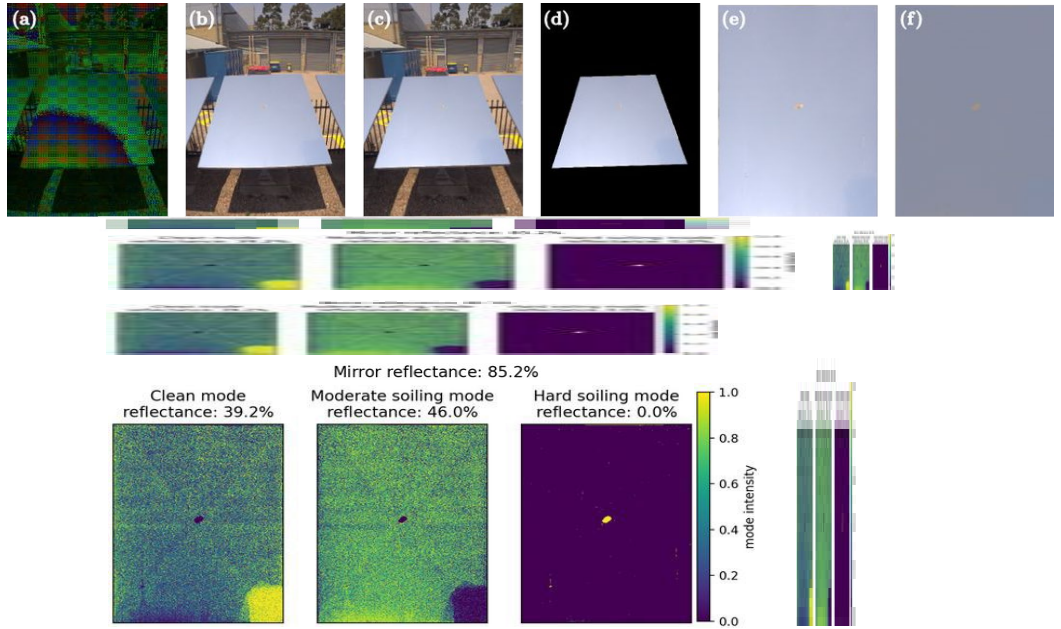


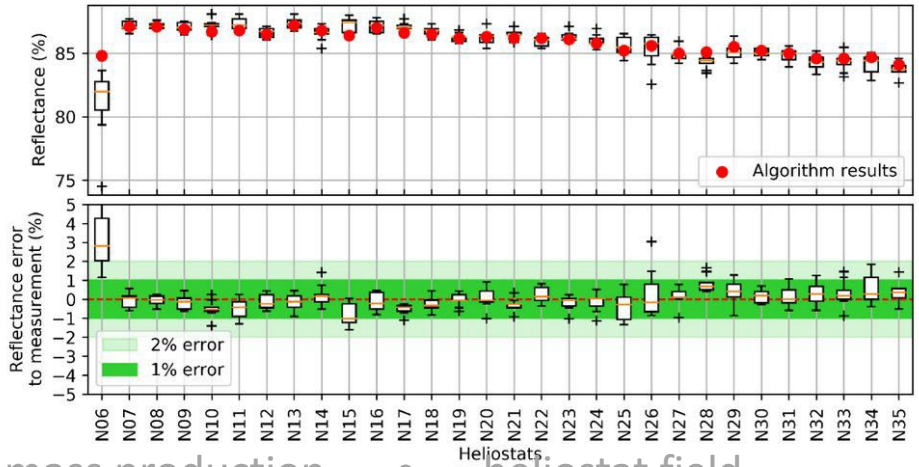


Leads: Johannes Pottas, Ye Wang, John Pye, Joe Coventry, ANU

Project: Soiling estimation from DSLR images

- **Objectives:**
  - Develop a cost-effective way to significantly improve the spatial and temporal resolution of soiling loss estimation.
- **Approach:**
  - Use an original color-space processing method to estimate mirror reflectance and soiling loss.
  - Gather camera images and reflectometer-based soiling measurements from multiple heliostat technologies and sites to test the method.
- **Status:**
  - Controlled conditions result in <1% error in reflectance estimation.
  - Currently evaluating the impact of the image acquisition parameters on the accuracy of the method.
- **Leads:** Charles-Alexis Asselineau & Joe Coventry





Australian National University

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Project: Using BCS for Heliostat Shape Estimation

Objective

- To use images from a beam characterisation system (BCS) for in- situ heliostat shape and slope error measurements and spillage quantification

Approach

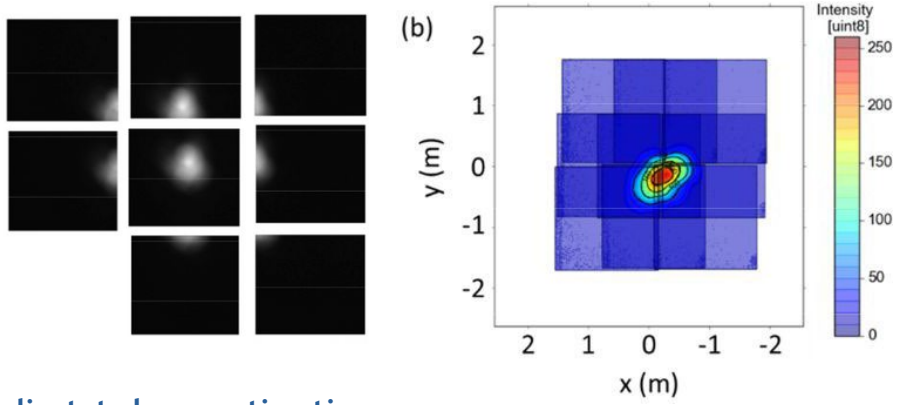
- Acquire beam images of a heliostat at different times of a day using BCS
- Matching the flux distributions from ray-tracing and image data by optimising the shape of the heliostat that is governed by coefficients of a quadric equation

Status

- Streamlined software process has been developed and applied to flux image data previously acquired at Vast Solar (Australia)
- New image data were acquired at IMDEA (Madrid, Spain) and are being processed to validate against deflectometry data

Leads: Ye Wang, Charles-Alexis Asselineau, Joe Coventry and John Pye

1. Image acquisition using BCS (with stitching if necessary)



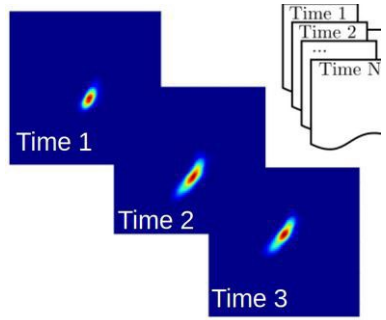
2. Heliostat shape estimation

$$z = ax^2 + by^2 + cxy$$

$$\begin{bmatrix} x^2 y^2 & x^2 y & x^2 \\ x y^2 & xy & x \\ y^2 & y & 1 \end{bmatrix}$$

Image data

ray tracing flux maps



Obtain the optimal *a*, *b*, *c* that minimise the difference in flux distributions

3. Optical performance of the entire field

N heliostats (*N* sets of {a,b,c}) → Randomly distributed in the field → Annual optical performance → Equivalent slope error

conceptual design • components • integration • mass production • heliostat field

Australian National University

Project: Mirror Soiling

Technical

- Complete a benchmarking study with different soiling models (underway now)
- Dust sampler installation at NSTTF and a long-term soiling campaign
- First camera-based soiling measurements at
- Workshop to get input and contributions for soiling database (via follow-up with contacts in SolarPACES Task III and other previous outreach efforts).
- Soiling campaigns in Port Augusta, South Australia (travel funding permitting)
- Activities to better understand soiling processes to support site selection:
    - Experiments on effects of moisture on adhesion and deposition
    - Refinement of reflectance model via Mie Scattering
    - Experiments at the ABLRF to understand key atmospheric boundary layer conditions that affect soil deposition
- Begin work on including cleaning considerations in design of plant (receiver capacity, solar field size/layout)

