OTT SVR 100 BEST PRACTICES

GUIDE

OTT HydroMet

Introduction

Surface velocity radars are applicable for measuring surface water velocities and computing real time mean channel velocities and discharge in rivers and open channels. The reliability of the measurement results depends crucially on:

- a careful selection of the measuring site, the flow conditions, the quality of scatterers or waveforms on the water surface
- the presence of environmental influences such as wind gradients, precipitation, and macro turbulences

The following best practices will provide you with compact, easy-to-follow guidance to successfully operate the OTT SVR 100.

"Besides the measured velocities, the sensor provides meta data for quality control and quality assurance with each single measurement."

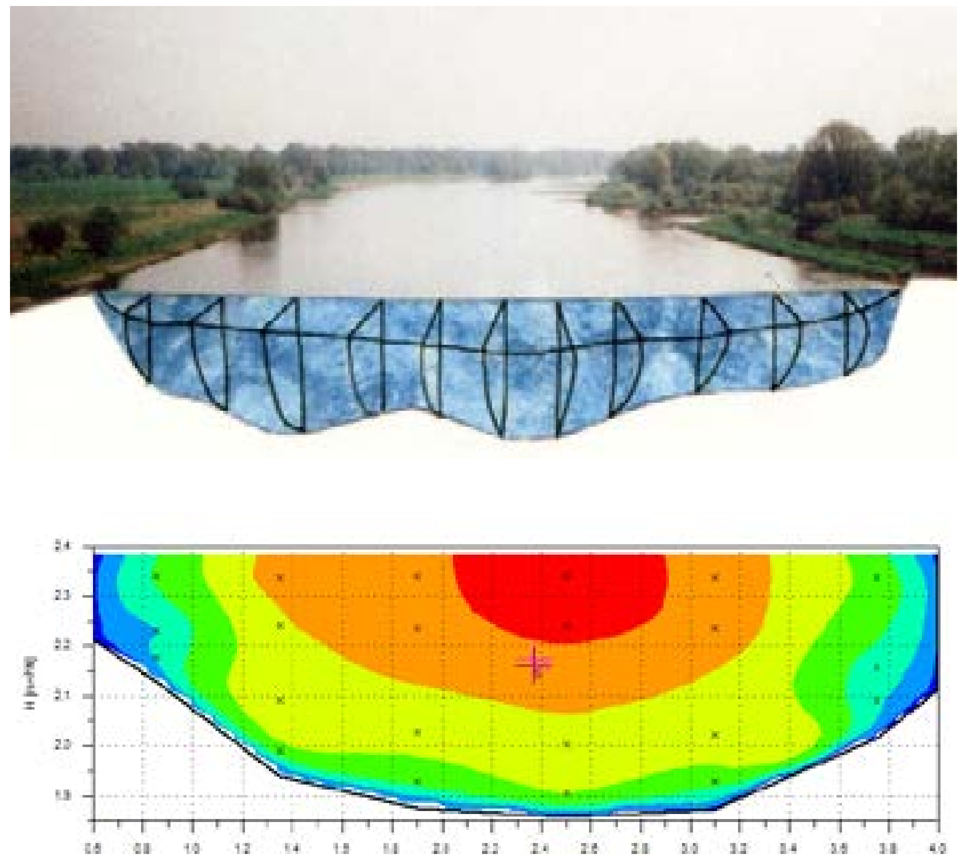
Site reconnaissance in the office

Selecting a good site for velocity radar measurements requires similar considerations as conventional streamgage sites, with the following principles:

1

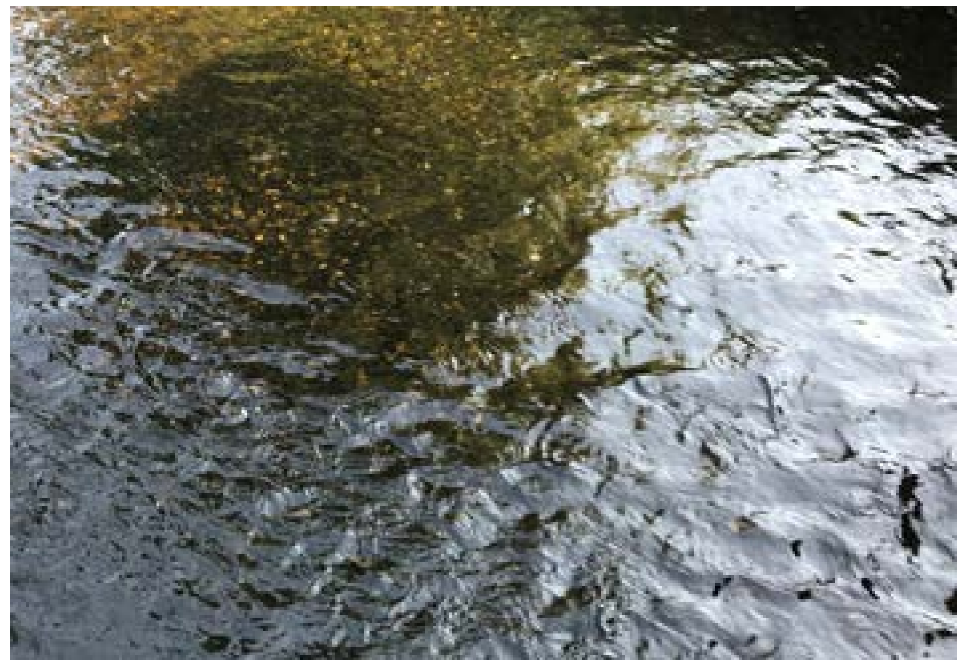
Straight course of the water with parallel streamlines and free of growing weeds, channel obstructions, rocks and macro turbulences.

2



Uniform shaped cross-sections with stable riverbed and banks, a regular velocity distribution, and a stable position of the maximum surface velocity.

3



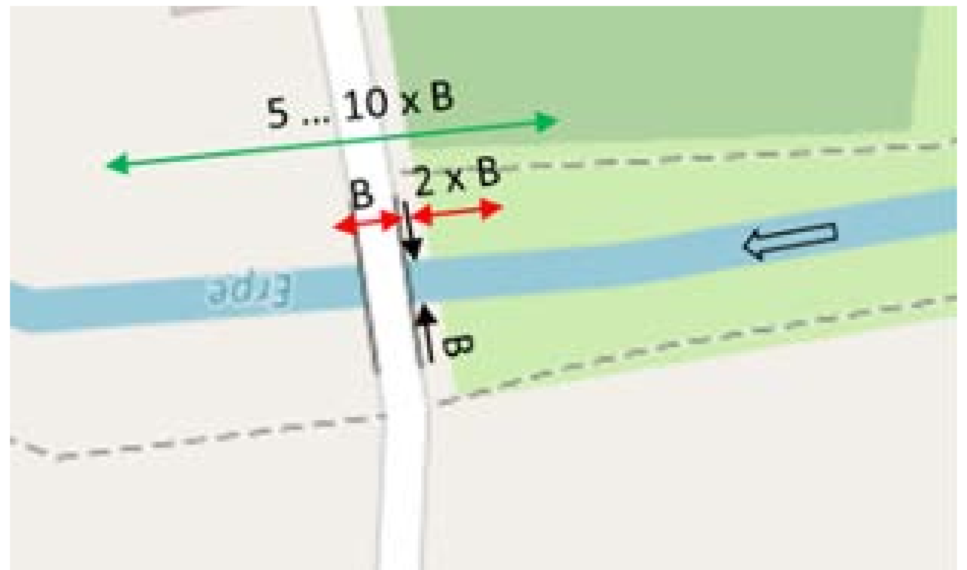
Rough water surface structure (min 3 mm wave height) with velocities greater than 0.10 m/s and minimized influence of wind gradients.

4

As a first step, it’s recommended to explore the site conditions by using topographic and geologic maps or aerial photos (e.g. satellite images). Those will provide an overview of the territory where potential measuring sites could be set up. Mark identified locations on the map.

