Measurand ShapeAccelArray (SAA)

Ordering Guide

See also our Installation and Specification documents: www.MeasurandGeotechnical.com

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Introduction

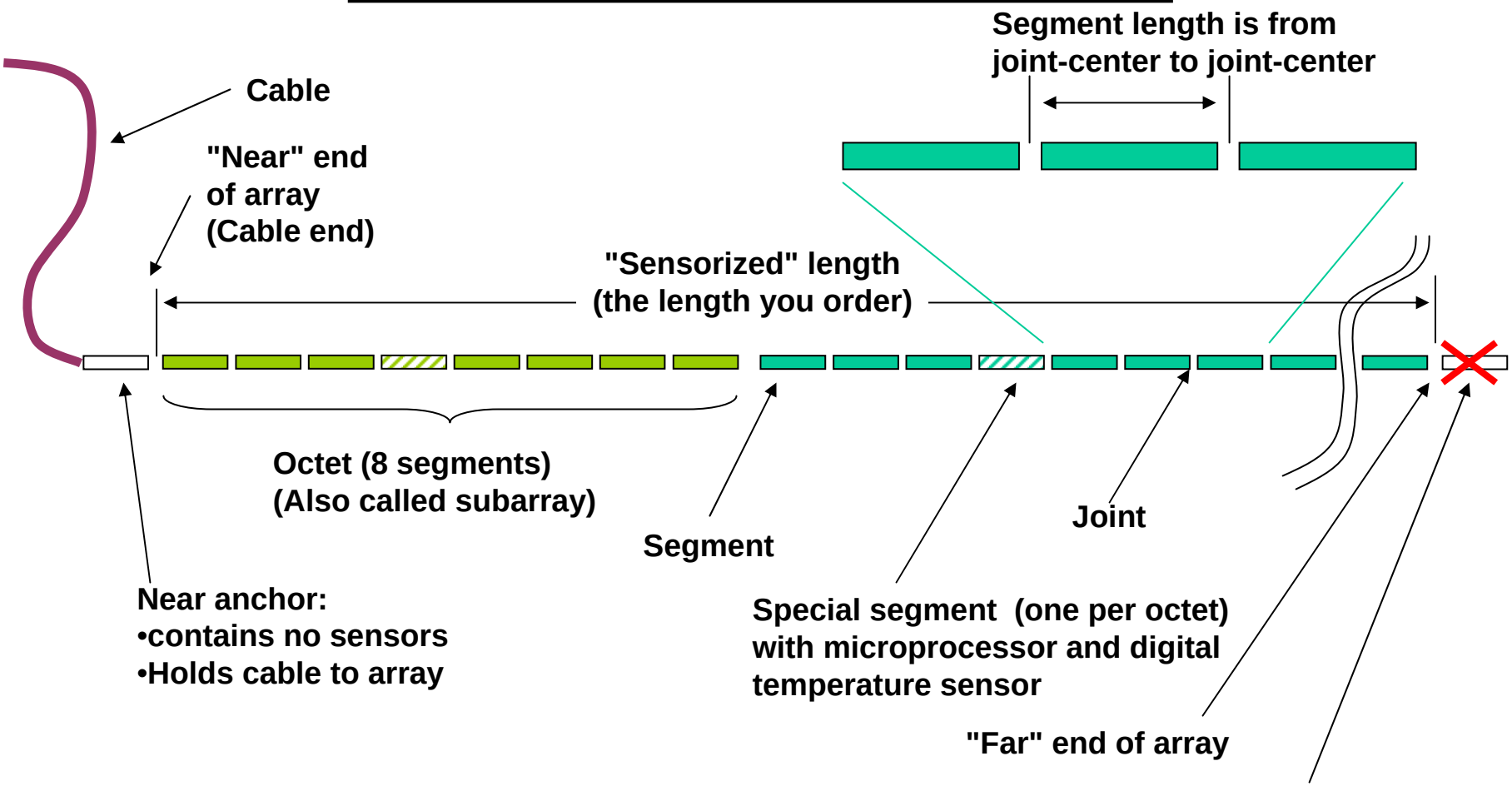
SAA is an array of rigid segments separated by special joints. MEMS gravity sensors in the segments measure tilt along three axes. When SAA is near-vertical, rotational transforms are used to calculate the 3D shape of the array. 2D shape is measured when the array, or some of its segments, are near-horizontal. In any pose, 3D vibration can be sensed at selected locations along the array.

There are two basic types: Field and Research. The main distinctions are speed, number of segments, and power consumption.

