Introduction to Geodetic-Grade Braced Monuments for Continuously Operating Reference Stations

John Galetzka
Chief, Geodetic Infrastructure Branch
NGS Webinar, May 9, 2024

Outline

- SCIGN braced monument story
- monuments matter
- types of braced monuments
- installation basics
- discussion

SCIGN

(Southern California Integrated GPS Network)

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EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

EOS

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PAGES 417–432

GREAT DEBATES IN GEODESY

Will a Continuous GPS Array for L.A. Help Earthquake Hazard Assessment?

PAGE 417

The striking landscapes and hospitable climate of Southern California are home to more than 20 million people and vital elements of the nation's economy. Unfortunately, the region is also laced with many active faults that can produce strong earthquakes. Scientists from several institutions are pursuing a new approach to studying earthquake hazards in a high-risk metropolitan area.

The Southern California Integrated GPS Network (SCIGN) is currently an array of about 40 Global Positioning System (GPS) stations distributed throughout the greater Los Angeles metropolitan region. There have been informal discussions about expanding the array to 250 stations, and formal proposals have been submitted to begin this expansion. To achieve high precision, the sites will be carefully monumented, and all the GPS receivers will operate continuously. The goals of the array are to provide an accurate and detailed velocity field from which to identify the deformation from known faults, test current models of the geologic structure, and make better estimates of the seismic potential in the populous parts of southern California.

At present SCIGN includes 38 stations installed and operated by the University of California, San Diego (UCSD), NASA's Jet Propulsion Laboratory (JPL), and the U.S. Geological Survey (USGS) (Figure 1). Funding from NASA and NSF is available to install another 70 sites and additional funding is being sought from other sources. New stations will be installed both regionally (~30-km spacing) and along three densely instrumented profiles (spacing 1 to 3 km, A-A', B-B', and C-C' in Figure 1). All data will be processed at UCSD and JPL and will be available on Internet (http://scec.gps.caltech.edu/scign.html).

If SCIGN grows to the 250 GPS stations that some have advocated, the cost of building the array will be about $7.5 million for equipment and installation. The operating cost is more difficult to estimate, but over 5 years, it could easily equal the capital cost, for a total cost on the order of $15 million. Is this a cost-effective use of our resources?—*William H. Prescott, U.S. Geological Survey, Menlo Park, Calif.*

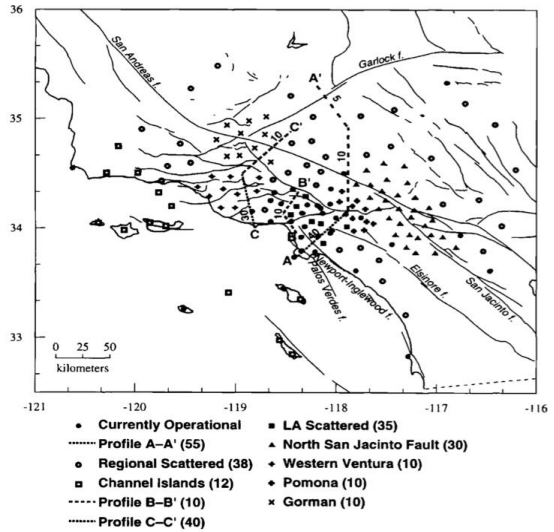
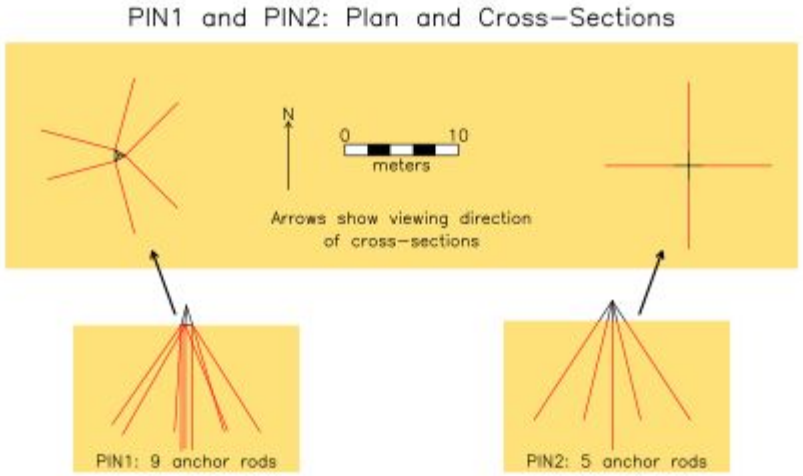


Fig. 1. Map showing existing and proposed SCIGN stations. Solid circles indicate currently operating stations; all the others are proposed sites. For three dense profiles (A-A', B-B', and C-C'), the number of stations on each profile is indicated rather than the individual sites. The map was the product of a Southern California Earthquake Center workshop held at the Jet Propulsion Laboratory in Pasadena, Calif., in March 1995. Various subexperiments are listed at the bottom of the figure in the priority order adopted at the workshop.



From Wyatt and Agnew, 2005

Mast Assembly

Monument Assembly

Hector Mine GPS Station Northwest, 6DEC99

Tectonic Motions of the Western United States

Horizontal velocities for western United States GPS stations. Data are processed by the Geodesy Advancing Geosciences and EarthScope (GAGE). Velocities are in the North America-fixed reference frame (NAM08). The number of stations shown in California has been greatly reduced to make it easier to see regional motion. For updated velocities, search the web for GPS/GNSS Velocity Viewer.

For this map and related links, go to EarthScope.org

NSF USGS NASA GAGE SAGE EarthScope Operated by UNAVCO Consortium

Comments on NGS Proposed CORS Monumentation

Duncan Carr Agnew, Yehuda Bock, Frank Wyatt

Institute of Geophysics and Planetary Physics
Scripps Institution of Oceanography
University of California, San Diego

1. Introduction

The National Geodetic Survey (NGS) Process Action Team 20 has developed a design for site monumentation for Continuously Operating Reference Stations (CORS) of a national GPS network. This design is described in admirable detail in the Team's final report of 20 December 2000 (hereafter the "Report"). It does not appear that any input from outside of NGS was sought during the development of the design; this note is an attempt to offer such input, with the perspective of a long involvement with issues of stable monumentation, and particularly close knowledge of the monumentation adopted for the Southern California Integrated GPS Network (SCIGN).

Since much of this note will raise some objections to the NGS Report, it should be said at the outset that it represents a step towards an important goal, namely better CORS monumentation. Certainly, this design is likely to be an improvement over some of the systems now in use (for example, mounting the antenna on a roof). Also, it can be installed at relatively low cost.

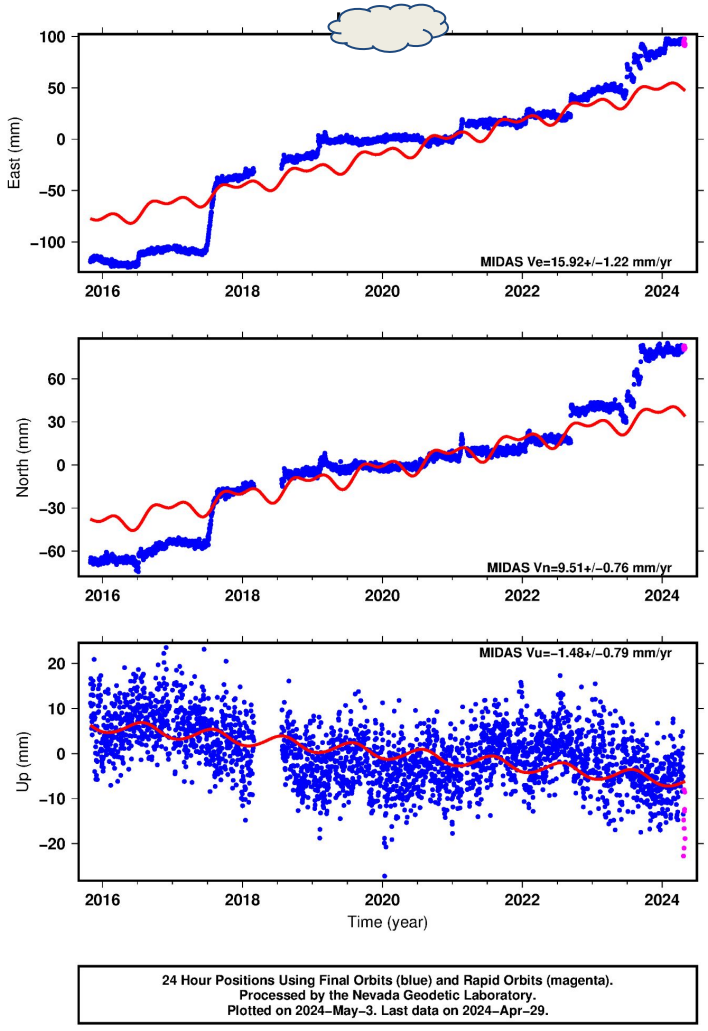
A summary of the comments made in more detail below would include the following points:

- The aim of a single design does not seem appropriate, given the range of geology in which a monument may need to be set.
- The criteria for monument stability used in the Report do not match those determined from other studies.
- The design given requires drilling a relatively large hole. Such drilling (unless done with fairly massive equipment) is likely to stop at the first moderately hard material (probably not "bedrock"), thus ensuring that the monument will not be coupled to stable material.
- The emphasis put on avoiding all metal in construction is not justified. Concrete also will scatter the signal, and tests of metallic monuments show that they can be built to have no significant effect on GPS positions.
- The Report does not include any discussion of the desirability of a stable electromagnetic environment.
- The cost estimate for the CORS monument does not show the total cost; when all costs are included the cost ratio between this and other monuments is not large, especially given the long lifetime expected for a geodetic monument.

