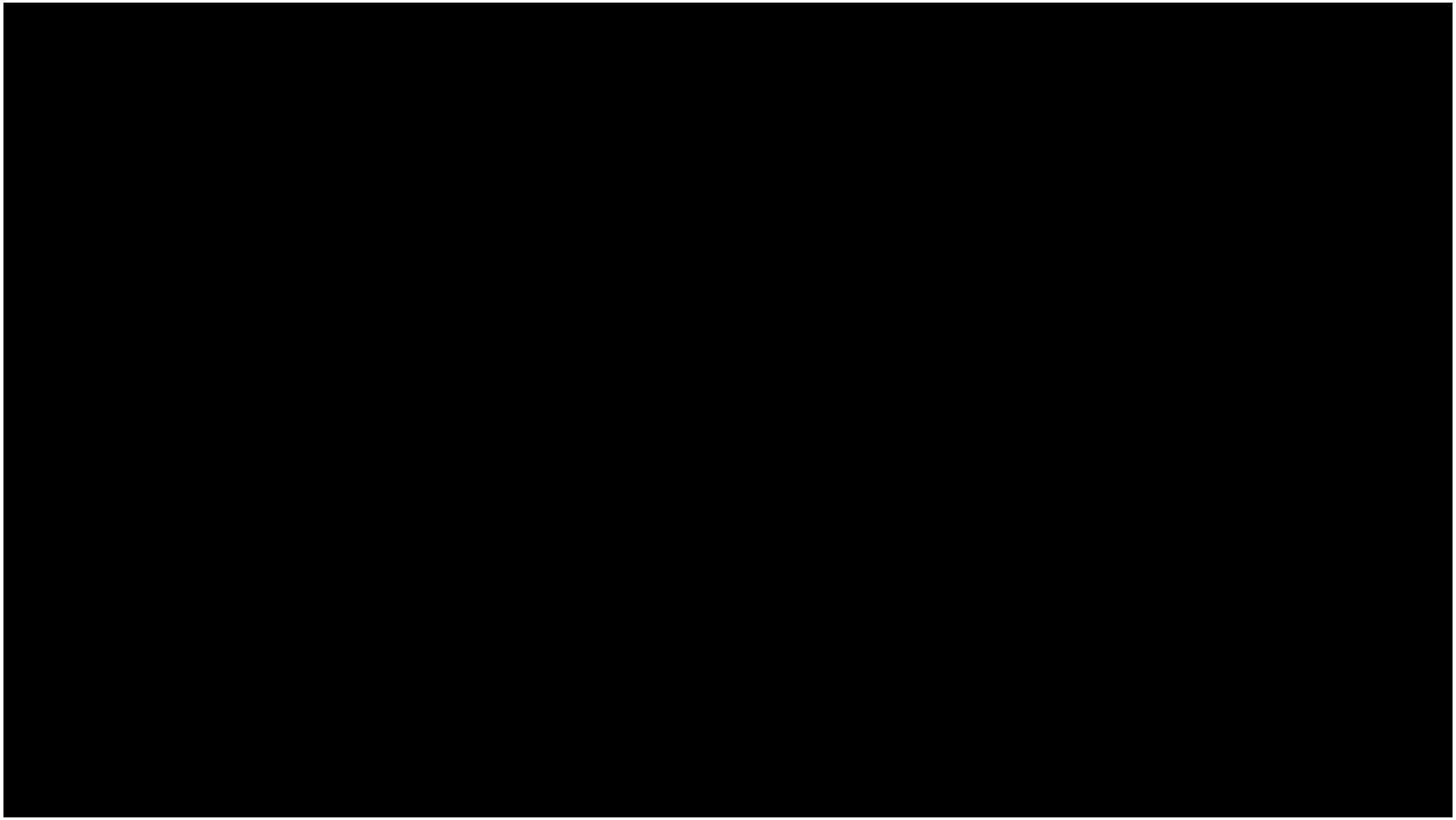
Radar hydrological measurements

Best practice

Tomislav Grubeša

Hydrology Instruments – Zagreb pilot project



RSS-2-300W
Radar surface velocity meter

- mounted above water with no contact with water
- robust IP68 design, and low power consumption
- advanced digital signal processing for accurate and robust measurements in all conditions
- wide measurement range from 0,02m/s to 15m/s
- high sensitivity enable mounting on distance up to 50m effective distance from radar to water surface