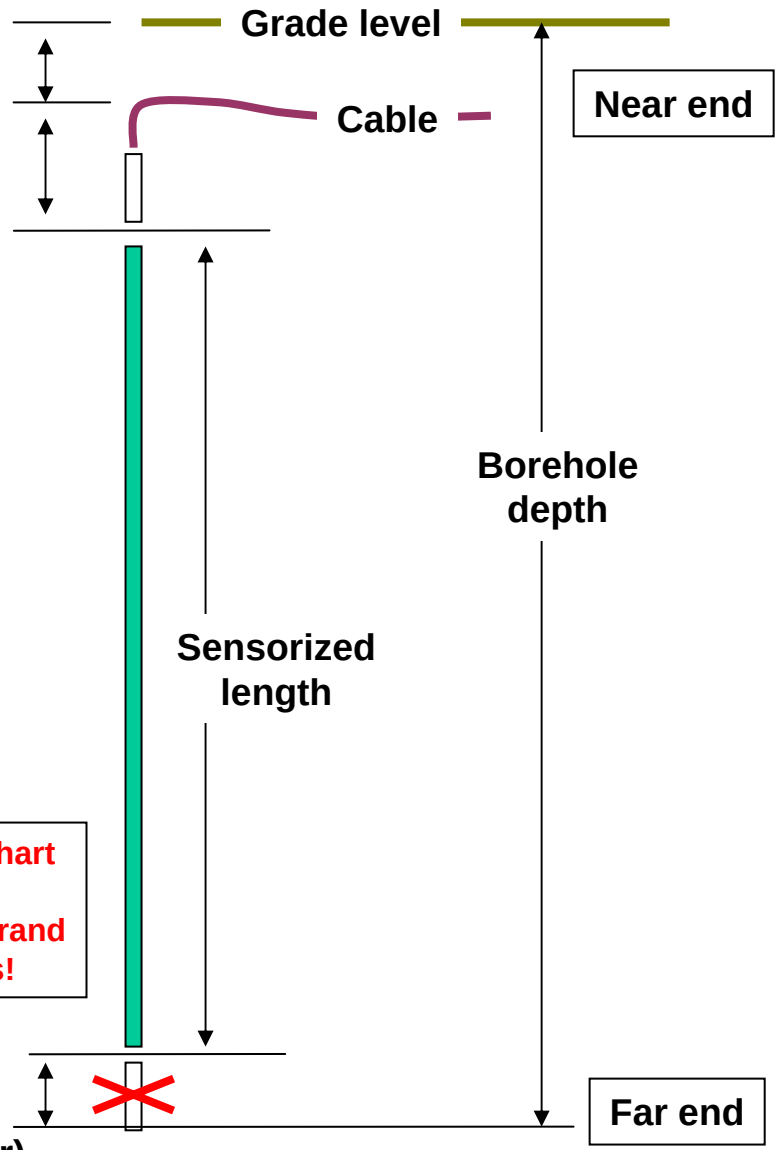
Each is available in increments of 8 segments ("octets"), where standard segment lengths include 305 mm (12") and 500 mm (19.7"). It is possible to order SAA with a partial octet, so as to achieve a more exact total length, but there is no cost advantage to doing so.

This document is intended to help customers work with Measurand staff to specify the best SAAs for each application.
Use the "SAA Order List" at the end to specify your arrays.

SAA Modularity & Terminology



SAA Lengths



Definitions

Segment length: The joint-center to joint-center length of a rigid sensorized segment.

Sensorized length: The length specified when ordering = the length of the data model. This length is normally in increments of 8 segment lengths.

Far anchor length: The length of a rigid portion, (IF ANY!) at the far end of the array. It contains no sensors.

"Near anchor and turn" length: Minimum to allow for changing direction of cable from vertical to horizontal or vice-versa.

Trench depth: Depth of cable from grade, if cable is to be run in a trench from array to data acquisition equipment.

Borehole depth: Minimum depth of borehole.

Borehole depth =
Sensorized length
+ "Near anchor & turn" length
+ Far anchor length (if any)
+ Trench depth

See Specification Chart for lengths, and confirm with Measurand before drilling holes!

