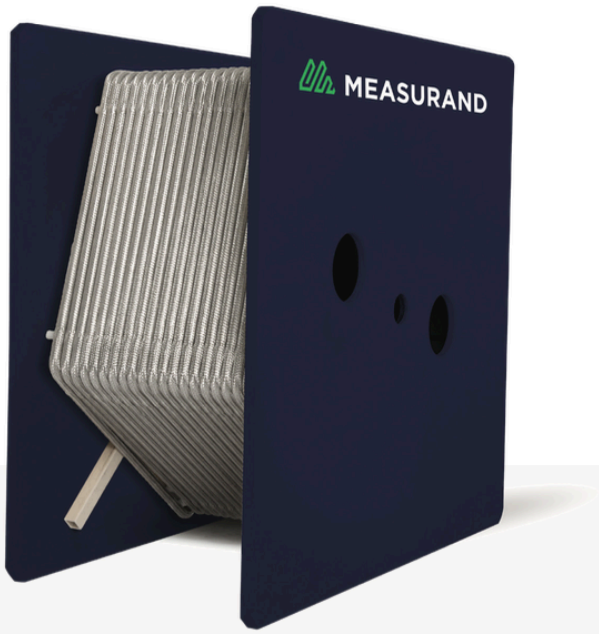
GEO MONITORING
Tecnología del Futuro

MEASURAND



SAAV

Model 001

ShapeArray and its cyclical installation are patented technology.

SAAV is designed to enable faster and simpler installation with direct installation in casing sizes from 47 mm to 100 mm inside diameter, as well as 27 mm ID conduit. SAAV can be installed into existing casings, even those that are too distorted for conventional use, which eliminates the need to drill new boreholes when converting from manual to automated monitoring. SAAV is available in 250[1] mm and 500 mm segment lengths and can be installed vertically, horizontally, or in an arc.

SAAV's rugged joint design enables the instrument to zigzag into various sizes of standard inclinometer casing sizes. A spring box at the top holds the joints firmly in contact with the casing, without any additional grouting. This cyclical installation method is unique to SAAV (patent pending). Software tracks the medial axis within the casing in 3D to produce traditional inclinometer data plots. Silent segments and extension tubes—two technologies specific to SAAV installed vertically/vertical SAAV installations—allow greater flexibility and control to place SAAV's sensorized segments in a zone of interest.

Clients may choose SAAV for vertical installation in 27 mm ID conduit or horizontally in schedule 80 (60 mm OD) casing, which can be configured at the time of order or changed in the field with the use of a conversion kit (purchased seperately). SAAV installed in an arc to monitor convergence feature a new installation method. SAAV sold for convergence applications are inserted into 21 mm ID PVC flex conduit at the factory and coiled onto its shipping reel, which arrive ready for the client to install directly to the tunnel wall with U-clamps.

All ShapeArray instruments are manufactured in an ISO 9001:2015 certified facility.

[1] Contact Measurand for additional details.

SPECIFICATIONS

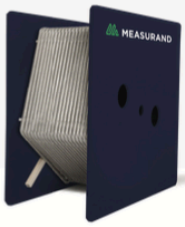
PHYSICAL PROPERTIES

SEGMENT LENGTH	250 mm or 500 mm (joint center to joint center)
STANDARD LENGTH OF SAAV	Up to 150 m (500 mm segments) or 50 m (250 mm) or 30 m (convergence installation)
CUSTOM LENGTH OF SAAV	Over 150 m (Contact Measurand for details)
CONDUIT & CASING INSIDE DIAMETERS	27 mm, 47 mm to 100 mm
JOINT DIAMETER	19 mm
LENGTH OF UNSENSORIZED NEAR CABLE END SEGMENT	500 mm
LENGTH OF FIBERGLASS EXTENSION	1 m or 2 m
LENGTH OF COMMUNICATION CABLE	Standard 15 m
WEIGHT	0.6 kg/m
MINIMUM AXIAL COMPRESSION TO PROVIDE SNUG FIT IN CASING	30 kgf
MAXIMUM JOINT BEND ANGLES	90°
STORAGE TEMPERATURE	-40°C to 60°C
INSTALLATION TEMPERATURE	-20°C to 60°C
OPERATING TEMPERATURE	-35°C to 60°C polynomial temperature algorithm corrected
WATERPROOF TO	2000 kPa (200 m Water)
POWER REQUIREMENTS	12 VDC at 1.8 mA/segment