Hydrology Instruments

LX80
Radar level meter

- mounted above water with no contact with water
- robust IP68 design, and low power consumption
- advanced digital signal processing for accurate and robust measurements in all conditions
- level measurement up to 35m with ±3mm accuracy
- maximal distance to water surface up to 35m

Hydrology Instruments

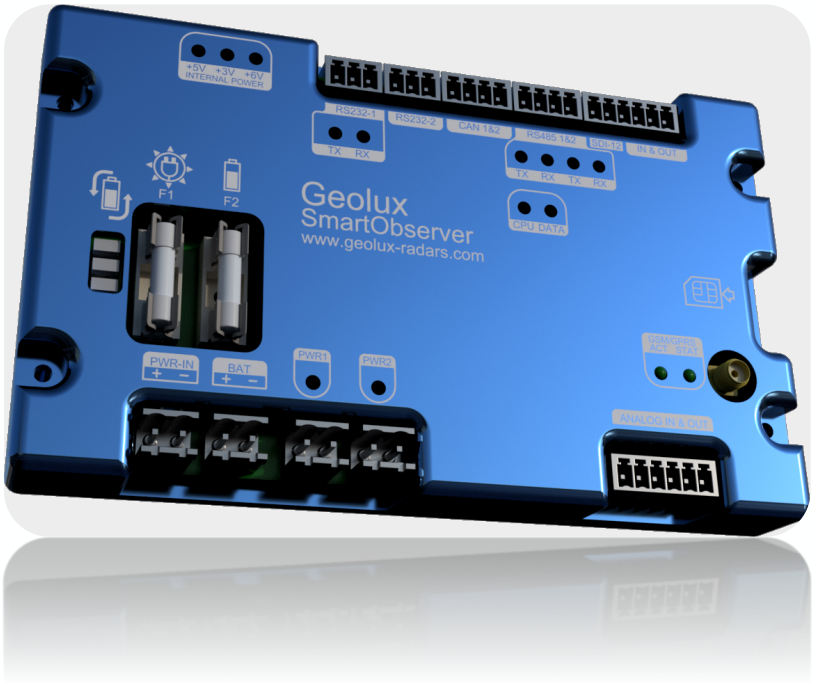
RSS-2-300WL

Radar surface velocity and level meter

- mounted above water with no contact with water
- robust IP68 design, and low power consumption
- advanced digital signal processing for accurate and robust measurements in all conditions
- wide surface velocity measurement range from 0,02m/s to 15m/s
- level measurement up to 35m with ±3mm accuracy
- maximal distance to water surface up to 35m

