

# VECTRINO PROFILER

P R O F I L I N G  
V E L O C I M E T E R



# **VECTRINO PROFILER**

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# Chapter 1

## Introduction

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Thank you for purchasing Nortek's Vectrino Profiler velocimeter! Your Vectrino Profiler has been designed to provide you with many years of safe, reliable service.

The Vectrino Profiler is a high-resolution acoustic Doppler velocimeter used to measure turbulence and 3D water velocity in a wide variety of applications from the laboratory to the ocean. The basic measurement technology is coherent Doppler processing, which is characterized by accurate data and no appreciable zero offset.

### Getting Started

This guide, in combination with the Quick Start guide which is part of the Help function, will help you getting started with your Vectrino Profiler. As initial preparation for using your new velocimeter, we recommend the following steps:

- 1 Verify that you have received all parts (see next page).
- 2 Install the Vectrino Profiler software on a computer (see chapter 5, Software).
- 3 Perform a functional test of your new Vectrino Profiler (see chapter 7, Test and Verification).
- 4 Mount the Vectrino Profiler in accordance with the guidelines (see chapter 6, Mounting Guidelines).

## Contents of Your Shipment

When you receive your Vectrino Profiler, the shipping box should contain the following components:



- 1 Transportation and storage case
- 2 Vectrino Profiler velocimeter
- 3 External power/signal cable
- 4 Tool kit, Nortek
- 5 RS-422 to USB high speed adaptor (model not as shown)
- 6 Seeding material (bottle of 250 ml)
- 7 AC/DC voltage transformer, 24 V DC
- 8 Universal plugs for AC/DC voltage transformer
- 9 USB memory stick with Vectrino Profiler software
- 10 This guide
- 11 Final test check list
- 12 Packing list
- 13 Warranty card

**Note:** If any part of the delivery should be missing, please contact Nortek immediately

# Chapter 2

## Product Specification

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### Mechanical

Vectrino Profiler cylinder:	70 mm
Vectrino Profiler height:	388 mm
Transport weight:	8 kg
Dimensions	
Transport box:	88 x 27 x 12 cm
Transport and storage box:	88 x 34 x 12 cm
Weight in air:	1.2 kg

### Sampling Volume

Distance from probe:	40 – 70 mm (full profiler)
	45–55 mm (point measurement)
Diameter:	6 mm
Height (user selectable):	1– 4 mm

### Echo Intensity

Acoustic frequency:	10 MHz
Dynamic range:	50 dB

## Sensors

Temperature:	Thermistor embedded in probe
Range:	-4 °C to +40 °C
Accuracy/Resolution:	1 °C / 0.1 °C
Time response:	5 min.

## Data Communication

I/O:	RS-422
Baud rate:	300-1250000 (user setting)
Max. cable length:	100 m
User control:	Vectrino Profiler Software
Synchronization:	Multiple Vectrino Profilers can be synchronized. Each can operate as either master or slave.

## Multi Unit Operation

Software:	Vectrino Profiler Software
I/O:	RS 422-USB support for devices with 1, 2 and 4 serial ports.

## Software

Operating system:	Windows 2000®, or newer
Features :	Instrument configuration Profile data collection Profile data display Data storage



## Power

DC Input:	12–48 VDC
Peak current:	2.5A at 12 VDC (user selectable)
Max. consumption at 100 Hz:	7W

## Connectors

Bulkhead:	Splash-proof connector or MCBH-12-FS waterproof connector
Cable:	Splash-proof or PMCIL-12-MP waterproof

## Materials

Standard model Delrin® housing. Stainless steel (316) probe and screws.

## Environmental

Operating temperature:	-4 °C to +40 °C
Storage temperature:	-15 °C to 60 °C
Shock and vibration:	IEC 721-3-2

## Options

Your Vectrino Profiler can be shipped with the following components to suit your requirements. For further information, contact Nortek.

- 4-beam down-looking probe or side-looking probe. Fixed stem or flexible cable
- 12-pin splash-proof connector or Impulse 12-pin underwater connector
- 10, 20, 30, 50 or 100 m cable with your choice of splash-proof or Impulse underwater connector
- Combined transportation and storage cage

# Chapter 3

## Technical Description

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### System Components

#### Probe

The probe is made of titanium and consists of four receive transducers and a transmit transducer. It is mounted either on a fixed stem connected to the main housing through the probe end bell, or on a cable connected to the main housing through the same probe end bell.

#### Transducers

Each of the four receive transducers is mounted inside a *receiver arm*. The transmit transducer is in the centre of the probe. The transducers are covered with hard epoxy.

#### Electronics Modules

The electronics module is located inside the pressure case and consists of a single board with the power transmitter, analog and digital signal processing, power conditioning, and interface circuits.

#### Temperature sensor

The temperature sensor (thermistor) is located inside the probe head.



The two available connectors

## Power and Communication Cable

The power and communication cable is connected to the end bell connector. The cable supplies external DC power (15–48 V) and provides two-way serial communication with an external computer.

The cable also provides synchronization options when the Vectrino Profiler is used as master or slave to synchronize measurements with other Vectrino Profiler's and/or other instruments.

**Cable Wiring.** By default, the Vectrino Profiler is shipped with a 12-pin connector and cable. The connector type is either a splash-proof connector or an MCBH-12-FS waterproof connector. The Vectrino Profiler power lines are diode protected, hence, you do not have to worry about wiring the Vectrino Profiler power backwards. If you do, it will not damage your instrument. The pin-out is shown in the side bar.