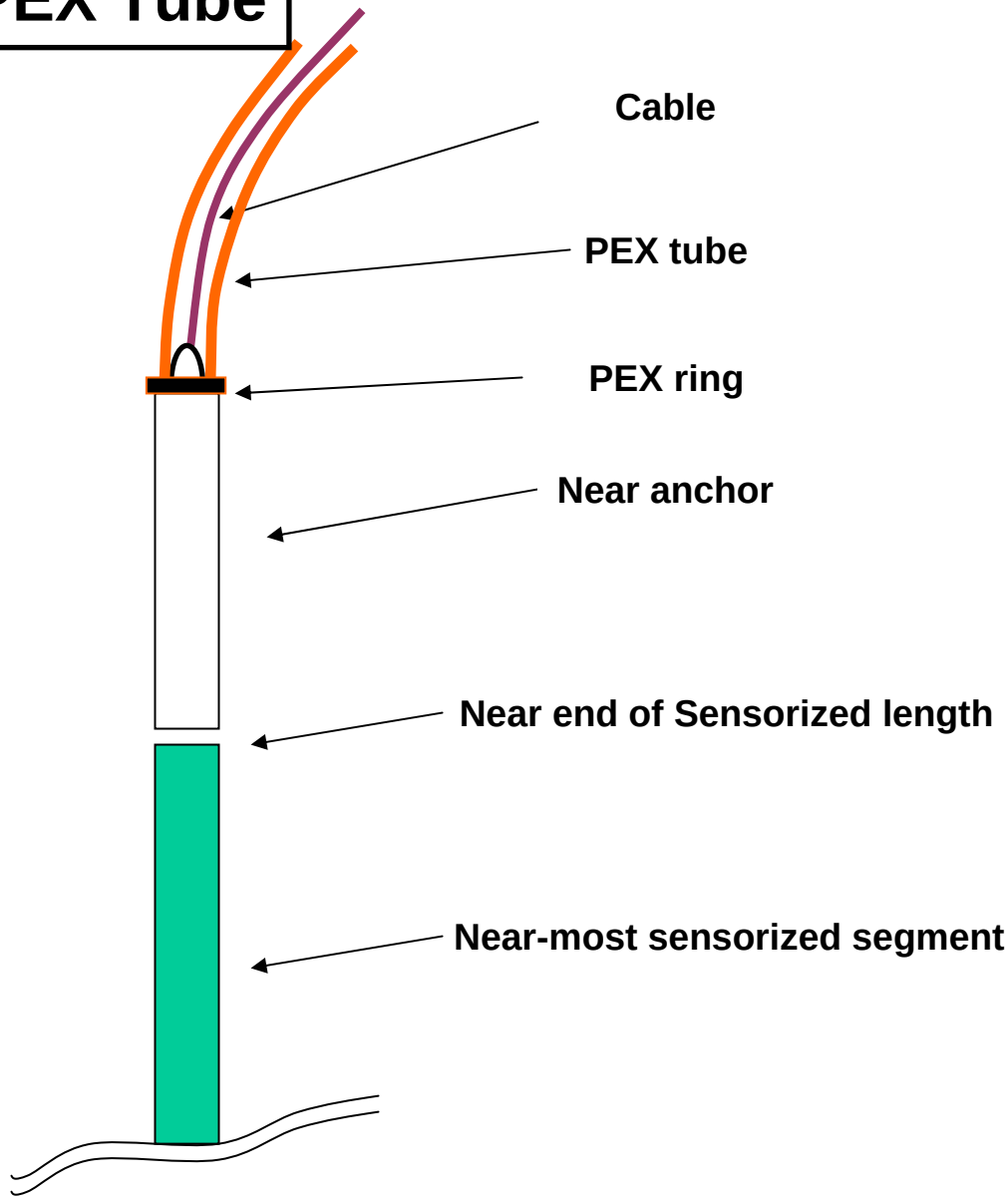
PEX Tube

SAA is now (Apr 2008) shipping with a short length (<1.5 m ; < 5') 19mm (3/4") **PEX tubing** surrounding the cable. Because PEX is stiff in torsion, it can be used to adjust the azimuth. PEX can also exert axial forces on the SAA when the near anchor is below the top of the casing. This aids in snugging and removal.

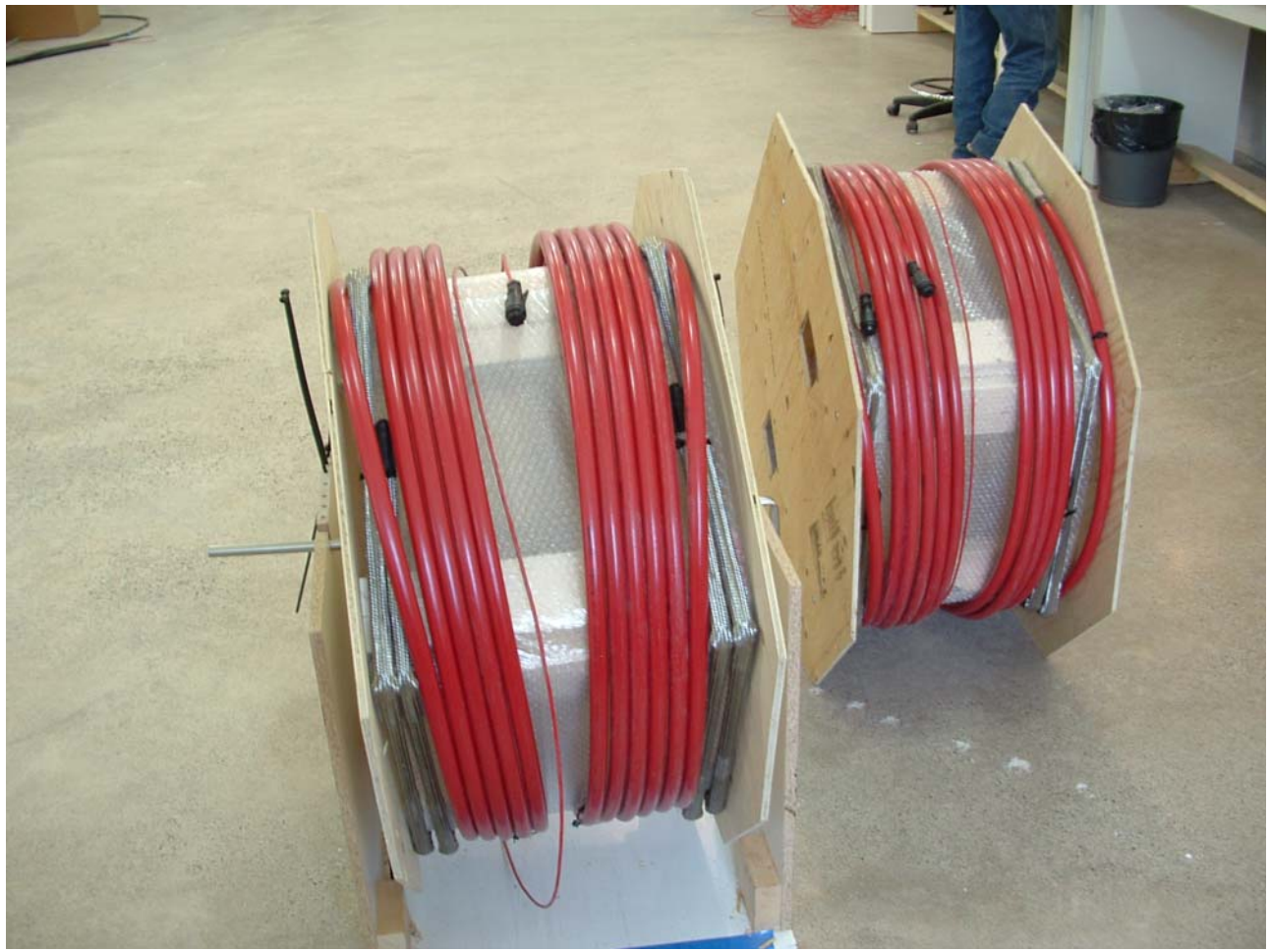
The PEX tubing may be extended using a PEX extension kit. Lengths beyond 10 m (32 ft) will provide only approximate control of torsion. For best resuts, if possible, order the SAA with integral magnetometers.

PEX tube and fittings have been tested to >300 kgf (660 lb) axial extension. PEX can be used to extract the array.

(PEX is plastic pipe used for domestic and commercial water supplies, and is available in most home-supply stores or from plumbing stores.