Site reconnaissance in the office

5



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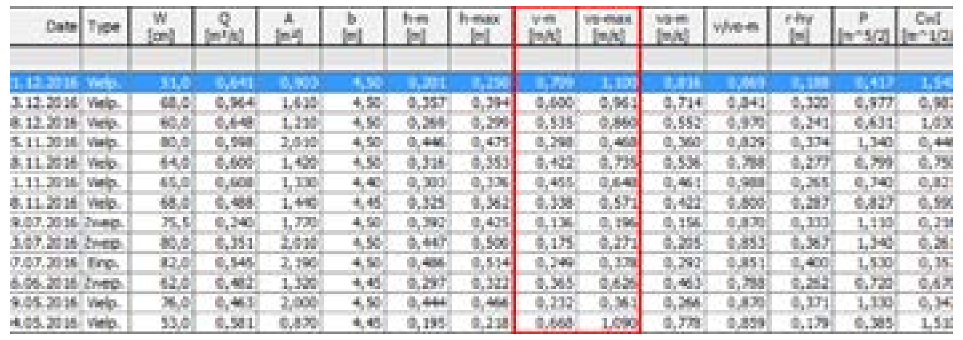
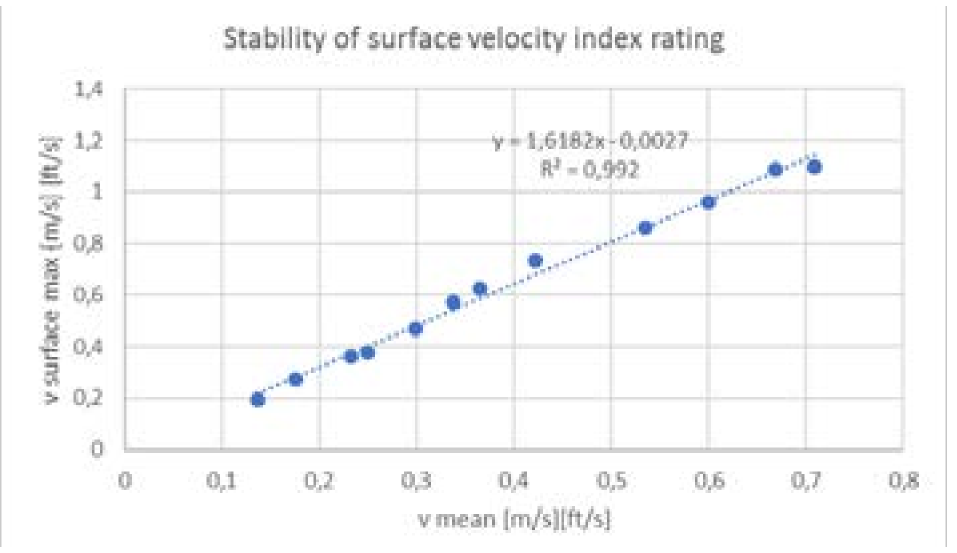


Date	Type	W [cm]	Q [m³/s]	A [m²]	b [m]	h-m [m]	h-max [m]	v-m [m/s]	vo-max [m/s]	vo-m [m/s]	v/vo-m	r-hy [m]	P [m^-1/2]	Cvd [m^1/2]
1.12.2016	Velp.	51,0	0,641	0,900	4,50	0,201	0,230	0,709	1,100	0,816	0,869	0,188	0,417	1,54
3.12.2016	Velp.	68,0	0,964	1,610	4,50	0,357	0,394	0,600	0,961	0,714	0,841	0,320	0,977	0,98
8.12.2016	Velp.	60,0	0,648	1,210	4,50	0,269	0,299	0,535	0,860	0,552	0,970	0,241	0,631	1,03
5.11.2016	Velp.	80,0	0,598	2,010	4,50	0,446	0,475	0,298	0,468	0,360	0,829	0,374	1,340	0,44
8.11.2016	Velp.	64,0	0,600	1,420	4,50	0,316	0,353	0,422	0,735	0,536	0,788	0,277	0,799	0,75
1.11.2016	Velp.	65,0	0,608	1,330	4,40	0,303	0,376	0,455	0,648	0,461	0,988	0,265	0,740	0,82
8.11.2016	Velp.	68,0	0,488	1,440	4,45	0,325	0,362	0,338	0,571	0,422	0,800	0,287	0,827	0,59
9.07.2016	2welp.	75,5	0,240	1,770	4,50	0,392	0,425	0,136	0,196	0,156	0,870	0,333	1,110	0,23
3.07.2016	2welp.	80,0	0,351	2,010	4,50	0,447	0,506	0,175	0,271	0,205	0,853	0,367	1,340	0,26
7.07.2016	Einp.	82,0	0,546	2,190	4,50	0,486	0,514	0,249	0,378	0,292	0,851	0,400	1,530	0,35
6.06.2016	2welp.	62,0	0,482	1,320	4,45	0,297	0,322	0,365	0,626	0,463	0,788	0,262	0,720	0,67
9.05.2016	Velp.	76,0	0,463	2,000	4,50	0,444	0,466	0,232	0,361	0,266	0,870	0,371	1,330	0,34
4.05.2016	Velp.	53,0	0,581	0,870	4,45	0,195	0,218	0,668	1,090	0,778	0,859	0,179	0,385	1,51

7



Check the course of the water. The course should be as straight as possible, providing flow which is parallel to the banks and without irregular velocity distributions. As a rule of thumb one can assume that the water is flowing parallel to the banks if the water course is straight over 5 – 10 times the channel width. It is recommended to ensure that the straight distance has at least double the length in the upstream direction as it has downstream from the measurement cross-section.

If you want to setup a velocity radar at an existing discharge measuring station, review the results of your historical field measurements first. Most software tools for the evaluation of discharge measurements report the mean channel velocity (v-m) as well as the maximum surface velocity (vo-max).

If there is a stable ratio between the mean channel velocity and the max surface velocity, the likelihood of succeeding with a surface velocity radar is great.

When you have decided on a location, the next step is to continue exploring the measuring site in the field.