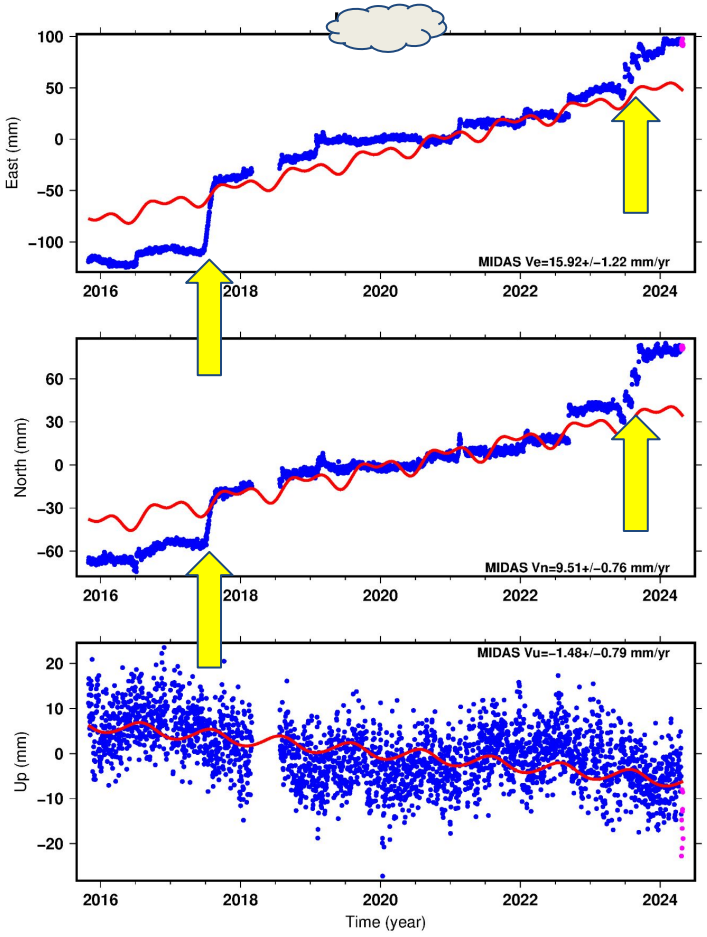
13 July 2001

monuments matter


AIR



24 Hour Positions Using Final Orbits (blue) and Rapid Orbits (magenta).
Processed by the Nevada Geodetic Laboratory.
Plotted on 2024−May−3. Last data on 2024−Apr−29.



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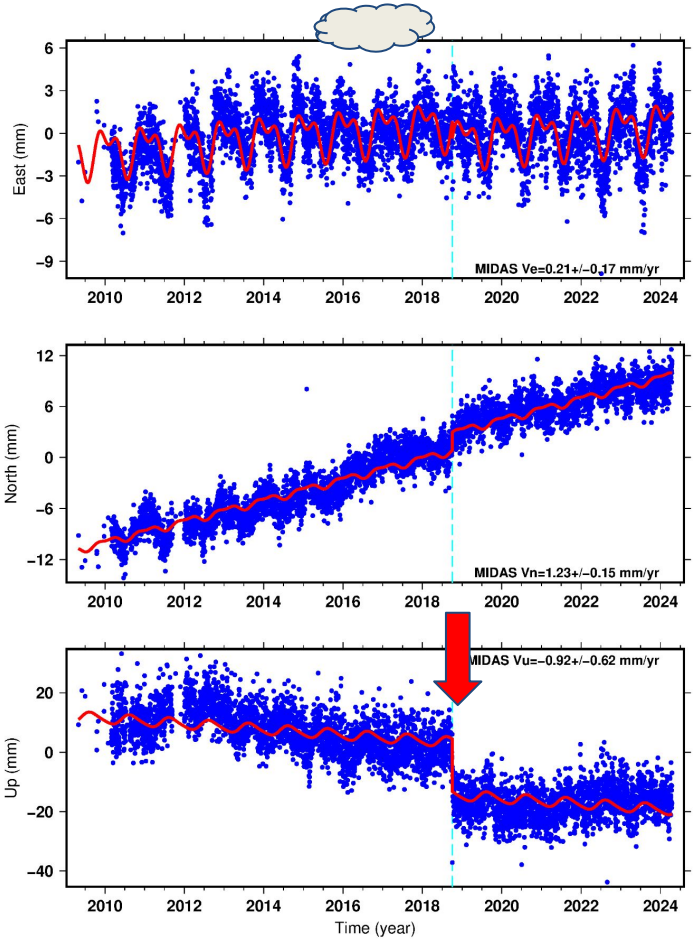
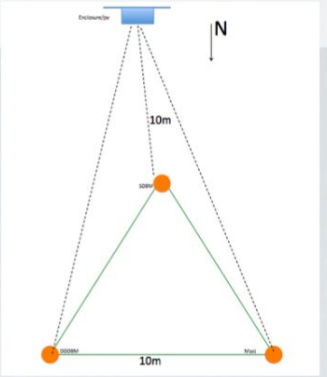


24 Hour Positions Using Final Orbits (blue) and Rapid Orbits (magenta).
Processed by the Nevada Geodetic Laboratory.
Plotted on 2024−May−7. Last data on 2024−Apr−16.

MULTI-MONUMENT LOCATIONS

Blume et al, 2013

	4-Char Code	Monument Type	Installation
The Rock, GA	P804	DDBM	Oct 2012
Granite	P805	SDBM	Oct 2012
	P806	Mast	Oct 2012
Wilbur, WA	P453	DDBM	Oct 2005
Basalt	P813	Mast	Aug 2013
	P814	SDBM	Aug 2013
Forks, WA	P401	DDBM	Apr 2005
Clay Substrate	P815	Pillar	Aug 2013
	P816	Driven SBM	Aug 2013
Delano, CA	P565	DDBM	Nov 2005
Clay/Silt/Sand	P809	Pillar	Feb 2013
	P810	Driven SBM	Feb 2013
California City, CA	P591	DDBM	June 2005
Sand	P811	Pillar	Feb 2013
	P812	Driven SDBM	Feb 2013



- 5 localities were chosen
  - 2 in California
  - 2 in Washington
  - 1 in Georgia
- 3 monument types at each
- Existing DDBM were utilized at 4 installations
  - Delano, CA - California City, CA - Wilbur, WA - Forks, WA
- Site selection criteria:
  - Low multi-path
  - Clear sky view
  - Multiple geological conditions

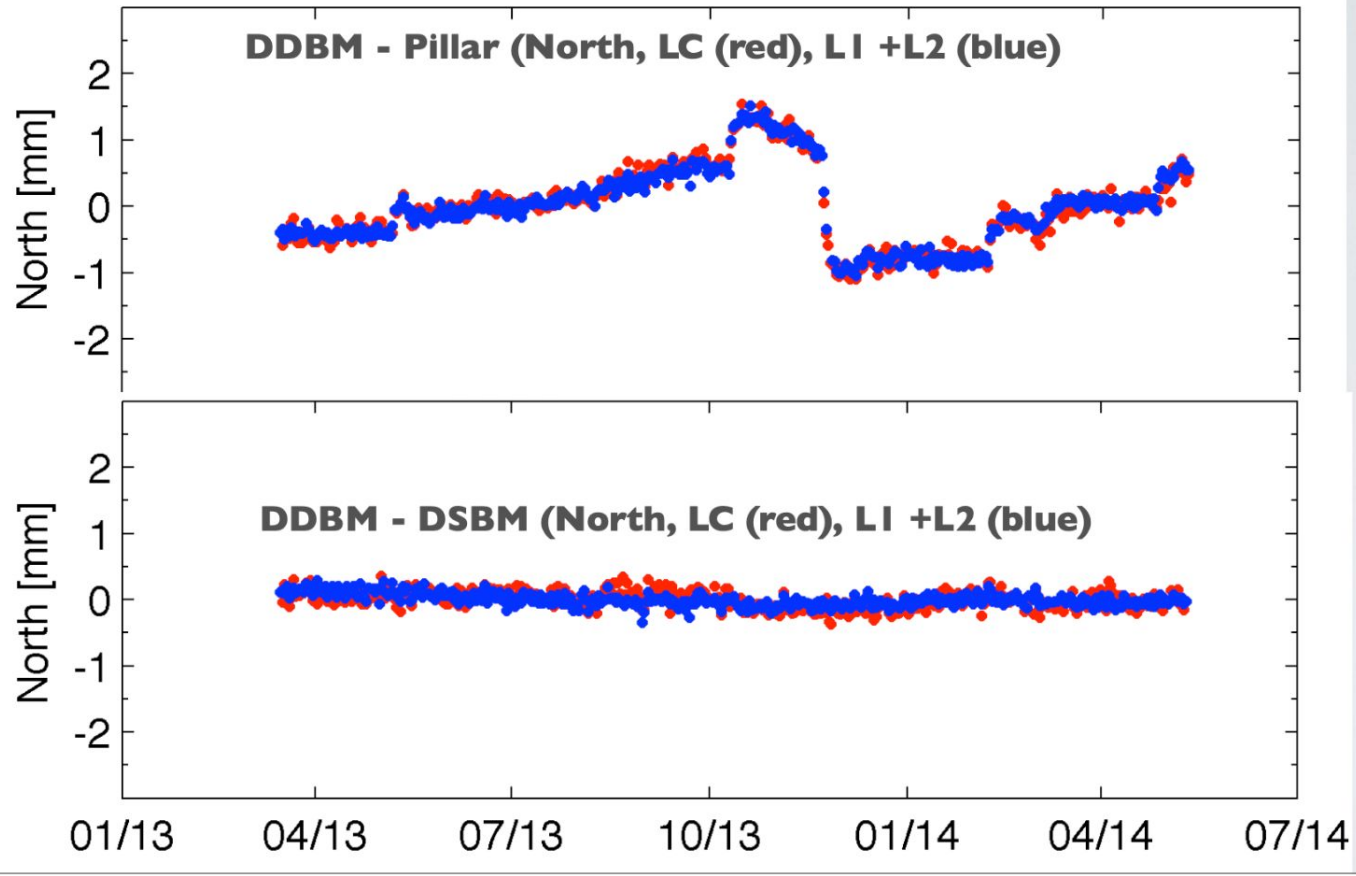
- Site Geometry
  - Triangular with 10m spacing

