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pv magazine webinars

Differential settlement and All Terrain Trackers

9 January 2024

9:00 am – 10:00 am | PDT, Los Angeles
12:00 pm – 1:00 pm | EDT, New York City
6:00 pm – 7:00 pm | CET, Berlin

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Nevados

Welcome!

pv magazine webinars

Do you have any questions? ❓ 🙋

Send them in via the Q&A tab. 👉 We aim to answer as many as we can today!

You can also let us know of any tech problems there.

We are recording this webinar today. 📹

We‘ll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience. 👀 💡

Differential Settlement Webinar 2024

PV Magazine

Jenya Meydbray

Rahul Chandra

Est. 2014 | Oakland, CA

About Nevados

Our objective is to offer cost-effective solar tracking solutions that eliminate the need for site grading.

LEADERSHIP

YEZIN TAHA

CEO & Founder

- Former Black & Veatch, Trane, GE
- Mechanical Engineer, Illinois at Urbana Champaign

JACK BENNETT

COO & President

- Founder and CEO of Novasource
- SunPower VP of Strategic Transformation

JENYA MEYDBRAY

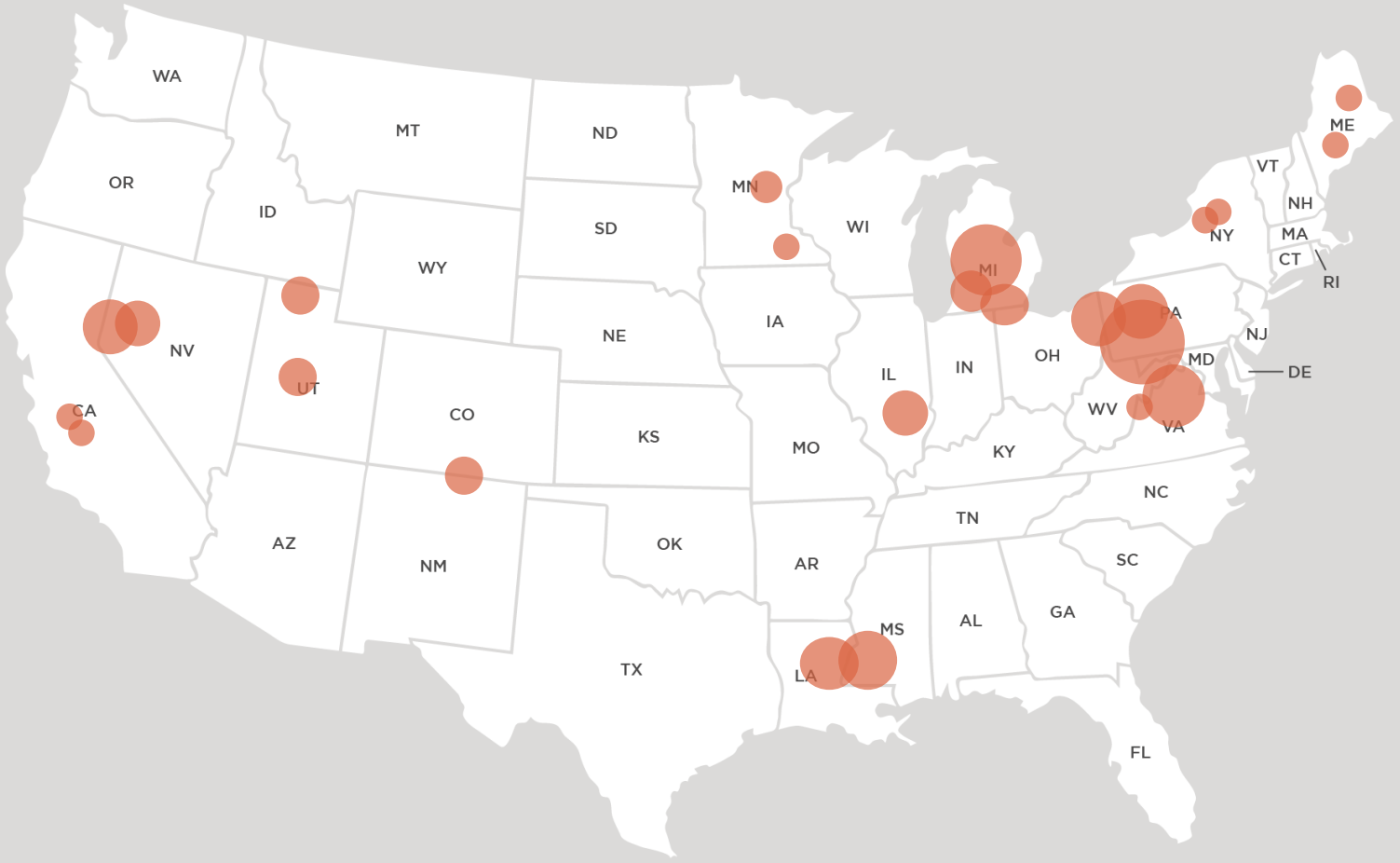
Chief Commercial Officer

- Founder and CEO of PVEL
- SunPower Reliability Engineer

Historical Experience

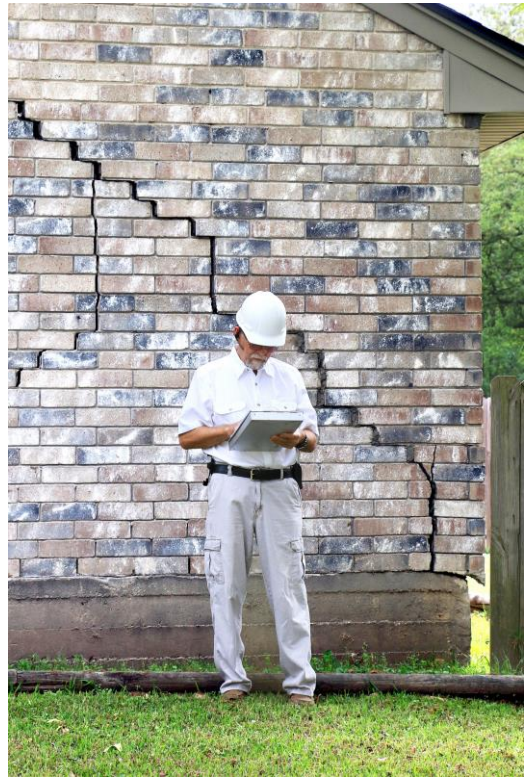
- > 1 GW installed and contracted
- 450+ MW of shipments in 2023
- More than double in 2024

NEVADOS PROJECTS



Differential Settlement