STATIC SHAPE MEASUREMENTS

ANGULAR RANGE OF MEMS SENSORS	± 360° (software selection required for 2D/3D modes)
RANGE OF 3D MODE (VERTICAL)	± 60° with respect to vertical
DEFORMATION ACCURACY[1,2,3,]	± 1.5 mm for 32 m ShapeArray
RESOLUTION OF SINGLE SEGMENT	+/- 1 arcsecond[4]
AZIMUTH ERROR IN JOINTS	< ±0.01°
LONG-TERM RELIABILITY MTBF[5]	38 years for 32 m ShapeArray

NOTES



[1] One-sigma value, based on cyclical installation in 59 mm ID casing. Accuracy degrades as square root of length.

[2] Value based on AIA (Average in Array) setting of 1000 samples.

[3] Specification is for 3D mode within ± 20° of vertical. Vertical accuracy degrades with angular deviation from the vertical.

[4] RMS, calculated from published noise figure of sensor (verified by Measurand Inc.), and bandwidth of system using highest AIA setting of 25,600 samples.

[5] Conservatively based on longevity data for electronic components used in ShapeArray, a) assuming total system failure if any single component fails, b) system powered on 100% of the time, c) ambient 6°C, d) internal temperature rise of 8°C above ambient due to 100% powered-on duty, and e) a benign ambient environment typical of geotechnical instrumentation. MTBF will increase for more typical duty cycles (not powered on 100% of the time). At higher temperatures, MTBF will decrease (e.g. by ~half at 52°C). MTBF is based on "MIL-HDBK-217F Notice 2" performed by, ALD/SoHaR.

PATENT INFORMATION

ShapeArray and its cyclical installation are patented technology.

Measurand's patents include, but are not limited to:

Shape-Acceleration Measurement Device and Method, Canadian Patent 2,472,421& 2,747,236

Shape-Acceleration Measurement Device and Apparatus, US Patent 7,296,363

Cyclical Sensor Array, Canadian Application 2,815,199 & 2,911,178

Bipartite Sensor Array, Canadian Application 2,815,195 & 2,911,175

ShapeArray patents include coverage in: United States, Canada, France, United Kingdom, Italy, Japan and Germany.

Installation patents include coverage in United States, Canada, France, Untied Kingdom, Italy, Germany, China, Hong Kong, and Korea.

Patent families are sufficiently broad to capture most or all usage of ShapeArray in longer lists of countries.