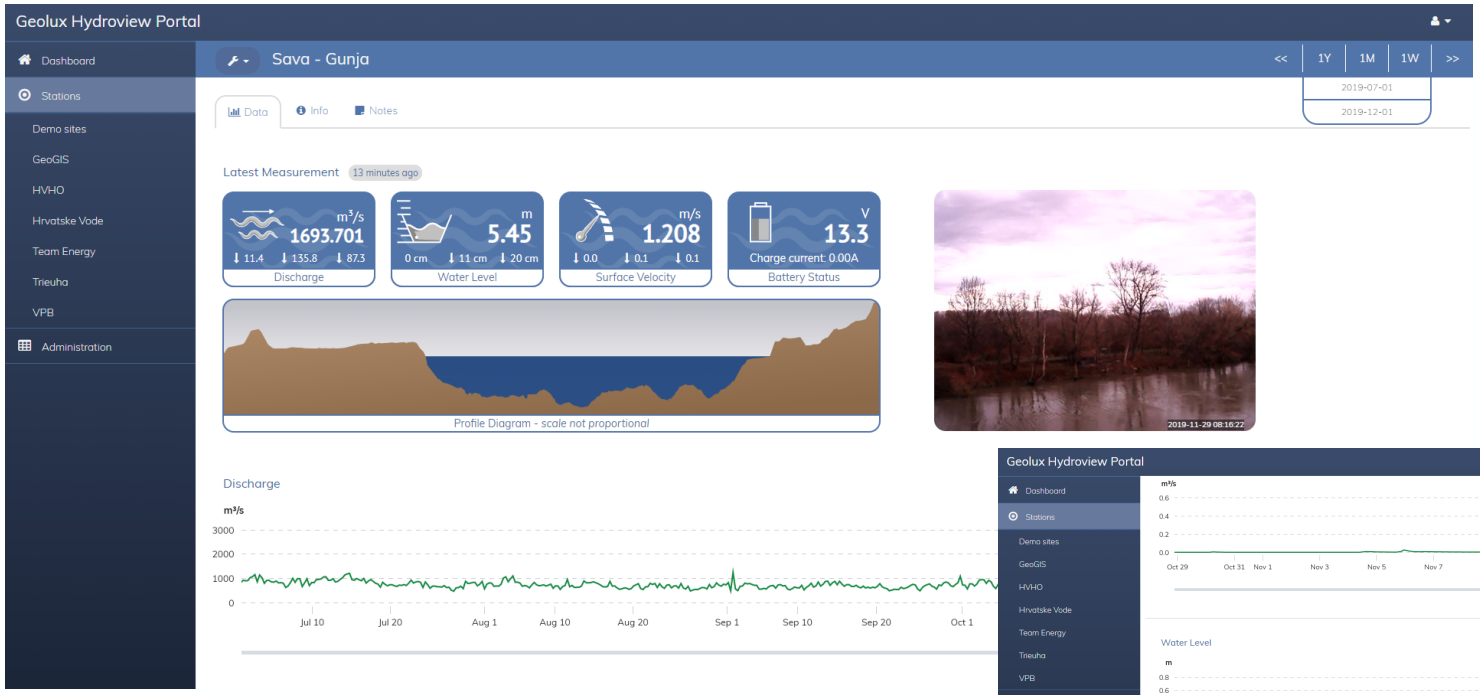
Hydrology Instruments

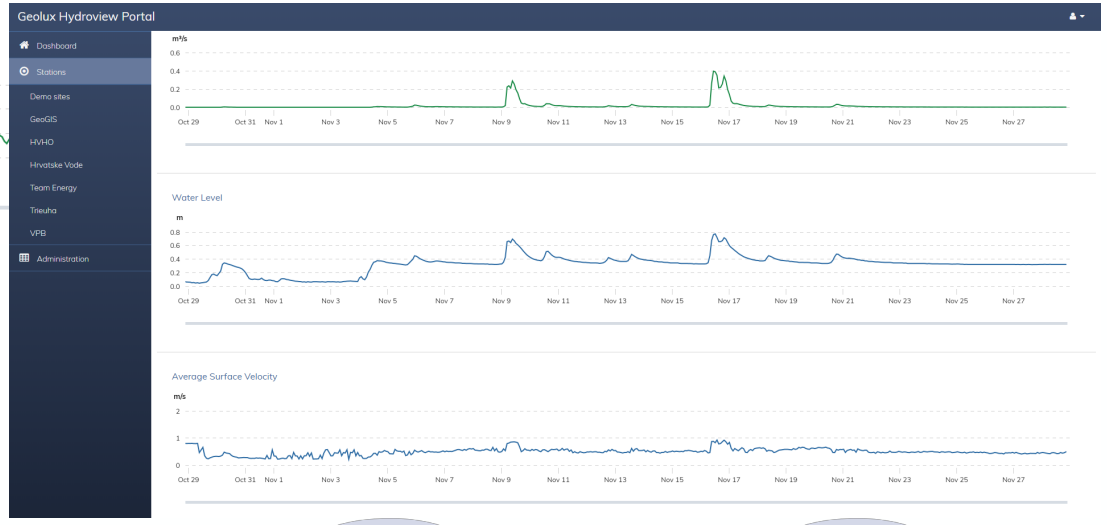
SmartObserver Data Logger



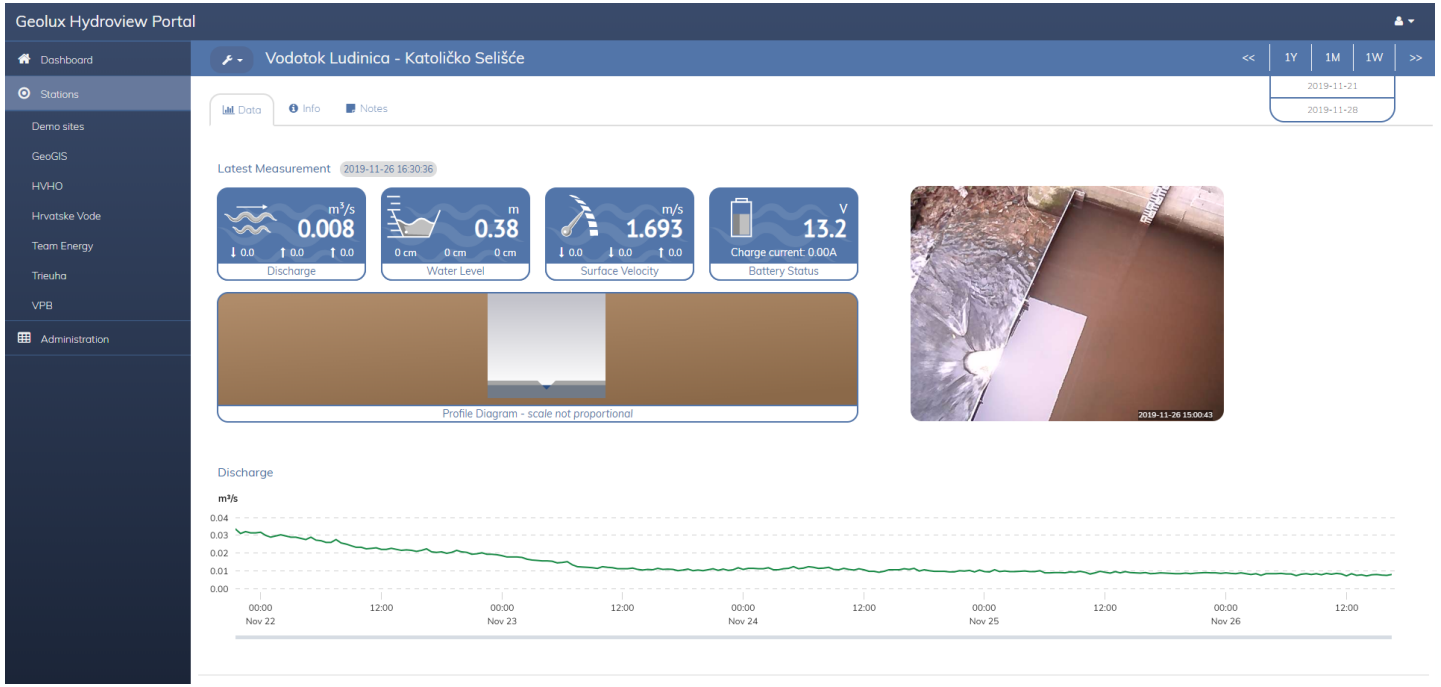
- Integrated battery charger with MPPT supports different battery types
- Digitally controlled power management system
- Versatile communication interfaces support various sensors
- Multiple optional communication modules: GPRS, LoRaWAN, WIFI, RF modem, Ethernet, optical...
- Compact, robust, low-power design for field operation
- Pluggable terminal block connectors for easy installation