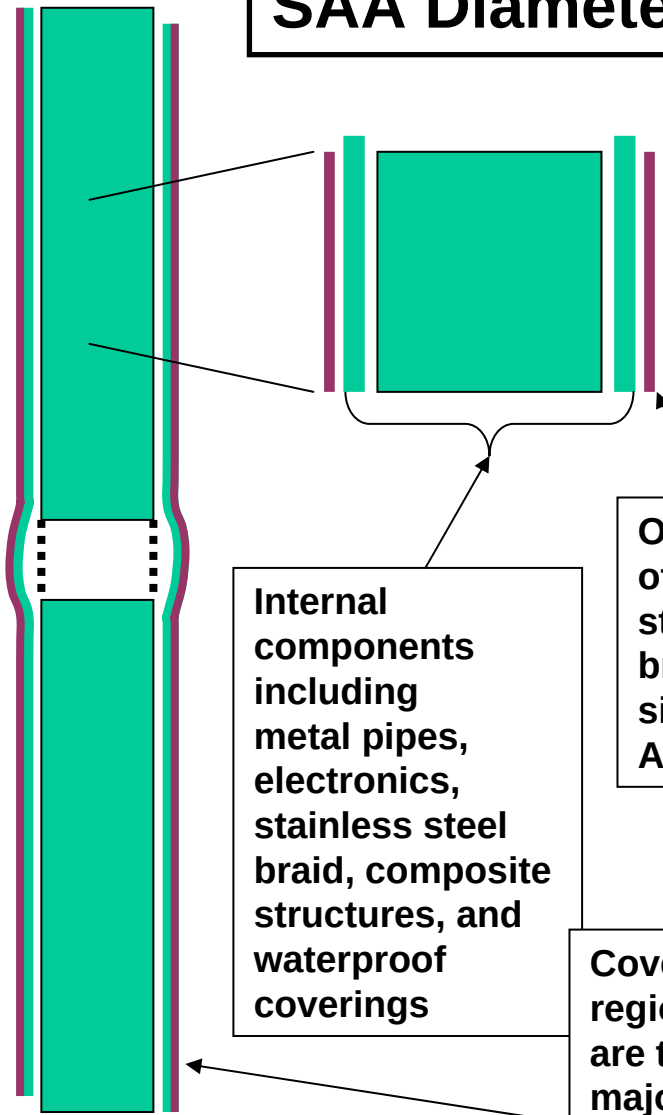
PEX Tube



Short SAAs with long PEX (special order)

SAA Diameter

The joints are designed to expand when the SAA is compressed axially. The weight of the array will expand all but the top joints, which may be expanded by pushing with ~10 kgf (22 lbs). This is important to snugging the array in 27mm casing.



Diameters

Joints: Auto-fitting (See below)

Overlap regions of coverings: <= 22mm (0.87").

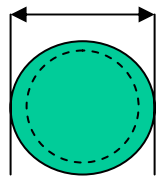
Majority of coverings: <= 20mm (0.79").

PEX ring at near end: <= 24mm (0.94").

Internal components including metal pipes, electronics, stainless steel braid, composite structures, and waterproof coverings

Over-covering of additional stainless steel braid (standard since approx. April, 2008)

Coverings include regions of overlap which are thicker than the majority of the array (Overlaps are not shown... but are specified above).



Auto-fitting joints

in axial extension:
clears 25 mm

in axial compression:
Joints expand to snug into 27mm (1.049") ID PVC electrical conduit.

SAAF vs. SAAR

SAAF (Field Arrays)
All microprocessors in an array (1 microprocessor per 8 segments) share the same communication line.
SAAF is designed for low power consumption and long length, and achieves the same accuracy and spatial resolution for 3D shape as do SAARs.
Vibration data are available from up to 3 segments along the array at 40 Hz sampling, and at 35 Hz from 4 segments.

SAAR (Hi-Bandwidth Research Arrays)
Each microprocessor in an SAAR (1 microprocessor per 8 segments) has a dedicated communication line.
SAAR is designed to produce high speed data from all sensors all the time.
The high-speed wiring limits the length of the SAARs.

Specifying a ShapeAccelArray (SAA)

Research or Field

SAAF (Monitoring of Slides, Construction):
<=97.5m(320') Sensorized.
Field Multiplexing enables capturing shape from all segments and 3D vibration from up to 4 segments sampled at 40Hz.
Acquisition options vary from Laptop to Wireless Data Concentrator (See following page).

Sensorized Length: 2438, 4877, 7315 mm, ... (8', 16', 24',...) to a maximum of 97.5m (320'). Order in increments of 2438mm (8'). (See also 500mm-segments)

Allow for Far Anchor (if any) and Cable Anchor/Turn (see previous page).

Cable Length 12.7m(50') standard

See Next Page for SAAF Communication Options

SAAR (High-Speed Research):
<=7.3m(24') Sensorized.
Special Multiplexing enables capturing from all sensors at high speed (>100Hz).
Requires Interface Box & RS485 Cards in PC

Sensorized Length: 2438, 4877, or 7315 mm (8', 16', or 24').

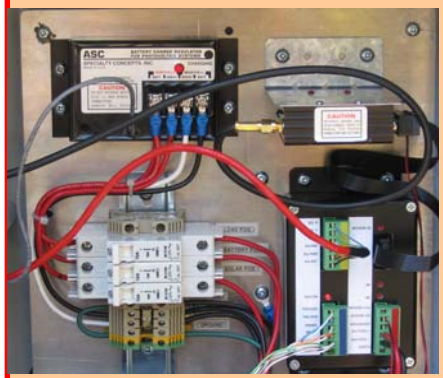
Allow for Far Anchor and Near Anchor/Turn (see previous page).