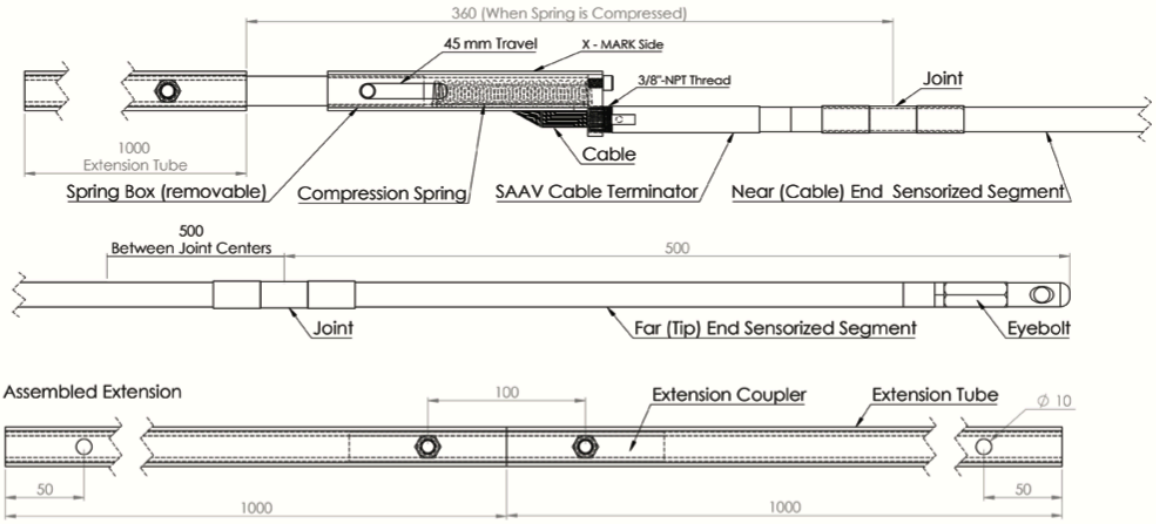
SPRING BOX ASSEMBLY

Capped SAAV length = Extension Tube (125 mm min) + Spring Box/Cable Terminator (360 mm) + Sensorized Length -

Extension Tubes: Two 1000 mm Extension Tubes are included. Additional Extension Tube kits are sold separately.

Sensorized length = Near cable end sensorized segment through far tip end sensorized segment.

Sensorized tolerance on measurement: +/- 2 mm unless otherwise stated.



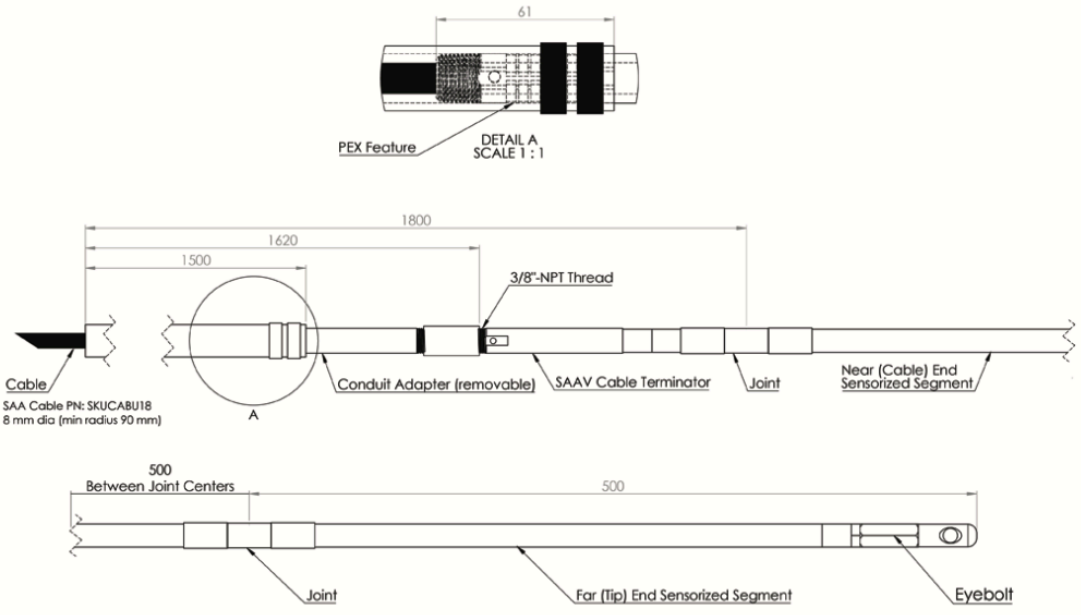
27 MM ID CONDUIT ADAPTER ASSEMBLY

Capped SAAV length = PEX length (80 mm min) + Conduit Adaptor/Cable Terminator (300 mm) + Sensorized Length - Packing (0.5 mm / segment)

Included 1500 mm PEX.

Sensorized length = Near cable end sensorized segment through far tip end sensorized segment.