- Consultative sale – holistic discussions about Nevados can help customers overcome unique challenges
  - New challenge across several sites
  - Solar Trackers use ASCE and Building codes to design structure – accounting for wind, snow and seismic loads



What is Differential Settlement?

- Uniform soil settlement after construction is expected and normal
- Differential settlement is non-uniform, downward shifting of soils
- Prominent example of impact on a structure
  - Leaning Tower of Pisa
  - Built on wetlands with significant groundwater

NEWS

The tilt of San Francisco's Millennium Tower has deepened as engineers work to reverse lean

By Katherine Donlevy

Published June 11, 2023 | Updated June 12, 2023, 8:20 a.m. ET

What is Differential Settlement?

- Solar projects typical design life: **30-40** years
- Tracker design needs to accommodate site changes over time
- Differential settlement, across a site
  - Creates a surface profile that is different than what the project was originally designed for
  - Can cause extensive damage especially if the tracker required a flat surface profile to begin with
- Differential settlement risks often flagged in site specific Geotechnical Studies

Causes of Differential Settlement

Soil Composition

Heterogenous soils can cause uneven settling across a site

Causes of Differential Settlement

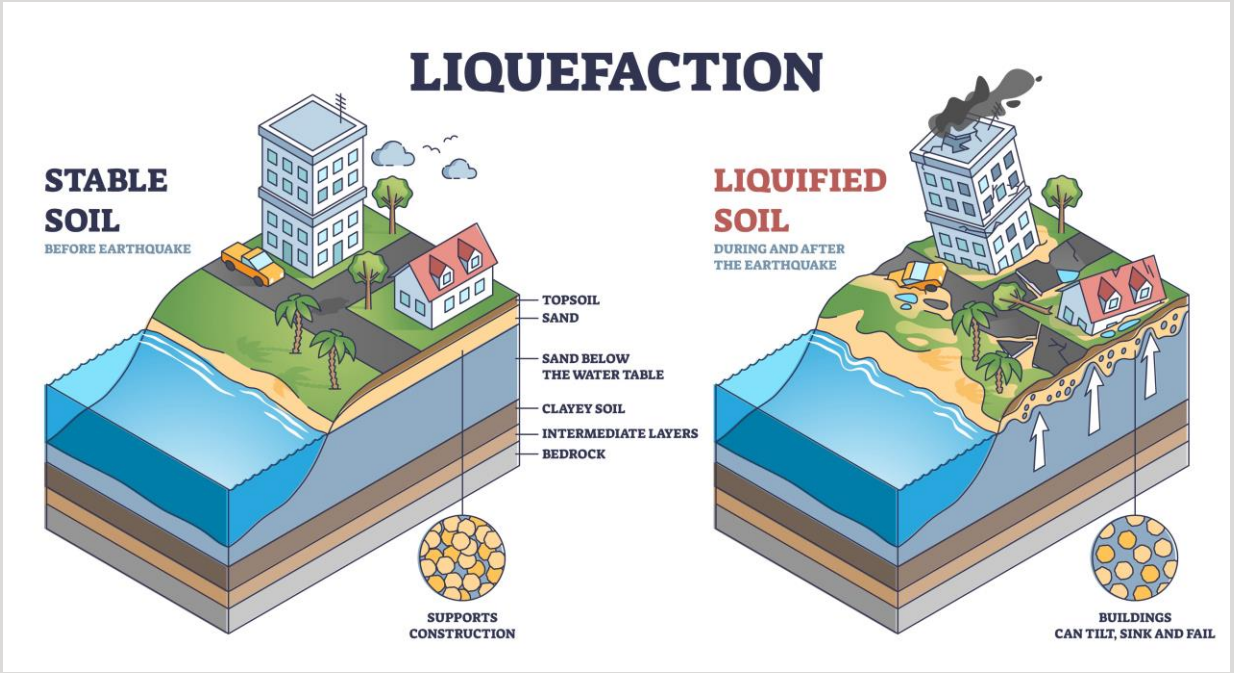
Soil Moisture

Soils with different moisture levels across a site will potentially settle at different rates