Soiling Rig at the Atmospheric Boundary Layer Research Facility

Engagement with Industry and Researchers

- Continue engagement with Vast Solar on soiling
- Visit to PSA by QUT PhD student Cody Anderson
- Participation (and NREL leadership within) SolarPACES Task III
- Seek out more companies designing cleaning systems

QUT Queensland University of Technology

Publications and reports

- Submit a paper on cleaning optimization work with Ivanpah (will require partner permission)
- Submit paper on moisture effects
- Submit a paper on the soiling predictive model benchmarking

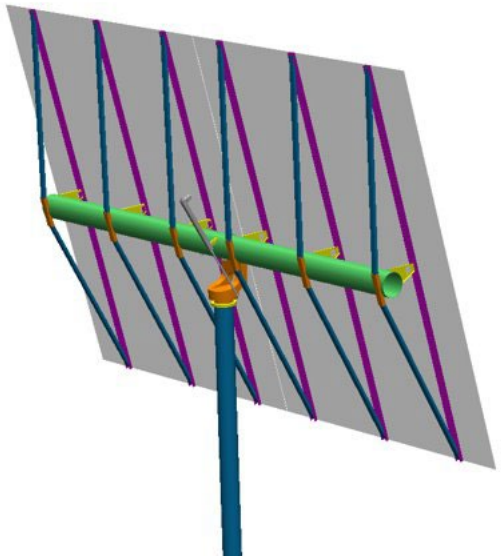
Leads: Michael Cholette, QUT

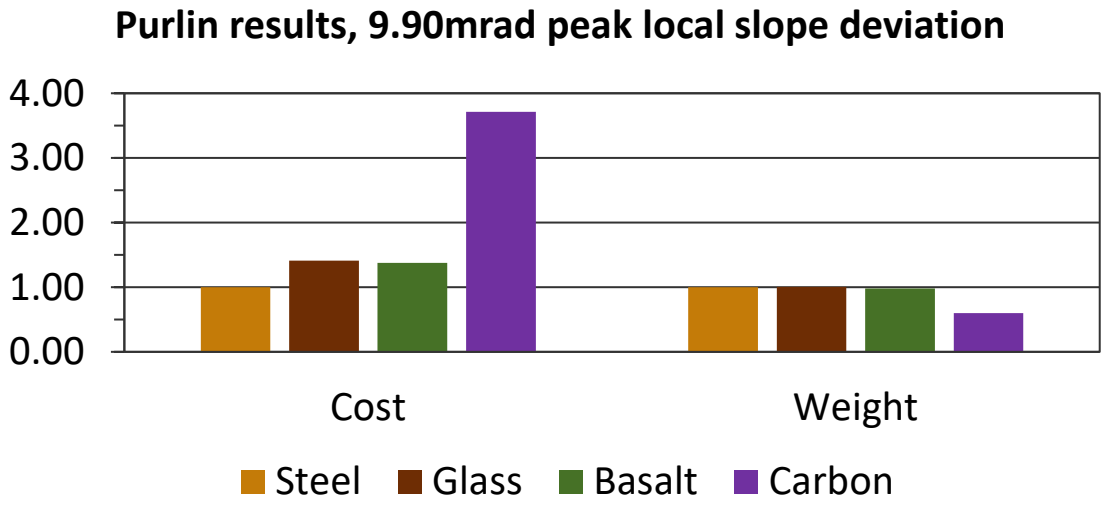
Outline

- HelioCon management
- Metrology & standards
- **Components & controls**
  - **Composite heliostat design evaluation**
  - **Solar field closed-loop control testbed**
  - **Heliostat design qualification standard**
- Field deployment
- Techno-economic analysis
- Resources, Training and Education
- RFP projects
- Not HelioCon, but related

Project: Composite Heliostat Design Evaluation

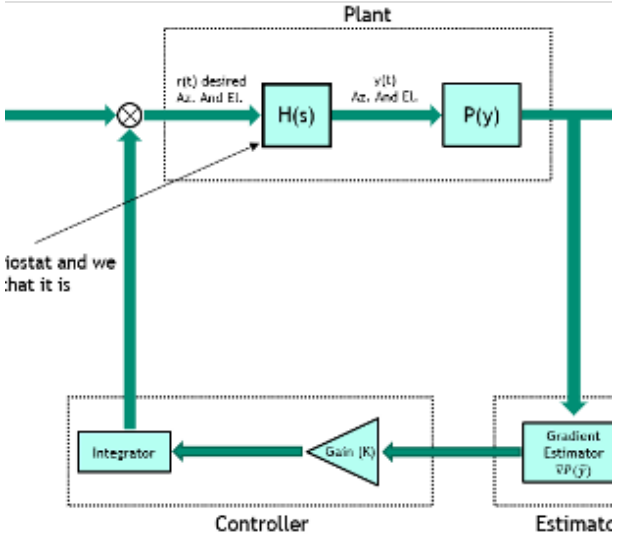
- **Objectives**
  - Evaluate potential of composite materials for heliostat mirror facets and structure for meeting the DOE cost target goal: $50/m2
- **Approach**
  - Perform initial design optimization for reducing heliostat cost
  - Carry out cost comparison between composites and the state of art materials/design
- **Status**
  - Initial results discourage use of unidirectional composites; structural facets (sandwiched composites) or alternatively-designed heliostats optimized for composite beams suggested
- **Leads:** Matt Muller, NREL





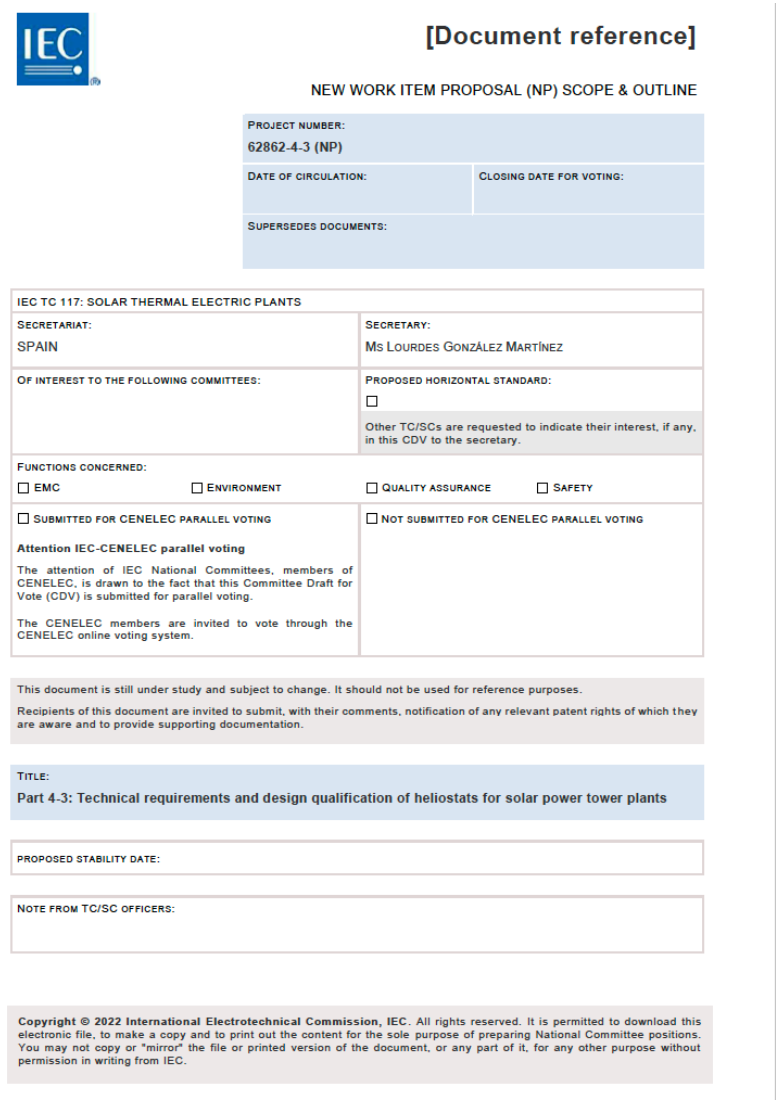
Project: Heliostat field closed-loop control system testbed development