Sensorized tolerance on measurement: +/- 2 mm unless otherwise stated.



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CONVERGENCE ASSEMBLY

SAAV 250: Casing length = ShapeArray length - 85 mm (if eybolt removed)

SAAV 500: Casing length = ShapeArray length

* Suggested Routing Clamps are stainless steel with two mounting points.

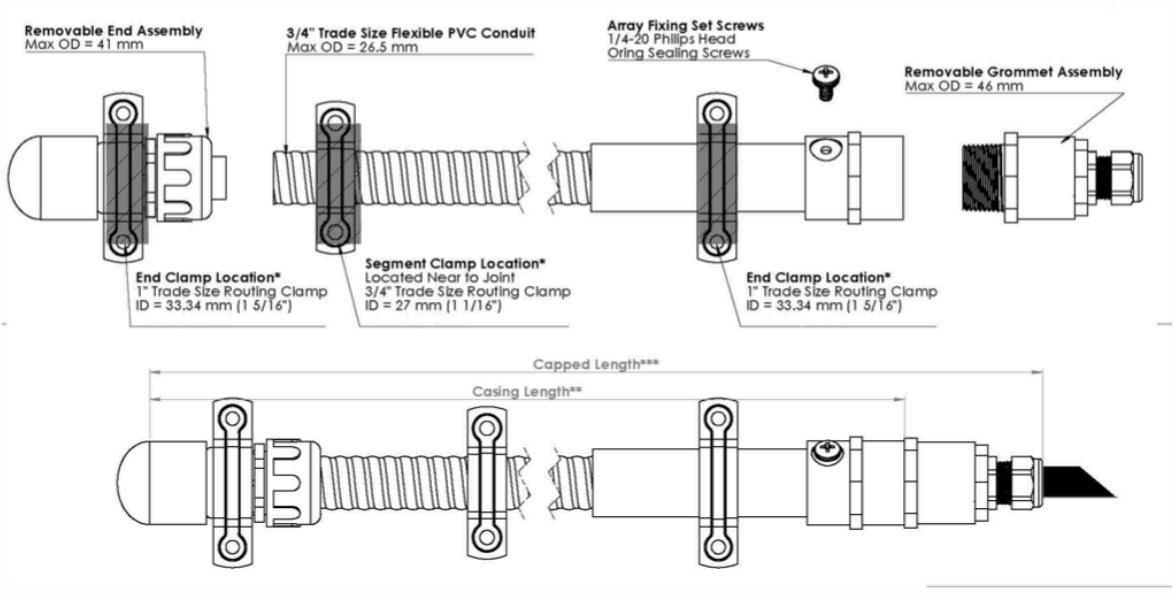
For the 1" Trade Size Clamp: Max Fastener Size = 6.7 mm (17/64")
Fastener Spacing = 63.5 mm (2 1/2")

For the 3/4" Trade Size Clamp: Max Fastener Size = 7 mm (9/32")
Fastener Spacing = 54 mm (2 1/8")

** Casing Length = ShapeArray Length (-85 mm for SAAV 250)

{Note: For SAAV 250, Measurand suggests to remove the eyebolt}

*** Capped Length = Casing Length + 75 mm



GEO MONITORING
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sensemetrics

CONNECTIVITY

THREAD X3

Broadband IIoT Sensor Connectivity

Deploy cost-effective and secure cloud managed IIoT networks in challenging environments.