Pin No.	Function
1	A Serial In +
2	B Serial In -
3	C Serial Out -
4	D Serial Out +
5	E N/C
6	F Sync -
7	G Sync+
8	H N/C
9	J N/C
10	K N/C
11	L Gnd (power -)
12	M Power + (12–48V)

The pin-outs for the connectors.

Wiring of Vectrino II cable for RS422 communications			
Underwater connector Teledyne MCIL-12-MP		Termination	
Pin No.	Purpose	Pin	Description
1	RS422 Rx +	3	DB-9 connector, pins 1 and 5 are grounded
2	RS422 Rx -	8	
3	RS422 Tx -	2	
4	RS422 Tx +	7	
5		Not Used	
6	Sync-		Terminal block
7	Sync+		
8		Not Used	
9		Not Used	
10		Not Used	
11	Power Ground		Power Supply Connector
12	Power +		
Shield	Power Ground		Connected internally to Power Ground

## Chapter 4

# Functional Description

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This section briefly describes some of the underlying principles that control the operation and application of the Vectrino Profiler velocimeter.

The Vectrino Profiler has two modes of operation:

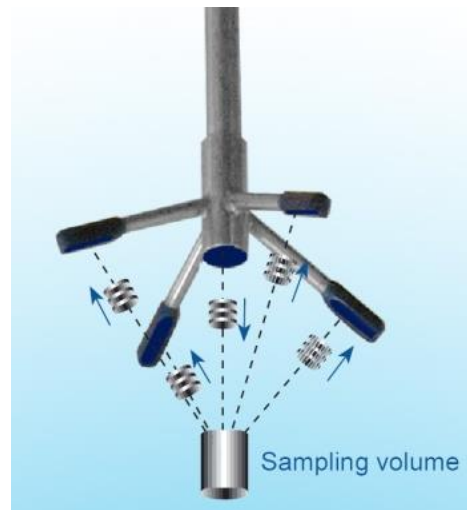
- **Command mode.** In command mode the Vectrino Profiler is ready to accept your instructions.
- **Data Acquisition Mode.** The Vectrino Profiler enters data acquisition mode when you click any of the **Start** commands (e.g. **Start Data Collection**) in the Vectrino Profiler software. The Vectrino Profiler collects data without interruption.

## Doppler Theory

Sound does not reflect from water, but from particles suspended in the water. These particles are typically suspended sediment or seeding particles, and move with the same average speed as the water. The velocity that is measured is consequently the velocity of the water.

The Vectrino Profiler uses the Doppler effect to measure current velocity. The Doppler effect is the change in pitch that is heard when either the source of a sound or the listener is in motion. When you hear a vehicle with a siren, the pitch is higher when the vehicle is heading towards you, and lower when it is going away. The change in pitch tells you how fast the vehicle is moving.

The Vectrino Profiler transmits short pairs of sound pulses, listens to their echoes, and, ultimately, measures the change in pitch or frequency of the returned sound.



#### The Vectrino Profiler velocimeter operating principle:

A pulse is transmitted from the centre transducer, and the Doppler shift introduced by the reflections from particles suspended in the water, is picked up by the four receivers.

**SNR Sweet Spot:** The profiling range of the Vectrino II is ultimately controlled by SNR. The SNR is highest at the sweet spot, located 5 cm from the transmitter. The best profiling range is a region centered on

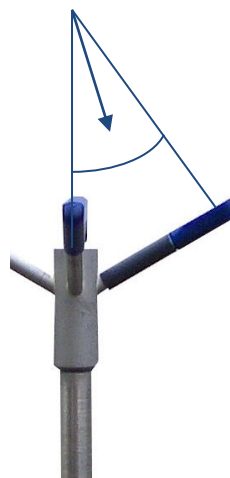
this sweet spot location.

## Vectrino Sonar Principles

In contrast to standard Doppler profilers and current meters, the Vectrino is a bistatic sonar. This means that it uses separate transmit and receive beams. It transmits through a central beam and receives through four beams displaced off to the side. The figure below shows how the beams intersect each other 50 mm from the transmitter. The measurement profile is defined by this intersection and by range gating in time. The transmit transducer sends a short pulse that transits the profiling region of approximately 30–80 mm and the receivers listen to echoes returned from this pulse gated in time. The Vectrino uses four receivers, all focused on the same volume, to obtain the three velocity components from that very volume.

The figure below shows that a transmit/receive beam pair is sensitive to velocity in the direction of the angular bisector between the beams. The arrow indicates a positive velocity.

The transmit/receive beam pair is sensitive to velocity in the direction of the angular bisector between the beams. The arrow indicates a positive velocity. Since the receive beams are slanted at 30°, all three beam pairs measure velocity that is 15° away from the transmit beam.

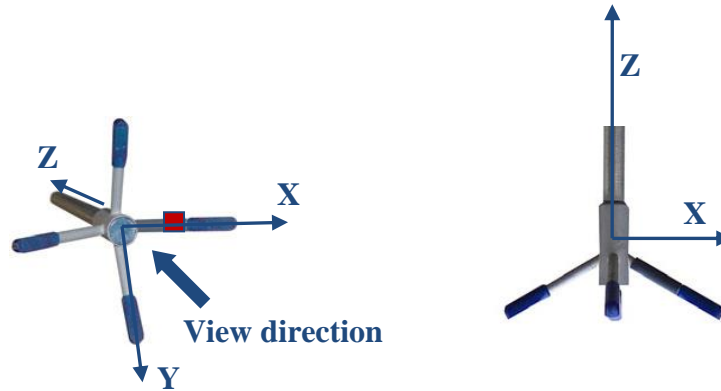


### Coordinate System

30°

The Vectrino measures velocity components parallel to its three beams, or in beam components. It reports data in Beam or XYZ coordinate systems.

