Utility Scale Solar Installation Webinar 2024

PV Magazine

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Agenda

- Company Introductions
- Market Install Expectations
- Tracker Type and Installation
- Nevados ATT® Field Experience
  - System Features
  - Grading Considerations
- New Tools and Analytics
- Eclipse-M Lean Method

NEVADOS
TRACKERS ANYWHERE

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

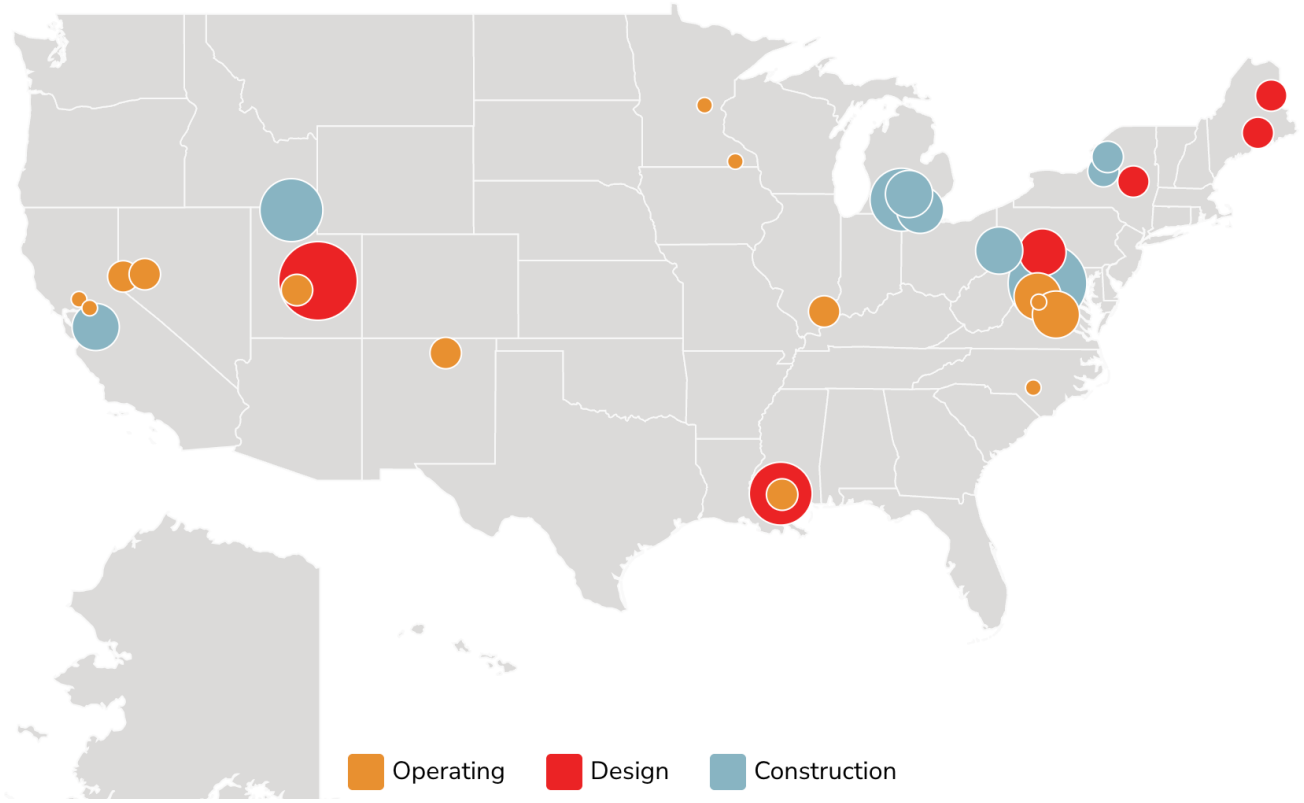
- Founder and CEO of PVEL
- SunPower Reliability Engineer

Project Experience

Nevados Project activity

- > 1 GW installed and in process
- 1 GW projected shipments in 2024

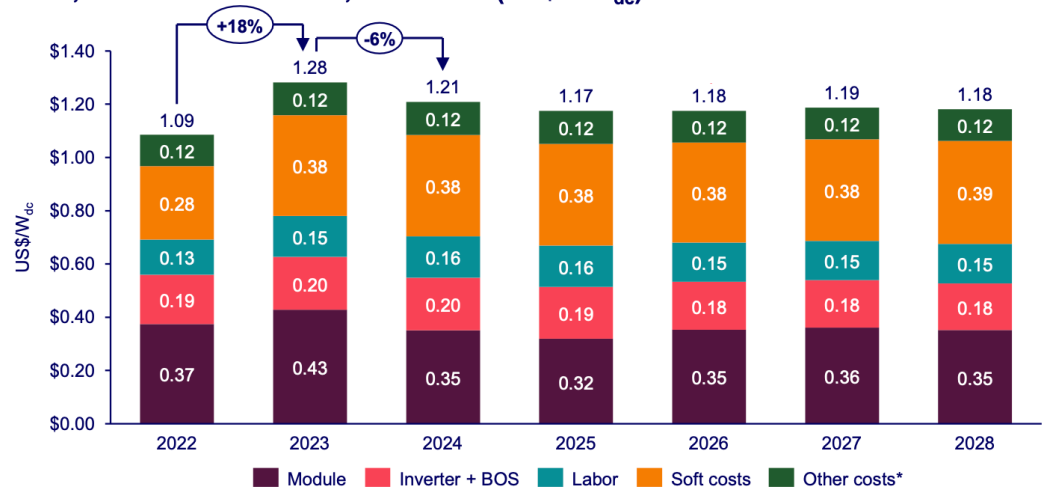
Interactive Project Tracker



https://nevados.solar/featured-projects/

Solar Tracker Installation

- Consultative sale to overcome unique challenges
  - Differential Settlement
- Installation Performance:
  - Electrical design of site
  - Labor profile and environment
  - Technology selection



Source: Wood Mackenzie's US solar PV system pricing: H2 2023 . *Note: Other costs include taxes, overhead, and margin

About Eclipse-M

- **Decades of Solar Project and Operations Expertise**
- **OEM Support, 3rd Party**
- **Project Execution Specialists**
- **Lean Construction**
- Driving Better Results
- Project Support
- CM and Owner's Rep Services
- Developer Support
- Improvement Programs
- *> 6 GW project experience*
- *>80 years Leadership Experience in PV*

Eclipse-M Methodology

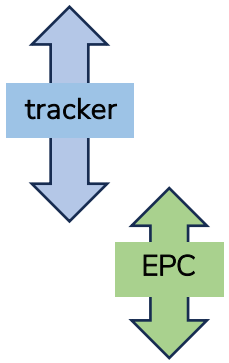
Problem – all time studies are not created equally!