UNAVCO

CALIFORNIA CITY, CA

Blume et al, 2013

18" diameter hole about 15ft deep



UNAVCO

CALIFORNIA CITY, CA

Blume et al, 2013

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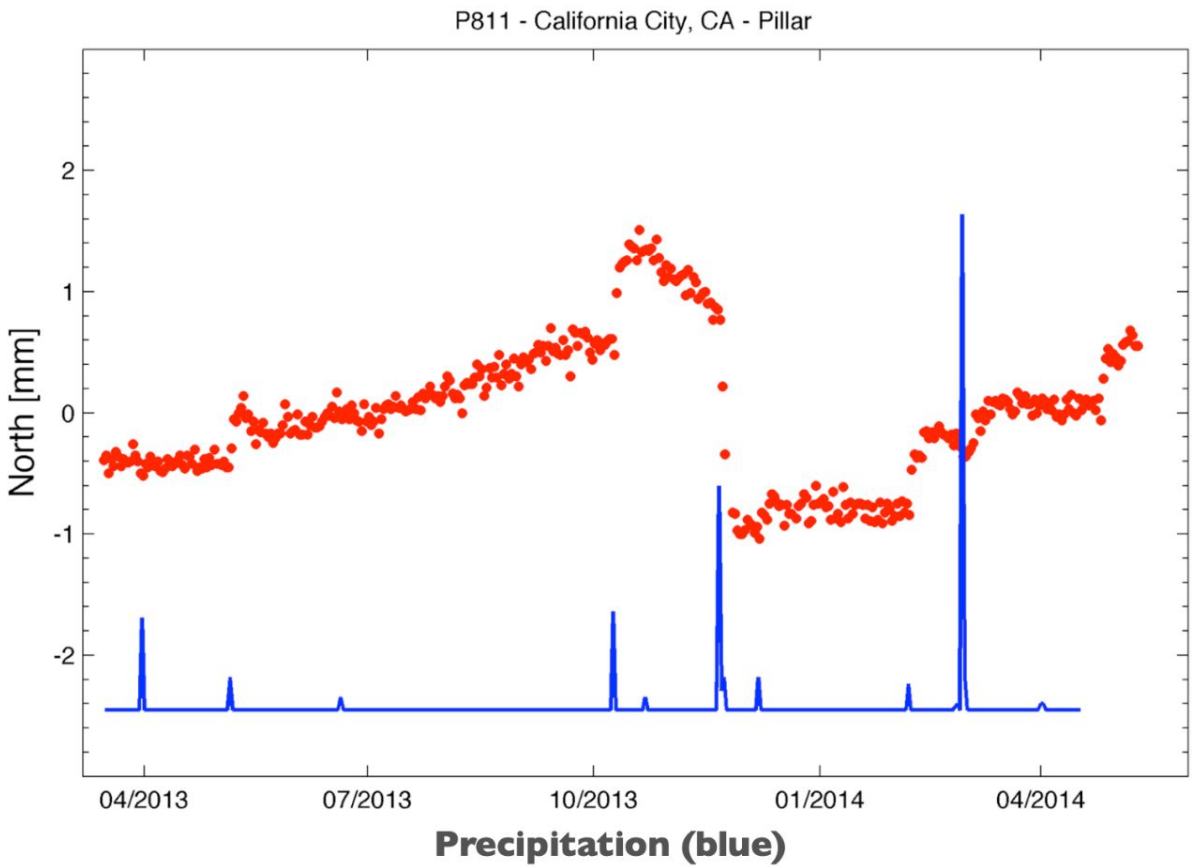


Effects of surface mass loading on the stochastic properties of GPS time series in the Great Lakes region

Jordan Krcmaric
May 6, 2024

Advisor: Dr. Corné Kreemer

Committee Members:
Dr. Geoff Blewitt, Dr. Anna Panorska

GPS monuments

NGL Monument Table + WISCORS = 831 sites with monument information

Classified into 5 categories:

DDBMs (n=11)

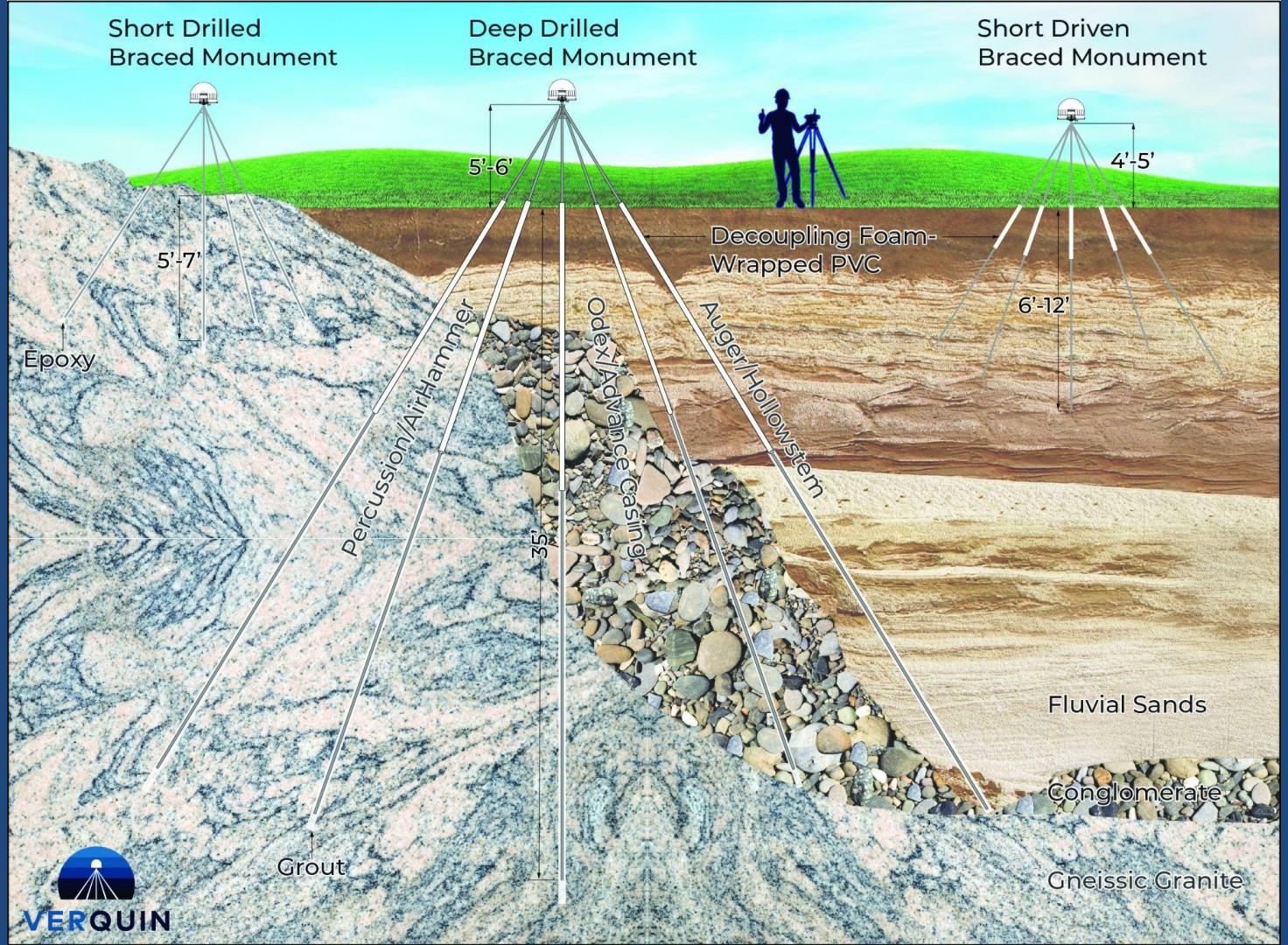
Roof mounted (n=461)

Concrete pillar (n=314)

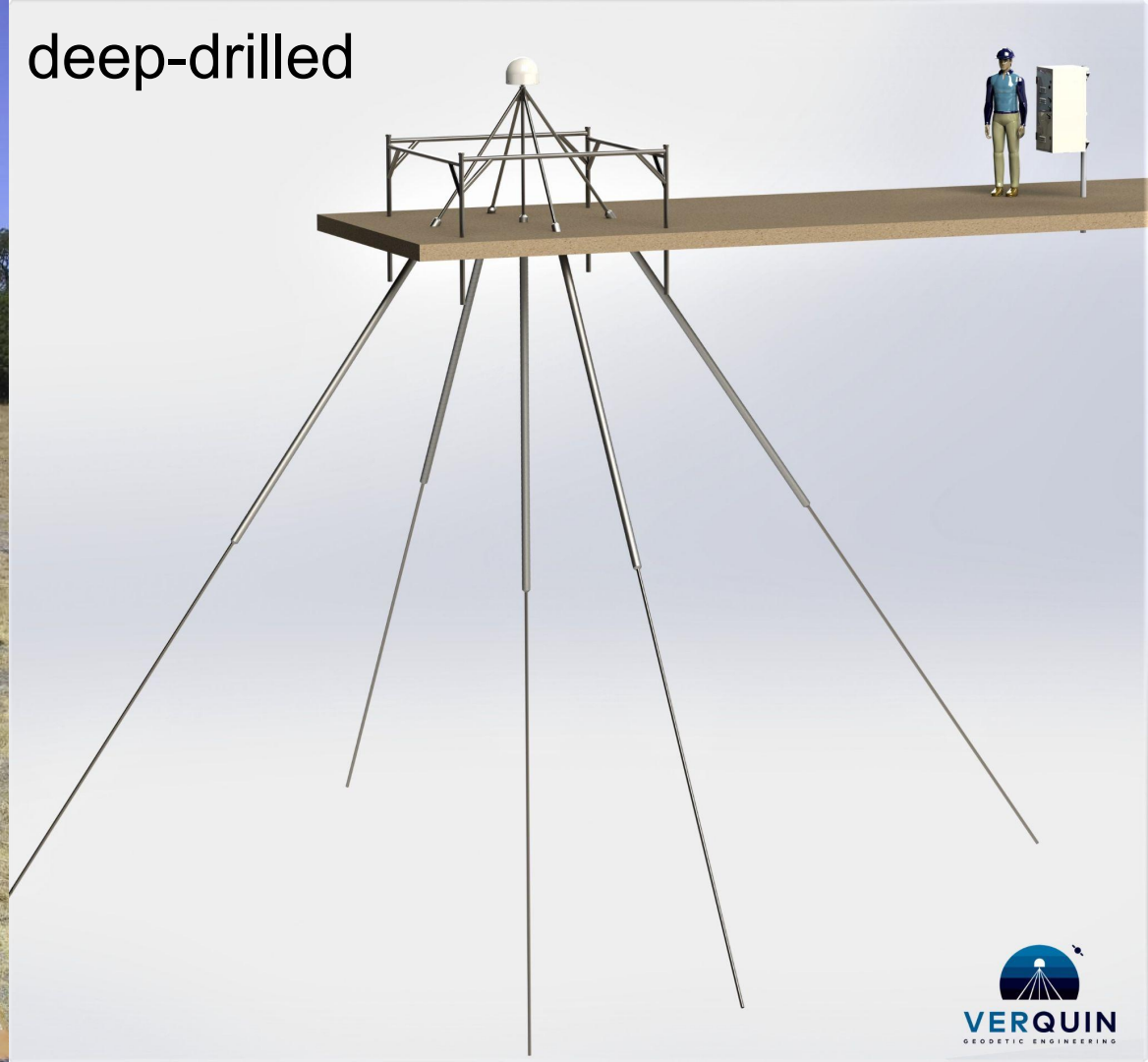
Steel tower (n=33)