The arm with the marking defines the X-direction. The Z-direction is towards the electronics of the Vectrino.



The XYZ coordinates are relative to the probe and independent of whether the Vectrino points up or down.

In XYZ coordinates, a positive velocity in the X-direction goes in the direction of the X-axis arrow.

### Velocity Uncertainty

The Vectrino velocity is an average of many velocity estimates (called *pings*). The uncertainty of each ping is dominated by the *short term error*. We reduce the measurement uncertainty by averaging together many pings. There is a limit to how much you can reduce your uncertainty. We call this limit the long-term bias. The long-term bias depends on internal signal processing, especially filters, and on the beam geometry. The long-term bias in the Vectrino is typically a fraction of 1 cm/s. The short-term error of a single ping depends on the size of the transmit pulse, the measurement volume, and the beam geometry. Averaging multiple pings reduces errors according to the formula:

$$\sigma_{V_{\text{mean}}} = \frac{\sigma_{V_{\text{ping}}}}{\sqrt{N}}$$

where  $\sigma$  is the standard deviation and  $N$  is the number pings averaged together.

**Note:** The Vectrino software minimizes the instrumental error only. In

many situations, the environmental turbulence or surface waves will dominate the short term velocity fluctuations.

## Data Handling

The Vectrino Profiler software saves data in binary files, which are easily converted to Matlab structured arrays or ASCII format files, using the conversion module in the software.

### Matlab:

- The `*.mat` file contains Data and Config structured arrays. Each array contains a “Comments” and “Units” field that describe the contents of each structure.

### ASCII:

- The `*.hdr` file is a self–documented table.
- The `*.dat` file contains velocity data at the full sample rate.

ASCII files are easily imported into most spreadsheets and data analysis programs.

# Chapter 5

## Software

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This chapter provides you with basic information about the software, installation of the software and its configuration. For further information, about the software, its configuration and use, please see the Help function in the Vectrino Profiler software.

Please see the Software Users Guide for more information on how to use the software.

### Installation

The Vectrino Profiler acquisition software on the included memory stick requires a Java virtual machine (JVM) to operate. The software has been tested with the Sun JVM available from <http://www.java.com/> but is also known to be fully functional with other JVMs. To install the software, double click on **Vectrino Profiler\_setup.exe** . This will copy the appropriate files to the installation directory and create a shortcut to the application on the desktop.

PDF versions of both manuals will be copied into the install directory when the software is first executed. More information on installation is available in the software user guide.

### Licensing

The firmware supports several functionally different variants based upon a license key which is provided when the instrument is purchased. The currently supported variants are:



Variant Name	Number of Velocity Cells	Velocity Sampling rate (Hz)	Maximum Velocity Range (m/s)	Adaptive Config	Bottom Check
Profiler	Full profile range	100	3.0	Yes	Yes with amplitude profile
Vectrino-ProfilerB+	1	200	5.0	Yes	Yes
Vectrino-Profiler+	1	200	5.0	No	No
Vectrino-Profiler	1	25	1.0	No	No

# Chapter 6

## Mounting Guidelines

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Follow these guidelines when you mount your Vectrino Profiler.

### What to consider

- Make sure that there are no obstructions between the sensor and the focal point (sampling volume) located about 5 cm from the transducers.
- Consider the effects of large objects on the flow itself. A rough rule of thumb is that objects disturb the flow as far as 10 diameters away from the object. Flow disturbance is greatest directly downstream in the wake behind the object.
- All acoustic transducers must be submerged during data collection. Operating your Vectrino Profiler when the transducers are out of water will not cause any damage, but your data will be meaningless. For side-looking probes, it is possible to collect 2D-data with only the lower receiver arms submerged.
- The best quality is achieved if the main flow direction is perpendicular to the transmit axis. Flow directly into the transmit axis should be avoided.
- Make sure your mounting structure is stable. Small vibrations in the mount can generate large accelerations in the data.

**Note:** When mounting your Vectrino Profiler, use the recessions to strap it to the structure. Never use the probe stem as mounting point.

# Chapter 7

## Test and Verification

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Verify that your equipment is working as expected.

### Communication

Check that you have installed the software correctly according to the procedure in chapter 5, Software, and then follow this procedure to test the communication:

- 1 Using the enclosed cables, plug in the AC adapter, and connect the Vectrino Profiler cable and USB converter to the USB port on your computer
- 2 Start the Vectrino Profiler software
- 3 Click on Connect: Vectrino Profiler
- 4 Select the appropriate serial port and communication speed
- 5 Click on Apply to initiate communications with the instrument