Eclipse-M endeavors to evaluate each tracker on a level playing field:

- Installation manuals are thoroughly reviewed and evaluated.
- All time data is obtained from actual field installation.
- Activities are videoed and carefully evaluated and compared to existing data to ensure a consistent treatment of similar activities (e.g., torquing).
- The impact of the skill of the installer is removed from the evaluation.
- The result is a clean, level-playing field value-add result that can be compared to other trackers in our database.

Market Tracker Install Rates

- What is a good installation rate/experience?
- Components of rate:



  - Value-add install requirements – *the physical work*
  - Materials/supply chain – *getting the tracker to point of install*
  - Site preparation requirements and readiness – *getting around the site, civil work, conditions (mud) and topography*
  - Material handling methods – *presenting materials to the install team*
  - *Module Size*

Components of rate of installation:

Value-Add

- Tracker Design
- Complexity
- Tools required
- Variation of hardware
- Ergonomics

Site Prep

- Roads
- Underground
- Cut-fill
- topography

Materials – Supply Chain

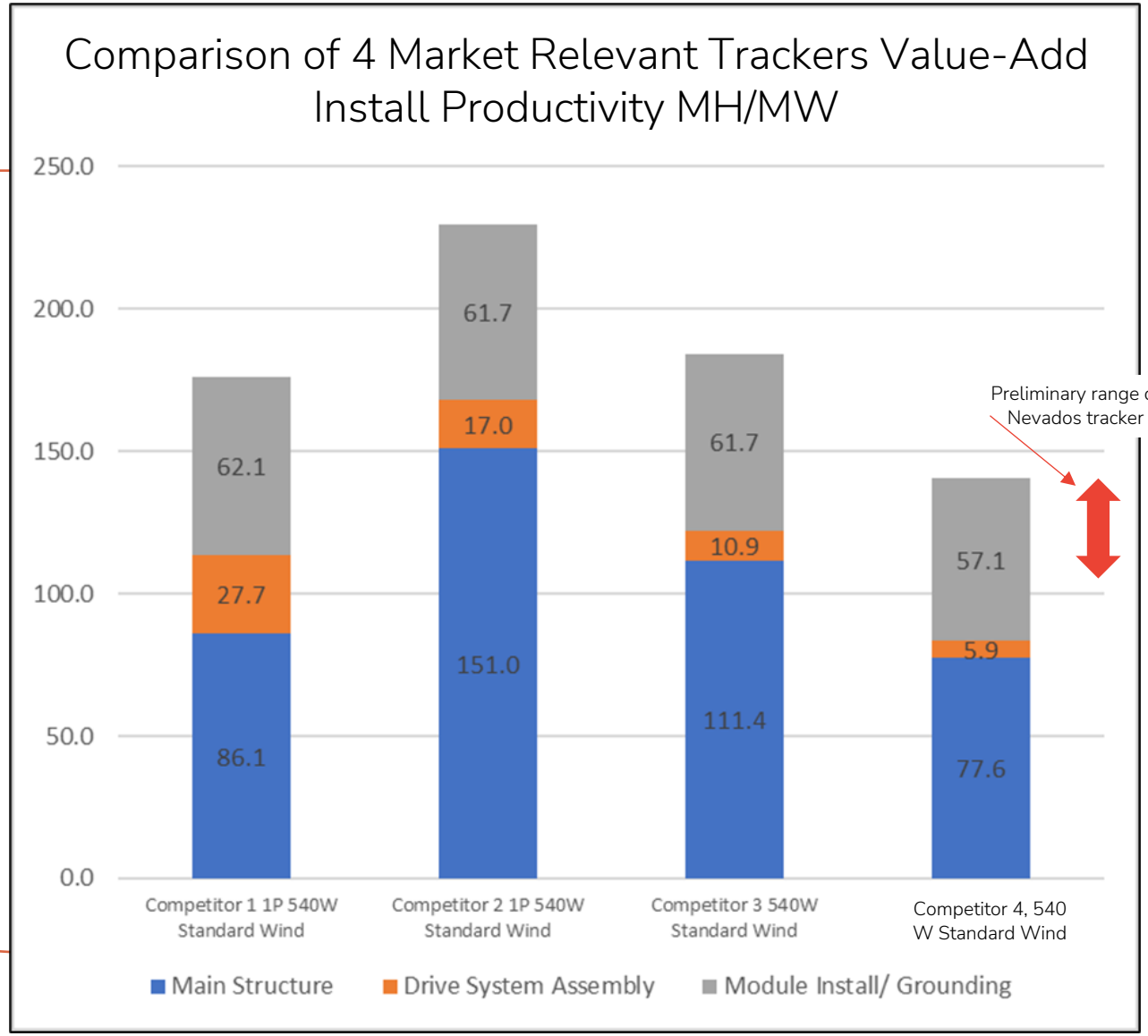
- Central vs. local
- Pre-assembly
- Truck offload
- Organized delivery

Materials Handling

- Number of moves
- Proximity to work
- Right materials
- packaging

Value-Add comparisons

- 4 trackers compared
- Work divided into 3 buckets
  - Structure – complexity, number of components, precision requirements
  - Drive system – type of drive, mounting system
  - Module attach- bolt/nut, lockbolt, top clamp, clip/clamp
- Effort to achieve <100 MH/MW in the industry



Solar Tracker Installation

Tracker selection has large impact on installation performance

- Type of tracker – 1P, 2P, single axis
- Piles per MW
- Tube length & Bay vs. through-bearing design
- Alignment requirements, pile positioning
- Structure Design – post cap, bearing/bushing, drive system, damper
- Module attachment methodology
- Overall complexity (# of fasteners / MW); fastener variation
  - Overall BOM / MW
- Tracker compatibility with site environment