Bedrock (n=12)

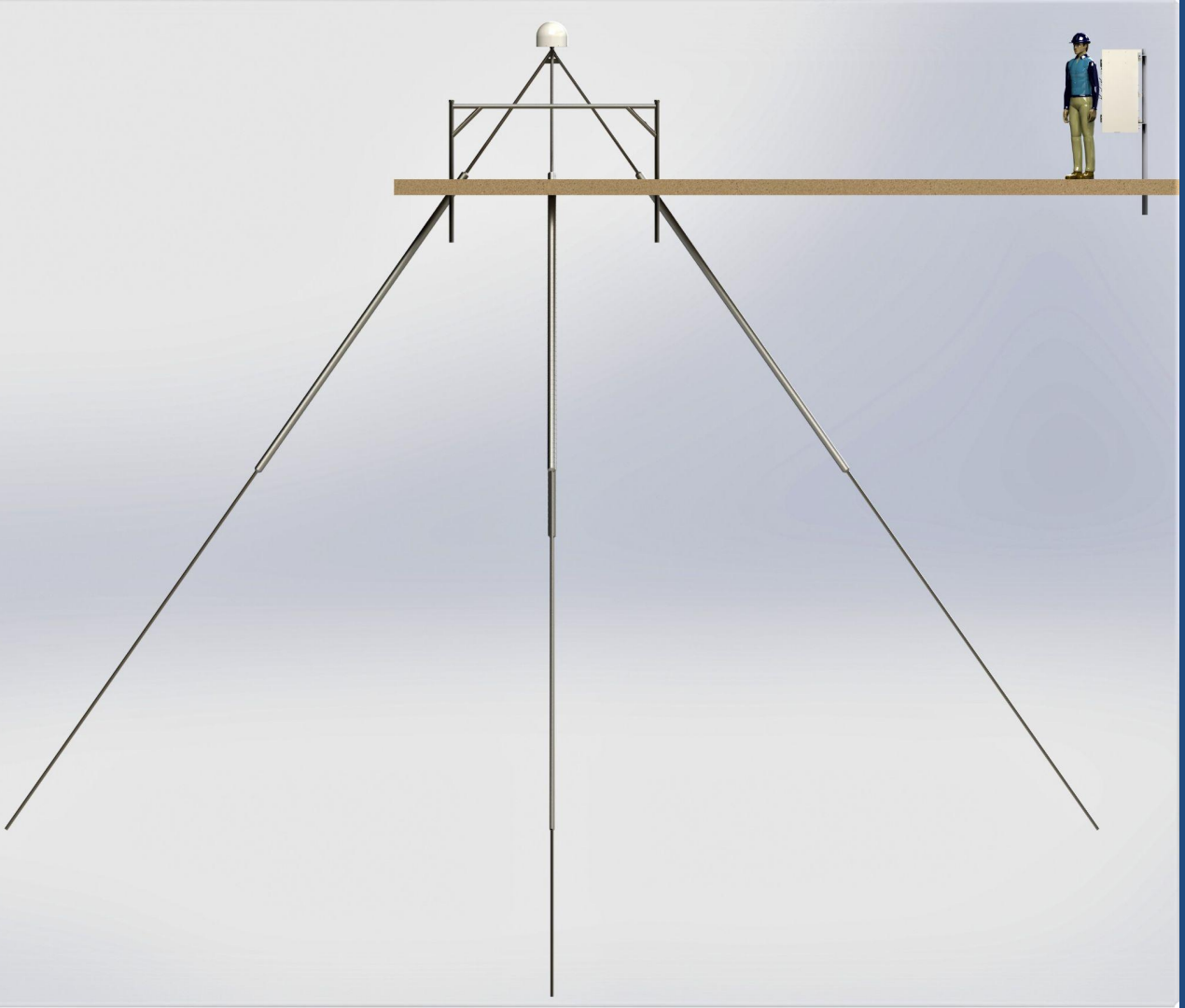
types of braced monuments

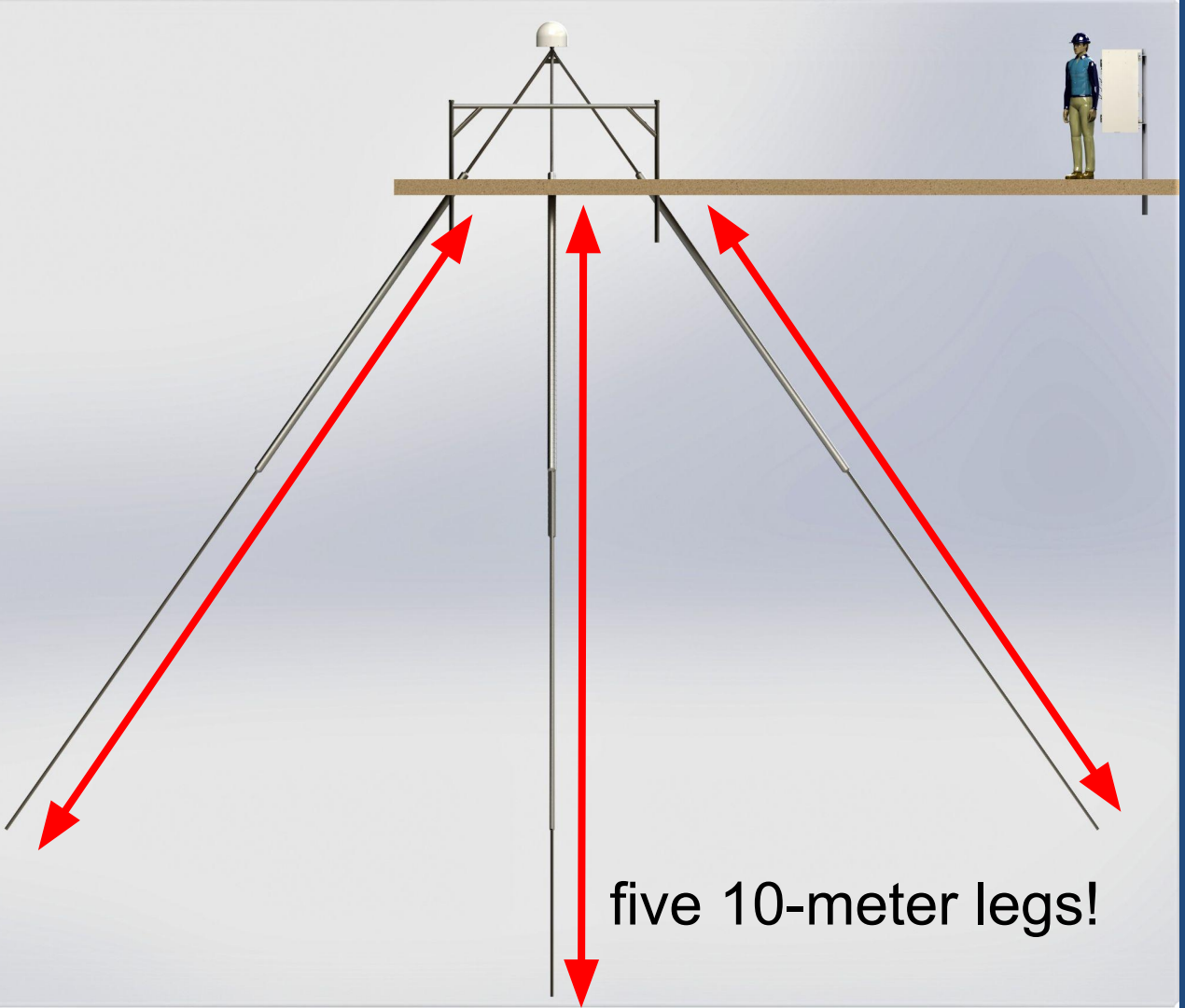

Short Drilled
Braced Monument
Deep Drilled
Braced Monument
Short Driven
Braced Monument
5'-6'
4'-5'
5'-7'
Decoupling Foam-
Wrapped PVC
6'-12'
Epoxy
Percussion/AirHammer
Odex/Advance Casing
Auger/Hollowstem
35'
Fluvial Sands
Conglomerate
Grout
Gneissic Granite
VERQUIN