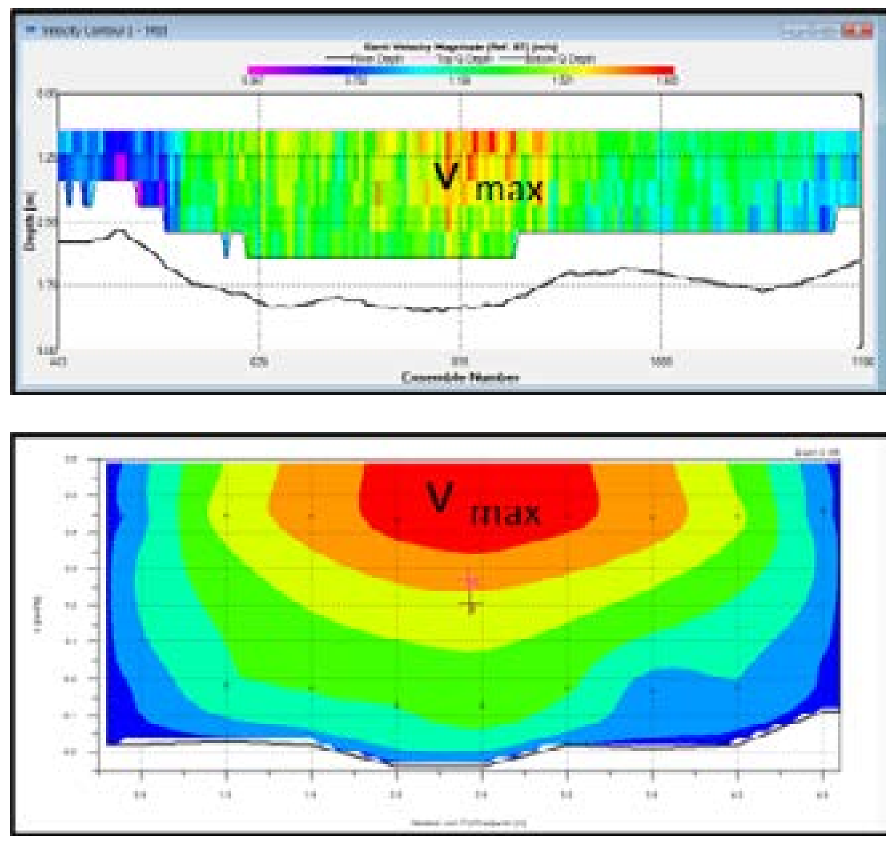
Site reconnaissance in the field

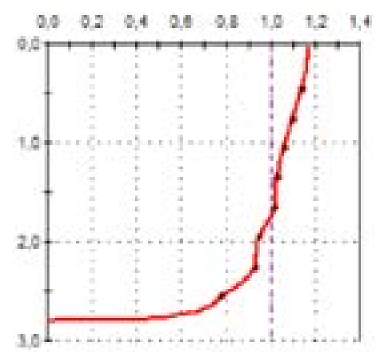
Apply portable flow meters (e.g. ADCP's, mechanical, acoustic or magnetic-inductive type flow meters) to determine the following parameters:

- Geometry of the measurement cross-section
- Stage related cross-sectional area
- Discharge and mean-channel velocity
- Position of the vertical where the maximum in-stream velocity or maximum velocity on the water surface is measured.

Furthermore, it is recommended to collect data of wind speed and direction if wind effects are expected on site.

Once the vertical with the maximum flow velocity is identified, perform a detailed velocity measurement along this vertical (e.g. near the bottom, at the water surface, and additionally at 8 points between).





Measuring sites that should be avoided

1

Sites with tributaries

Watch out for inflows of tributaries or contributing drainage systems. Those may cause cross flow and a shifting of the position of the maximum surface velocity which in the end causes unstable index velocity ratings.

2

Sites with macroturbulences

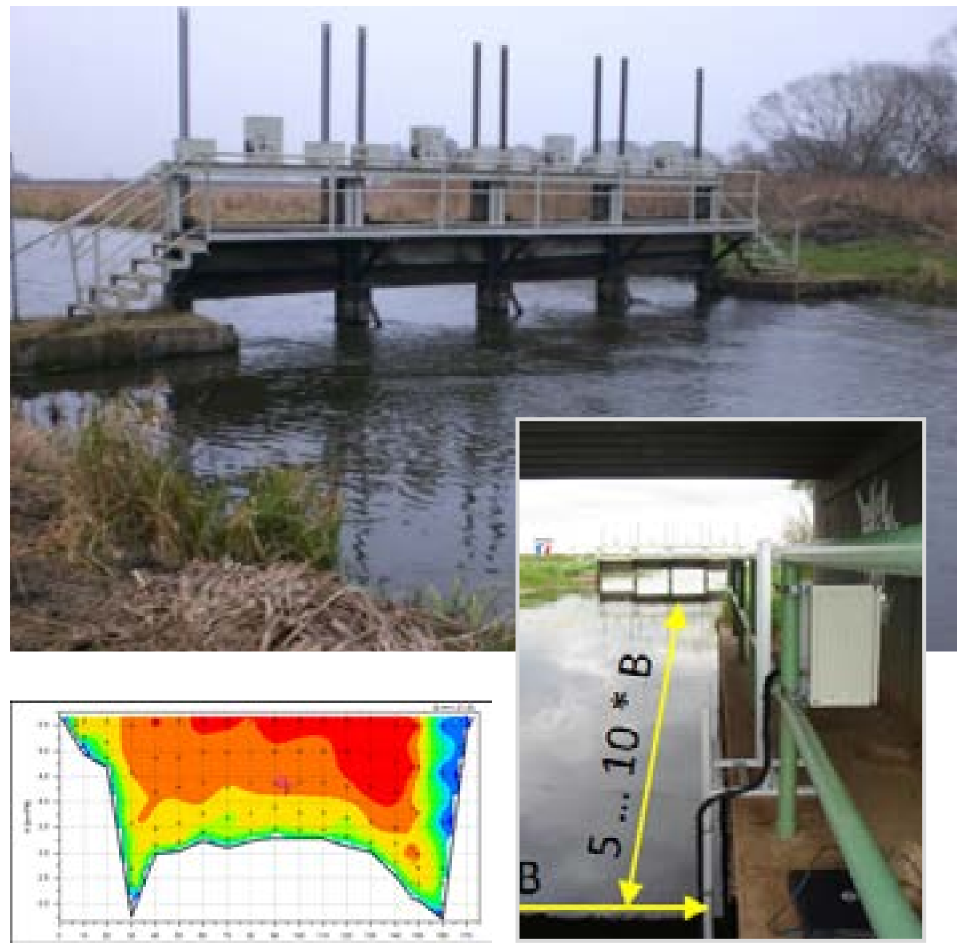
Watch out for highly turbulent flow conditions. Those will have too much noise on the water surface which makes signal evaluation difficult and affects the accuracy of the final velocity measurement.

3

Sites with obstacles on the riverbed

Watch out for large rocks or other obstructions. Those may create turbulence or slack water.

4

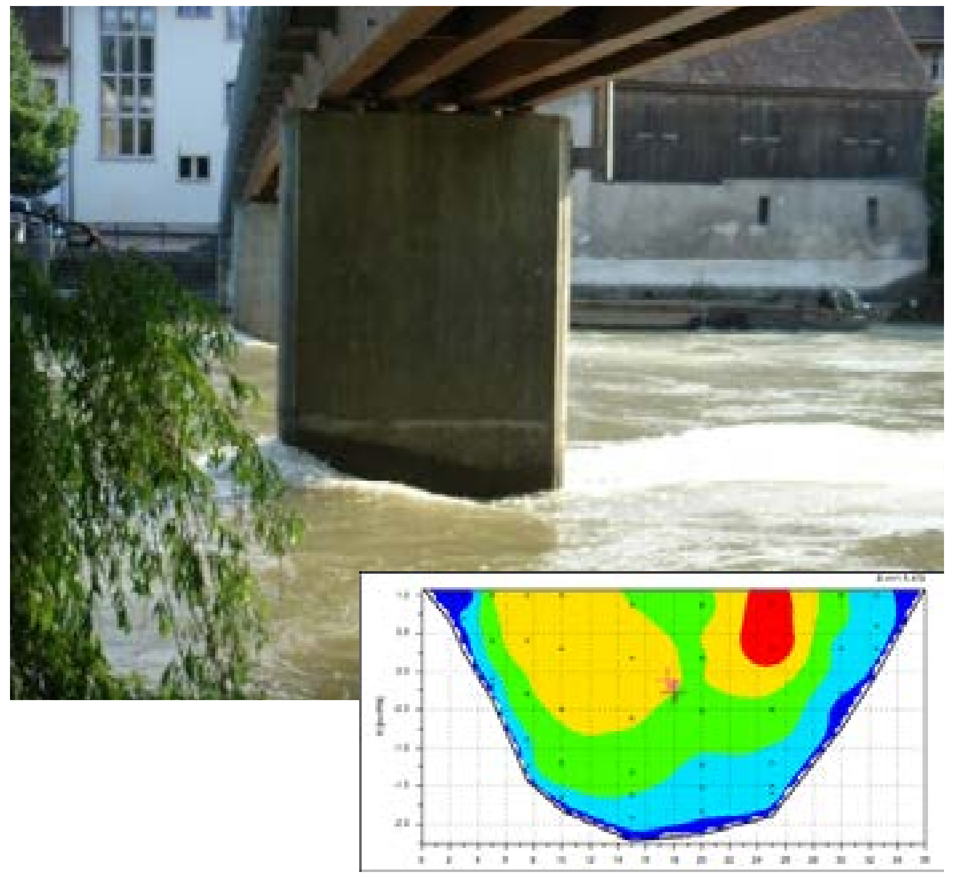


Sites near channel obstructions

Watch out for variable flow conditions downstream of channel obstructions (e.g. gates / weirs). Those may cause inhomogeneous velocity distributions and a shifting of the position of the maximum surface velocity. This ultimately causes unstable index velocity ratings. Stay away from those structures at least 5 ... 10 times the channel width upstream and downstream.