Tracker: 1P v. 2P

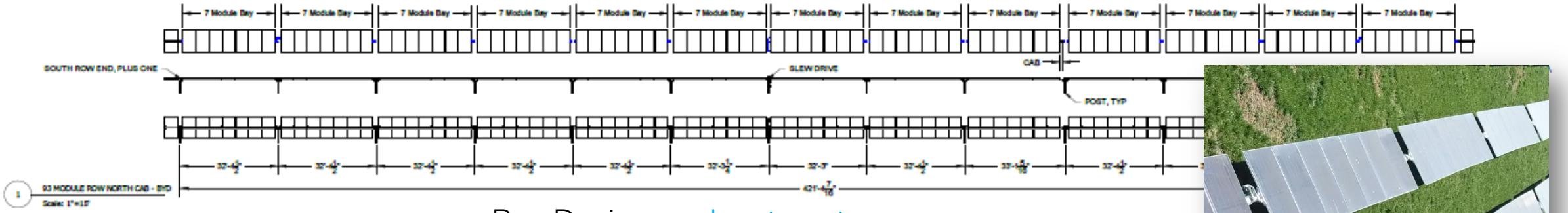
1P suitable:

- General applications
- Challenged Geotech
- Topographical variations

2P suitable:

- Longer posts, bigger structure
- Large flat sites
- Easy Geotech

Tube Length & Bay vs. Continuous Design



Bay Design – advantage topo

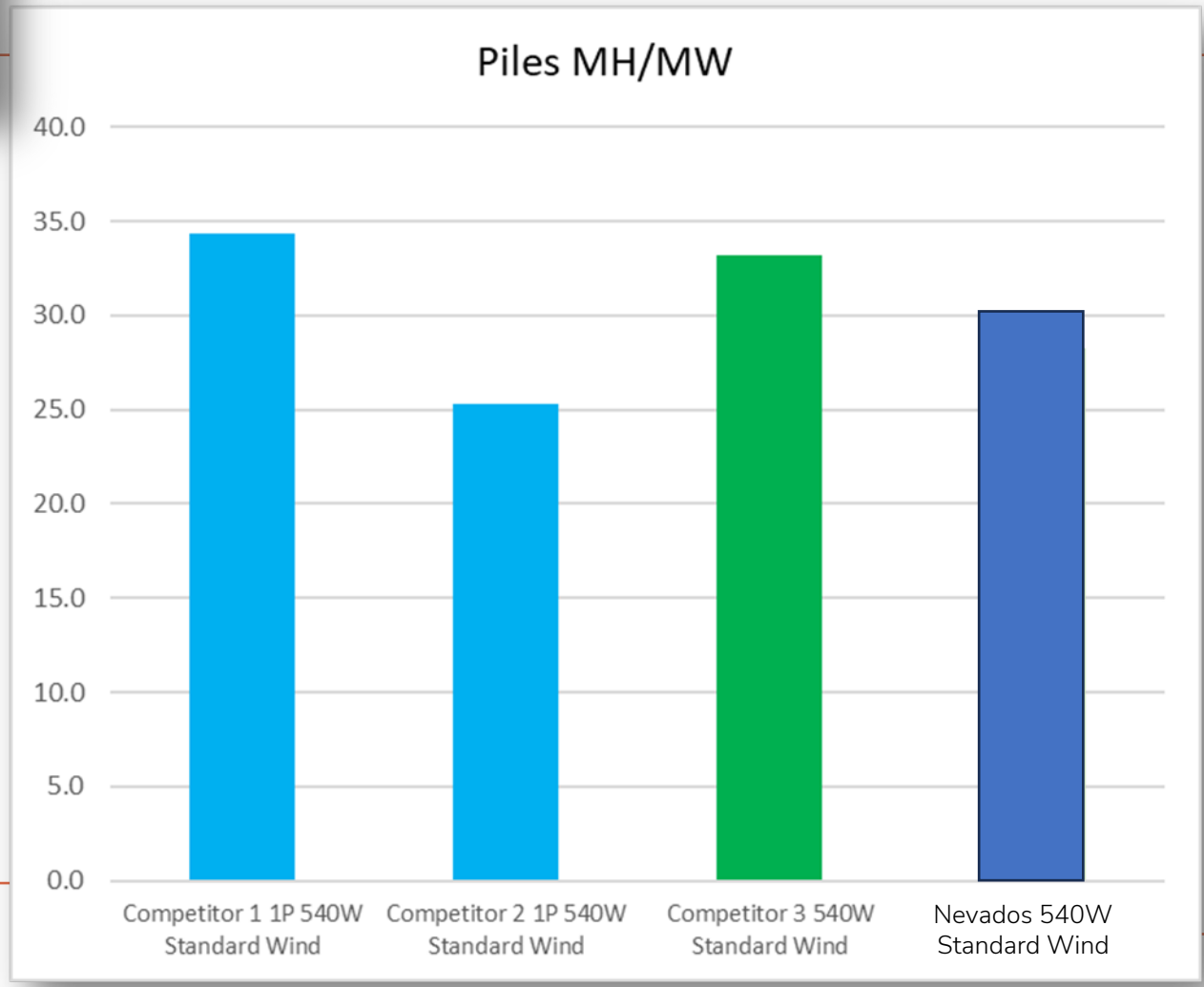
Continuous Design – higher density of mods

Major Tracker Tube Style and Terrain Capability

Tracker	Tube Style	Terrain Following
Nevados	Bay	YES (N-S, E-W) non-planar
Nextracker	Bay	NO – planar; (NX Horizon – XTR)
ATI	Continuous	Partial (E-W) planar (N-S)
FTC (2P)	Continuous	Planar
Soltec (2P)	Continuous	No - Planar
PVH Axone-Duo	Continuous	No - Planar
Gamechange	Continuous	No - Planar
Valmont	Bay	No – Planar (shorter)
SFR	Continuous	No - Planar

Piles/MWdc

- Pile accuracy can be critical to install experience/cost.
- Piles per mw can impact overall Tracker install cost:
  - total number
  - refusals and out of alignment issues
  - materials handling
- Sites with difficult topography and Geotech create a challenge to trackers with longer and more piles