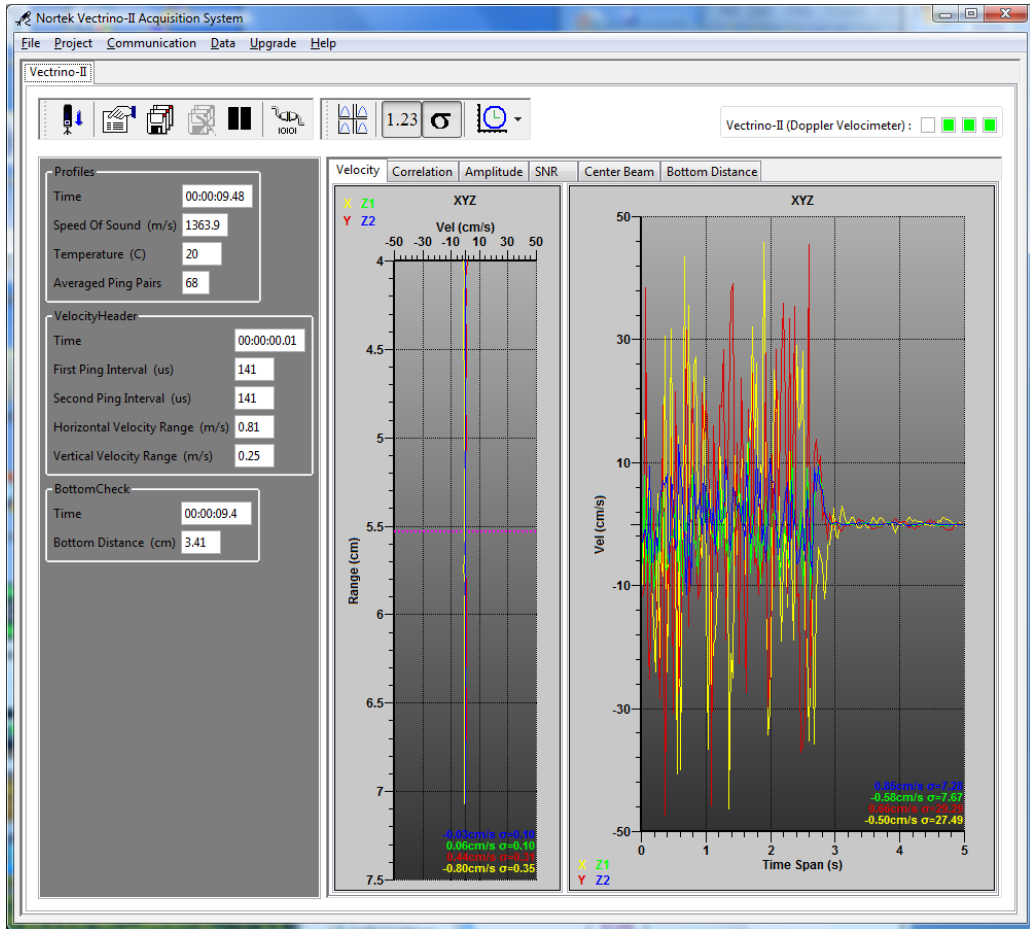
### Transducers

- 1 Fill a bucket with water and a little dirt (as sound-scattering material).
- 2 Click the **Start Collecting Data** button. While the transducers are in the air, the velocity measurement will look like random noise.
- 3 Immerse the transducers in the water, and observe the velocity, the standard deviation, and the amplitude. Note the change in the graphical view of the velocity when the probe is lowered into the water. In the air the

graphs are noisy; in water they should be smooth.

Measurement in air (left part of the graph) and in water (right part of the graph).

**Noisy velocity graphs:** If the velocity graphs remain noisy when the probe is immersed in water, try varying the position of the probe, or add some seeding like dirt or small particles to the water.



## Probe Check

Previous generations of the Vectrino velocimeter used a separate Probe Check mode to verify the integrity of the instrument. When licensed for profiling, the Vectrino Profiler collects amplitude profiles from the beams (showing how the signal varies with range) as part of its normal operation. For single measurement licensed instruments, a “beam check” mode is provided which produces an equivalent amplitude profile for a range up to 30cm. Amplitude profiles can be used to diagnose and correct problems and to optimize data collection.

### To check probe operation:

- 1 Make sure the probe is submerged in water with the transducers within 20 cm of the bottom.
- 2 Enable the **Probe Check** option in the configuration.
- 3 Click the **Start Data Collection** button.

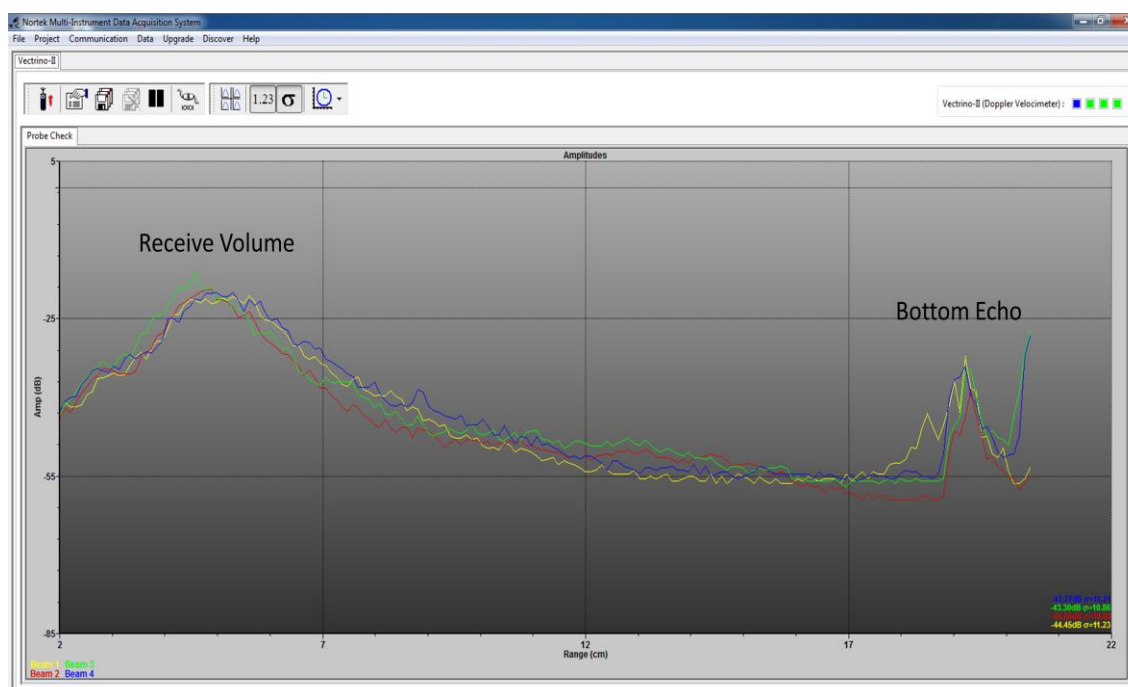
The four colored graphs in the profile display window on the left correspond to each of the four receive beams.