Measuring sites that should be avoided

5



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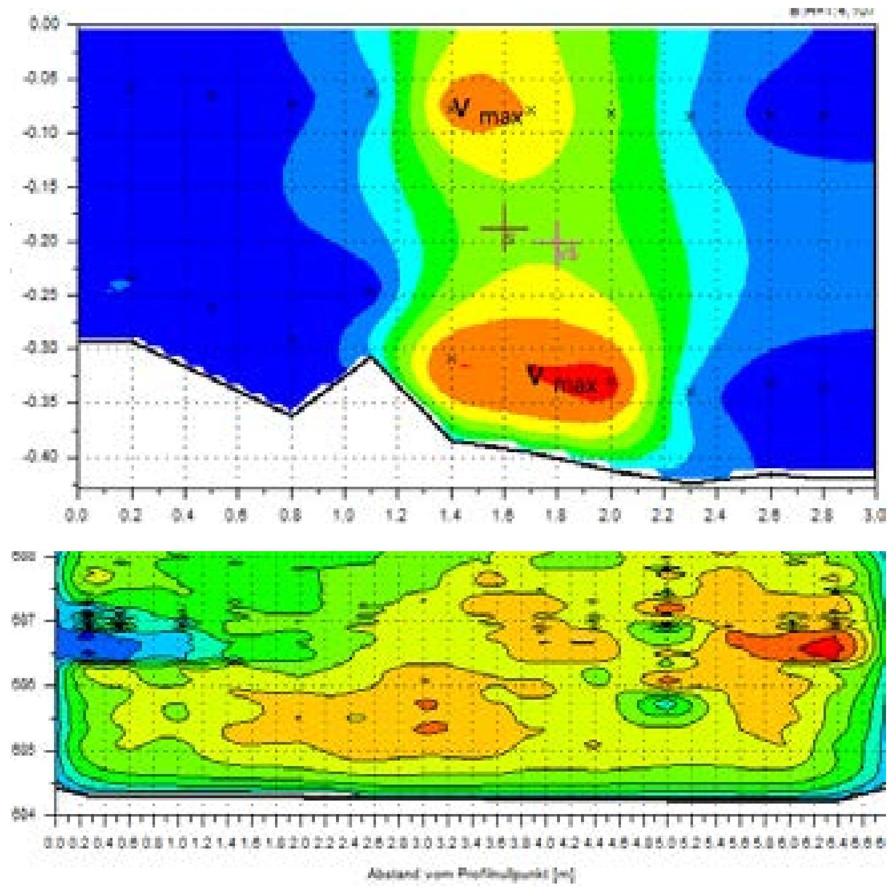


Bridges with piers

Watch out for variable flow conditions upstream and downstream of piers. Those may cause standing waves and macro turbulences which effect the accuracy of the velocity measurement and the stability of the velocity – index – rating. If a bridge with pier is used for installation, then always point the radar upstream.

Sites with growing weeds

Watch out for growing weeds within the cross-section. Those may create slack water and cause unpredictable velocity distributions. Additionally, returning echoes of floating plants are noisy and are not representative of the echoes of the flowing water surface waves.

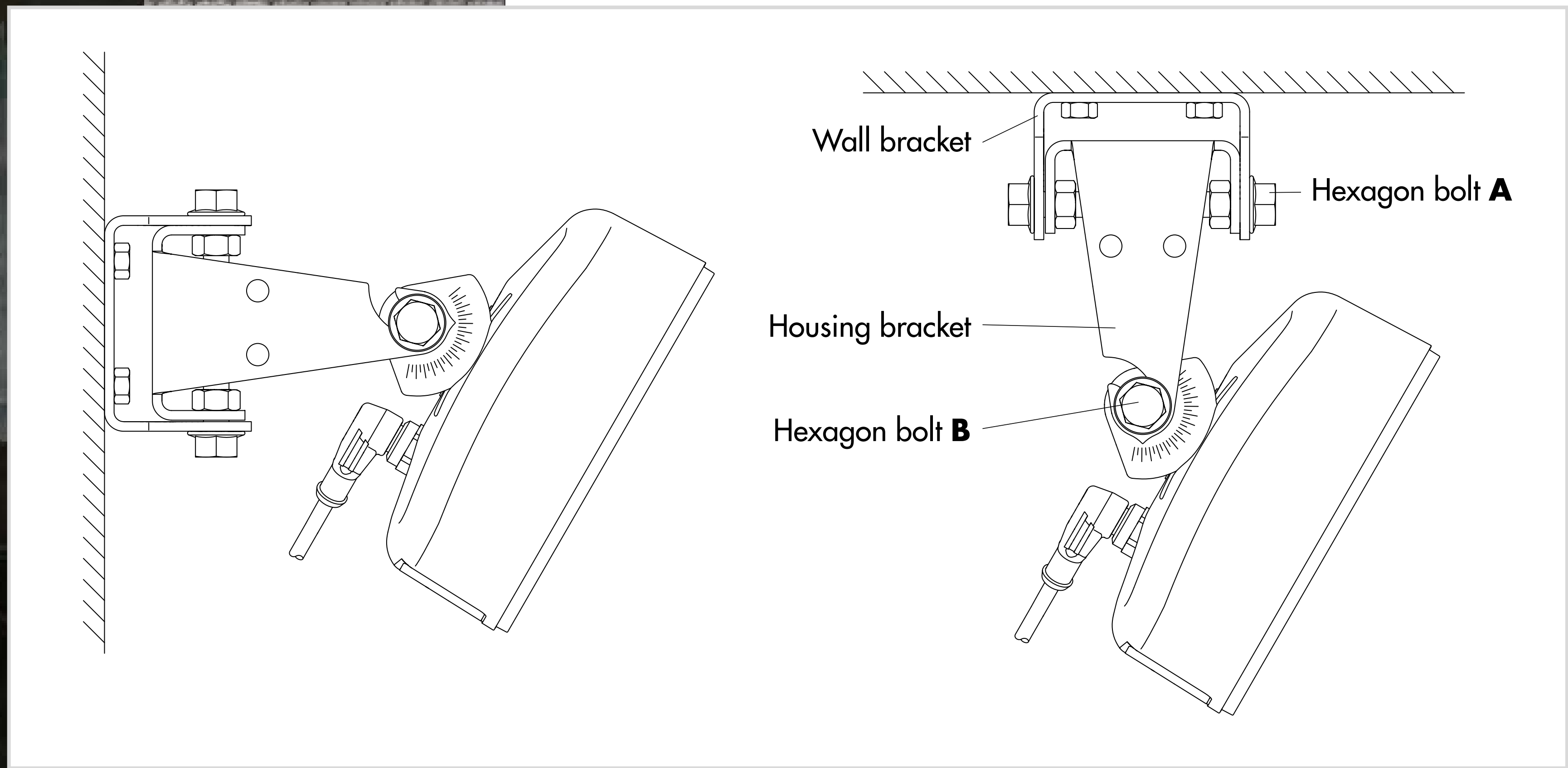
Sites with stratified flow

Watch out for stratified flow. Stratified flow provides at least two areas of maximum velocity and therefore irregular velocity distributions, which again causes unstable index velocity ratings.