Alignment Requirements

- Most 1P and 2P trackers require installation in a plane.
  - The tracker cannot follow the terrain
  - Civil work is required on many sites to smooth the topography
  - Tube to tube alignment is typically within ½ degree
  - This is especially true for continuous trackers
- Bay Trackers can have more flexibility
  - Some flex at each pile
  - Terrain following systems can greatly ease requirements for alignment
  - Can eliminate the use of lasers or string lines
- New designs such as the ATT can also greatly relieve pile requirements

Tracker Structure Design

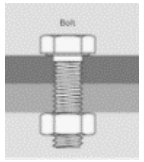
	Good	Better	Best	
Post Cap	One-Piece	Multi-piece	**Integrated with Bearing**	
Bearing/Bushing	One piece	Multi-piece		
Tube Attachment	Complex	Through Bearing	**Cradles**	Splice issues
Tube Count	**Bay Design**	Continuous Design		
Drive System	Drive Arm	**Slew**	Actuator	Hybrid
Dampers	Many	Few	**None**	

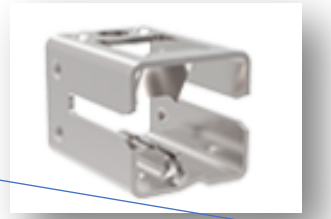
Nevados ATT®

Module Attach Technology

Very active area, really drives overall install

- Bolt / Nut
- Top Down
- Lock Pin (Huck)
- Clip/Clamp
- Hybrid





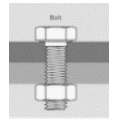
Module Attach Technology

Module install can be 40% of the total install time

Slow

Fast

Type	Pre-Position and Lock Rails?	Rate of Install of Hardware
Bolt/Nut	Yes	Slow
Lock Pin (Huck)	Yes	Medium
Clip/Clamp	Yes	Fast
Hybrid	Maybe	Fast
Top Down	No	Fast



Hardware / MW

- Hardware count and variation is a driver of complexity.
- The number of connections not including module interconnection range from 3660 per MW to 5000 per MW.
- Tracker may have a few variations in hardware size to 10 or more.
- Consideration to hardware count and complexity is an important component in the consideration of installation experience with various trackers.
- Pre-assembly by the OEM can reduce part count and hardware count – this is a current industry trend.

Grading considerations

- **Planar vs. Topo** following- *topo little to no grading*
- **Pile Accuracy** (tolerance table) – *Nevados greatly reduces pile accuracy requirements*
- **Additional considerations** – *topo following reduces length of pile (drive to minimum embedment requirement.)*
- **Soil stability** – *settling of ground concerns are minimized with topo following.*

What does the ability to follow the terrain buy you?

- Little or no grading
  - ($0.04-0.12/w)
- Wide-open tolerances on
  Pile design
- Much fewer pile variations (length)
- Reduces mud and the need for as many retention ponds.

How does the Nevados All Terrain Tracker® help your installation?

The same features that allow for unparalleled terrain capabilities help with installation times

Nevados All Terrain Tracker®

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

Tracker Architecture

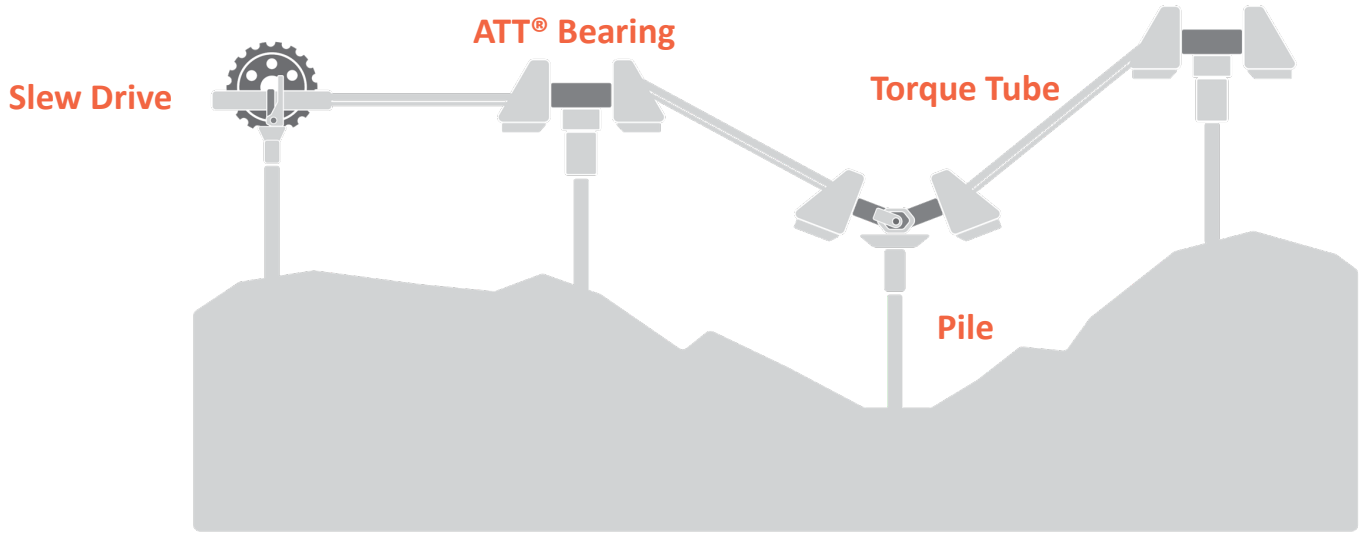
Continuous Torque Tube Tracker on terrain with variable piles

Nevados ATT®

- Typically eliminates grading
- Articulating bearings
- Consistent pile reveal heights

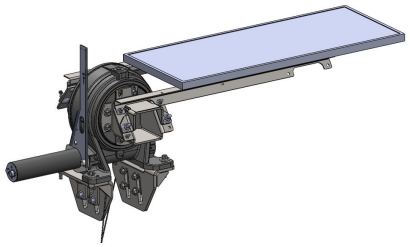
Navigate **undulating terrain** without grading or adding steel

Savings of over 3c/w



ATT® System Architecture

SLEW DRIVE



- Kinematics drive – over 53 GWs supplied globally
- Controlled via row controller