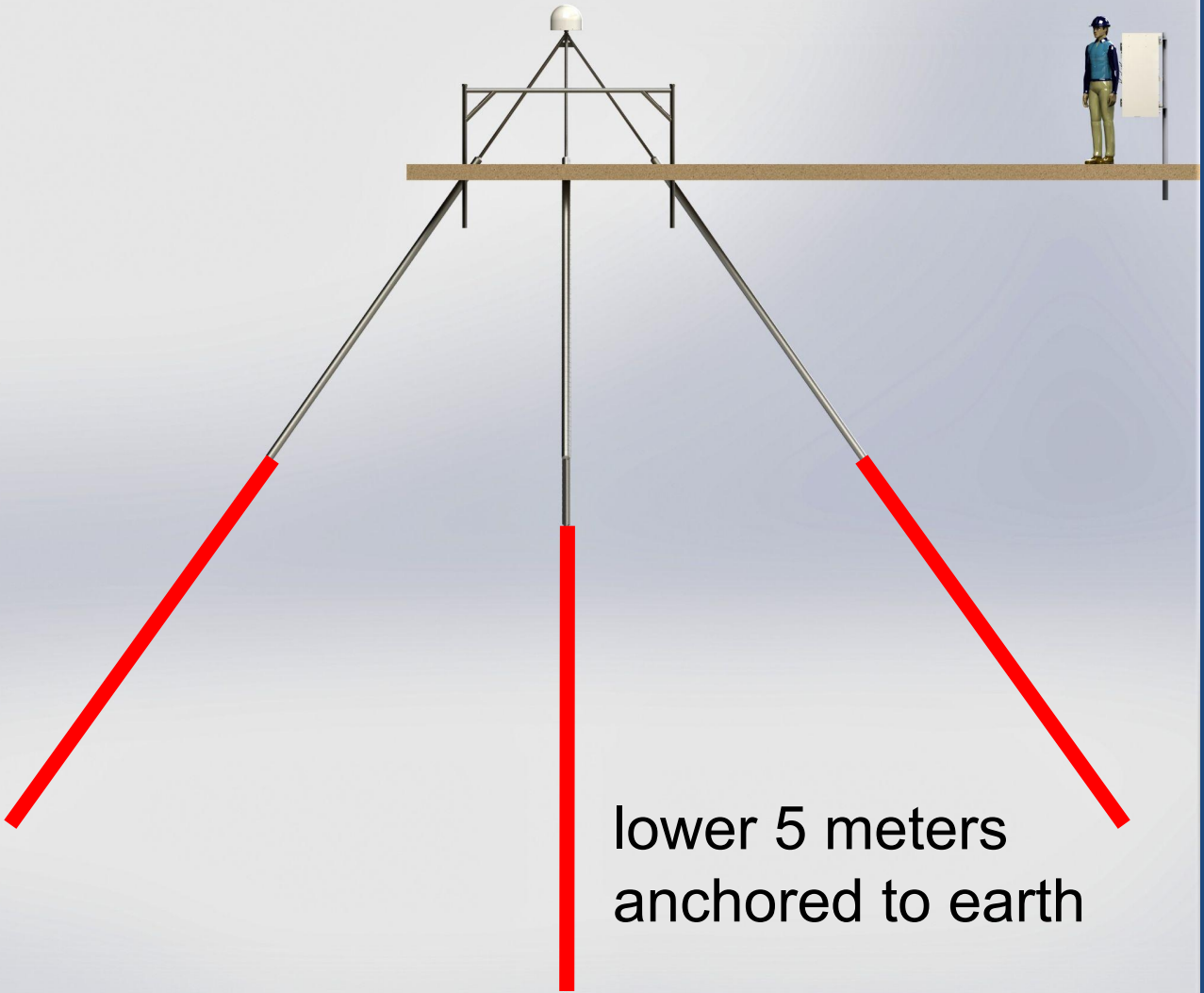
deep-drilled

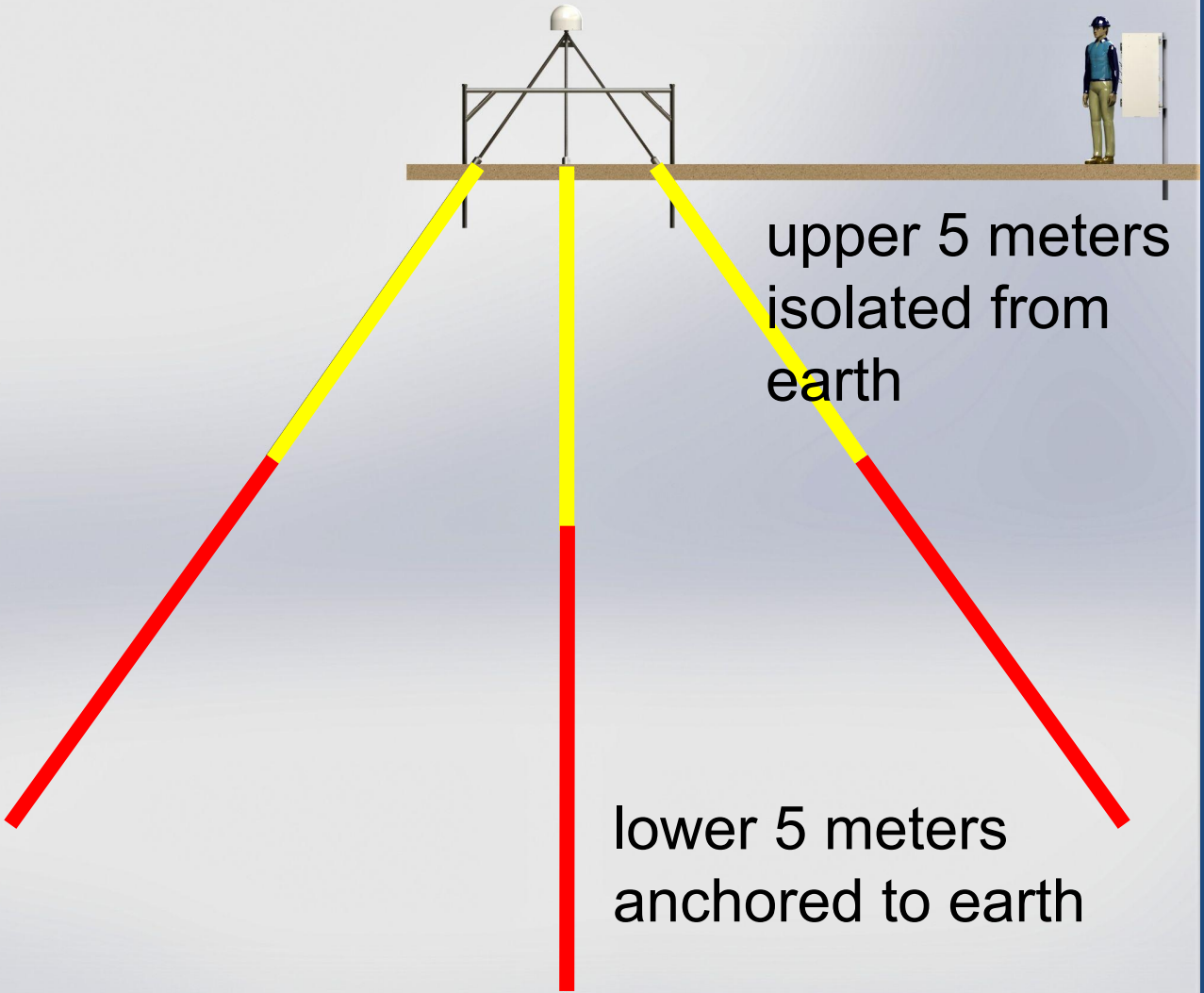


VERQUIN
GEODETIC ENGINEERING




five 10-meter legs!

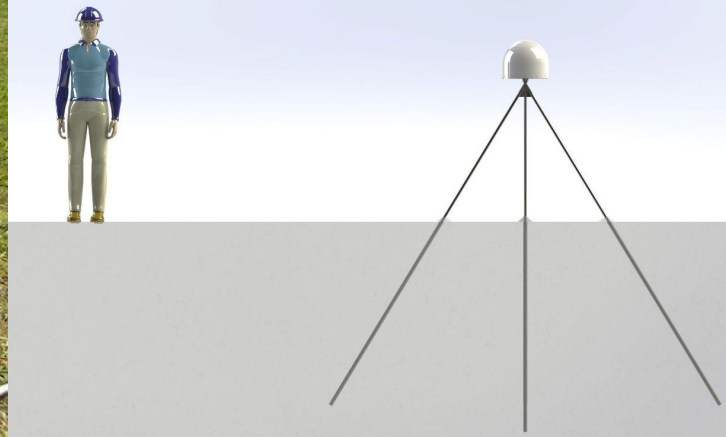

lower 5 meters
anchored to earth


upper 5 meters
isolated from
earth
lower 5 meters
anchored to earth

MG05 Deep-Drilled Braced Monument and VLBI radio telescope at McDonald Observatory, TX