HydroView Cloud Software





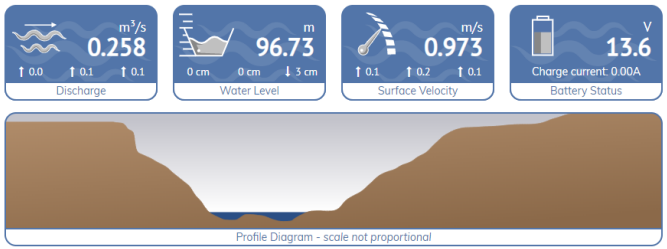
HydroView Cloud Software



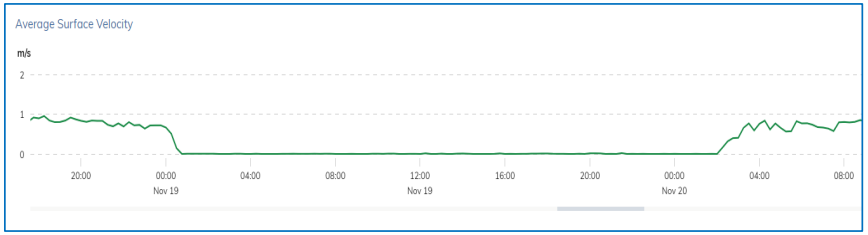
- Continuous real time measurements with intervals between readings 30s to 1h
- Data storage on data logger or sending over communication interface to data centre, or combination
- Multiple communication interfaces available for connection to data centre (cloud)

Level and Surface velocity - WHY?

- Locations with possible downstream accumulation of water
- Q-H method based only on level measurement has extreme errors for the case