Cable Length 12.7m(50') standard

See later page for SAAR acquisition setup

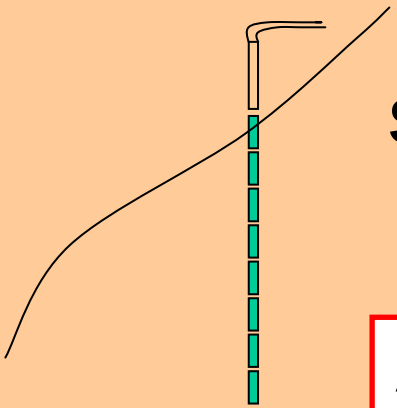
Typical Field Installation

Antenna,
Solar Panel



Data Conentrator
(3 yr Storage),
Cell Modem
Power Control

new standard
= CR1000



SAAF

Array &
Earth Station

Connection

Cellnet
(GPRS
or CDMA)
2-way
FTP

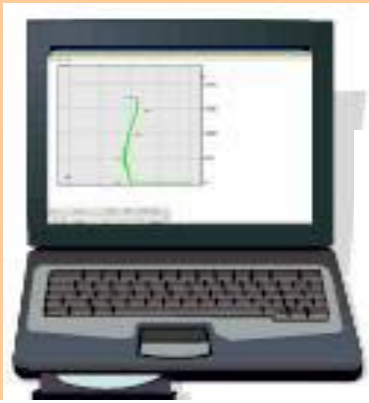
or
Wireless
LAN

or
Laptop

or Cable

Destination

World Wide Web
(or direct)



Password- Protected

Data access

Data Viewing
&
Array
Re-Configuration

Campbell Scientific CR1000 installation for three SAAFs and dozens of other sensors including vibrating-wire piezometers, crack sensors, extensometers, and a weather station.

In this installation a land-line modem was used. A wireless cellnet modem would be more typical.

The CR1000 or CR800 have replaced DL1 loggers in most recent installations.

Field Configurations

Data Delivery

[Note 1: Measurand DL1 (formerly DC) logger is no longer available, but will continue to be supported for existing installations.
Note 2: some configurations may require Measurand's new AIA-ready SAAFs.]

Simplest (direct)
Connect SAAF to PC USB port using Measurand SAAUSB connection kit (includes power supply) and acquire/store/visualize/export ASCII or Matlab XYZ data using SAARecorder software. Data are viewable in SAA3D viewer software.

Most common wireless
Connect SAAF(s) to Campell Scientific CR1000 data logger using Measurand SAA232 adaptor(s) (controls power, provides surge protection, converts protocol). Collect raw data wirelessly using cellnet modem and Loggernet software. Convert raw data to ASCII or Matlab XYZ data using Measurand SAACR_raw2data software. This entire process can be set to run autonomously. This process can be used with or without Measurand web delivery. Data are viewable in SAA3D viewer software.

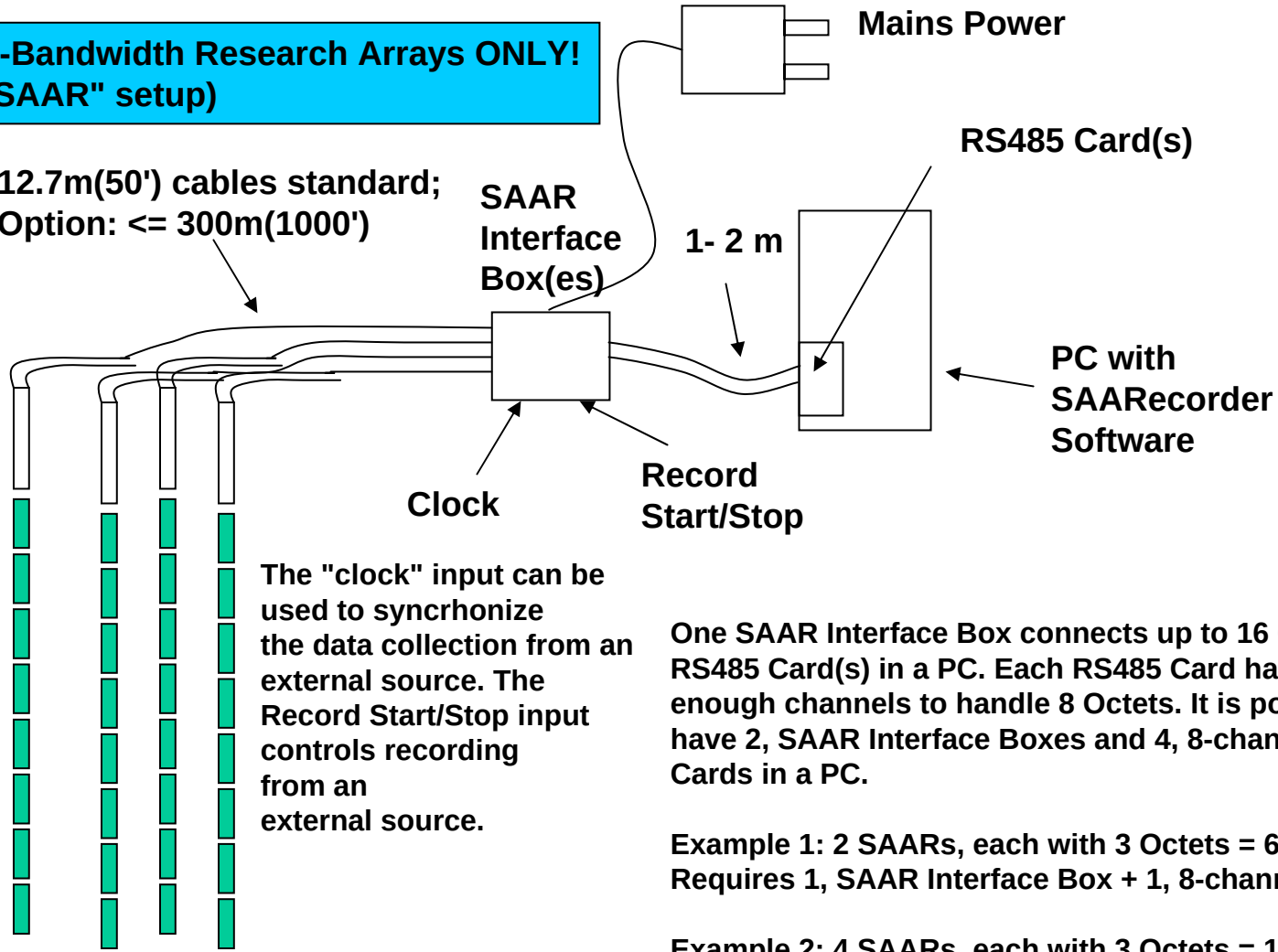
Simplest logger
As above in "Most common wireless" but data are collected manually from Campbell logger.