- **Objectives**
  - Develop a closed-loop control system testbed to assess the durability of heliostat components and closed loop controls, and ensure their qualities under realistic operational conditions in future commercial projects
- **Approach**
  - Upgrade Sandia's NSTTF heliostat field with respect to both software and hardware
  - Develop new control software able to accommodate real-time heliostat aiming and closed loop feedback algorithm.
  - Develop new communication infrastructure for wireless communication test
- **Status**
  - The testbed is in the design stage
  - Software architectures utilized to determine optimal pointing of each heliostat, accounting for unique metrology considerations
- **Lead**: Ken Armijo, Sandia



Project: Heliostat Design Qualification Standard

- **Objectives**
  - Develop a standard on: Technical requirements and design qualification of heliostats for solar power tower plants
- **Approach**
  - NREL is co-leading the development with Cosin Solar from China
- **Status**
  - Working group has been formed
  - New standard proposal was just submitted to IEC for the NP approval.
- **Lead**: Daniel Tsvankin, NREL



IEC

[Document reference]

NEW WORK ITEM PROPOSAL (NP) SCOPE & OUTLINE

PROJECT NUMBER:
62862-4-3 (NP)

DATE OF CIRCULATION: | CLOSING DATE FOR VOTING:

SUPERSEDES DOCUMENTS:

IEC TC 117: SOLAR THERMAL ELECTRIC PLANTS

SECRETARIAT:
SPAIN

SECRETARY:
MS LOURDES GONZÁLEZ MARTÍNEZ

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:
☐
Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:
☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY

☐ SUBMITTED FOR CENELEC PARALLEL VOTING

Attention IEC-CENELEC parallel voting

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.

The CENELEC members are invited to vote through the CENELEC online voting system.

☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:
Part 4-3: Technical requirements and design qualification of heliostats for solar power tower plants

PROPOSED STABILITY DATE:

NOTE FROM TC/SC OFFICERS:

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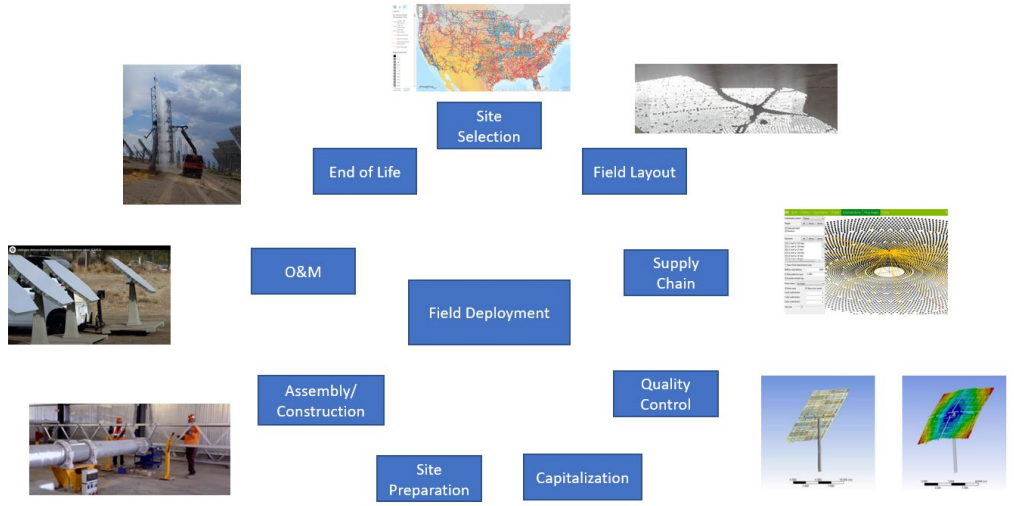
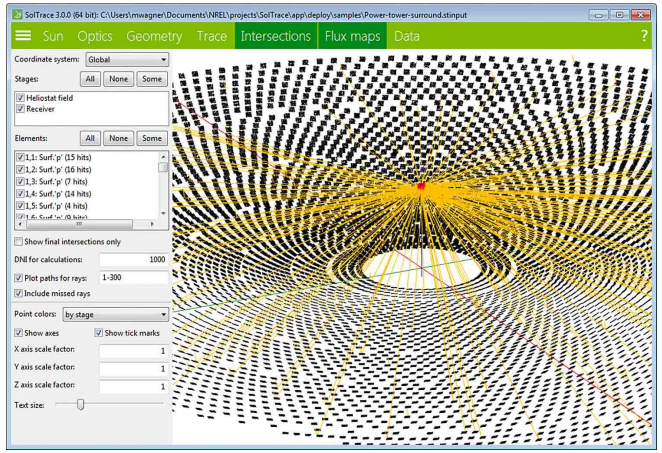
Outline

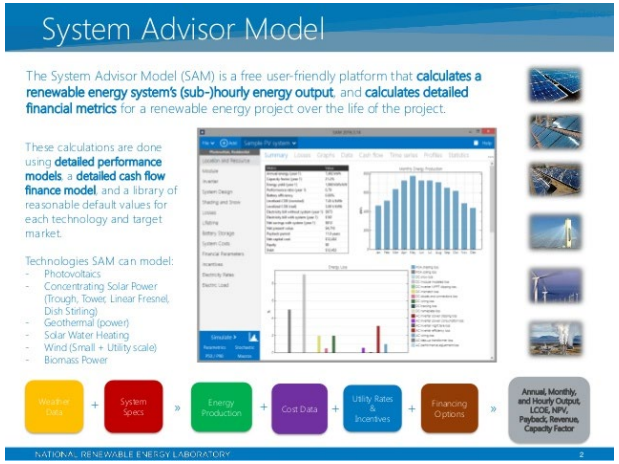
- HelioCon management
- Metrology & standards
- Components & controls
- **Field deployment**
  - **Third-party high-fidelity solar field performance prediction model**
  - **Analysis of Heliostat O&M at Ivanpah**
  - **Ecological impacts**
  - **Wind load characterization**
- Techno-economic analysis
- Resources, Training and Education
- RFP projects
- Not HelioCon, but related

Project: High-Fidelity Performance Model

- **Objectives**
  - High-fidelity performance model to fill the gap between project developers and investors
- **Approach**
  - Define required site-specific data
  - Define required heliostat and heliostat field data
  - Define performance output metrics with associated uncertainties
  - Integrate a suite of modeling tools with necessary improvement
- **Status**
  - Identifying key sources of uncertainty in performance models
- **Lead**: Alex Zolan, NREL