#### Signal-to-noise ratio:

The signal-to-noise ratio (SNR) is defined as follows:

$$SNR = 20 \log_{10} \left( \frac{\text{Amplitude}_{\text{signal}}}{\text{Amplitude}_{\text{noise}}} \right)$$

Strictly speaking, some noise will always be present, so  $\text{Amplitude}_{\text{signal}}$  should read  $\text{Amplitude}_{\text{signal} + \text{noise}}$ . However, for SNR values in the magnitude applicable to typical Vectrino Profiler situations, the difference is negligible.



There are two peaks visible in the amplitude data. The broad peak centered at ~5cm is the valid profiling volume. The sharper secondary peak (located at ~19 cm in this data set) is the bottom return.

## Chapter 8

# Synchronizing Multiple Instruments

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Your Vectrino Profiler can serve as master for other Vectrino Profiler's, or its sampling can be controlled by other sensors. This comes in handy when you need to use several Vectrino Profilers for a single set of measurements.

If you connect a controller to the Vectrino Profiler, you can set up a fairly sophisticated system in which the controller can power the Vectrino Profiler and provide it with sync pulses to control the sampling accurately. The controller can serve as a storage device.

Your Vectrino Profiler can be synchronized with other instruments via a pair of sync lines. To avoid noise problems and to make cabling easier, the two sync lines use an RS-485 chip which is balanced and bi-directional.

The sync lines are labeled *Sync-* (n) and *Sync+* (p).

### Synchronizing Multiple Vectrino Profilers

- 1 Connect all the *Sync+* lines together and all the *Sync-* lines together. All instruments should share a common ground.
- 2 Select one instrument as the master and the rest as slaves (Input sync) in the software.
- 3 Start data collection in all slaves (click the Start Collecting Data icon) before starting the master. The slaves will then wait for the

**Note:** On some older instruments the sync lines are labeled *Sync in* and *Sync out*. These should be treated as *Sync-* (Sync In) and *Sync+* (Sync Out).

first sync pulse from the master before sampling commences.

If you use **Sample on sync**, all instruments should be configured with the same sampling rate.

## Synchronizing From a TTL Source

TTL signal levels can be mixed with the RS-485 levels of the Vectrino Profiler.

Connect your sync pulse (0 – V volts) to **Sync-** and connect **Sync+** to a constant voltage  $V/2$  (where V is the ON voltage of the sync pulse). This provides a defined transition when the TTL signal changes, which is not the case if you ground **Sync+**. The SYNC inputs are diode limited to 5V through a 4.7 ohm resistor. Input voltages above 5V are not recommended for use.

**RS485 levels:** These differential levels define the signal the Vectrino Profiler reads for Input Sync:

**High level:** Sync- > Sync+ by 200 mV

**Low level:** Sync- < Sync+ by 200 mV

**Noise problems:** If you encounter noise problems, try terminating the **Sync-** line at the TTL input by connecting a 120 ohm resistor in series with a 1nF capacitor between the **Sync-** line and ground. The best solution for external sync is using RS485 as the input / output device.

**Note:** This implies that a Vectrino Profiler can operate as a master for a Vector, but the opposite is not possible.

When the Vectrino Profiler functions as master, the **Sync-** line can be connected to the TTL input and the two systems must be connected so they share common ground.

## How Synchronization Works

**Output Sync** (operating as the master) transmits a pulse with a duration of 50  $\mu$ s. The Vectrino Profiler transmits a pulse at the end of the sampling interval and a single pulse at the beginning of the first sampling interval to start everything when in “Master (Vectrino)” mode. When in “Master (Other)” mode, a pulse is transmitted in the middle of each sampling interval.

**Input Sync** triggers on the falling edge of the **Sync+ / Sync-** signal. After each trigger the input is discarded for the next 100  $\mu$ s.

## Chapter 9

# Maintenance

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Before you assemble a system that involves custom cables, power supplies or the like, first assemble and test the Vectrino Profiler using just the cables and power supply that came with the system. This is the easiest way to get the system up and working. If you encounter problems, you can always return to this setup to confirm that they are not caused by a faulty instrument.

### Preventive Maintenance

Preventive maintenance is your primary tool to keep your Vectrino Profiler in shape and ready for action and deployment.

Clean your Vectrino Profiler Velocimeter regularly. Use a mild detergent, and pay special attention to the transducers.

### Corrective Maintenance

Only qualified personnel are allowed to perform corrective maintenance activities. Please refer to the separate service manual or contact Nortek for further assistance.



# Chapter 10

## Upgrading

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### Upgrading Software

**Note:** If you enter the download section without logging in, you will be prompted to log in when you attempt to download a file. If you are not a registered user, simply follow the link to the registration form.

You will find the latest release of the software for your Vectrino Profiler at: <http://www.nortekusa.com/usa/support/> . To upgrade the software, follow the procedure for software installation (see Chapter 5).

### Upgrading Firmware

Firmware refers to the internal software of the instrument, as opposed to the instrument software running on a computer and described in this manual.

When you purchase a brand new instrument from the factory, it contains the latest firmware version, and there is no need to upgrade the firmware.