BEARINGS

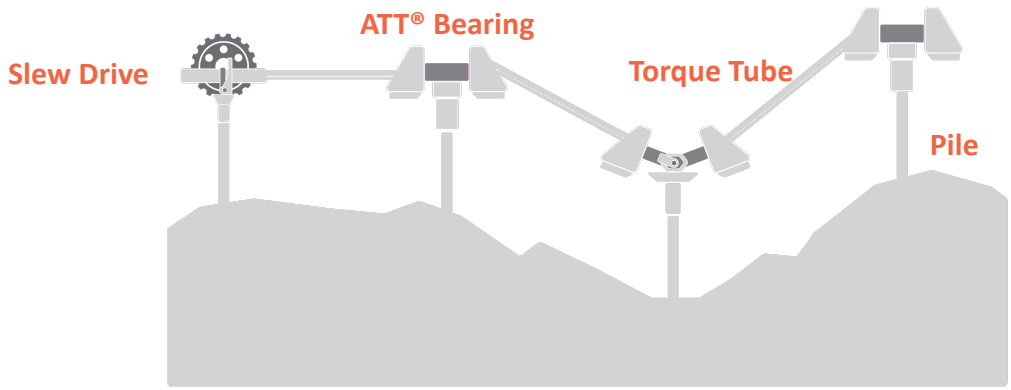
- Couples torque tubes
- Every non-drive pile
- Articulation to navigate terrain

MODULE CLIPS

- E/W alignment tabs
- Spring loaded top clamp
- Integrated grounding features

STEEL

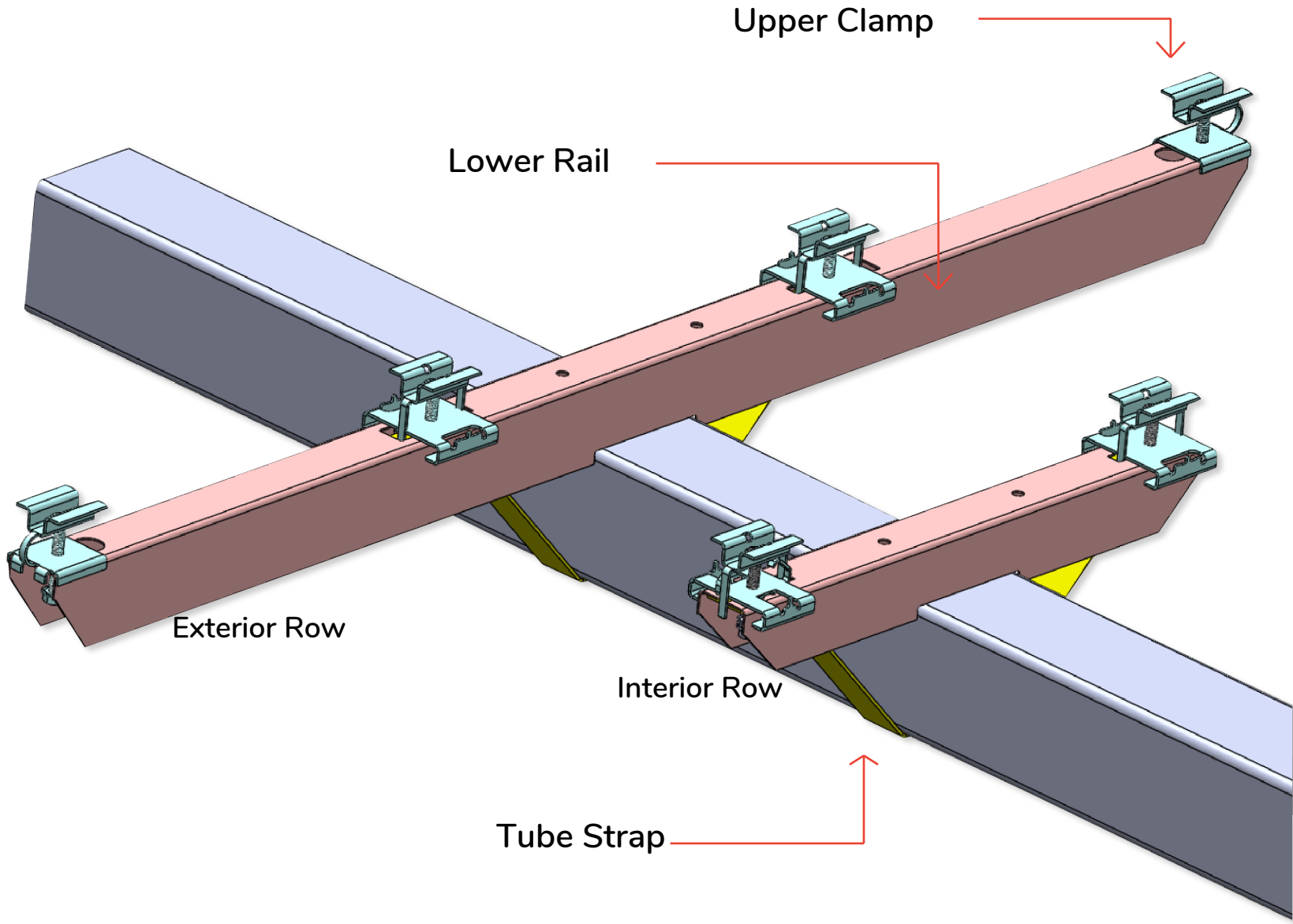
- Consistent pile reveal heights across site
- Square sectioned torque tube designs – easy alignment on bearing cradles