Installation Variants

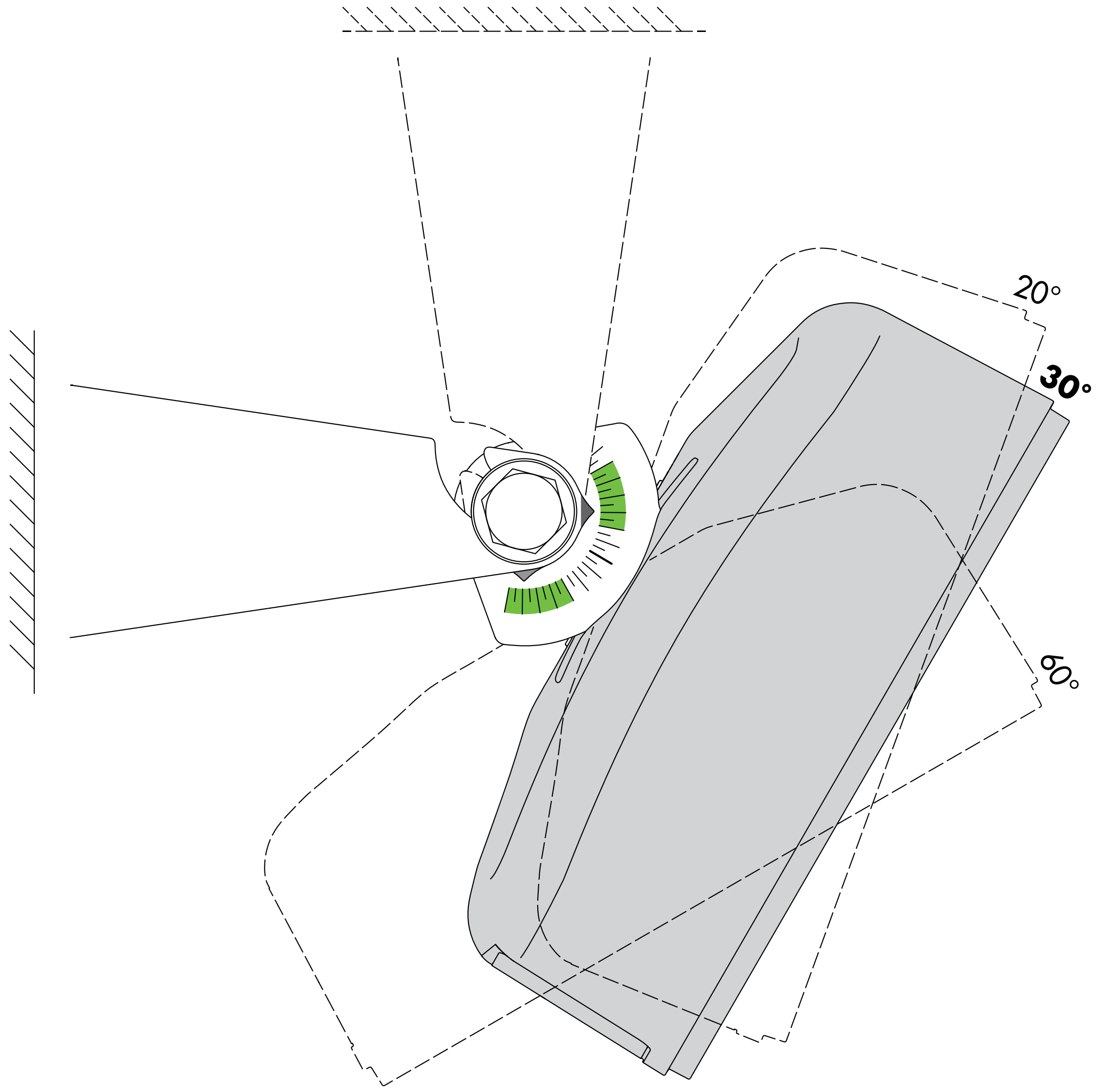
Bridge mounting
The swivel mount, included in the scope of delivery, enables the sensor to be mounted on both horizontal and vertical mounting surfaces. Bracket dimensions and mounting hole positions are documented in appendix B of the OTT SVR 100 operating instructions. If the situation on site permits, attach the sensor below the bridge. This way the bridge provides cover from the rain directly in front of the instrument which enables a better rain suppression in the signal processing.

Additionally, a combined mounting support with a protection cover can be used to mount both the OTT RLS level sensor and the OTT SVR 100 velocity sensor.



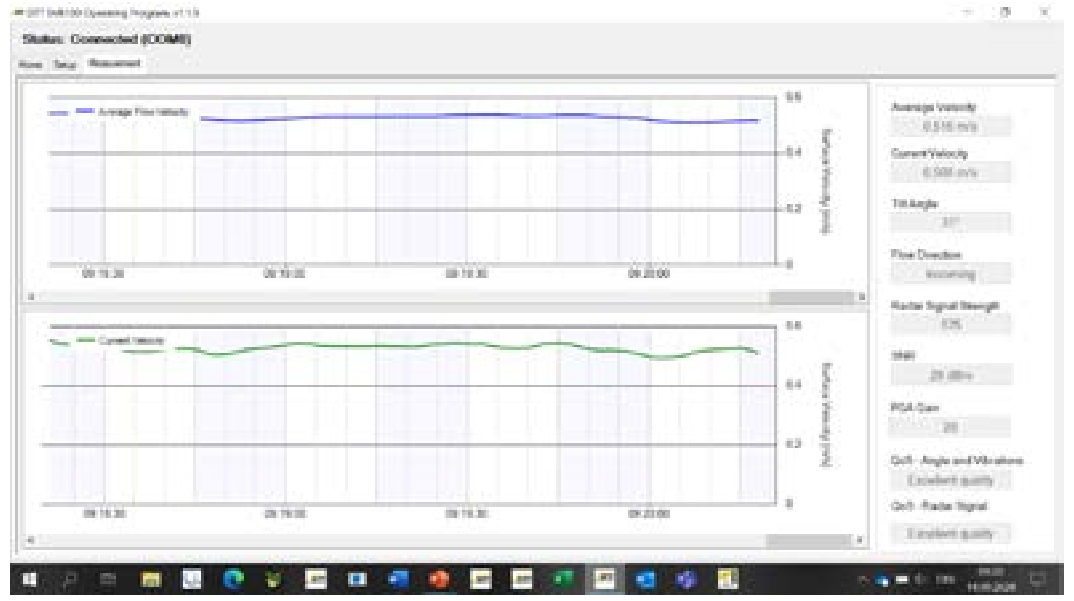
Cantilever mounting
For narrow rivers where there is no bridge, the installation of a cantilever arm can be considered. In this way, continuous flow measurement in small streams and channels that do not have any bridges is possible at any time.

> "An optimized sensor position is a basic requirement for reliable measurement results."



Instrument positioning

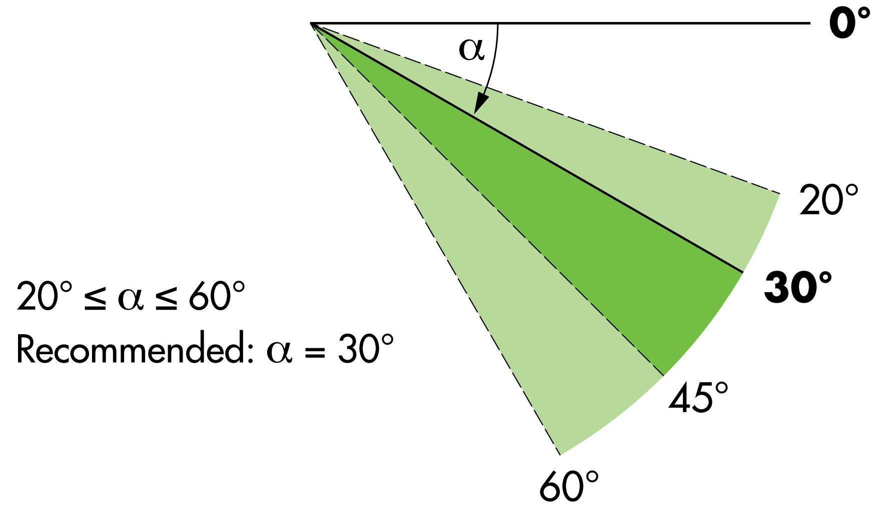
An optimized sensor position is a basic requirement for reliable measurement results. To estimate the best sensor position, rely on the location of the maximum in-stream velocity or maximum velocity on the water surface. The instrument should be oriented in parallel with the main direction of flow and pointed upstream, so that the water flows towards the sensor.