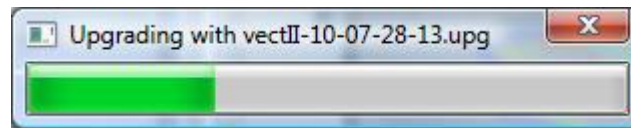
However, new functionality (and in rare cases bug fixes) will likely be offered in the future, requiring an upgrade of the firmware. New firmware is posted on our web site at: <http://www.nortekusa.com/usa/support/> . When you upgrade your firmware, make sure you also have the latest version of the software as new versions are often released at the same time.

## Firmware upgrade procedure

**Note:** If you have not registered with us already, you will need to do this first. Click the link **New User** on the right, and fill in the registration form to register.

- 1 Download the most recent firmware to your computer from: <http://www.nortekusa.com/usa/support/>
- 2 Click on **Upgrade** in the Vectrino Profiler software, select the relevant instrument and then browse to the downloaded firmware file and select it.
- 3 If you have the standard Vectrino Profiler, simply click OK to start downloading the file to the instrument. This will produce the following box:

The **License Key** dialogue box will appear when you attempt to upgrade the firmware.



To ensure that the Vectrino Profiler firmware is not corrupted if the download transmission fails during the download process, the Vectrino Profiler runs a check on the received file before it is allowed to replace the existing firmware. After the file is received by the instrument (indicated by completion of the progress bar), there can be up to a 30 second wait as the new firmware is validated and programmed into place.

If the firmware file is not accepted, repeat the upgrade process until the firmware file is successfully downloaded.

# Chapter 11

## Further Information and Help

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### Visit [www.nortek-as.com](http://www.nortek-as.com)

At our website, [www.nortek-as.com](http://www.nortek-as.com), you will find technical support, user manuals, and the latest soft- and firmware updates for the Vectrino Profiler and our other products, as well as more general information, technical notes and user experience regarding data analyses and related matters.

Our aim is that our users should be able to find any information they may need regarding our instruments and the use of them online. If you are unable to find the information you are looking for, we encourage you to use our forum.

### Nortek's Forum

Nortek's forum on the web is where users from all over the world meet to discuss and share their experience with Nortek's instruments.

If you have comments, questions, application tips, suggestions for improvements, or simply want to learn from others or share your own experience with other users all over the world, we encourage you to register and post to our forum.

# Chapter 12

## Returning Your Vectrino Profiler for Repair

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### Returning your Vectrino Profiler

Before you return a product for repair you must have obtained a Return Merchandise Authorization (RMA) in writing from Nortek AS. You can send your RMA request by e-mail to [inquiry@nortek.no](mailto:inquiry@nortek.no)

Your shipment must be accompanied by a proforma invoice. You can either copy the proforma invoice on the next page, or make your own, but make sure you include the same information.

Remember to include a copy of all shipping and export documents in the freight box.

### Insurance

We recommend that you fully insure your return shipment in case it is lost or damaged, as Nortek AS does not cover freight insurance on repairs.

Nortek AS is not responsible for instruments damaged or lost in transit. Nor shall we be held responsible for consequential damage as a result of instruments being damaged or lost in transit.

Nortek AS will insure the instrument upon returning the goods to you. We will bill you for the insurance along with the costs for repair and

freight.

**For warranty repairs, the transport and freight insurance from Nortek AS to you will be covered by Nortek AS.**

## **Customs regulations**

The regulations and requirements covering the export and re-import of items sent for repair varies from country to country. In the past, some of our customers have experienced problems because they have failed to provide the proper documentation. If these matters are not managed correctly, you may be charged import duties and taxes for a second time when your instrument is returned to you.

At Nortek we must meet our own country's regulations when instruments are repaired and subsequently returned. This, however, may not be sufficient for your country.

To avoid problems, we strongly recommend that you, as part of your own procedures for handling returns, always check with your customs authorities as to what information, documents etc. they need from you and from us. Then let us know what you need from us by e-mail, fax or mail. We will do our very best to help you.

***NOT A SALE – TEMPORARY EXPORT TO  
NORWAY FOR REPAIR ONLY***

## PROFORMA INVOICE

SENDER (Exporter)	RECEIVER
Name:	Name: NORTEK AS
Address:	Address: Vangkroken 2
City:	City: NO-1351 RUD
Country:	Country: NORWAY
Tel.:	Tel.: +47 67 17 45 00
E-mail:	Fax: +47 67 13 67 70
Fax:	E-mail: <a href="mailto:inquiry@nortek.no">inquiry@nortek.no</a>
Contact:	Contact: Jonas Røstad

### ABOUT THE GOODS

Date:  
No. of Units:  
Tracking no.:  
Weight:  
Value:  
NORTEK RMA No.:  
Reason for Export:

---

Exporter's signature

# **APPENDIX**

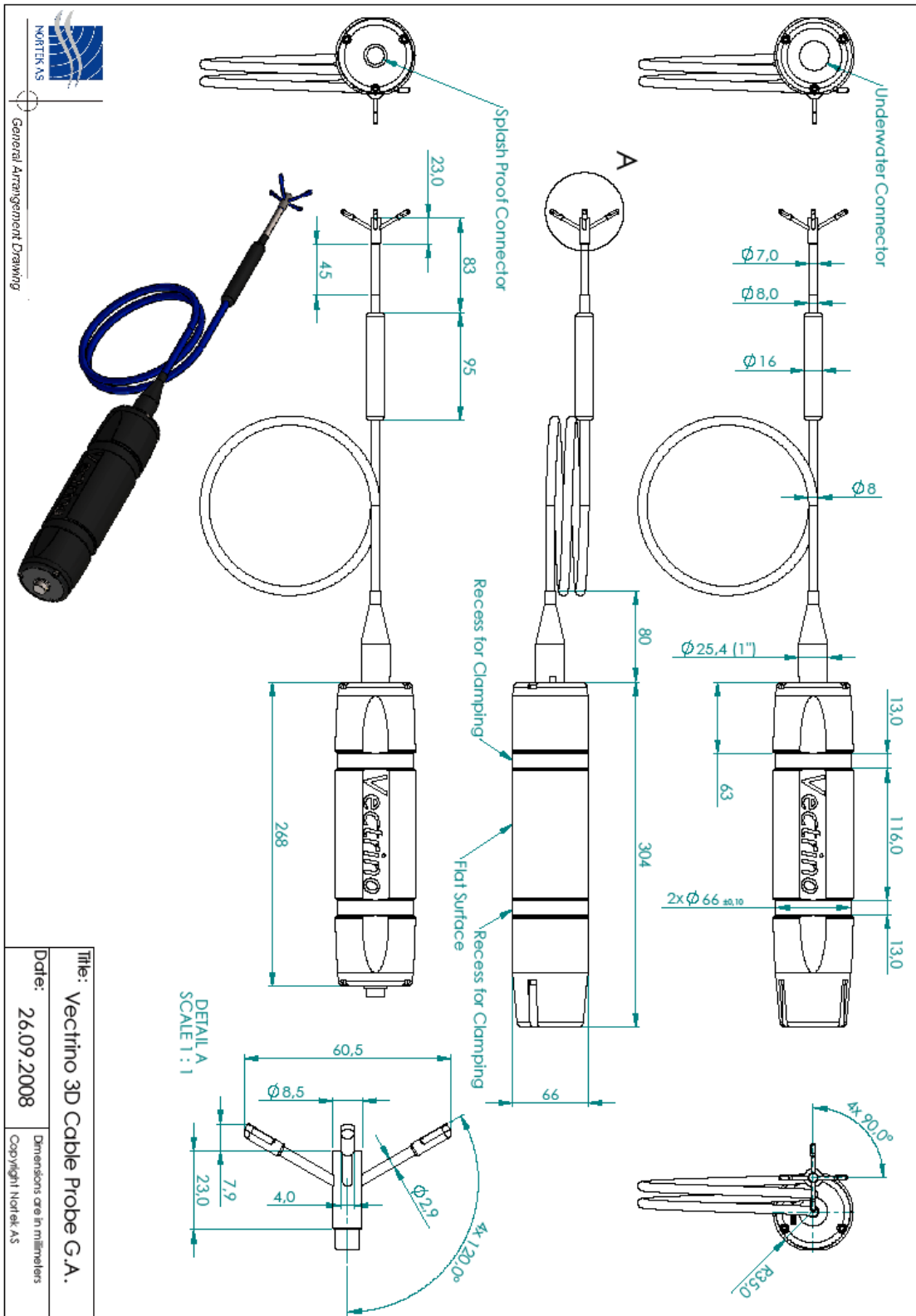
## **Drawings and Dimensions**

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On the following pages you will find drawings with dimensions for your Vectrino Profiler.