NEVADOS

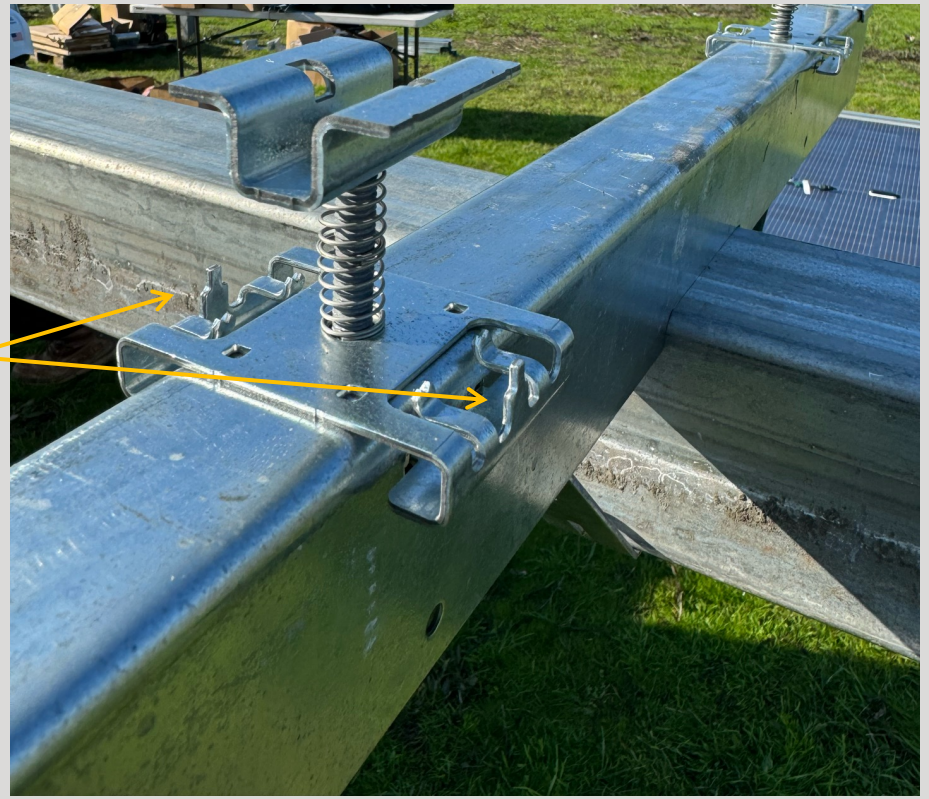
Module Clamps

- Compatible with all Cr-Si and First Solar modules
- Self aligning (no jigs needed)
- Accommodate module changes easily, module clamps slide on torque tube
- Integrated grounding (UL 2703)



Module Clamps

E-W Module Alignment Pins

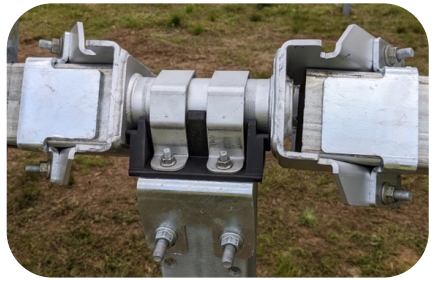


Nevados ATT® Installation Features

Bearing Features

- Articulation at every post to navigate terrain
- Bearings ship pre-kitted
- Entire system uses only two bolt sizes for tool and training simplification
- Integrated wind dampening *(no external dampers)*

Straight Through



+/- 4.4%

Articulating

+/- 26 %

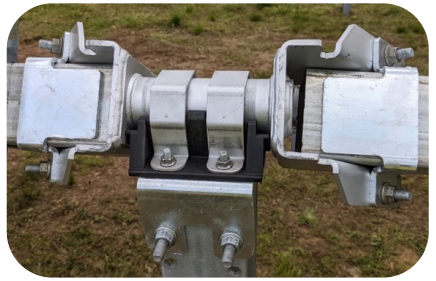
Nevados ATT® Installation Features

Bearing Tolerances

Terrain capabilities also create installation friendly tolerances

N/S Pile Tolerance	±1 inch
Vertical Pile Tolerance	+/- 80 inches
Plumb Tolerances	±2°
Twist	±5°

Straight Through



+/- 4.4%

Articulating

+/- 26 %

Nevados ATT® Installation Features

Flat Bill of Materials

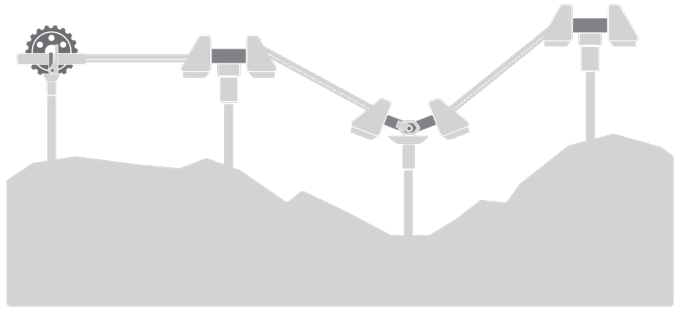
- Simplifies on-site staging and inventory management
- Standardized components – projects are configurations based on topography and other project requirements