Causes of Differential Settlement

Liquefaction

Excessive shaking/vibrations can cause soils to lose strength and stiffness



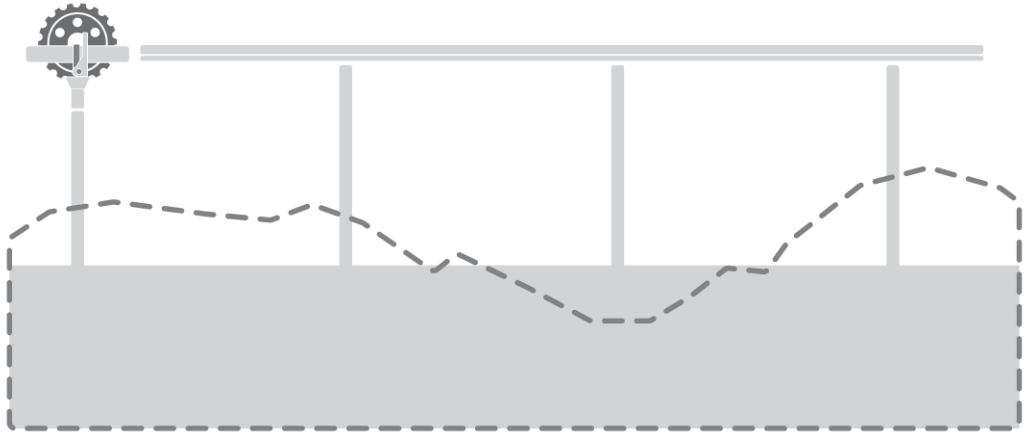
Causes of Differential Settlement

Underground Cavities

Internal erosion (Karsts) of soils can be caused by mines, natural cavities or piping

Effect on Trackers

- Uneven soil shifts can cause extensive damage to tracker structures
  - Some sites expect up to 2 ft of settlement
- Trackers with continuous torque tubes will see increased stress beyond design limits
  - Bent torque tubes
  - Tracker malfunction (loss of production)



Continuous Torque Tube Tracker on graded terrain

Continuous Torque Tube Tracker on terrain with variable piles

Poll!

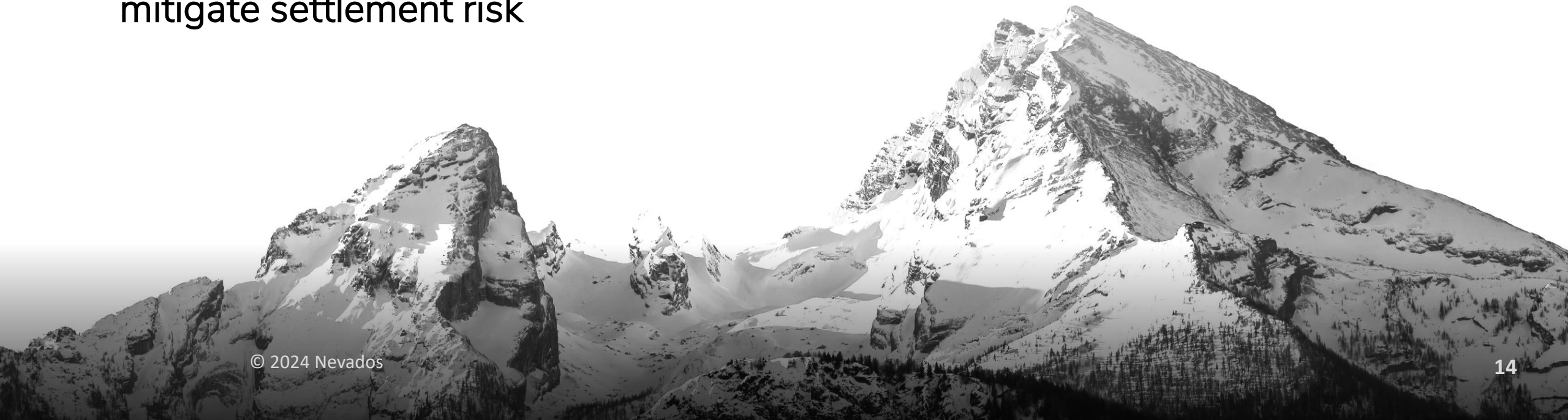
- How many of you have current projects in your pipeline with differential settlement risk?

- Current Nevados activity ~over GW:
  - South, 1 ft of pile-to-pile settlement
  - Midwest, 2-3 ft
  - Seismic liquefaction zones
  - Coal mines with bowl shaped depressions
    - Up to 5 feet deep and 800 foot wide

How does the Nevados All Terrain Tracker® help you overcome differential settlement risk?