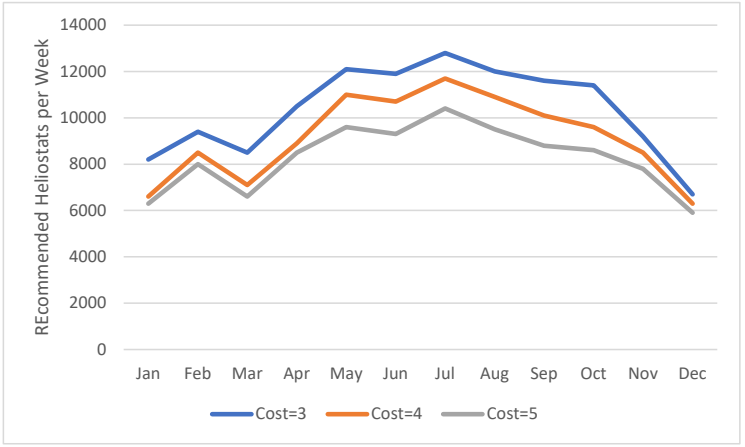


conceptual design • components • integration • mass production • heliostat field

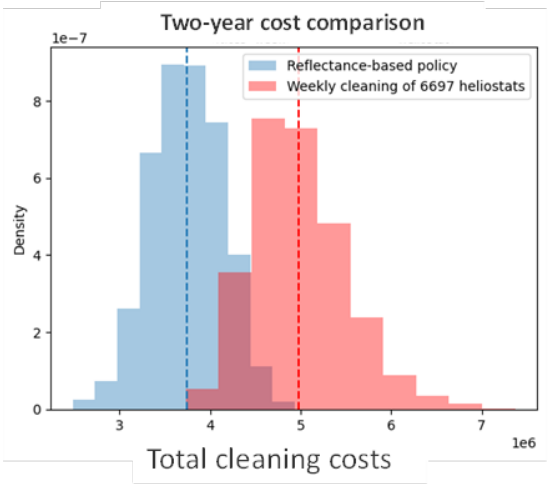
Project: Analysis of Heliostat O&M at Ivanpah

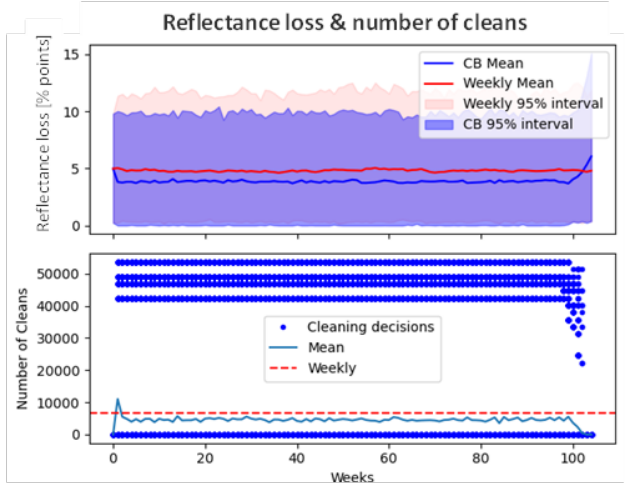
- **Objectives**
  - Obtain field measurements at an operating facility to observe soiling conditions
  - Compare performance of measurement devices and analyze mirror cleaning activities
- **Approach**
  - Obtained >500 measurements across ~120 heliostats in solar field of Unit 1
  - Developed separate models of soiling and cleaning optimization using (a) field-collected data, and (b) historical measurements shared by Ivanpah
- **Status**
  - Results confirmed that Ivanpah's cleaning frequency is appropriate, but it may be worth considering adjusting the cleaning schedule seasonally
  - Final report including analysis completed
  - Report on lessons learned for planning field measurement campaigns under development
- **Lead**: Alex Zolan, NREL

Heliostats in Ivanpah Solar Field, Unit 1



Summary of recommended heliostats to wash per week, assuming 0.1% loss per day, using field data





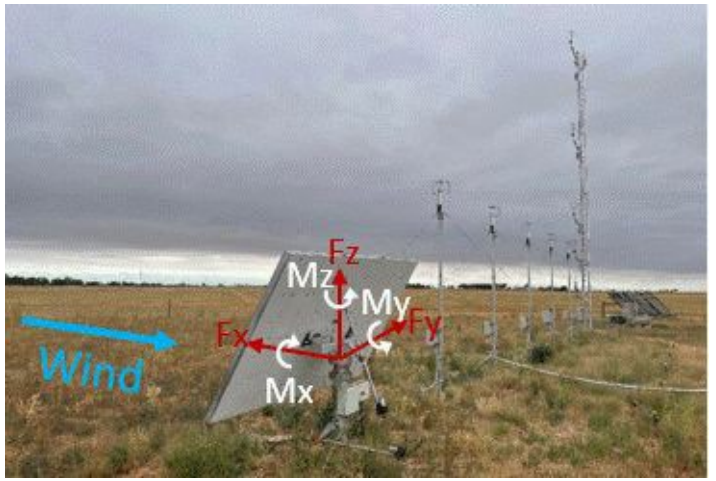
Similar results obtained through a stochastic soiling model using historical measurements

Project: Analysis of Ecological Impacts

- **Objectives:**
  - Quantify the effects of heliostats on habitats and survivability of tortoises
  - Determine a methodology for field deployment and O&M that conforms to US Fish and Wildlife goals and regulations with coexistence of protected species and heliostats
  - Demonstrate automated detection techniques using UAVs as part of methodology
- **Approach:**
  - Measure temperature, moisture, and vegetation in quadrats at an existing plant, approved future plant sites to determine the impacts of heliostat shading on habitat
  - Work with Ivanpah Biologists for historic observations on the 2013 plant deployment and leverage existing data on the health and tracking of desert tortoises near Ivanpah
  - Consulting with US Fish and Wildlife Service to refine study approach, advise permitting requirements, and co-develop a methodology to satisfy the ESA and industry viability.
  - Conducts tortoise surveys with UAVs and will help to inform the best practices approach to minimize the cost of identifying tortoises
- **Status:**
  - Project scoping study initiated with biologist collaboration
  - Identified contacts at US Fish and Wildlife Service and Ivanpah Solar Energy Project
- **Lead**: Jeremy Sment, NREL

Project: Heliostat Wind Load Field Measurements

- **Objectives**
  - Develop detailed measurement procedure to reconcile single heliostat load field measurements with wind tunnel experiments
  - Investigate loads in low- and high-density arrays of heliostats for wind load prediction in a heliostat field at different elevation angles
- **Approach**
  - Field measurements at UoA Atmospheric Boundary Layer Facility (ABLRF) Roseworthy campus to verify single heliostat loads with wind tunnel data
  - Heliostat field array load and flow measurements in different rows of linear staggered field array
- **Status**
  - Single heliostat load field measurements consistent with wind tunnel data for prevailing wind direction, other wind directions to be analyzed
  - Increasing load reduction in downstream rows of heliostat array for increasing elevation angle and increasing field density
- **Lead**: Matthew Emes, U. Adelaide