Wireless serial modem
Measurand's Wireless serial modem (WSM), connected to an SAAF through Measurand's SAA232 adaptor, enables communication with a PC fitted with a second WSM, as if connected through a serial cable, but wirelessly, at ranges of at least several km (1 km in EU with WSMEU).

Land line
For those rare situations where a telephone land line is used, the Campbell logger described in "Most common wireless" would use a landline modem instead of a wireless cellnet modem.

SAAR
Resarch SAAs ("SAAR") have a special interface for acquiring data in a PC at the highest possible rate.

Hi-Bandwidth Research Arrays ONLY! ("SAAR" setup)



The "clock" input can be used to syncrhonize the data collection from an external source. The Record Start/Stop input controls recording from an external source.

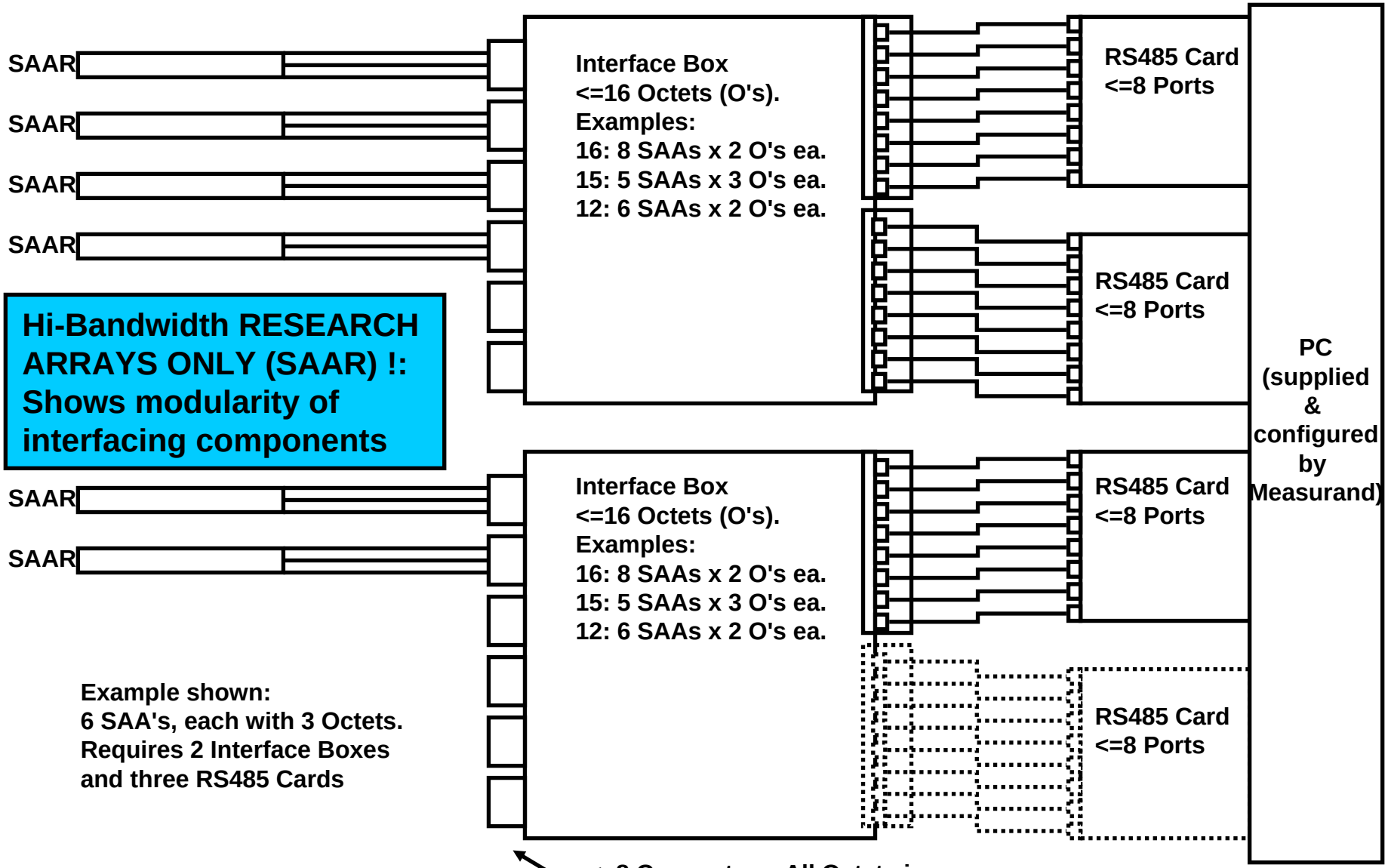
One SAAR Interface Box connects up to 16 Octets to RS485 Card(s) in a PC. Each RS485 Card has enough channels to handle 8 Octets. It is possible to have 2, SAAR Interface Boxes and 4, 8-channel RS485 Cards in a PC.

Example 1: 2 SAARs, each with 3 Octets = 6 Octets Total. Requires 1, SAAR Interface Box + 1, 8-channel RS485 Card.

Example 2: 4 SAARs, each with 3 Octets = 12 Octets Total. Requires 1, SAAR Interface Box + 2, 8-channel RS485 Cards.