Installation of Shallow-Drilled Braced Monument at Franklin, NC

shallow-drilled



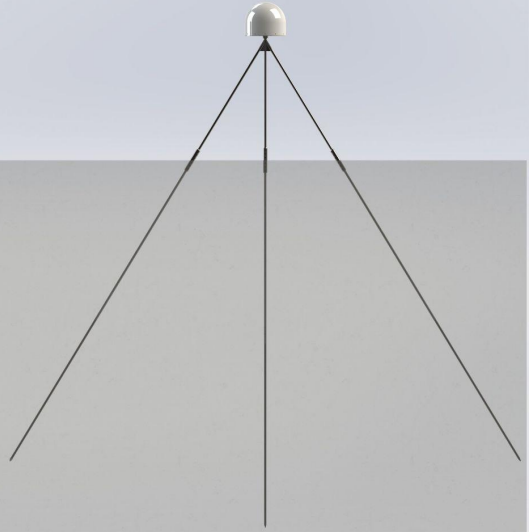
JMSM, Nepal

PTLO, Indonesia

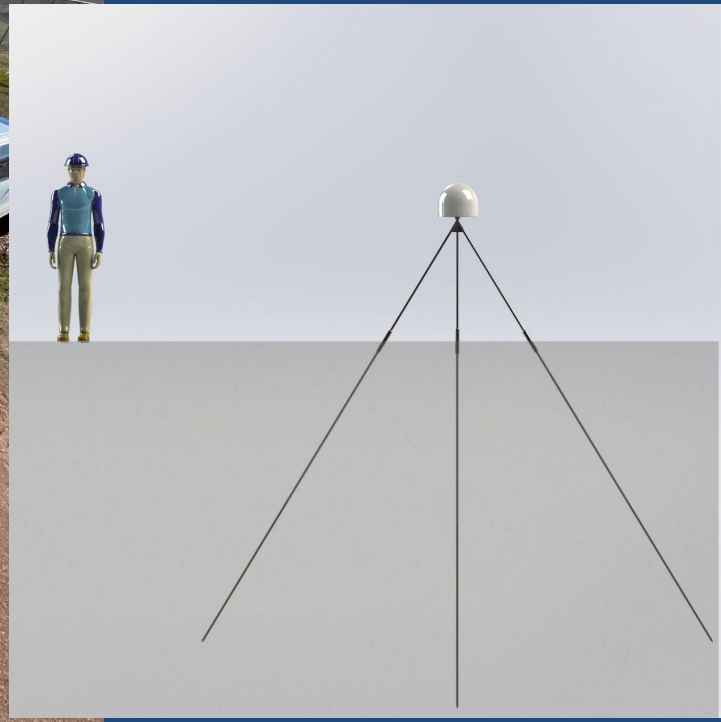

NCFR Franklin, NC

Installation of Shallow-Driven Braced Monument near Sierra Cucapah, Mexico

shallow-driven



Installation of Shallow-Driven Braced Monument, Greenlee County, AZ

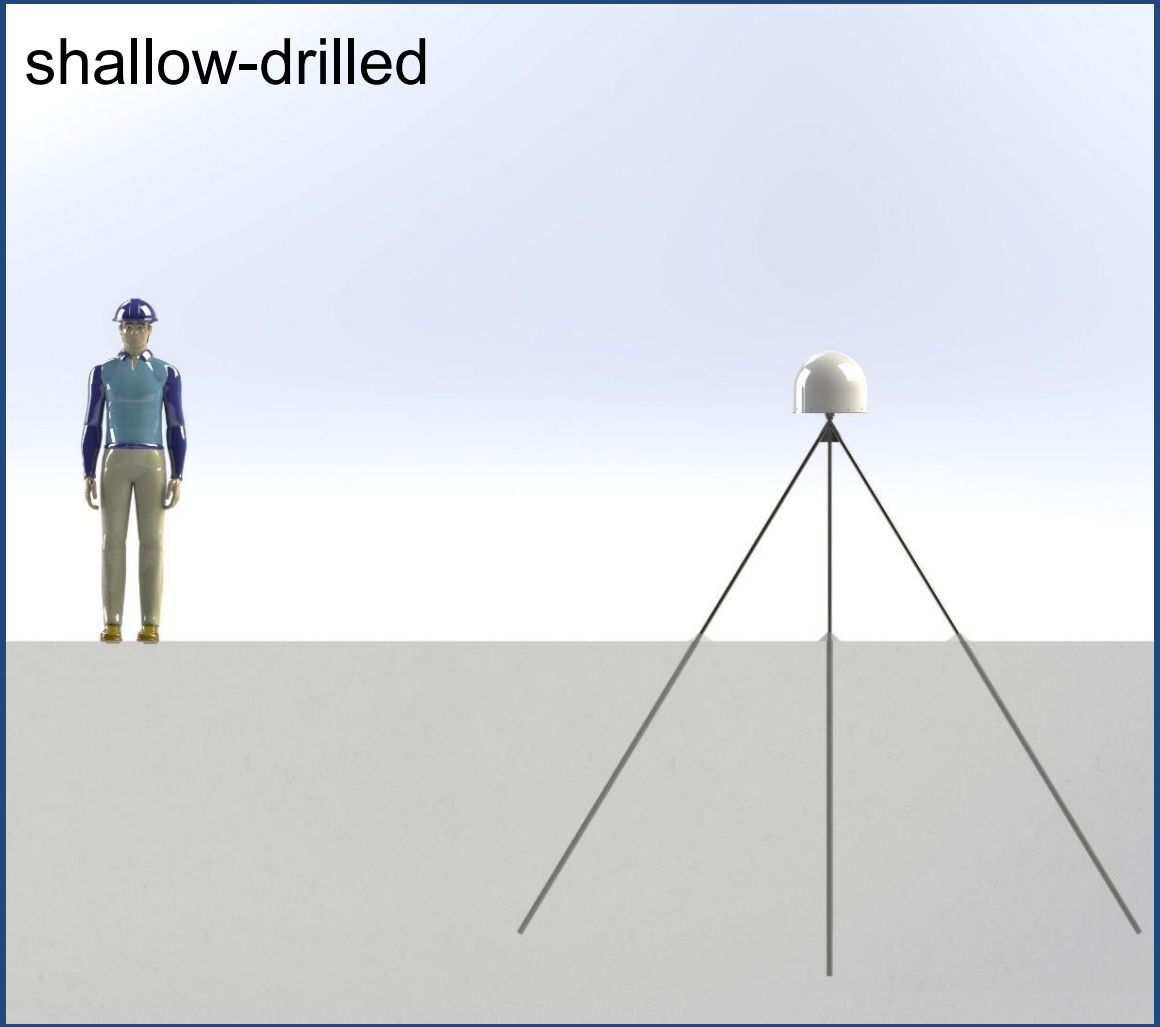