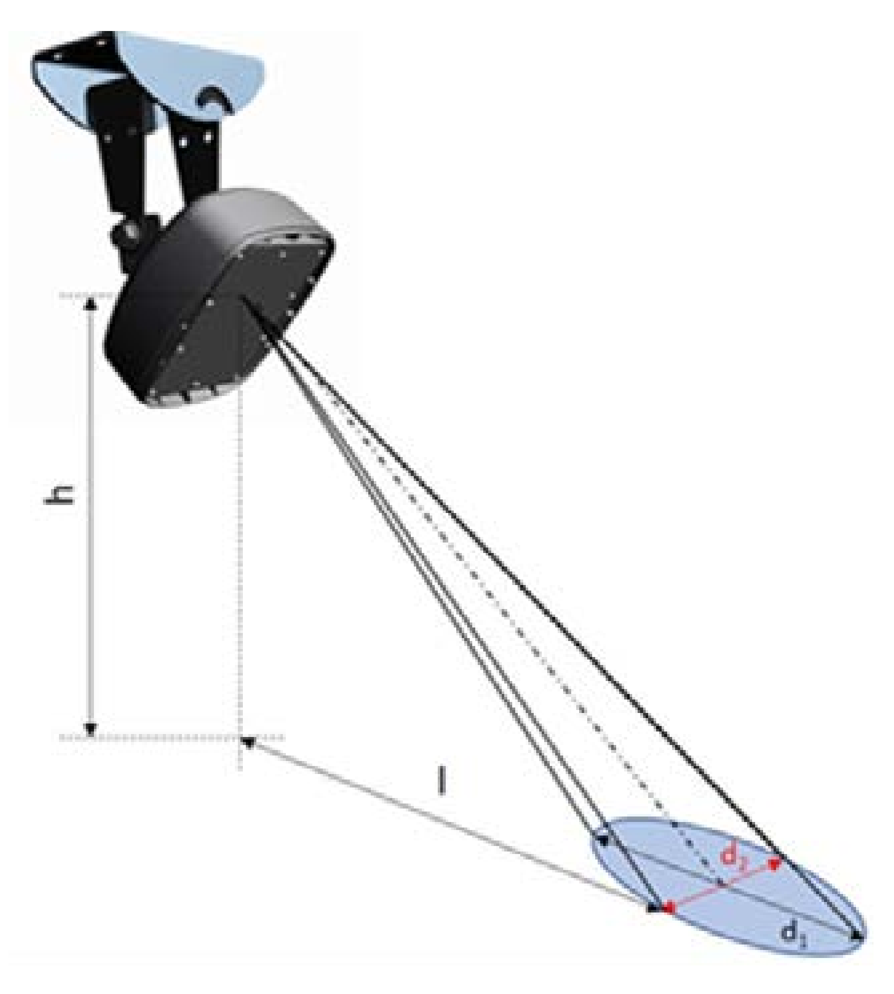


For extra peace of mind, you may connect to the radar via RS-232 and run the OTT SVR 100 user software on site to search for the max surface velocity area. The user software outputs the velocities in real time together with all quality parameters.

Instrument alignment

Aligning the sensor with an appropriate tilt angle is important for the measurement quality. While the angle is adjustable in a range of 20° to 60°, the optimal range is between 30° and 45°. A graduated scaling at the swivel mount facilitates the sensor alignment on site. Please note, an angle of 30° is recommended as the best setup to ensure the best performance for most applications where the height of the sensor above the water surface is less than 10 m. Nevertheless, good results at 30° inclination can also be expected for sensor heights up to 20 m distance. It is recommended that the tilt angle does not exceed 45°.





Angel [°]	30°			45°			60°		
Heigth h [m]	l [m]	d1 [m]	d2 [m]	l [m]	d1 [m]	d2 [m]	l [m]	d1 [m]	d2 [m]
1	1,7	2,0	0,4	1	0,9	0,3	0,6	0,6	0,2
2	3,5	3,9	0,8	2	1,8	0,6	1,2	1,2	0,5
3	5,2	5,9	1,3	3	2,7	0,9	1,7	1,7	0,7
4	6,9	7,9	1,7	4	3,6	1,2	2,3	2,3	1,0
5	8,7	9,8	2,1	5	4,5	1,5	2,9	2,9	1,2
6	10,4	11,8	2,5	6	5,3	1,8	3,5	3,5	1,5
7	12,1	13,8	2,9	7	6,2	2,1	4,0	4,0	1,7
8	13,9	15,7	3,4	8	7,1	2,4	4,6	4,6	1,9
9	15,6	17,7	3,8	9	8	2,7	5,2	5,2	2,2
10	17,3	19,7	4,2	10	8,9	3	5,8	5,8	2,4

Footprint computation

Calculating the footprint prior to defining the final sensor height and orientation is important to ensure the footprint will be within the channel. You may apply equations of trigonometry for this purpose. The table to the right gives an example for different heights and angles.

Instrument connection

There are three serial interfaces available to connect the sensor (RS-232, RS-485 and SDI-12). A data collector can communicate with the sensor via SDI-12 or Modbus. The factory preset communication protocol is SDI-12. For connecting the instrument to a data logger, please refer to the OTT SVR 100 operating instructions.

If you want to communicate directly with your sensor, you'll need to connect the sensor via RS-232 with your PC / Laptop and run the OTT SVR 100 user software. Direct communication may be required if:

- a change of the communication protocol is required (e.g. from SDI-12 to Modbus).
- a firmware update is required.

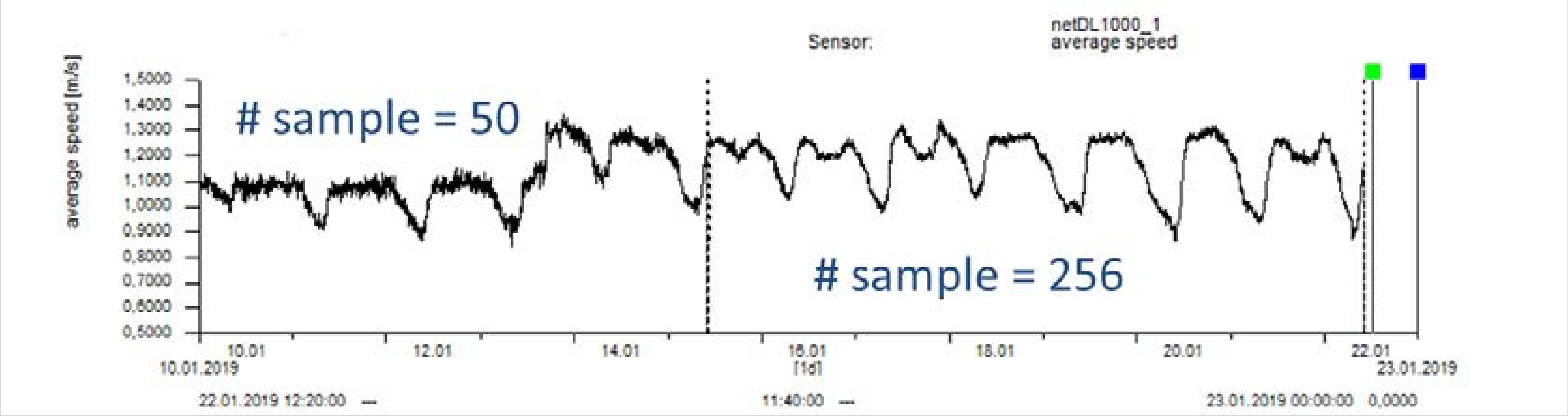
Instrument setup

The table gives an overview of the factory default settings highlighted in bold.