Example 3: 8 SAARs, each with 3 Octets = 24 Octets Total. Requires 2, SAAR Interface Boxes + 3, 8-channel RS485 Cards.

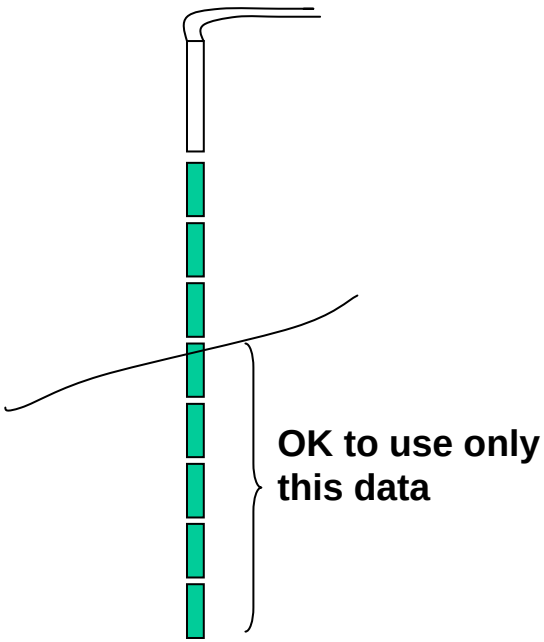
Measurand will supply the PC and Cards, with installed Software.


SAAR
SAAR
SAAR
SAAR
Interface Box
<=16 Octets (O's).
Examples:
16: 8 SAAs x 2 O's ea.
15: 5 SAAs x 3 O's ea.
12: 6 SAAs x 2 O's ea.
RS485 Card
<=8 Ports
RS485 Card
<=8 Ports
PC
(supplied
&
configured
by
Measurand)
Hi-Bandwidth RESEARCH ARRAYS ONLY (SAAR) !:
Shows modularity of interfacing components
SAAR
SAAR
Interface Box
<=16 Octets (O's).
Examples:
16: 8 SAAs x 2 O's ea.
15: 5 SAAs x 3 O's ea.
12: 6 SAAs x 2 O's ea.
RS485 Card
<=8 Ports
RS485 Card
<=8 Ports
Example shown:
6 SAA's, each with 3 Octets.
Requires 2 Interface Boxes
and three RS485 Cards
<=8 Connectors. All Octets in an SAA go to one Connector. Connectors may not all be on one side of box.

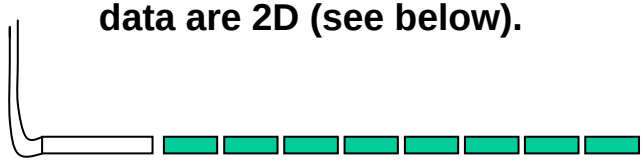
SAA Installation Notes

[Be sure to use our more detailed Installation Guide]

Calculation usually begins at the bottom of the SAA, so data above ground level may be ignored.



SAA may be installed Vertically or Horizontally. When near-horizontal, data are 2D (see below).