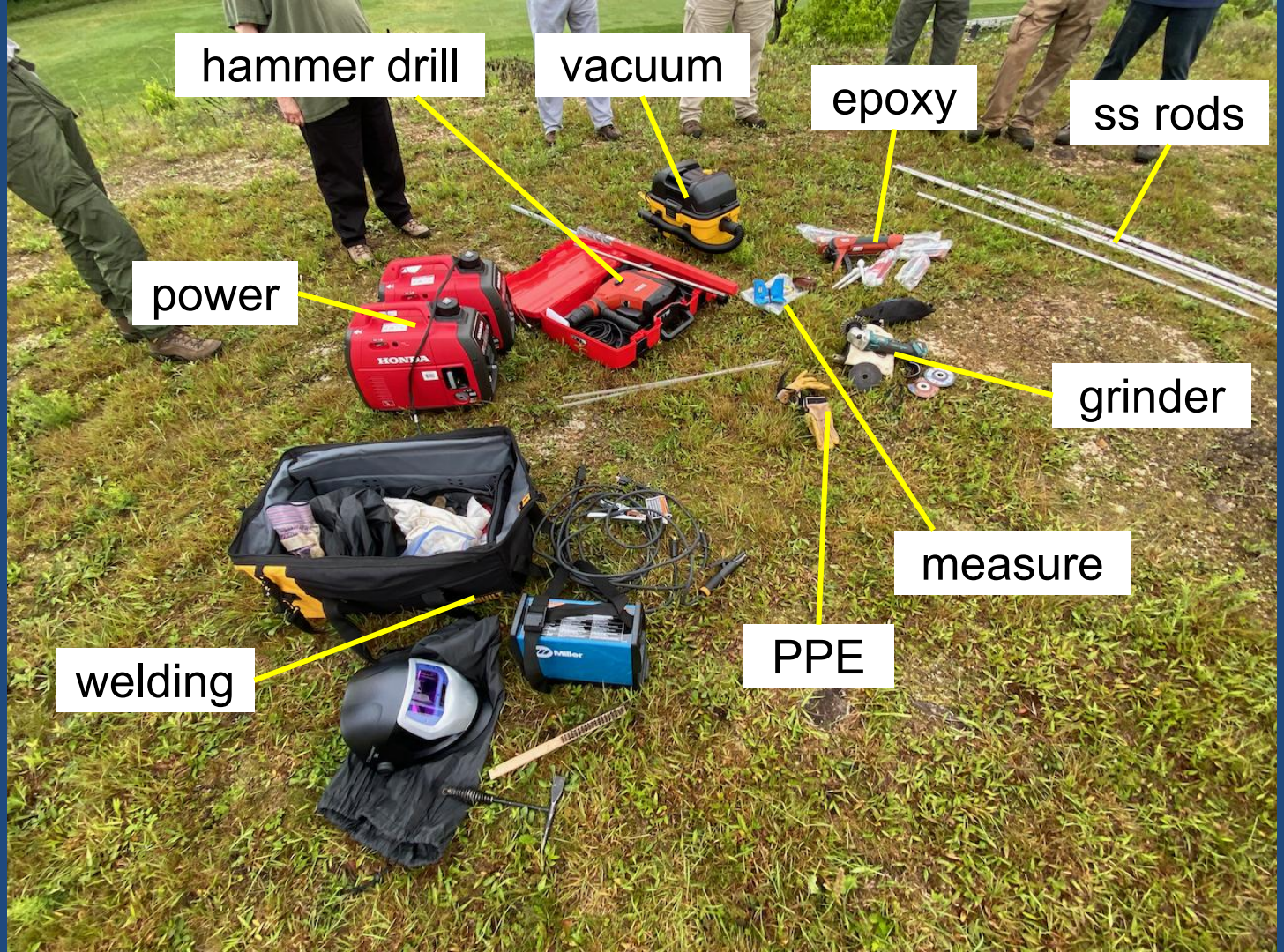
SIM4, Simara, Nepal

SAP1, Sapelo Island, GA

installation basics

shallow-drilled




hammer drill
vacuum
epoxy
ss rods
power
grinder
measure
PPE
welding

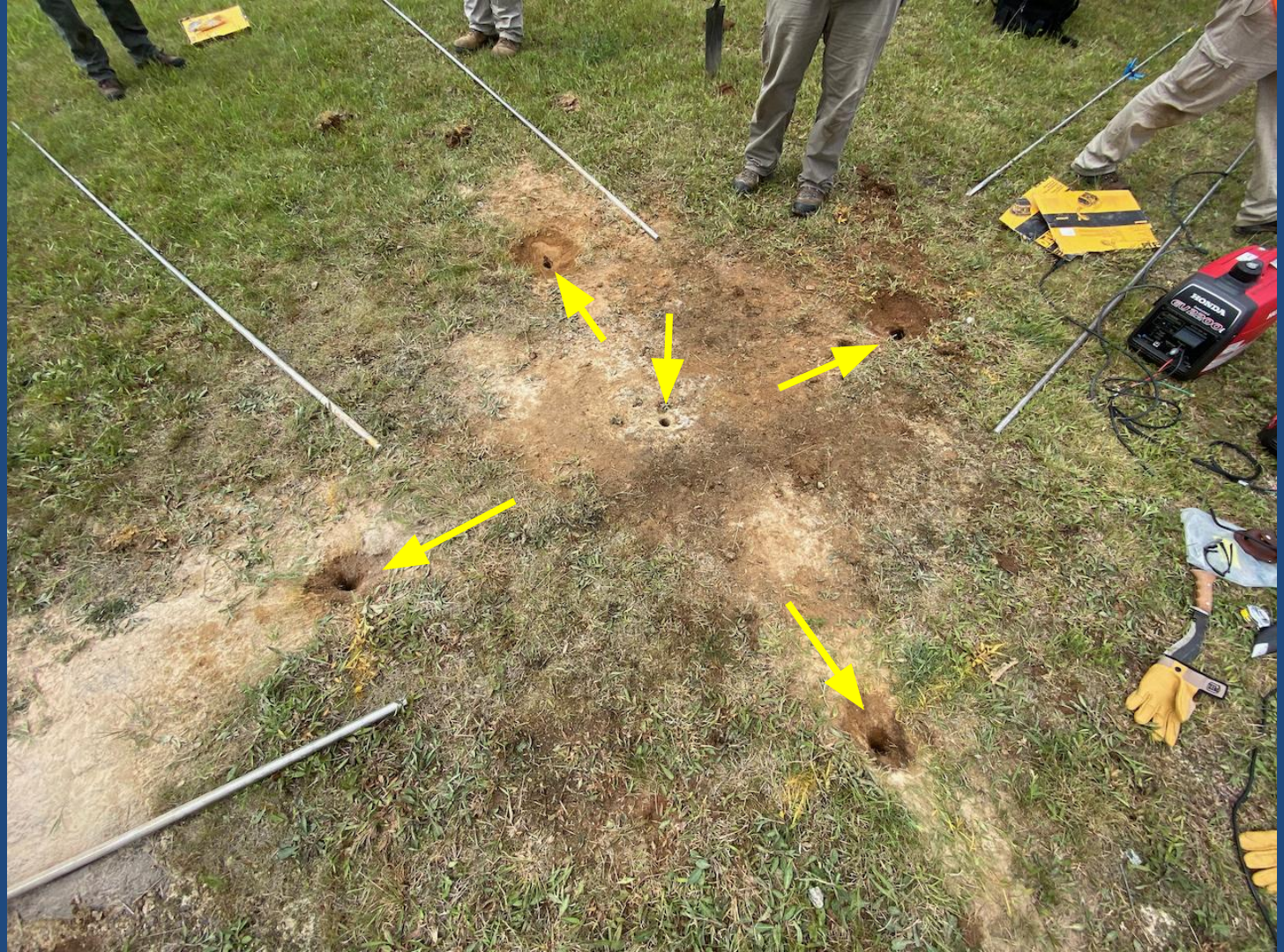

DEWALT


DEWALT


HONDA
HONDA


4X4


HONDA
HONDA


HONDA
EU2200i


HONDA


SL
metabo
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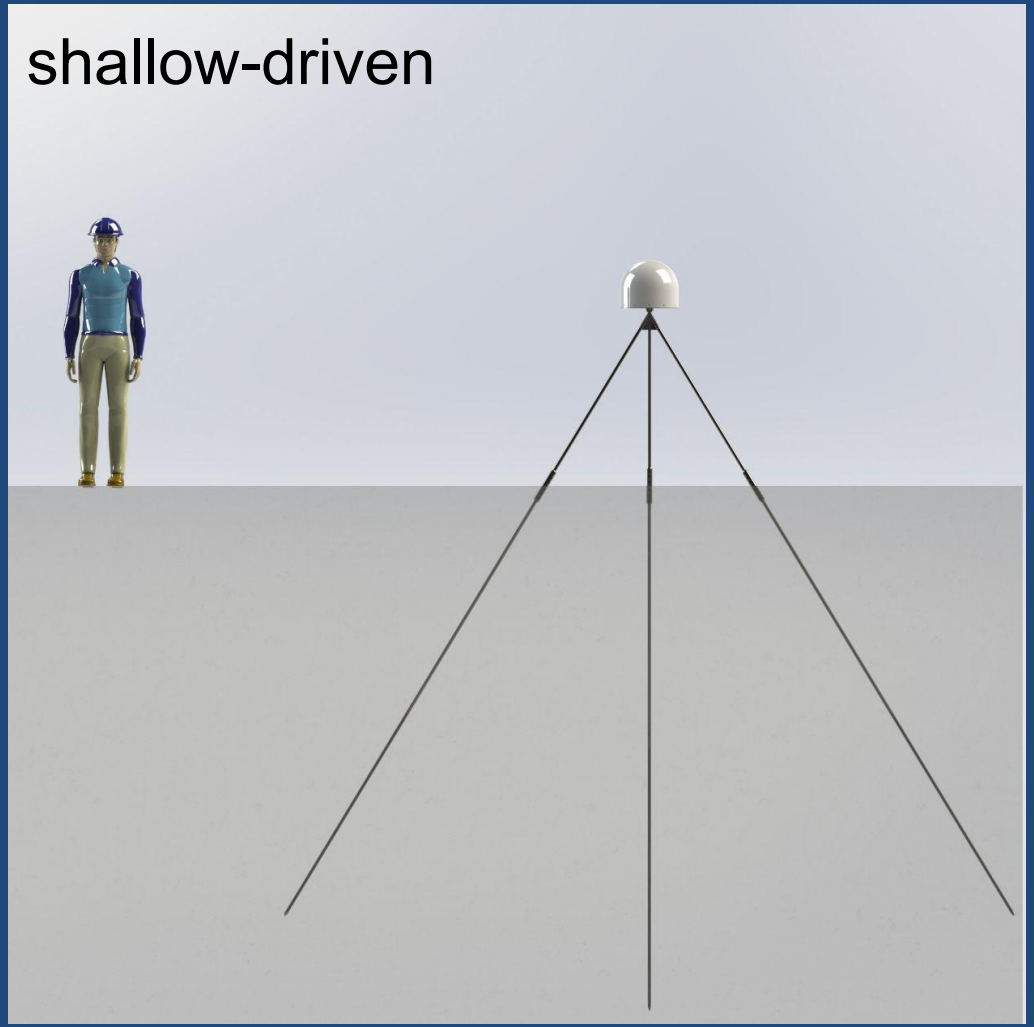
NSFR CORS 2022