The graphic illustrates the effect of an extended averaging time on the velocity hydrograph.

It can be clearly seen that a longer averaging time produces data with less noise and may reduce the effect of oscillation.

Parameter	Recommended Settings	Comments
Radar sensitivity	**45 (default)** (if the water surface is very smooth reduce to 11 or 8)	The parameter regulates the threshold at which the sensor reports there is no movement. Lower values (10 or lower) can cause the radar reporting not existing flow velocity when the riverbed is dry.
Filter type	**Moving average (default)** or IRR filter	
Device address	**0** (initial address)	Change if several devices will be connected
Filter length	**50 (default)** ... 512	Filter length defines number of samples used for moving average calculation. Extended filter length = smoother data.
Flow direction filter	Incoming / Outgoing or **Off (default)**	Set 'Off' if both flow directions are possible (e.g., tidal influenced flow)
RS-485 protocol	**SDI-12 (default)**, MODBUS	Protocol changeable with OTT SVR 100 user software



Velocity

The sensor provides two velocity values, the current velocity and the averaged velocity. Two filter types are supported by the sensor, the IIR filter (infinite impulse response filter) and the moving average filter. The default setting is the moving average filter with a filter length of 50 samples. One sample corresponds with a time period of 1/10 seconds.

The current velocity is the first available value and will be provided after processing a Kalman filter and the moving average filter. The averaged velocity will be provided after additional processing of an IIR filter.

The averaged value should be used for the subsequent discharge calculation.

Meta data

Besides the measured velocities, the sensor provides Meta data for quality control and quality assurance with each single measurement for:

- tilt angle
- signal quality index
- vibration index
- signal to noise ratio (SNR)

Make sure you watch the angle regularly. This keeps you up to date on events that have taken place in the field (e.g. sensor damage due to storm events or vandalism). In case the angle is changing significantly you should consider a maintenance trip to the site.

The signal quality index indicates the signal quality in a range of 0 (good signal) to 3 (very bad signal). The values are corresponding with the measured SNR value. A SNR of greater than 6 represents a good signal quality.

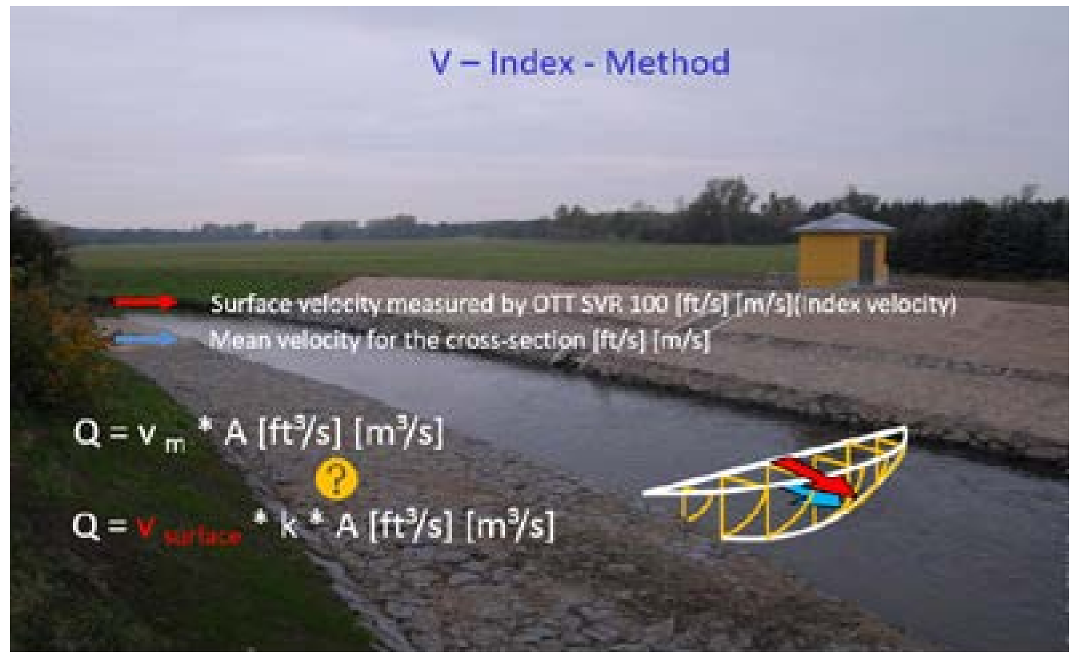
The vibration index informs you about sensor vibrations caused by wind, traffic or other factors. If vibration is reported for a longer period, the measured velocities may be affected by the oscillation factor and a careful plausibility check of the measured values is recommended.

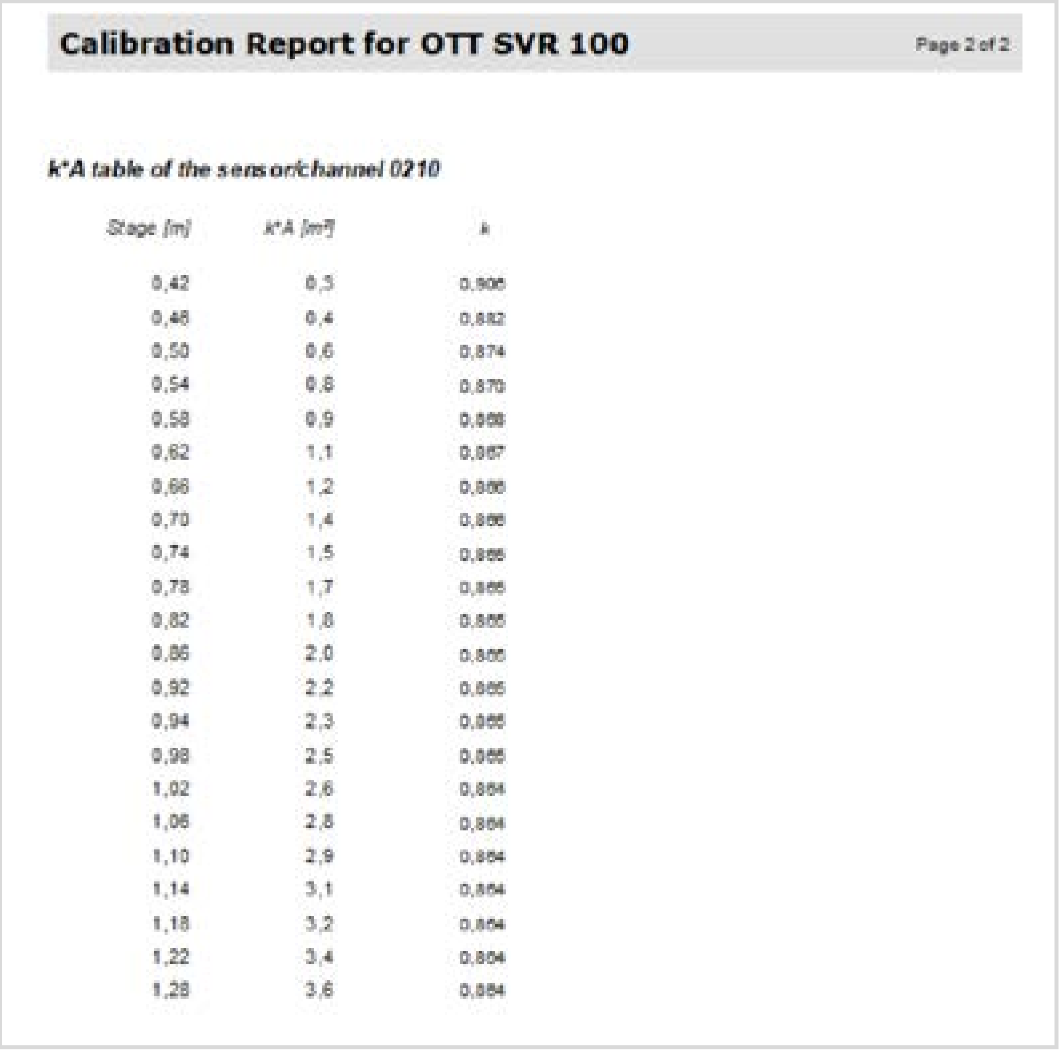
A good signal-to-noise ratio (SNR) is the most important parameter of a radar signal that provides accurate and stable surface velocity measurements. When more radar energy is reflected from the water surface to the radar sensor, the overall signal strength is higher, but SNR will drop if the water surface becomes very smooth or there are no flow conditions. To improve SNR internally, the radar uses low-noise programmable gain amplifier (PGA). If the strength of reflected signal is low, the radar will increase gain level on PGA. If the strength of reflected signal is higher, gain level will be automatically reduced. To learn more about this, please have a look into the OTT SVR 100 White Paper.