- Adaptive tracker – discrete (non-continuous) torque tube sections
- Articulating bearings on every pile

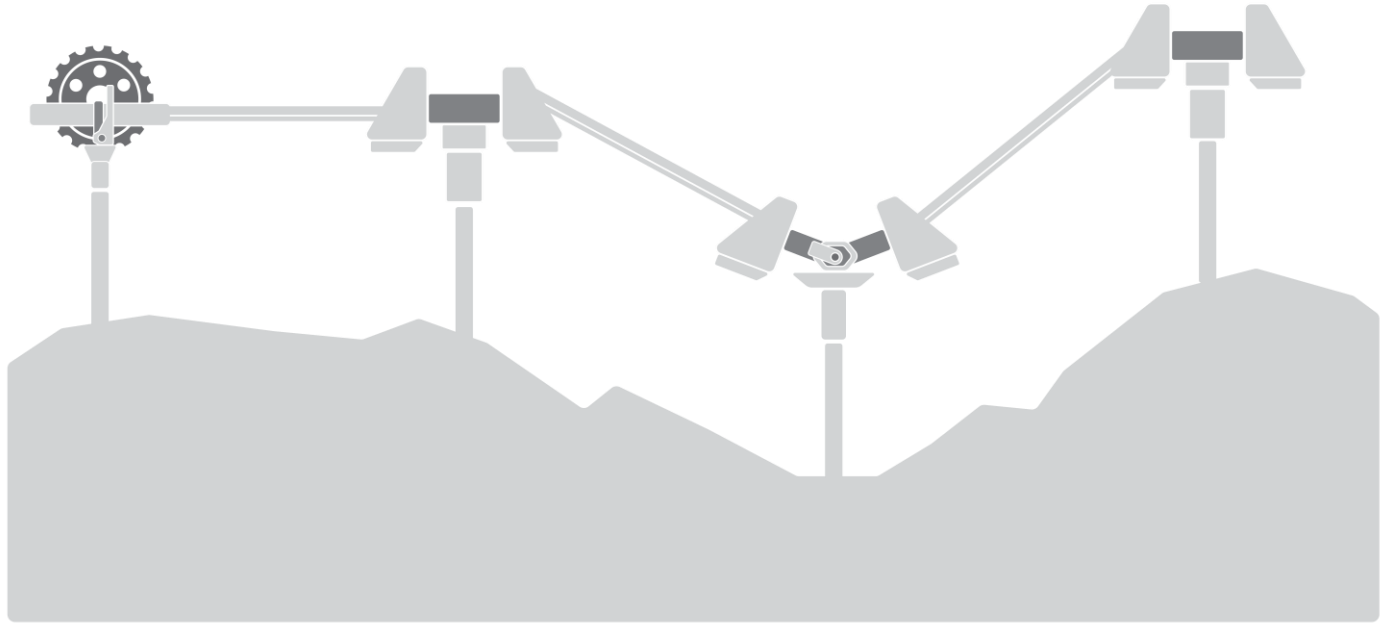
The same features that allow for unparalleled terrain capabilities mitigate settlement risk



Nevados All Terrain Tracker

- Self-powered, independent row, 1P tracker system
- Up to 26% (15 degrees) of angle change every 6 - 8 modules
- Integrated distributed friction dampers
- Entire system has 2 bolt sizes, no jigs or fixtures.

Nevados All Terrain Tracker®



Typical deployment of a Nevados ATT on a terrain challenged site:

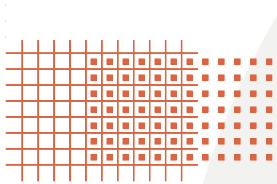
- Typically eliminates grading
- One of two bearings utilized across the site depending on undulation profile

Undulating terrain is far more challenging for traditional trackers to navigate without grading or adding steel

OUR TECHNOLOGY

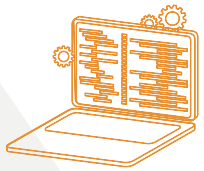
Structure

- Bearing assemblies
- Saves millions on pile steel and grading
- Designed for chest-height installation anywhere



Controls

- Nevados Row Controller, Zone Controller, and Current Sensor
- Row-by-row backtracking
- Proprietary current sensor for shade and analytics



Software

- Custom TRACE performance optimization software
- Zero inter-row shading
- Custom 3D site design optimization engine

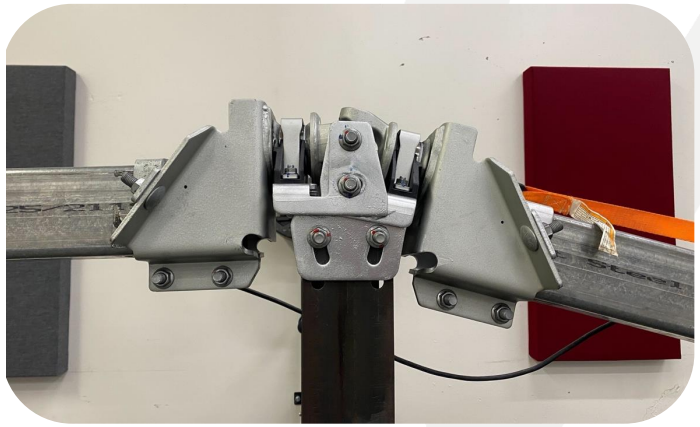
2 Nevados Bearings with Angle Change Capabilities