- **Cloud Management**
  Secure off-site management tools for persistent system access and administration
- **Industry Leading Security**
  End-to-end data encryption from sensor to cloud using the Transport Layer Security (TLS) 1.2 protocol
- **Stay Current**
  Future-proof hardware with free lifetime feature updates delivered efficiently as firmware over the air (FOTA)
- **Powerful and Intelligent**
  Built-in environmental, status and diagnostics sensors advance troubleshooting and increase device uptime
- **Edge Compute Environment**
  Secure virtualized container environment or operation of proprietary edge analytics applications
- **Never Lose Data**
  Securely store data when uplink is unavailable

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MULTIPLE MODES OF COMMUNICATION

with prioritization and intelligent fail-over

Ethernet
Connect to existing networks where wired Internet infrastructure exists

Cellular
Deploy distributed devices connected to Cellular networks

Long-range Wireless
Extend sensor networks with resilient wireless mesh technology

LONG-RANGE WIRELESS

Wireless Gateway

As a wireless gateway, the Thread X3 enables efficient connectionless low-power wide area (LPWA) wireless communication with compatible devices and smart sensors. Our industry-defining interface built on the MQTT-SN standard, provides scalable and secure wireless network management, security, and cloud connectivity.

Intelligent Wireless Networking

Automatic network role detection Gateway, Repeater, or Endpoint

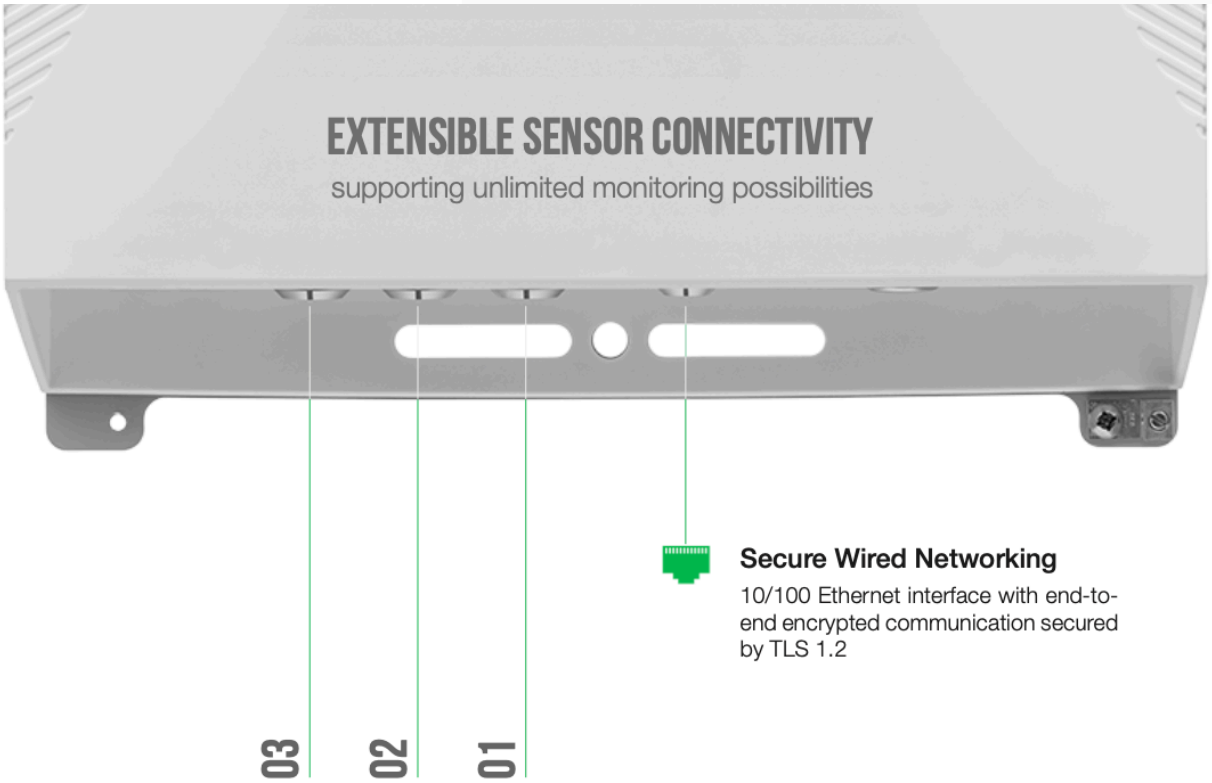
Adaptive and Resilient

Self-forming long-range wireless mesh networking

CELLULAR

Globally Compliant Cellular

Operate on 600+ cellular networks across 190 countries. No provisioning or carrier management required



Secure Wired Networking

10/100 Ethernet interface with end-to-end encrypted communication secured by TLS 1.2

CONFIGURABLE SENSOR INTERFACES

Dense Sensor Installations

Cost-effectively manage nested sensors. Attach multiplexer (MUX) devices to support up to 128 sensors.