Calculating discharge

There are two ways available for translating surface-water velocities into a mean-channel velocity, which are the directly one (Probability Concept) and the indirectly one (Index Velocity Rating). The traditional method is the indirect one. Discharge will be computed based on the velocity – area – method. With this method the discharge can be obtained by the formula $Q = v\ index * k * A\ [m^3/s]\ [ft^3/s]$

where:
Q = discharge $[m^3/s]$ $[ft^3/s]$
A = cross-sectional area $[m^2]$ $[ft^2]$
v index = measured surface velocity [m/s] [ft/s]
k = index – coefficient





Calibration Report for OTT SVR 100 Page 2 of 2

*k*A table of the sensor/channel 0210*

Stage [m]	k*A [m²]	k
0,42	0,3	0,906
0,46	0,4	0,882
0,50	0,6	0,874
0,54	0,8	0,870
0,58	0,9	0,868
0,62	1,1	0,867
0,66	1,2	0,866
0,70	1,4	0,866
0,74	1,5	0,865
0,78	1,7	0,865
0,82	1,8	0,865
0,86	2,0	0,865
0,92	2,2	0,865
0,94	2,3	0,865
0,98	2,5	0,865
1,02	2,6	0,864
1,06	2,8	0,864
1,10	2,9	0,864
1,14	3,1	0,864
1,18	3,2	0,864
1,22	3,4	0,864
1,28	3,6	0,864

The velocity index coefficient is an index to obtain the mean channel velocity from the observed surface velocity. For establishing index – velocity – ratings it is required to conduct discharge measurements on site for a variety of flow conditions. The measured discharge divided by the cross-sectional area will provide the mean-channel velocity which then will be related to the contemporaneous surface velocity readings. There is a software tool Prodis 2 available which can be used to manage site configurations and system calibrations (k –values) and to compute index – velocity – ratings. It outputs a calibration report with stage values and corresponding index – coefficients as both XML – file and PDF.

The values of the table can be imported directly into the OTT netDL data logger family or translated via Python script to SUTRON loggers like the XLINK 500, Xpert, and others.

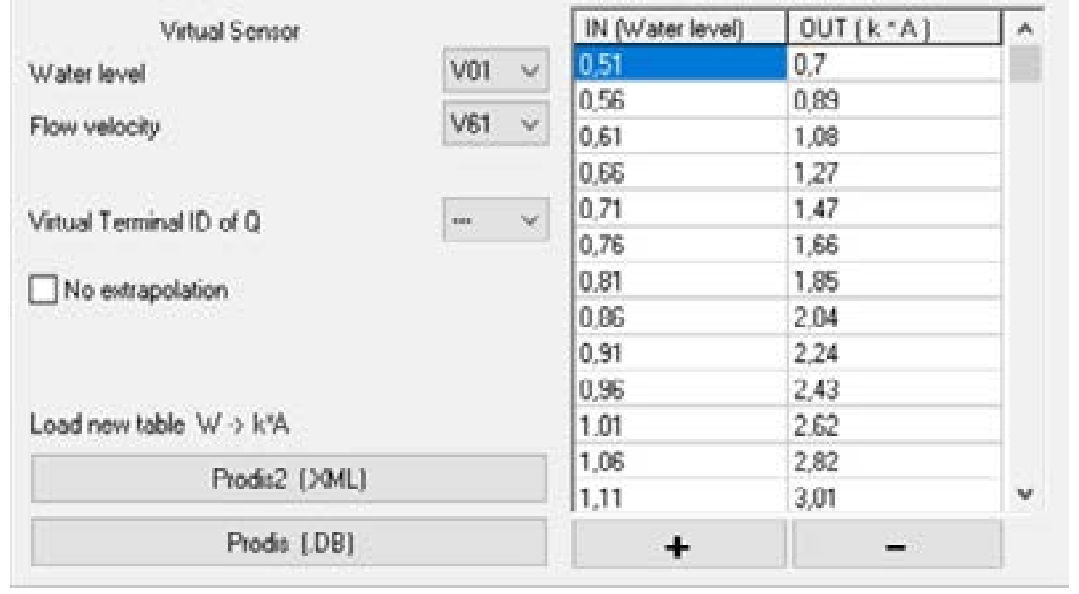
The Probability Concept Method offers an alternative approach for computing the average velocity v_{mean} at a cross-section of interest. It has been pioneered by Chiu (1989). This method requires the identification of the vertical on which the maximum in-stream or maximum surface water velocity is measured. This vertical is termed the ‘y-axis’ and can be determined by conducting measurements using portable flow meters just as ADCP, pygmy meters or others. Depending on the existence of secondary flow components in open channels, the maximum velocity often drops below the water surface (so called dip-in effect). By measuring point velocities as a function of depth from the riverbed up to the water surface, the maximum in-stream-velocity v_{max} can be derived together with the location of v_{max} below the water surface. Field studies have shown that the stationing of the y-axis is stable for a given transect and does not vary with changing hydraulics on site (Chiu et al., 2001; Fulton and Ostrowski, 2008). Therefore, it is possible to compute the mean-channel velocity from the maximum in-stream-velocity and two additional parameters. For more info on this please refer to the ‘how-to-articles’ published on the website of the OSW Surface Velocity Workgroup.

References:

Chiu, C.-L., 1989, Velocity distribution in open channel flow, Journal of Hydraulic Engineering, 115 (5), 576 – 594.

Chiu, C.-L., Tung, N.C., Hsu, S.M., and Fulton, J.W., 2001, Comparison and assessment of methods of measuring discharge in rivers and streams, Research Report No. CEEWR-4, Dept. of Civil and Environmental Engineering, University of Pittsburgh, Pittsburgh, PA.

Fulton, J.W. and Ostrowski, J., 2008, Measuring real-time streamflow using emerging technologies: Radar, hydroacoustics, and the probability concept, Journal of Hydrology 357, 1-10



IN (Water level)	OUT (k * A)
0,51	0,7
0,56	0,89
0,61	1,08
0,66	1,27
0,71	1,47
0,76	1,66
0,81	1,85
0,86	2,04
0,91	2,24
0,96	2,43
1,01	2,62
1,06	2,82
1,11	3,01

```
# retrieve water velocity from meas labeled Av_Veloc
Av_Veloc = measure ("Av_Veloc").value
print("Level= ", Level, " Av_Veloc= ", Av_Veloc)

# Level, k_a pairs (Level needs to be > first Level pair)
     # up to 20 k_pairs possible
CORRTABL = ((0.42,0.23),
            (0.47,0.38),
            (0.52,0.53),
            (0.57,0.68),
            (0.62,0.84),
            (0.67,0.99),
            (0.72,1.15),
            (0.77,1.30),
            (0.82,1.46),
            (0.87,1.61),
            (0.92,1.76),
            (0.97,1.91),
            (1.02,2.07),
            (1.07,2.22),
            (1.12,2.38),
            (1.17,2.53),
            (1.22,2.69),
            (1.28,2.87))
```

“It is possible to compute the mean-channel velocity from the maximum in-stream-velocity and two additional parameters.”

Insights for Experts

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