Straight Through

2.5°

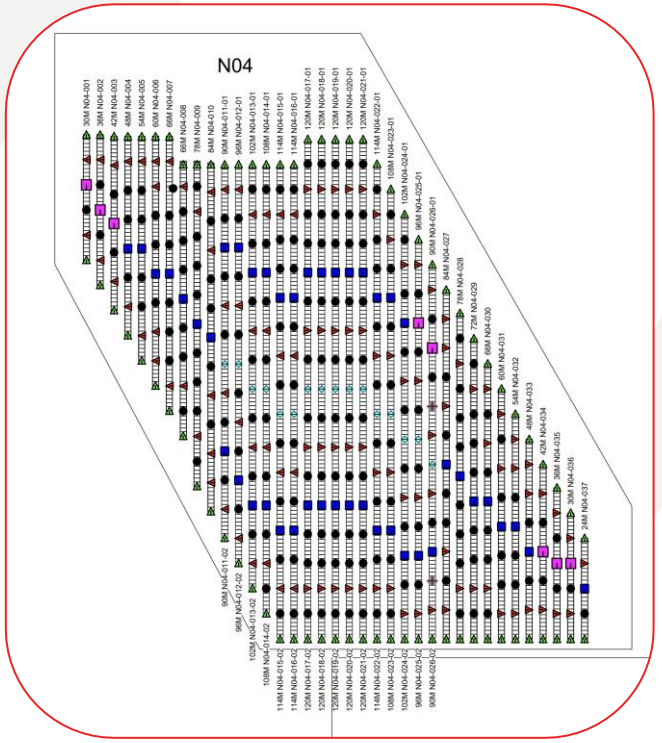
+/- 4.4%

Articulating



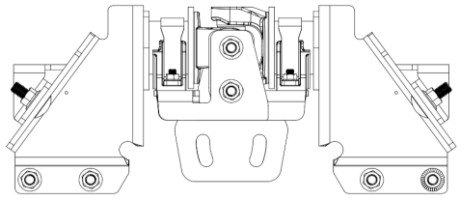
15°

+/- 26 %



Most Flexible Tracker

As-built foundation location can be impacted by construction quality, ground movement, etc.



FOUNDATION TOLERANCE / DEFLECTION

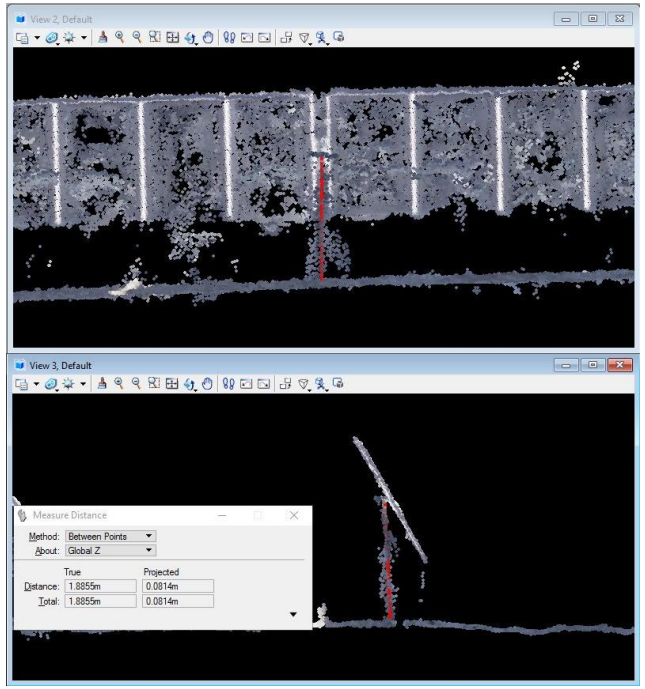
N / S foundation location	1.5 inches
Vertical	Straight through: ± 12 inches Articulating: ± 90 inches
E / W	
Twist	9°
Slope any direction	37%
Max slope change across each foundation	5% to 26%
Foundation Reveal above ground	Consistent across the site

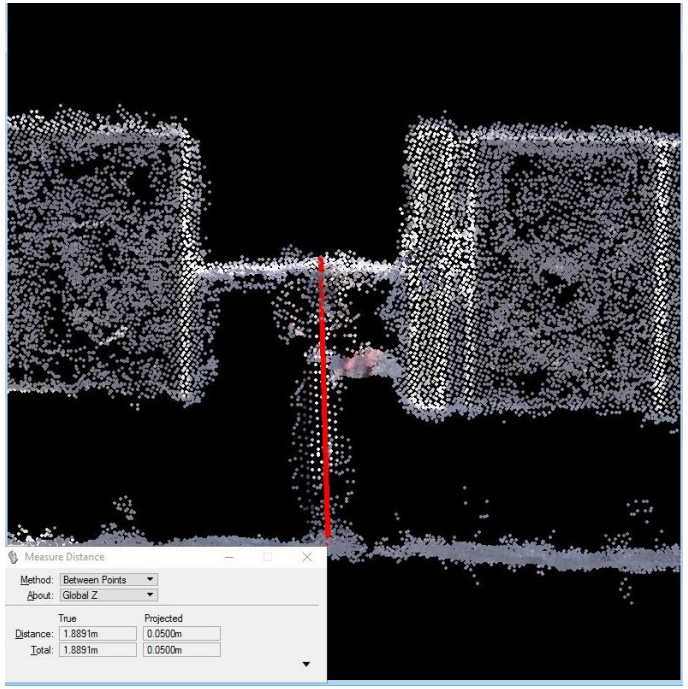
Quantify a Differential Settlement Event