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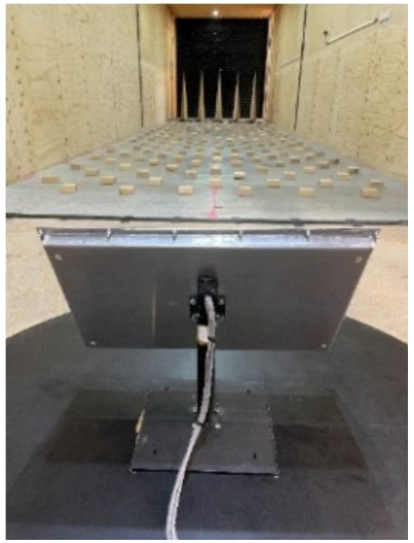
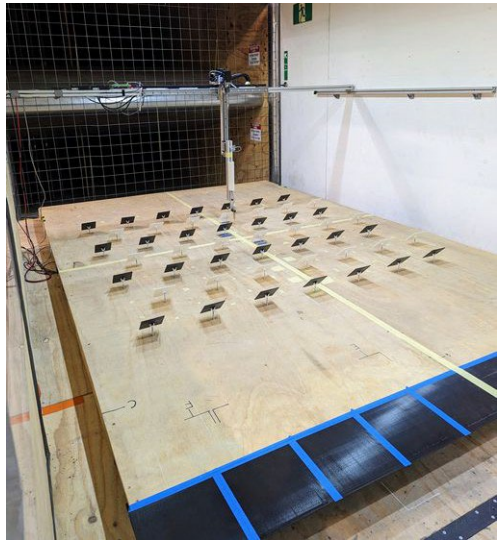




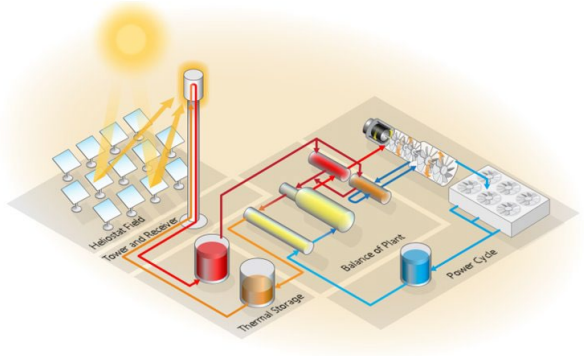
conceptual design • components • integration • mass production • heliostat field

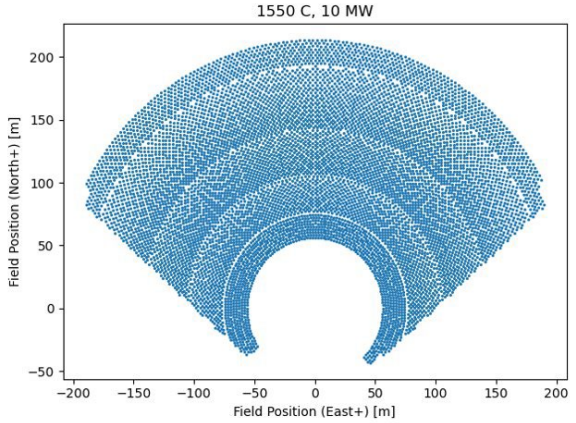
Outline

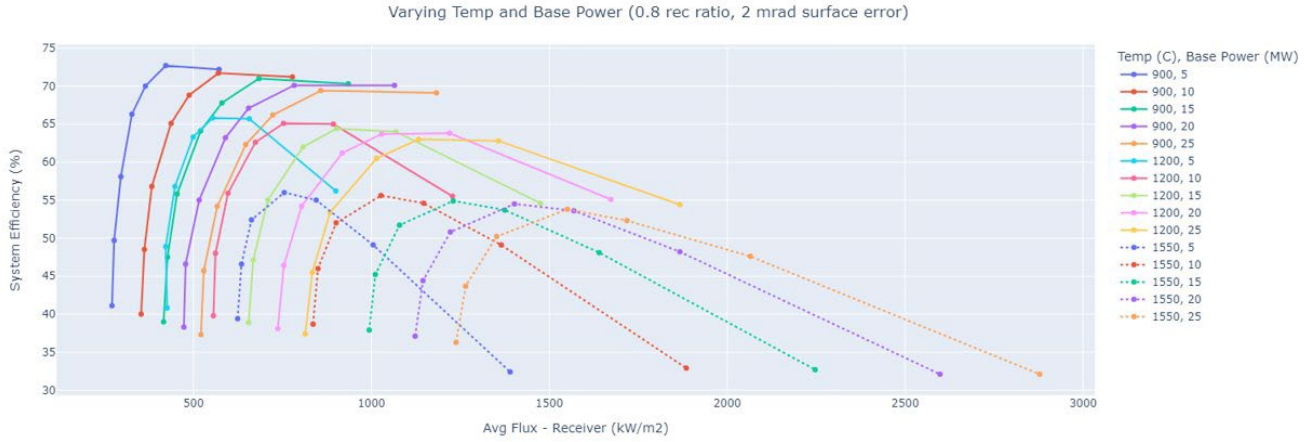
- HelioCon management
- Metrology & standards
- Components & controls
- Field deployment
- **Techno-economic analysis**
  - **Process heat system of heliostats**
- Resources, Training and Education
- RFP projects
- Not HelioCon, but related

Project: Heliostat Field Optimization for Power Tower Solar Industrial Process Heat Applications

- **Objectives**
  - Develop heliostat field, tower, and receiver model for industrial process heat (IPH) applications.
  - Determine practical and commercial operating limits for IPH applications (temperature, project size, impact of receiver media, etc.)
  - Develop field layout “best practices” for IPH applications
- **Approach**
  - Develop cost correlations for tower and receiver for IPH
  - Optimize base case field layouts based on cost correlations
- **Status**
  - Improving models required for TEA analysis
  - Carrying out initial sensitivity analysis
- **Lead**: Chad Augustine, NREL





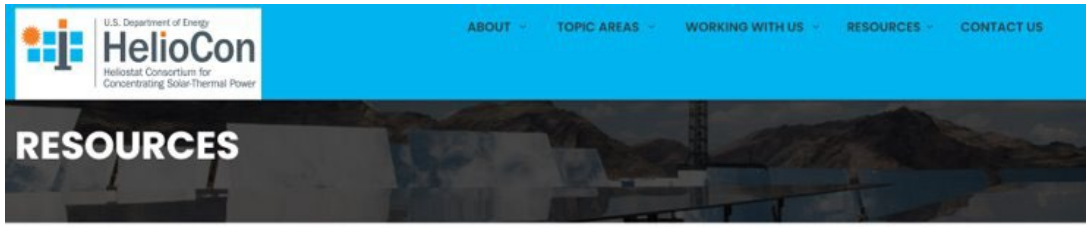


Outline

- HelioCon management
- Metrology & standards
- Components & controls
- Field deployment
- Techno-economic analysis
- **Resources, Training and Education**
  - **HelioCon database**
- RFP projects
- Not HelioCon, but related

Project: HelioCon Database

- **Objectives**
  - Establish a publicly accessible web-based resource database containing fundamental and expert knowledge
- **Approach**
  - HelioCon will gather available resources and knowledge into web database:
    - Industry knowledge: stakeholder contacts, O&M/manufacturing/design practices)
    - Resource library: references, trainings, software tools
    - Resources/guidance for promoting diversity, equity, and inclusion
- **Status**
  - Has completed 1)reference library; 2) Education and training resources; 3) Lists of heliostat component suppliers and developers, metrology tools, and software tools; 4)Existing power tower plant database
- **Lead**: Rebecca Mitchell, NREL



Resources

The resources in this section include background on concentrating solar power (CSP), available scientific publications, videos, and additional information on heliostats.

- Background on Concentrating Solar Power
- HelioCon Seminar and Educational Videos
- Zotero References
- HelioCon Publications

An Overview of Heliostats and Concentrating Solar Power Tower Plants

This downloadable report, '*An Overview of Heliostats and Concentrating Solar Power Tower Plants,*' includes a summary of design types and concerns, components, field implementation and performance assessment of heliostats, along with the standard solar power tower plant design as a reference to those interested in heliostats and CSP tower technology.