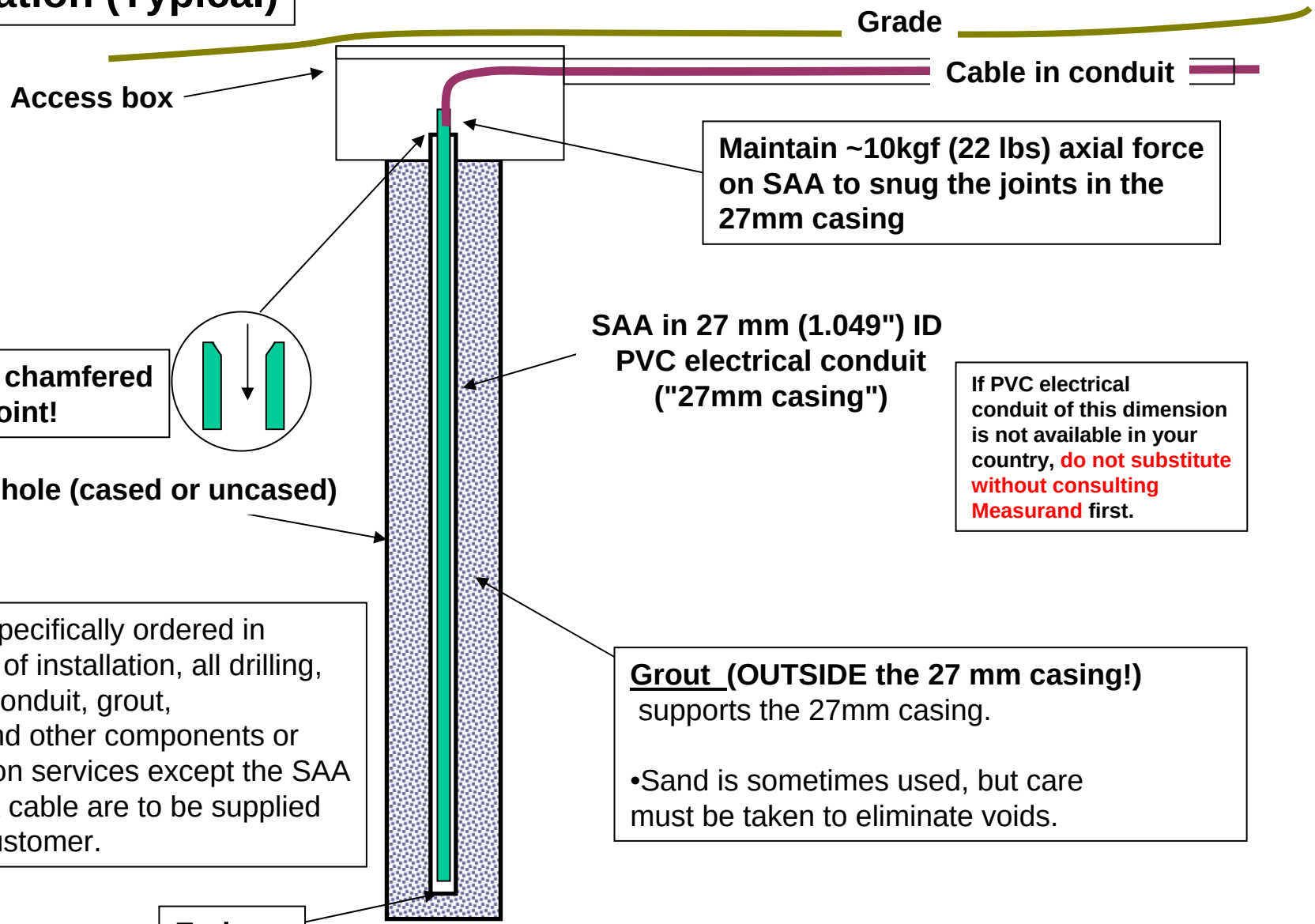


Horizontal

MEMS gravity sensors in the segments measure tilt along three axes. When SAA is near-vertical, rotational transforms are used to calculate the 3D shape of the array.
2D shape is measured when the array, or some of its segments, are near-horizontal. Thus, settlement is a 2D measurement (data are in a vertical plane).
In any pose, 3D vibration can be sensed at selected locations along the array.

Data may be calculated from either end. When no stable soil is available, it is often possible to survey to one end. (The orientations of segments, and thus the shape, are gravity-referenced, so will be correct; the survey places the shape at an exact geographical location.)

Installation (Typical)



27 mm Casing (Example)

If PVC electrical conduit of this dimension is not available in your country, **do not substitute without consulting Measurand** first.

In Europe, a similar casing with dimensions 32 x 2.4 mm (OD, wall thickness) is suitable, because it also has ~27 mm ID. The EU casing has external couplers and no end bells.

The casing must have an inside diameter 26mm +1, -0. The specification on this page is available from many suppliers. Note the "One inch" is a "Trade Size"; it has an ID of 26.6mm (1.049").

Allied **PVC Electrical Conduit**

Formerly Georgia Pipe

UL LISTED RIGID SCH-40 ELECTRICAL CONDUIT RATED FOR 90 DEGREE CELSIUS WIRING

Allied Schedule-40 is sunlight resistant and manufactured in accordance and complies to:

Underwriters Laboratories, Inc.	UL-651
NEMA	TC-2

UL LISTED

Meets or exceeds the requirements of NEMA TC-2 and UL-651 for Schedule 40 Conduit.

Lengths are glued with PVC cement during insertion. Use end reamer or knife to smooth the inner lip of the near-most length.

Schedule 40 PVC Conduit Dimensions (10' lengths with belled ends)

Trade Size	No.	O.D.	Min. I.D.	Wall	Wt/Ft	Ft/Pallet
½	8102	.840	.622	.109	.164	6000
¾	8103	1.050	.824	.113	.218	4400
1	8104	1.315	1.049	.133	.321	3600
1¼	8105	1.660	1.380	.140	.434	3300
1½	8106	1.900	1.610	.145	.518	2250
	08	2.375	2.067	.154	.695	1400
	10	2.875	2.469	.203	1.096	930
	12	3.500	3.068	.216	1.435	880
	14	4.000	3.548	.226	1.729	630
	16	4.500	4.026	.237	2.043	570
	20	5.563	5.047	.258	2.776	380
	24	6.625	6.065	.280	3.600	260

Magnetometers

SAA can be ordered with magnetometers installed in selected segments. Magnetometers are “electronic compasses” that provide accurate azimuth (heading) data relative to magnetic north. They do not increase the diameter or length of the SAA. They share segments with the normal MEMS accelerometers.

Like compasses, magnetometers will not work in environments containing ferrous or otherwise magnetic materials.

Typically, magnetometers are installed at top, middle and bottom of an array, to provide overall azimuth and also relative azimuth along SAA, where Measurand algorithms use their data to reduce any twist of the array. This is useful when arrays are very long (>30 m).

Magnetometers are also useful on short arrays that are at the end of a long run of PEX. In that case, usually only one magnetometer is required and is at the bottom end of the array.

SAA Order List

(Completing this list will enable more accurate and timely deliveries/quotes)

(One foot = 304.8 mm)

SAAF or SAAR

- **Number of Arrays**
- **Sensorized Lengths (304.8 mm segments)**
  - **SAAF: 8, 16, 24, 32, 40, 48, 56, 64, 72, 80, 88, 96, 104, … 320 feet (2.4m ... 97.5m)**
  - **SAAR: 8, 16, 24 feet (2.4m, ... 7.3m).**
- **Sensorized Lengths (500mm segments)**
  - **SAAF: 4, 8, 12, 16, ... 100m (13.1', ... 328')**
  - **SAAR: 4, 8, 12 m (13.1', ... 39.4').**
- **Remember to allow for additional "Far Anchor", "Near Anchor & Turn" lengths & Trench depth.**
- **Specify cable length if over 50' (at additional cost; max = ~1000', some restrictions apply).**
- **Specify extra PEX length if required.**
- **Specify magnetometers if desired.**

SAAR: Number of Interface boxes and RS485 Cards, speed/triggering/synchronization requirements.

- **SAAF Communication/Acquisition Options**
  - **Earth Station (Solar, Wireless Cellnet, Data Concentrator)**
  - **Wireless Cellnet plan (1 year or more)**
  - **Short-haul wireless serial link to PC (with optional extension to Cellnet)**
  - **Data Concentrator only (optional battery or solar supply)**
  - **Direct laptop (pick up real-time data with laptop)**

  (Please discuss communication options with Measurand).