3D47


DEWALT


GNSS
Trimble
GNSS

shallow-driven




the spot


UNAM
FES
Aragón

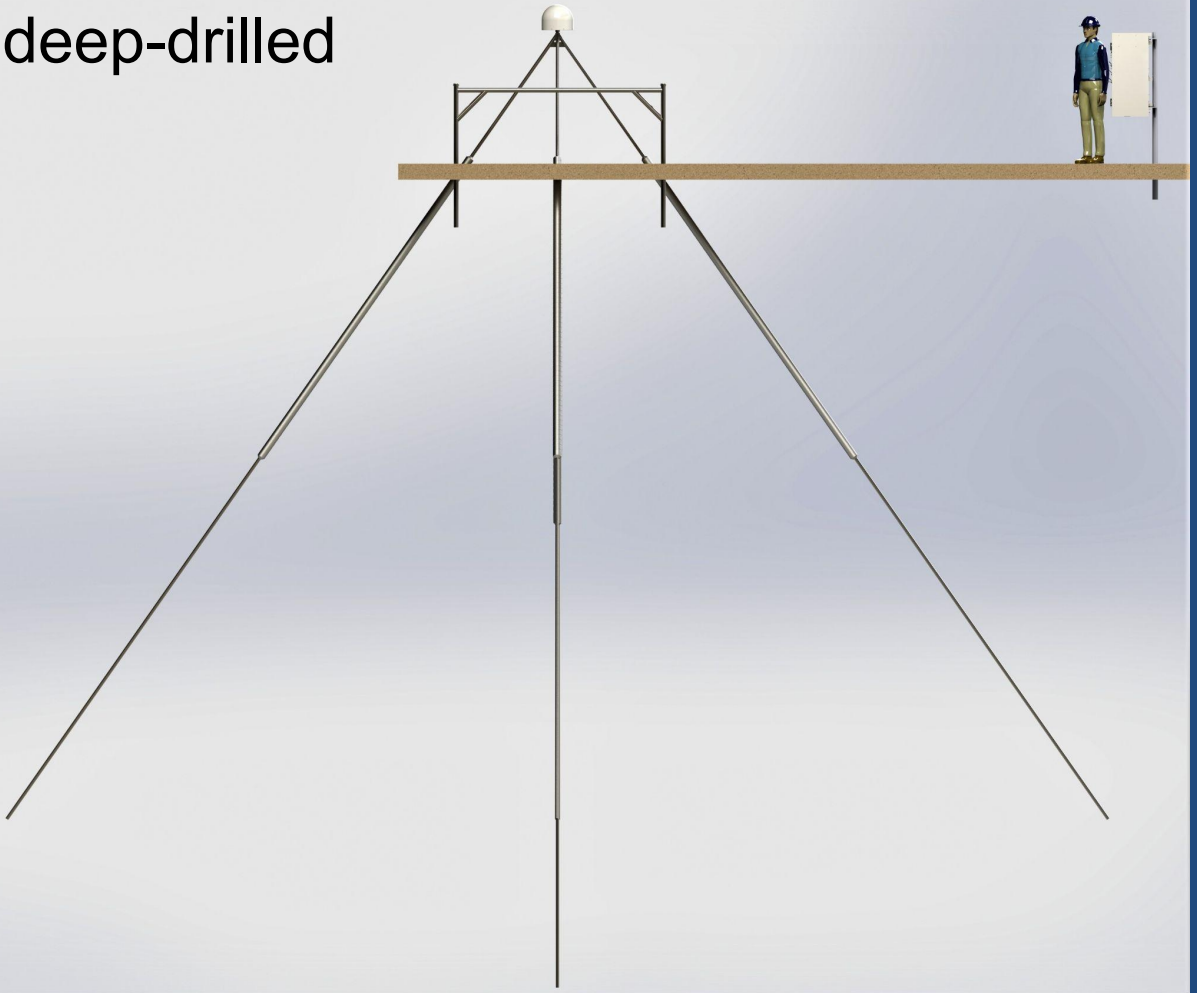

CAT
Photo Brian Conway, AZ DWR


GEORGIA


GRAND

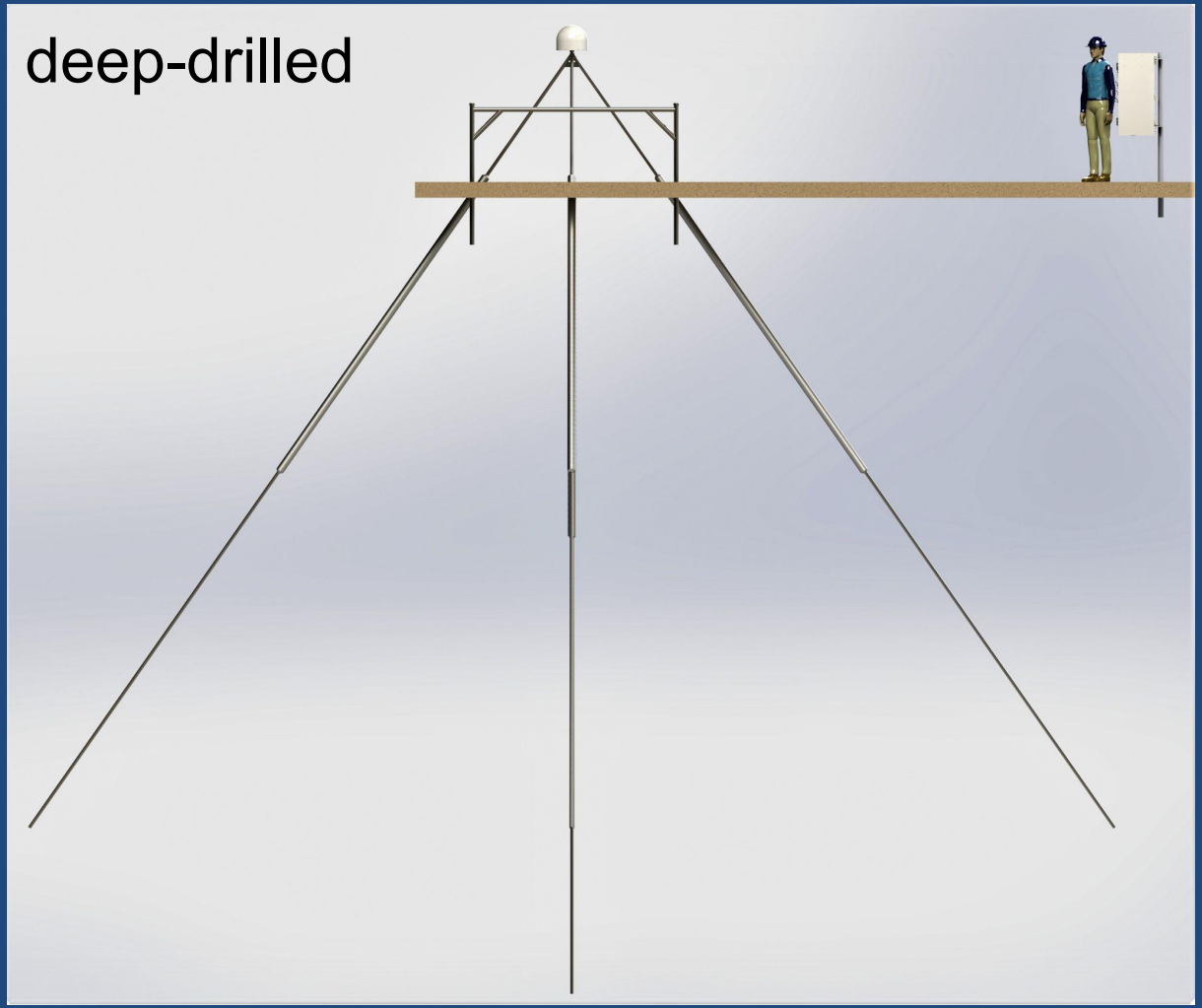

Sarasota County
LAND
SURVEYOR
4X4

deep-drilled

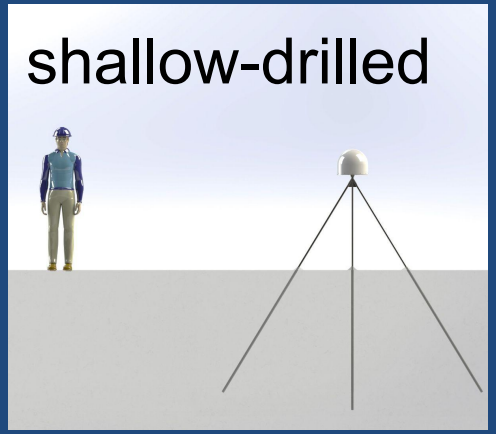


discussion time

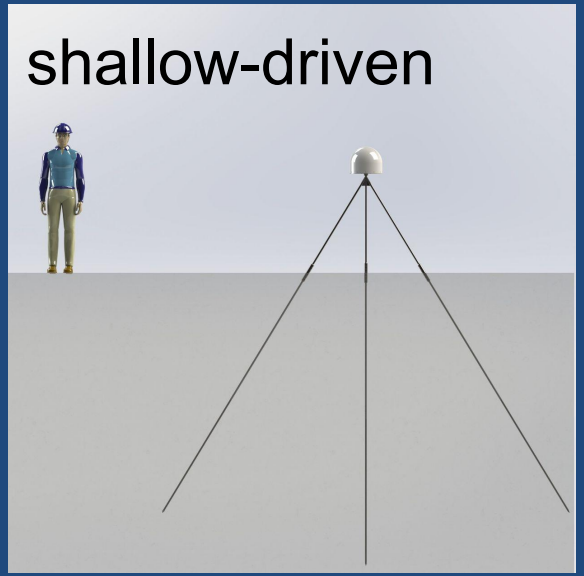
deep-drilled



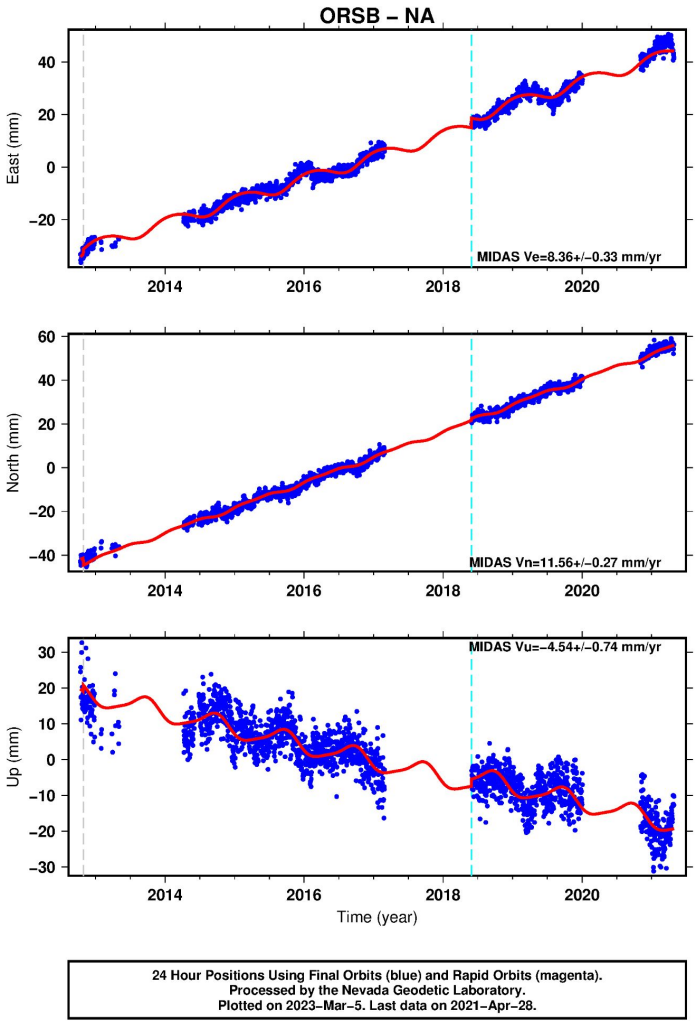
shallow-drilled



shallow-driven



Blessing a new CORS in Tibet



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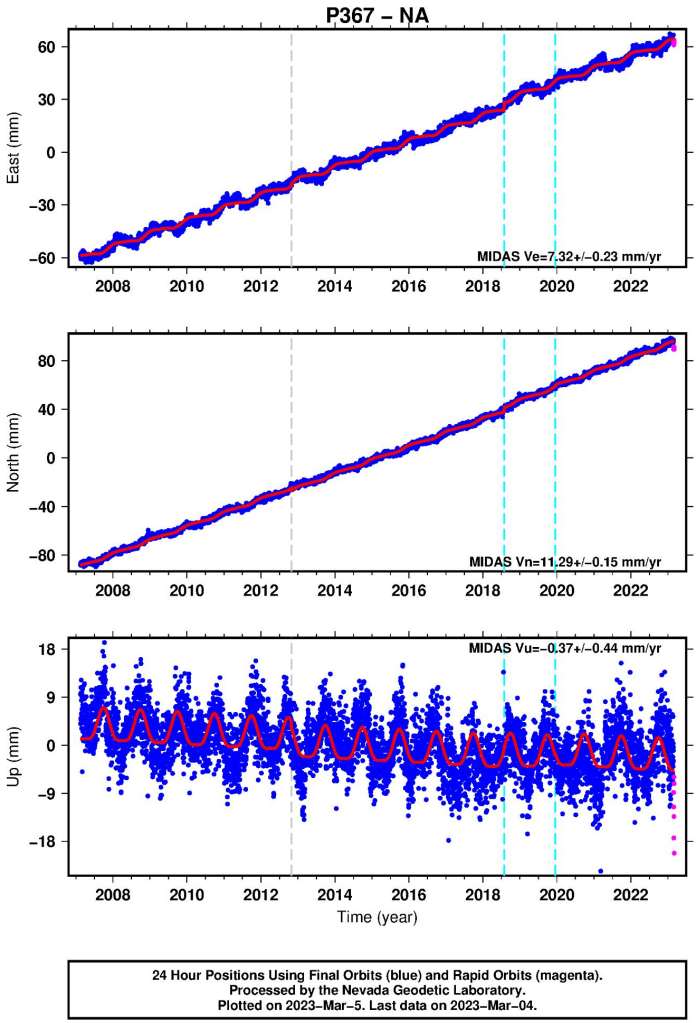

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