Downloads:

- An Overview of Heliostats and Concentrating Solar Power Tower Plants (PDF)
- Metrology Tools List (.xlsx)
- Software(.xlsx)
- Component supplier (.xlsx)

Outline

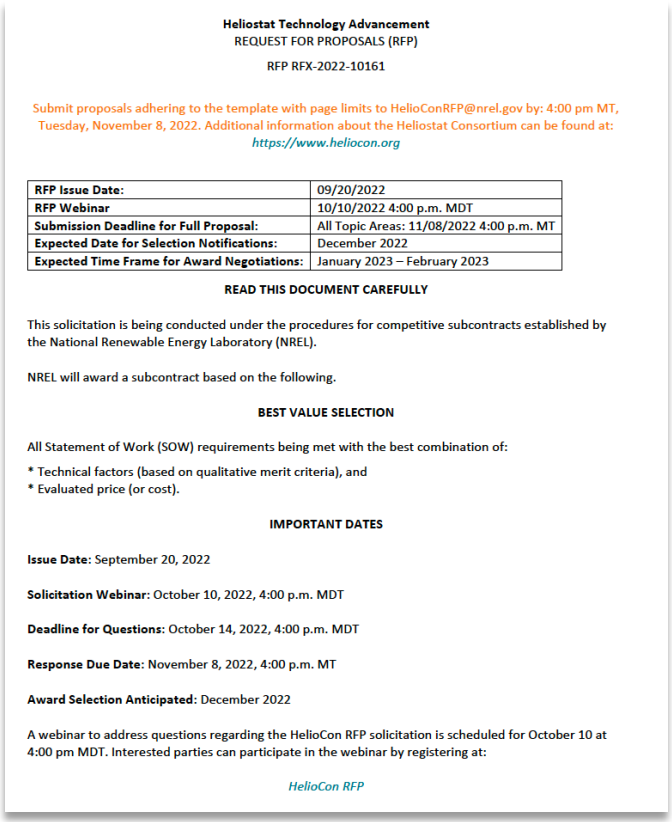
- HelioCon management
- Metrology & standards
- Components & controls
- Field deployment
- Techno-economic analysis
- Resources, Training and Education
- **RFP projects**
  - **7 issued in Round 1**
- Not HelioCon, but related

U.S. Department of Energy HelioCon Heliostat Consortium for Concentrating Solar-Thermal Power

NREL Transforming ENERGY

Sandia National Laboratories

ASTRI Australian Solar Thermal Research Institute



Heliostat Technology Advancement
REQUEST FOR PROPOSALS (RFP)

RFP RFX-2022-10161

Submit proposals adhering to the template with page limits to HelioConRFP@nrel.gov by: 4:00 pm MT, Tuesday, November 8, 2022. Additional information about the Heliostat Consortium can be found at: *https://www.heliocon.org*

RFP Issue Date:	09/20/2022
RFP Webinar	10/10/2022 4:00 p.m. MDT
Submission Deadline for Full Proposal:	All Topic Areas: 11/08/2022 4:00 p.m. MT
Expected Date for Selection Notifications:	December 2022
Expected Time Frame for Award Negotiations:	January 2023 – February 2023

READ THIS DOCUMENT CAREFULLY

This solicitation is being conducted under the procedures for competitive subcontracts established by the National Renewable Energy Laboratory (NREL).

NREL will award a subcontract based on the following.

BEST VALUE SELECTION

All Statement of Work (SOW) requirements being met with the best combination of:

* Technical factors (based on qualitative merit criteria), and
* Evaluated price (or cost).

IMPORTANT DATES

Issue Date: September 20, 2022

Solicitation Webinar: October 10, 2022, 4:00 p.m. MDT

Deadline for Questions: October 14, 2022, 4:00 p.m. MDT

Response Due Date: November 8, 2022, 4:00 p.m. MT

Award Selection Anticipated: December 2022

A webinar to address questions regarding the HelioCon RFP solicitation is scheduled for October 10 at 4:00 pm MDT. Interested parties can participate in the webinar by registering at:

HelioCon RFP

Round 1 RFP Awardees Announced in June 2023: Total $3.5M, 7 Awardees

- Solar Dynamics - SunRing: Advanced Manufacturing and Field Deployment
- UNM HELIOCOMM: A Resilient Wireless Heliostats Communication System
- Northeastern U. - An Educational Program on Concentrating Solar Power and Heliostats for Power Generation and Industrial Processes
- Solar Dynamics - Demonstration of a Heliostat Solar Field Wireless Control System
- U. of AZ - Actively Focused Lightweight Heliostats
- Tietronix - Digital Twin and Industry 4.0 in Support of Heliostat Technology Advancement
- Sarcos - Robotic-Assisted Facet Installation (RA-FI)

Outline

- HelioCon management
- Metrology & standards
- Components & controls
- Field deployment
- Techno-economic analysis
- Resources, Training and Education
- RFP projects
- **Not HelioCon, but related**
  - **Ray-trace round robin test**
  - **Laboratory slope error metrology round robin**
  - **Windload test campaign**
  - **Avian hazard mitigation**

Project: Raytrace Model Round Robin Test

- **Objectives**
  - Examine/improve (if necessary) accuracy of raytrace models available in the market
- **Approach**
  - Perform case studies to validate three raytrace models through round robin test
  - Validate other soltrace models per request
- **Status**
  - Near completion of round robin test of three raytrace models
- **Leads**: Rebecca Mitchell, Ye Wang (ANU), Michel Izygon (TieTronix), John Pye (ANU)

NREL Transforming ENERGY

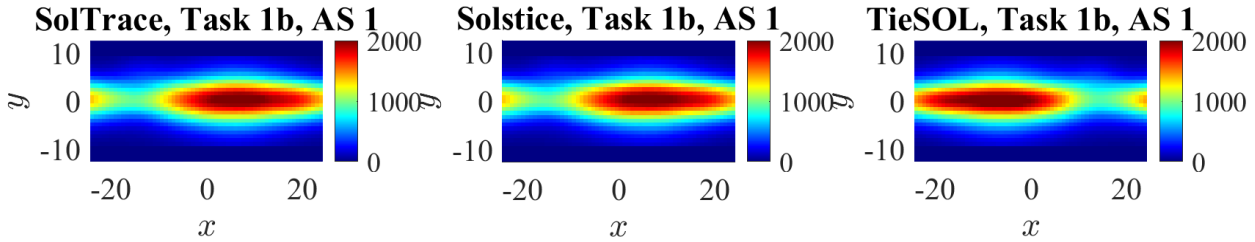
Australian National University

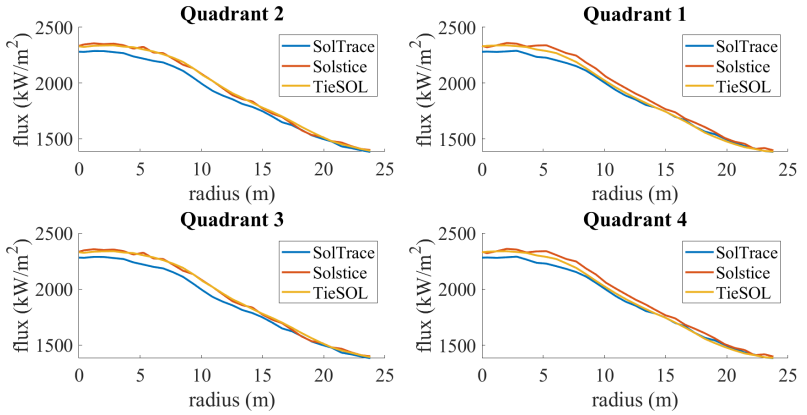
TIETRONIX

SolTrace

Solstice

TieSOL





Project: Laboratory Slope Error Metrology Round Robin Test

- **Objectives**
  - Examine/improve (if necessary) accuracy of laboratory slope error metrology available in the market
- **Approach**
  - Perform round robin test within 5 institutes: ENEA, DLR, Fraunhofer, Sandia, NREL
  - Collaborate with international community with support from EU program
- **Status**
  - Collecting and measuring mirror facets shipped from Europe partners
- **Lead:** Marco Montecchi, ENEA