COMPONENT CATEGORY	PART NUMBER	DESCRIPTION
SLEW DRIVE KIT	NE21P-0009	Post Mount, Slew Drive (Inch)
	NE21P-0095	Cradle, Concentric, Slew Drive, HE6 (Inch)
	NE21P-0096	Cradle Clamp, Concentric, Slew Drive, HE6 (Inch)
	NE21P-0097	Bracket RC Antenna, Slew Drive (Inch)
	NE21P-0084	Slew Drive, HE6, 16 mm Motor Shaft
	NE21P-0098	Motor, Slew Drive, 16mm Shaft, 120Nm Torque, RC Gen 2
	NE61P-0070	Bolt, Ser. Flange, M12x1.75x25mm, Grade 8.8, HDG
	NE61P-0005	Carriage, Bolt, M12x1.75x40 mm, Grade 8.8, HDG
	NE64P-0001	Nut, Ser. Flange, M12x1.75 mm, Grade 8.8, HDG
	NE61P-0009	Bolt, Ser. Flange, M12x1.75x65mm, Grade 8.8, HDG
	NE63P-0128	Washer, Flat, ID 9/16" x OD 1.375" x HT 0.125", 316SS
	NE45P-0004	Bonding Strap, A2250-18
	NE61P-0016	BOLT, Ser. Flange, M6x1x25mm, Passivated, 18-8 SS
	NE64P-0005	Nut, Ser. Flange. M6x1mm, Passivated, 18-8 SS
	NE21P-0093	Cradle, Concentric, Slew Drive, HE8 (Inch)
	NE21P-0094	Cradle Clamp, Concentric, Slew Drive, HE8 (Inch)
	NE21P-0083	Slew Drive, HE8, 16 mm Motor Shaft, Horizontal Motor Mounting Holes
	NE61P-0070	Bolt, Ser. Flange, M12x1.75x25mm, Grade 8.8, HDG
	NE66P-0004	Screw, Socket Head Cap, M12x1.75x30mm, Grade 8.8, HDG
MODULE CLIP KIT	NE61P-0007	Bolt, Hex, M8x1.25x60 mm, Fully Threaded, Grade 8.8 HDG
	NE64P-0002	Nut, Ser. Flange, M8x1.25 mm, Grade 8.8, HDG
	NE32P-0065	Clamp, 35mm tall, Group A Holes, c-Si Module Clip
	NE32P-0066	Tube Strap, Interior, c-Si Module Clip
	NE32P-0067	Lower Rail, Interior, c-Si Module Clip
	NE32P-0068	Standoff, c-Si Module Clip
	NE32P-0072	Clamp, Exterior, 35mm tall, c-Si Module Clip
	NE32P-0069	Tube Strap, Exterior, c-Si Module Clip
	NE32P-0070	Lower Rail, Exterior, c-Si Module Clip
MECHANICAL ASSEMBLIES	NE22A-0066	Compact Straight-Through Bearing Assembly (Inch)
	NE23A-0016	ASY U-Joint, Post Top
	NE22A-0067	Compact Mechanical Stop Bearing Assembly (Inch)
	NE22A-0005	Compact Row End Bearing Assembly (Inch)
	NE22P-0118	Compact Mechanical Stop Weldment (Inch)
POST TOP FASTENERS	NE61P-0011	Bolt, Ser. Flange, M12x1.75x45mm, Grade 8.8, HDG
	NE64P-0001	Nut, Ser. Flange, M12x1.75 mm, Grade 8.8, HDG
	NE61P-0005	Carriage, Bolt, M12x1.75x40 mm, Grade 8.8, HDG
TORQUE TUBES	NE-F10-332-585	10 Ga, 80 ksi, Torque Tube, 332.585 Inch
	NE-F10-287-019	10 Ga, 80 ksi, Torque Tube, 287.019 Inch
	NE-F13-332-585	13 Ga, 80 ksi, Torque Tube, 332.585 Inch
	NE31P-0244	80 ksi, Torque Tube, 2 Inch
	NE-F10-403-000	10 Ga, 80 ksi, Torque Tube, 403 Inch
	NE41P-0064	MOUTING STRAP, ROW CONTROLLER GEN 2 (INCH)

Nevados ATT® Installation Features

Consistent Pile Reveal Heights

- Simplified pile driving
- Allows for fast installation performance
- Designed for chest height install



Nevados ATT® Installation Features

Disconnected Torque Tube System

- Sections of bays can be left “open” to allow material handling equipment to pass through
- Material handling savings
- Convenience for long N/S rows

Nevados ATT® Customer Feedback

Nevados All Terrain Tracker Installation Efficiency

From: Allen Oldroyd, General Superintendent MYR Group
Note: Budgeted rates are defined based on averages of other tracker manufacturers.

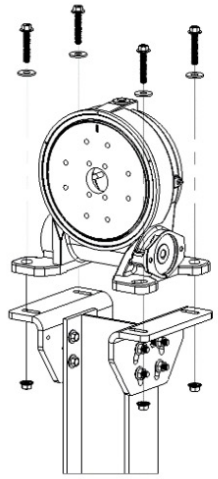
Tracker staging and shakeout	Consistently getting 2-3x better efficiency than the budgeted production rate.
Tracker Drive Motors	Consistently getting 2x better efficiency than the budgeted production rate.
Torque Tube Set	This one fluctuates a bit but is comparable to others. A little slower than best-in-class competitor due to the module rails needing to be slid on during installation. Estimated 25% less efficient than the fastest competition.
Tracker Final Install and Torque	Huge efficiency gains here. Averaging 2-3x better efficiency than budgeted. This is our largest crew and the labor savings have been immense.
DC Cable Install	The ability to leave out the torque tube by the cab line has had us get an average of 1.5x the budgeted productivity rate.
Pile Install	Constant pile elevations have made pile install simple and efficient. Requiring less people, lasers, string line, etc. Efficiency gains of 2x budgeted production.

Testimonial Video here: https://vimeo.com/853499154/0f88acb1a6

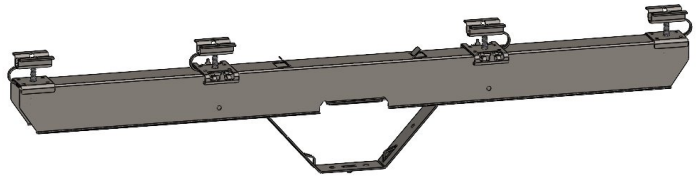
Customer Feedback Loop

Upcoming Product Changes

- Components arriving to site pre-kitted
- Bearing clamp caps shipped separately
- Continued reduction of component counts



Slew Drive cradles pre-assembled



Module clips shipping pre-assembled

ATT® Bearing cradles shipped separately

Emerging Installation Tools

New Tools/Techniques

- Drone Flyovers
- Torque Control Tools
  - CTIW, Controlled Torque Impact
  - Nut Runner
  - Torque Coupler
- Lean Construction Methodologies – Eclipse-M Lean Method
  - Materials Handling
  - Pre-assembly
  - Optimized Operations