Connect any Sensor

Use our patented Sensor Integration Builder (SIB) to build customized or proprietary drivers that can be securely deployed to connect and control any sensor you may need to automate.

Sensor Library

Select from thousands of published sensor drivers available in our cloud-hosted library. Mobile and browser app driven workflows support plug & play connectivity, control, and automation of simple to complex components.

Variable Frequency Drives

Robotic Total Stations

Deformation Sensing Arrays

Imaging Devices

Multi-Parameter Weather Stations

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THREAD X3 SPECIFICATIONS

MECHANICAL	
Dimensions:	14.27 in [36.25 cm] x 12.47 in [31.63 cm] x 3.39 in [8.61 cm]
Weight:	8.6 lbs [3900 grams]
IP Rating:	66
Humidity:	5 to 95% non-condensing
Operating Temperature:	-40°F to 158°F (-40°C to 70°C)
Wireless Connector:	N-Type Female coaxial
Cellular Connector:	N-Type Female coaxial
Network Connector:	Lemo 5-pin
Sensor Connector:	Lemo 8-pin

GENERAL	
EMMC Flash Memory:	8 GB

MESH WIRELESS NETWORKING			
Mesh Wireless Frequency:	870 MHz	900 MHz LP	900 MHz HP
Mesh Wireless Range:	0.5 miles	3.5 miles	7.5 miles
Output Power:	25mW	250mW	1000mW
RF Data Rate (max):	80 kbps	250 kbps	250 kbps

POWER	
Input Voltage:	12-24 VDC +/- 10%
Power Input:	Up to 2500mA (Charge mode) 200mA RMS (Standard mode) 20mA RMS (Low power mode) @24 VDC
Direct Connect Solar Panel:	12 Volt, 30W-160W
Battery:	12.8V 9.9AH (126.72Wh) LiFePO4

INTERNAL SENSORS	
System Temperature:	-40°F to 158°F (-40°C to 70°C), precision +/- 0.5°F
Barometer:	measurement range 0.26 bars - 1.26 bars, precision 0.00025 bars RMS

WIRED INTERFACES		
	Communication	Power
Network I/O:	10/100 Ethernet	None
Sensor I/O:	Interface 01: USB, RS232, RS485, 4-20mA Interface 02: RS232, RS485, 4-20mA Interface 03: RS232, RS485, 4-20mA	12 or 15VDC Out, up to 20 watts

CELLULAR NETWORKING			
	4G Bands	3G Bands	2G Bands
North America:	B2[1900], B4[1700], B5[850], B12[700], B13[700], B14[700], B66[1700], B71[600]	B2[1900], B4[1700], B5[850]	-
Europe:	B1[2100], B3[1800], B7[2600], B8[900], B20[800]	B1 [2100], B8 [900]	GSM900, DCS1800
Australia:	B1[2100], B3[1800], B5[850], B8[900], B9[1800], B18[850], B19[850], B26[850], B28[700]	B1[2100], B5[850], B6[800], B8 [900], B19[800]	-
South America:	-	B1[2100], B2[1900], B4[1700], B5[850], B8[900]	GSM850/900, DCS1800, PCS1900

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CONNECTIVITY

DIMENSIONS

CONFIGURATIONS

Thread X3MC

Thread X3 with Ethernet, Cellular, and Wireless

Thread X3M

Thread X3 with Ethernet and Wireless Mesh communications modules

Thread X3

Thread X3 with Ethernet communications module

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