Solar Facilities for the European Research Area

SFERA-III WP10 Task3 round-robin on 3D shape measurements: recommended procedure and ENEA results

Marco Montecchi, Giuseppe Cara, Arcangelo Benedetti

DISTRIBUTION LIST

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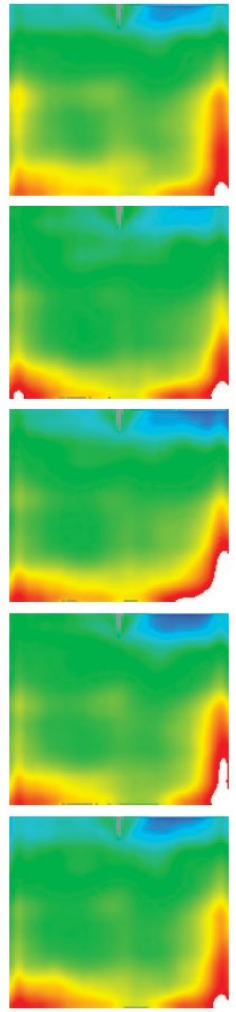
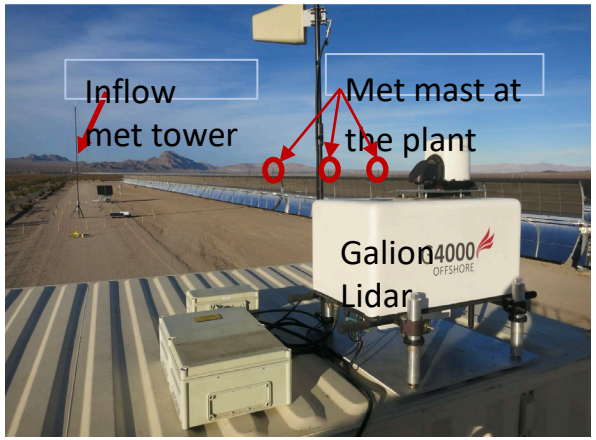
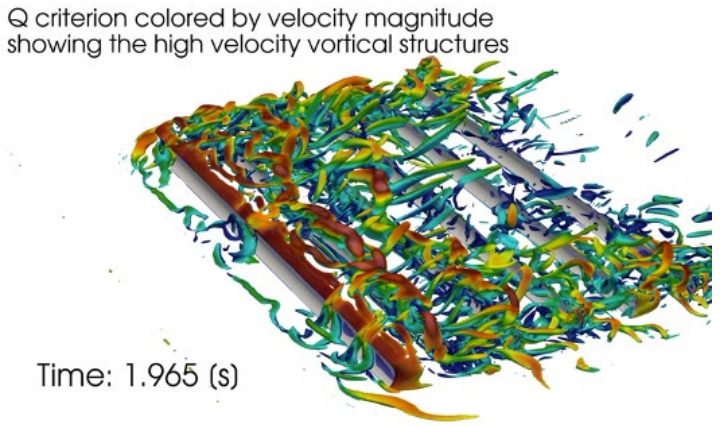
Valeria RUSSO	(TERIN-STSN-ITES)
Michela LANCHI	(TERIN-STSN-SCIS)
Adio MILIOZZI	(TERIN-STSN-SCIS)
Julian KRAUTH	(DLR)
Tim SCHLICHTING	(DLR)
Marc ROGER	(DLR)
Gregor BERN	(F-ISE)
Devon KESSELI	(NREL)
Rebecca MITCHELL	(NREL)
Guangdong ZHU	(NREL)
Randolph BROST	(SANDIA)
Maurizio Della Casa	(MARPOSS Italia Spa)
Augusto MACCARI	(Rioglass)
Archivio TERIN-STSN	

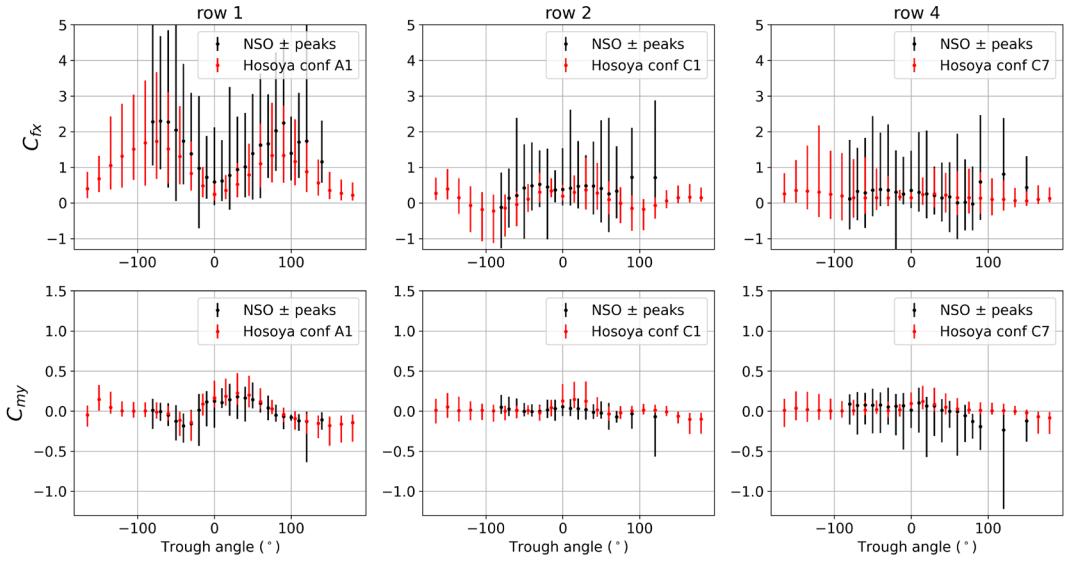


Project: Wind load Characterization

- **Objectives**
  - Develop detailed measurement procedure to characterize the prevailing wind conditions and resulting operational loads
  - Develop and validate a computationally efficient, high-fidelity modeling tool capable of predicting wind-loading in deep-array installations.
- **Approach**
  - Carry out measurement campaign at parabolic trough power plant – Nevada Solar One
  - Carry out measurement campaign at Crescent Dunes power tower plant
  - Validate CFD model with experimental data
- **Status**
  - Near to completion of parabolic trough collector field measurement and model validation
  - To plan the measurement campaign at Crescent Dunes power plant
- **Lead**: Shashank Yellapantula, NREL