- For sites with Differential Settlement risk:
  1. Take ”As-Built” pile height measurements
  2. Verify the magnitude of settlement after event
  3. ATT® Exclusive: Piles in exposed view from above allows for Drone readings

Drone Flyover

- Using low cost RGB camera
- Can be used to:
  - measure as-built angle “capacities” at each pile
  - verify that a settlement event has occurred
  - determine magnitude of settlement
- Measured precision:
  - 1-2 inches across x,y,z dimensions

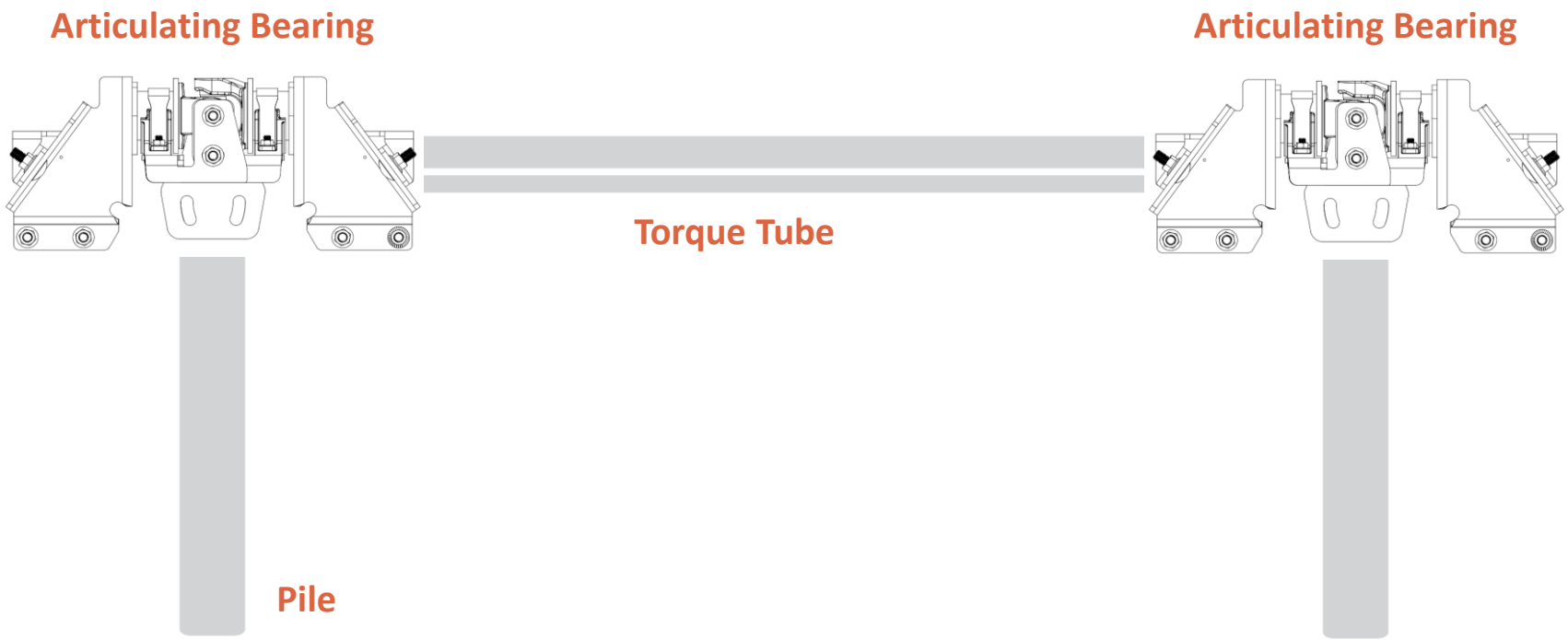




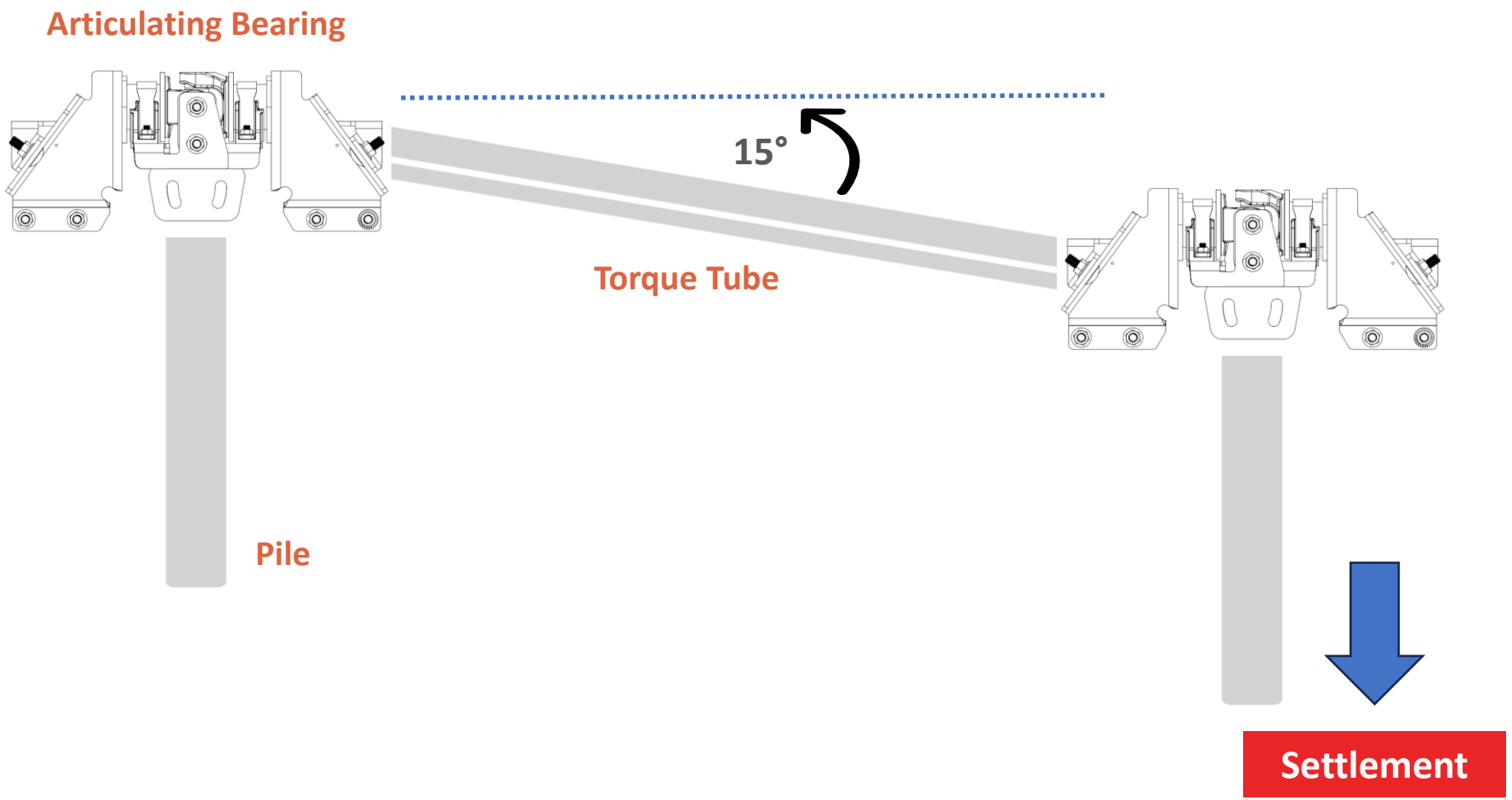
What to do after a settlement event?

- Determine the amount of settlement
- ATT® Exclusive:
  - Make necessary adjustments and/or
  - Replace straight through bearings with articulating ones