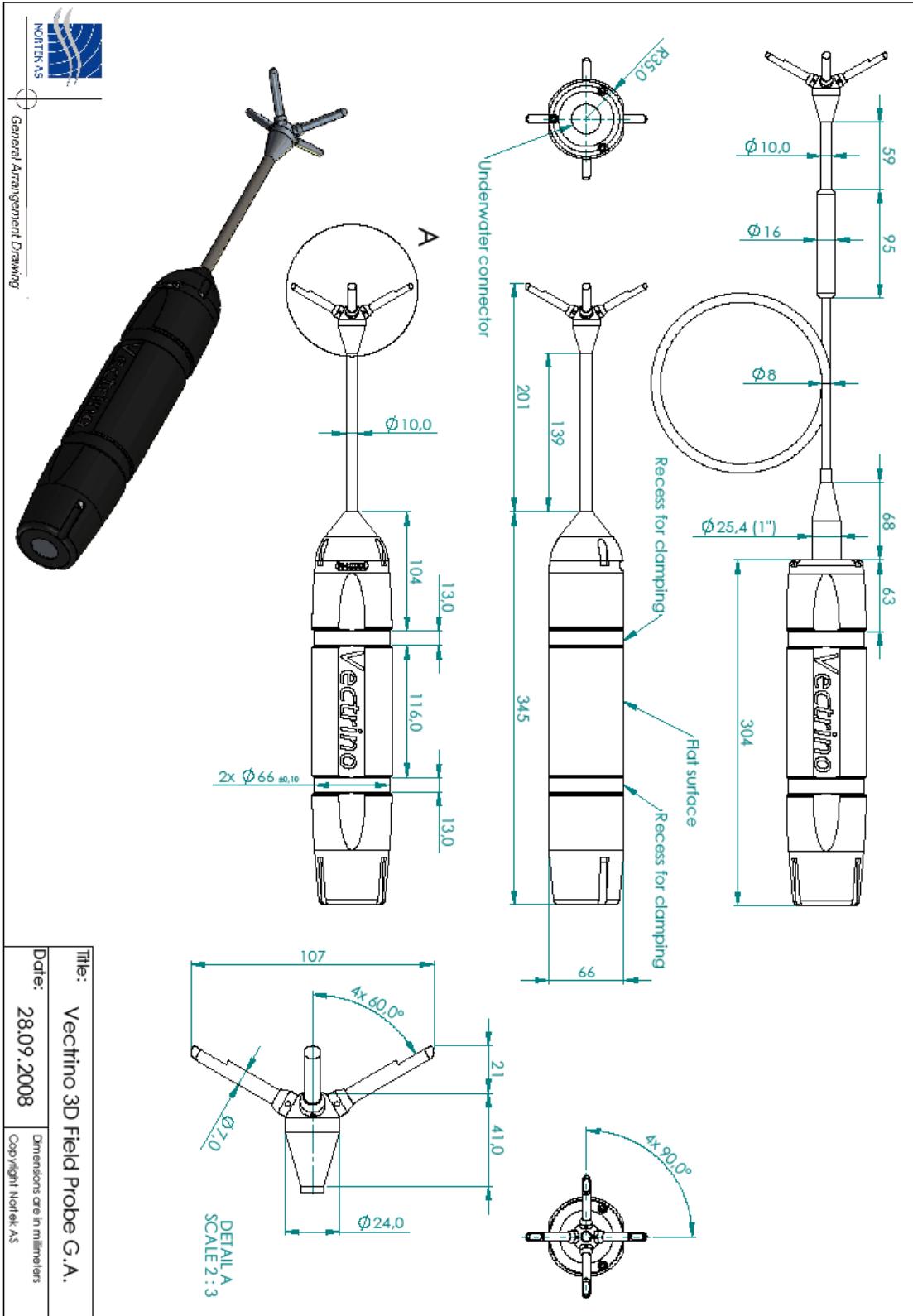


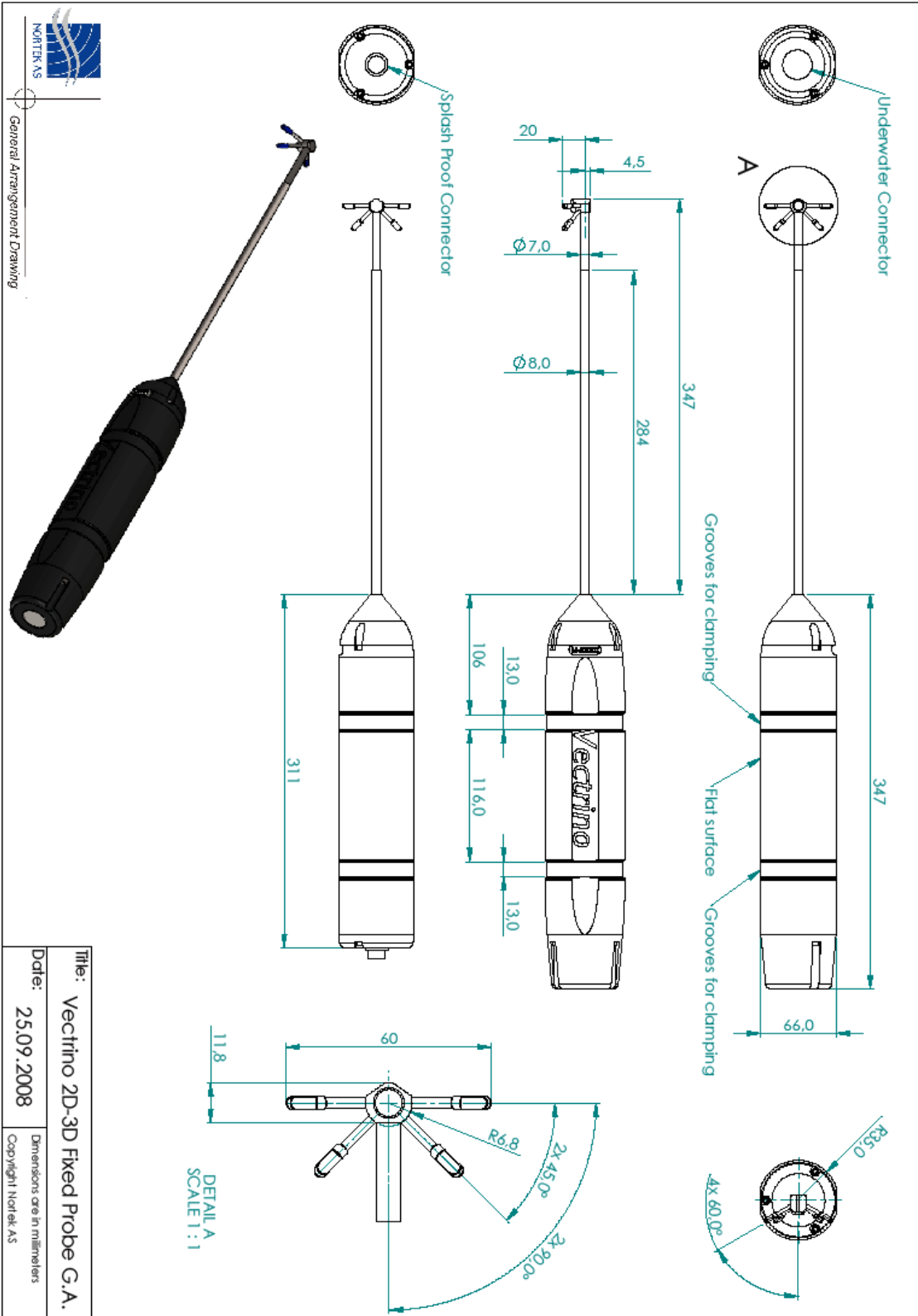




General Arrangement Drawing

Title:	Vectrino 3D Cable Probe G.A.
Date:	26.09.2008
Dimensions are in millimeters	Copyright Nortek AS





General Arrangement Drawing

Title:	Vectrino 2D-3D Fixed Probe G.A.
Date:	25.09.2008
Dimensions are in millimeters	Copyright Nortek AS