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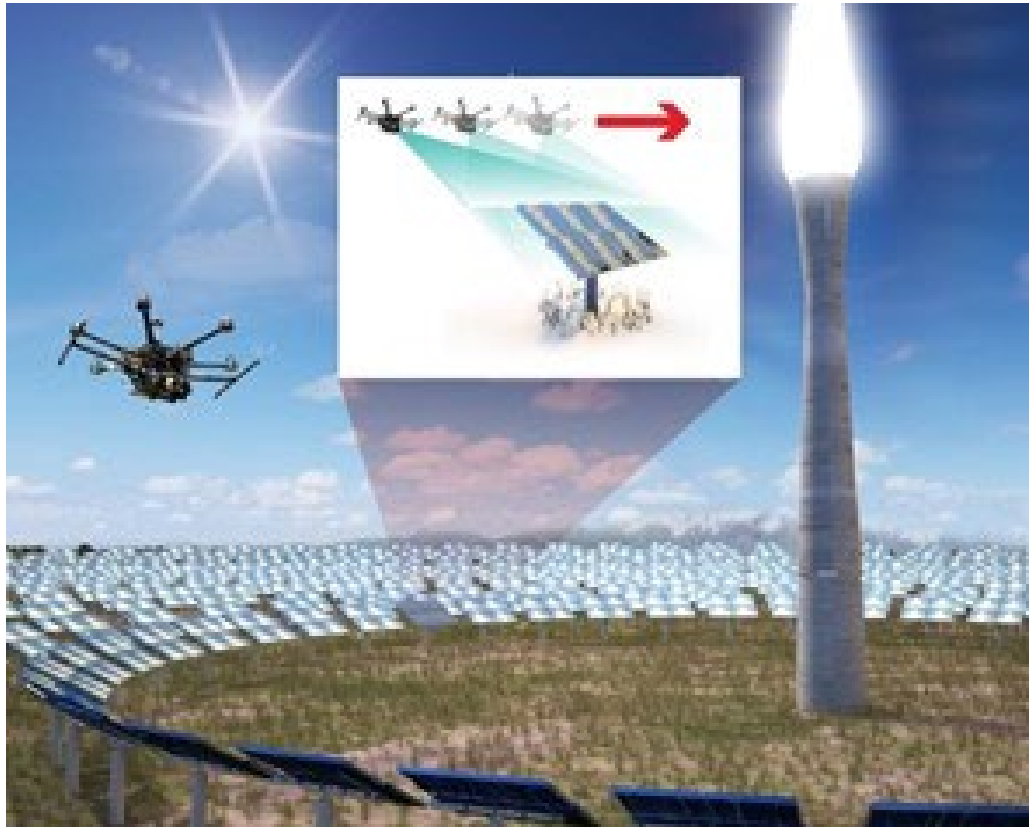
Project: Surveillance and Mitigation of Avian Flux Hazards

- **Objectives**
  - Protect avian wildlife at operating CSP tower facilities.
  - Inform site design and operation decisions of future CSP tower facilities that optimize for minimum disruption to avian wildlife.
- **Approach**
  - Reconfigure the Temporal Frequency Analysis (TFA),
  - Create the Avian Detection and Collection System (ADACS),
  - Develop and design a new industry-focused Full-Field Irradiance Analysis Model (FFIAM) to summarize the expected irradiance of a heliostat field when in standby.
- **Status**
  - Completed an initial optical design and prototype of ADACS
  - Began on work on the FFIAM tool.
  - Began on work on the avian mortality review of the Ivanpah CSP.
- **Lead**: Dan Small, Sandia

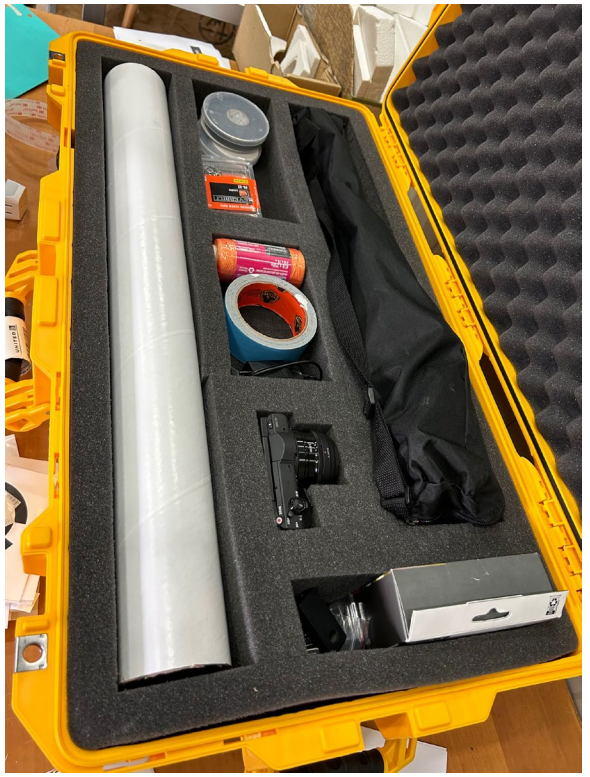
Project: Commercialization of Non-Intrusive Optical (NIO) Technology

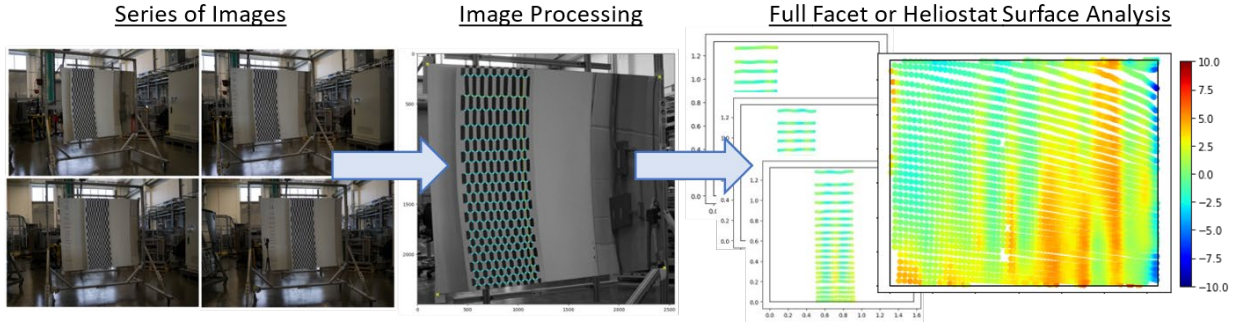
- **Objectives**
  - Create a commercial NIO package with a user-interface and documentation and training, and capability services to meet stakeholder needs.
  - Perform a commercial demonstration of the NIO tool by performing data collection activities and providing optical error data deliverables to a plant partner.
  - Produce a business strategy to market and launch a beta version of the commercial tool package at the conclusion of the project
- **Approach**
  - Design NIO services and capabilities based on industry stakeholder feedback
  - Test NIO commercial tool capabilities and operation procedures with a large-scale data collection campaign at a commercial plant.
- **Status**
  - Streamlining and validating NIO algorithm performance
  - Coordinating with candidate commercial plants for data collection activities
- **Lead**: Rebecca Mitchell, NREL



Project: Commercialization of the Reflected Target Non-intrusive Assessment (ReTNA)

- **Objectives**
  - Create a commercial NIO package with a user-interface and documentation and training, and capability services to meet stakeholder needs.
  - Perform a commercial demonstration of the NIO tool by performing data collection activities and providing optical error data deliverables to a plant partner.
  - Produce a business strategy to market and launch a beta version of the commercial tool package at the conclusion of the project
- **Approach**
  - Design NIO services and capabilities based on industry stakeholder feedback
  - Test NIO commercial tool capabilities and operation procedures with a large-scale data collection campaign at a commercial plant.
- **Status**
  - Streamlining and validating NIO algorithm performance
  - Coordinating with candidate commercial plants for data collection activities
- **Lead**: Devon Kesseli, NREL





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