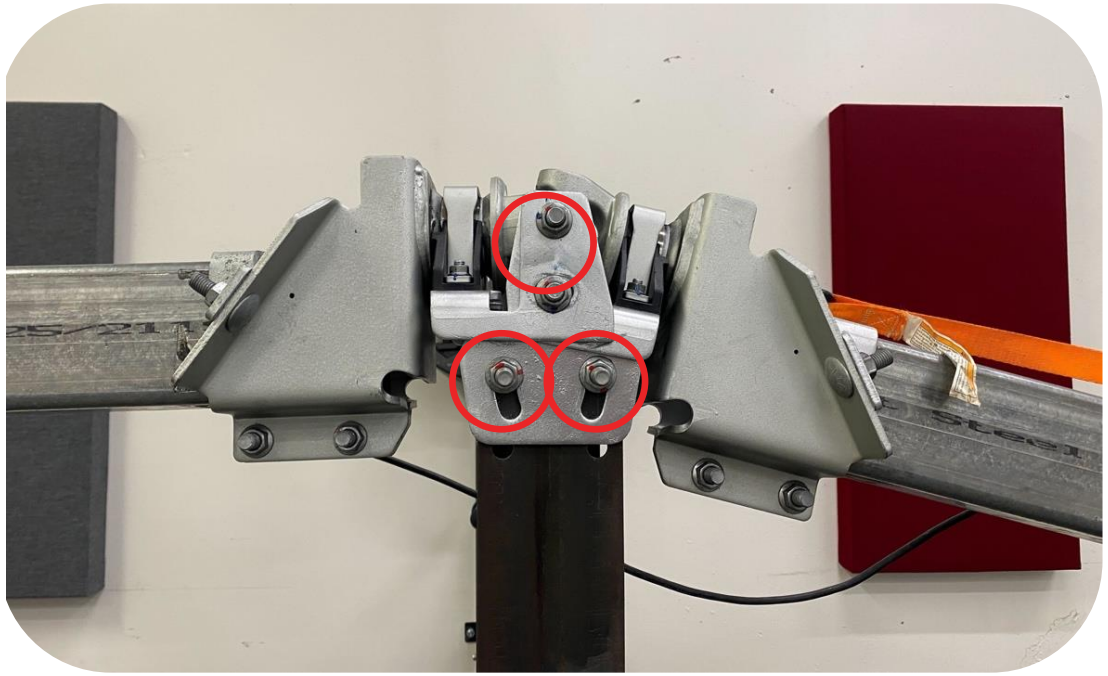
ATT® Before Settlement



ATT® After Settlement

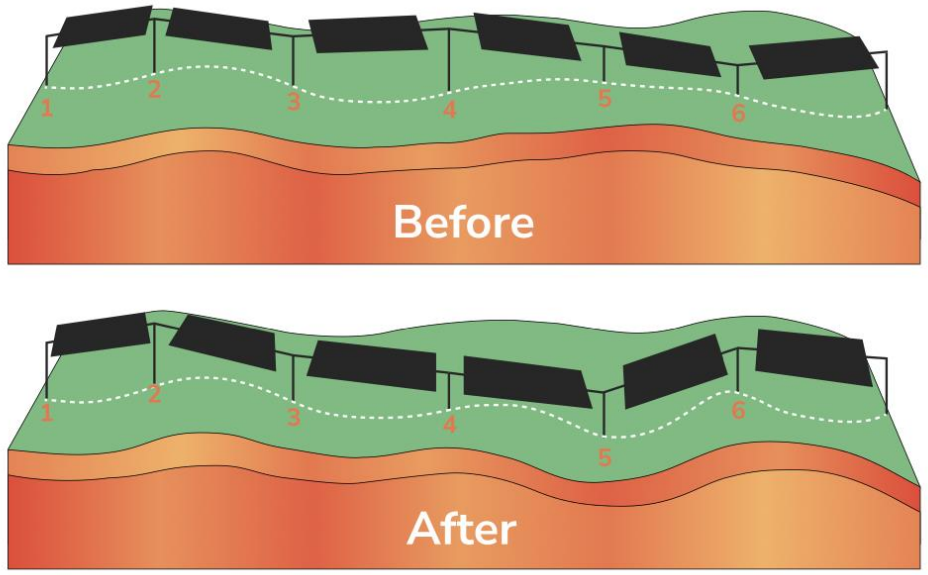


ATT® After Settlement



- Bearing Adjustments
  - Each cradle can accommodate +/-1.25° of angle change
  - Settlement event may not require bearing replacement – only an adjustment
    - Bearing to foundation bolts
    - Pivoting bearing support bolts

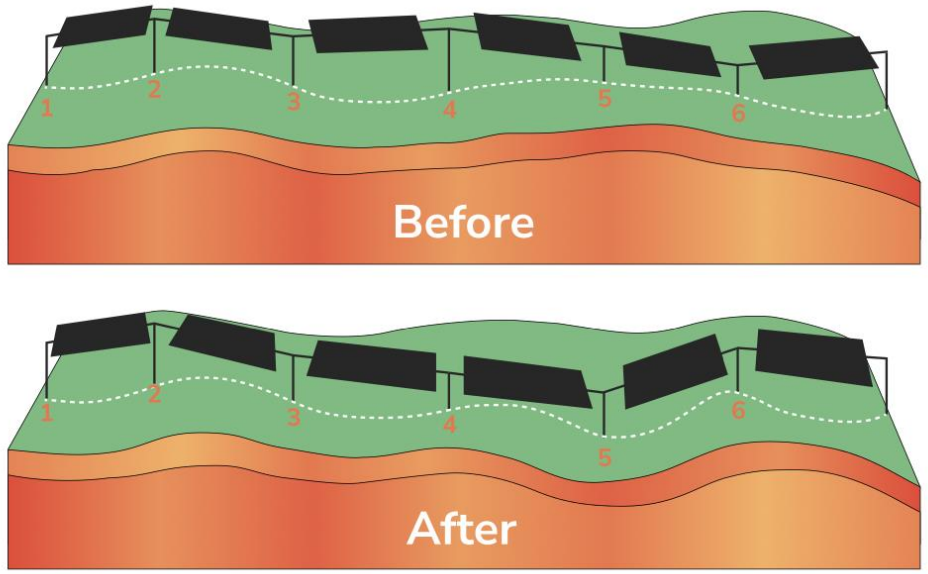
Differential Settlement with ATT®



Angle Change at Bearing

	Before Differential Settlement	After Differential Settlement	Within Bearing Capacity?
Foundation 1	+1.3°	+0.3°	Yes
Foundation 2	+1.5°	+0.5°	Yes
Foundation 3	-0.5°	-1.8°	Yes
Foundation 4	+0.1°	-0.8°	Yes
Foundation 5	-2.0°	-4.8°	No, replace with Articulating Bearing
Foundation 6	-1.8°	+1.3°	Yes

Differential Settlement with ATT®



Adjacent Pile Settlement (in)	Hypotenuse Elongation Relative to 0 (in)	Torque Adjustment
6	0.06	None
12	0.24	None
24	0.94	None
36	2.11	Insert Spacer into Cradle
48	3.74	Insert Spacer into Cradle

Final Thoughts

- While you may not be able to prevent Differential Settlement you can safeguard your project with the All Terrain Tracker®
  - Non-continuous torque tube sections
  - Flexible and articulating bearings

Designed for uneven terrain and soil movement, beyond installation

Continue the conversation

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Q&A

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