Drone Flyover

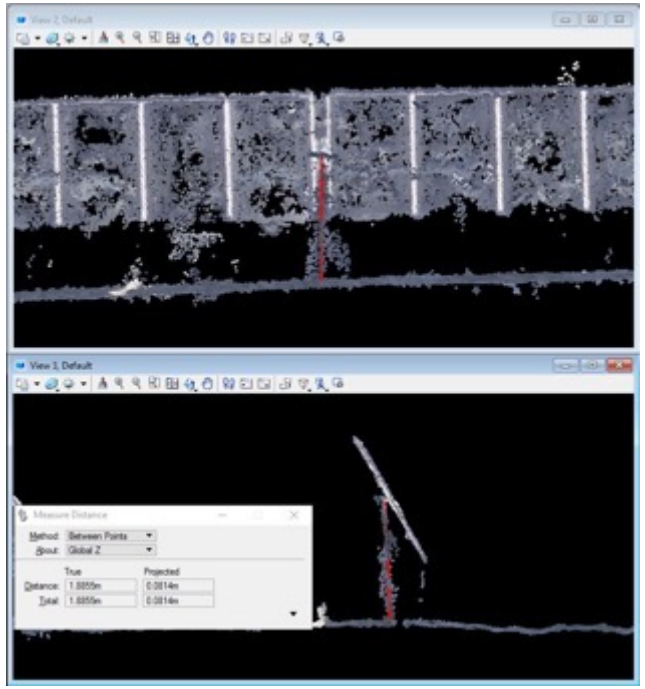
Using low cost RGB camera

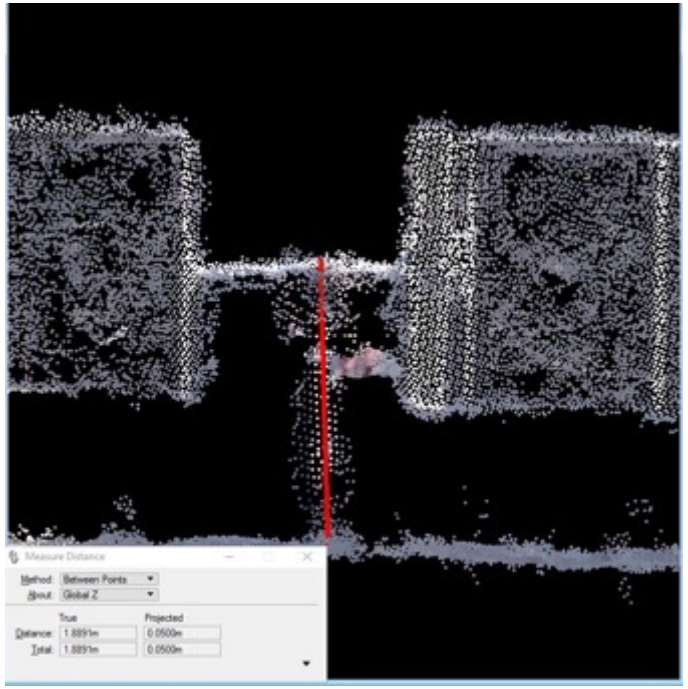
Can be used to:

- 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





Smart Tools

WHAT IS IT?

- Alternative to torquing every bolt with a torque wrench
- Establishes a controllable statistical window of torque – achieving requirements of some trackers.
- Have evaluated the Milwaukee CTIW system with Nevados and it meets requirements.
- Faster nut runners can improve nut-bolt module installation

SAVINGS IMPACT

- Reduces the install labor for hardware nearly in half

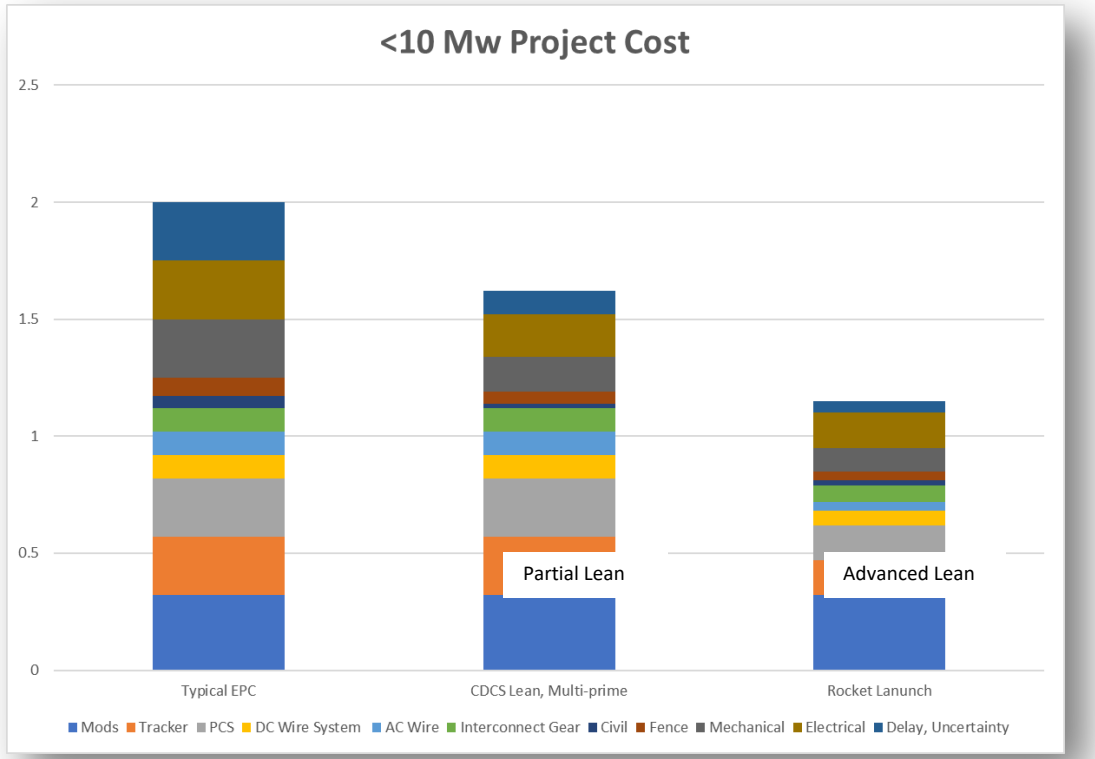
Eclipse-M Lean Method

WHAT IS IT?

Lean based construction methods

- Lean strategy and work sequencing
- Standard Work Instructions
- Headcount Planning – based a balance daily output (takt time) approach
- Materials Handling Systems greatly reducing site logistics cost
- Use of Pre-assembly
- Documented Project Execution Plan

Installation Cost Example



Closing Thoughts

- Understand the tracker architecture and how it might affect installation
- Maintain partnership with equipment providers to improve current and future projects
- 3rd party experts like Eclipse-M
  - Documentation, training is critical
  - Standard Work, implementing a system creates sustainable progress

NEVADOS
TRACKERS ANYWHERE

Continue the conversation

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Bill Poulin
Managing Partner, EM
bill@eclipse-m.com

- Oakland HQ Training
- Sandbox Training at Davis, CA
- Virtual Consults
- Meet with us at tradeshows

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Questions