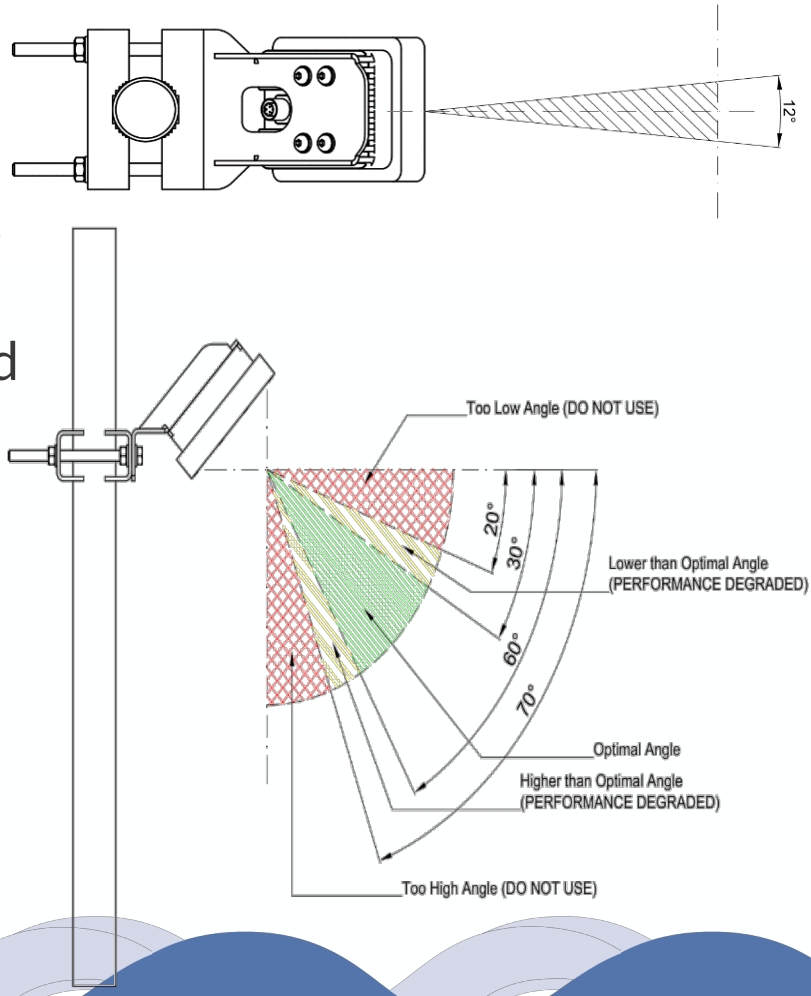
Zoom



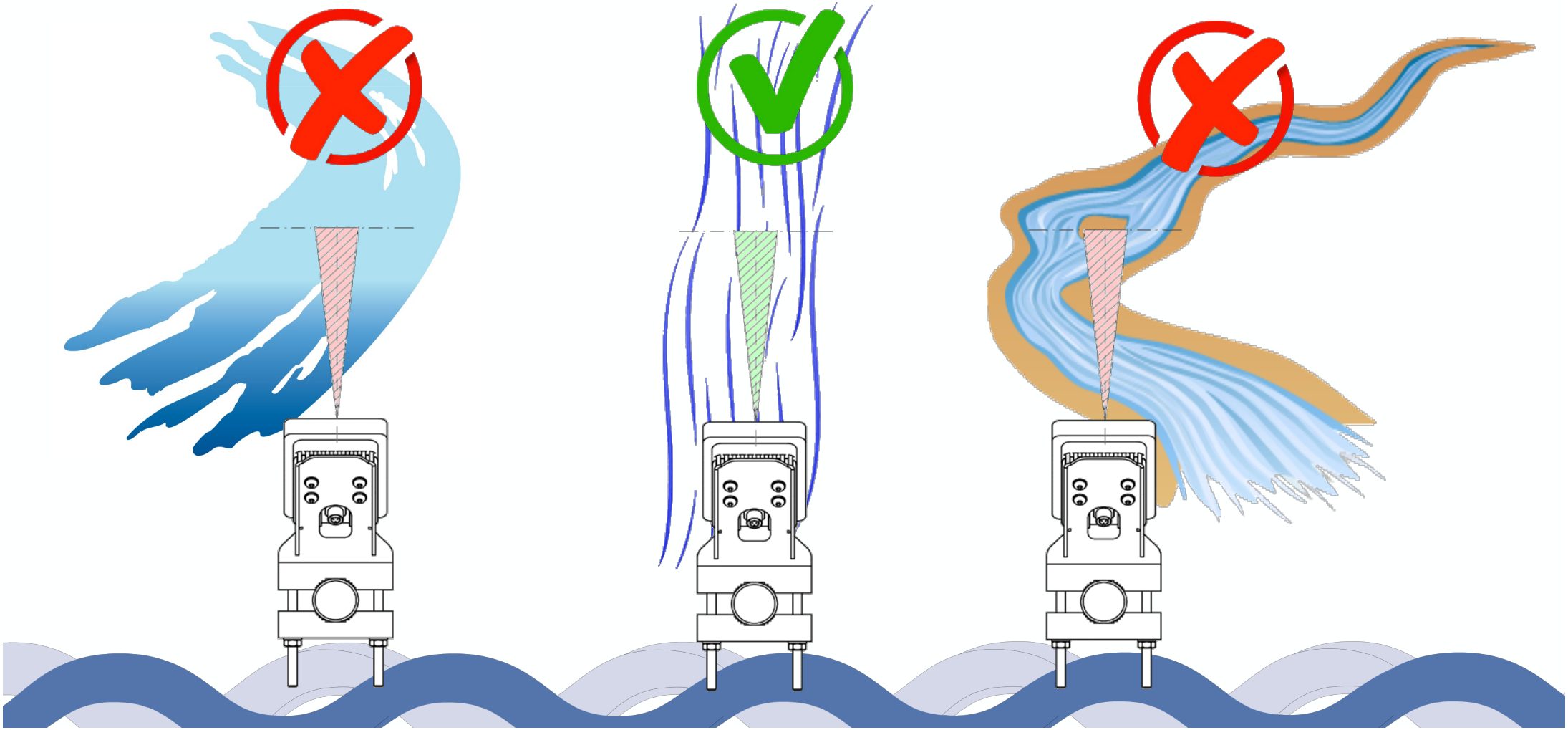
Surface velocity – best practice

INSTALLATION & MAINTENANCE

- Mounting angle - 30° to 60°
- Flow direction – incoming preferred
- Power supply – 12V DC / 24V DC for longer cable operation
- Measurement duration & frequency – 20s standard time, 30s for slower and flat waters
- Low power operation – low power mode and possible fast measurement in only 10s
- **Location selection**
  - infrastructure
  - avoid curved water flow
  - select location with “rough” water surface
  - avoid vibrations on mounting fixture

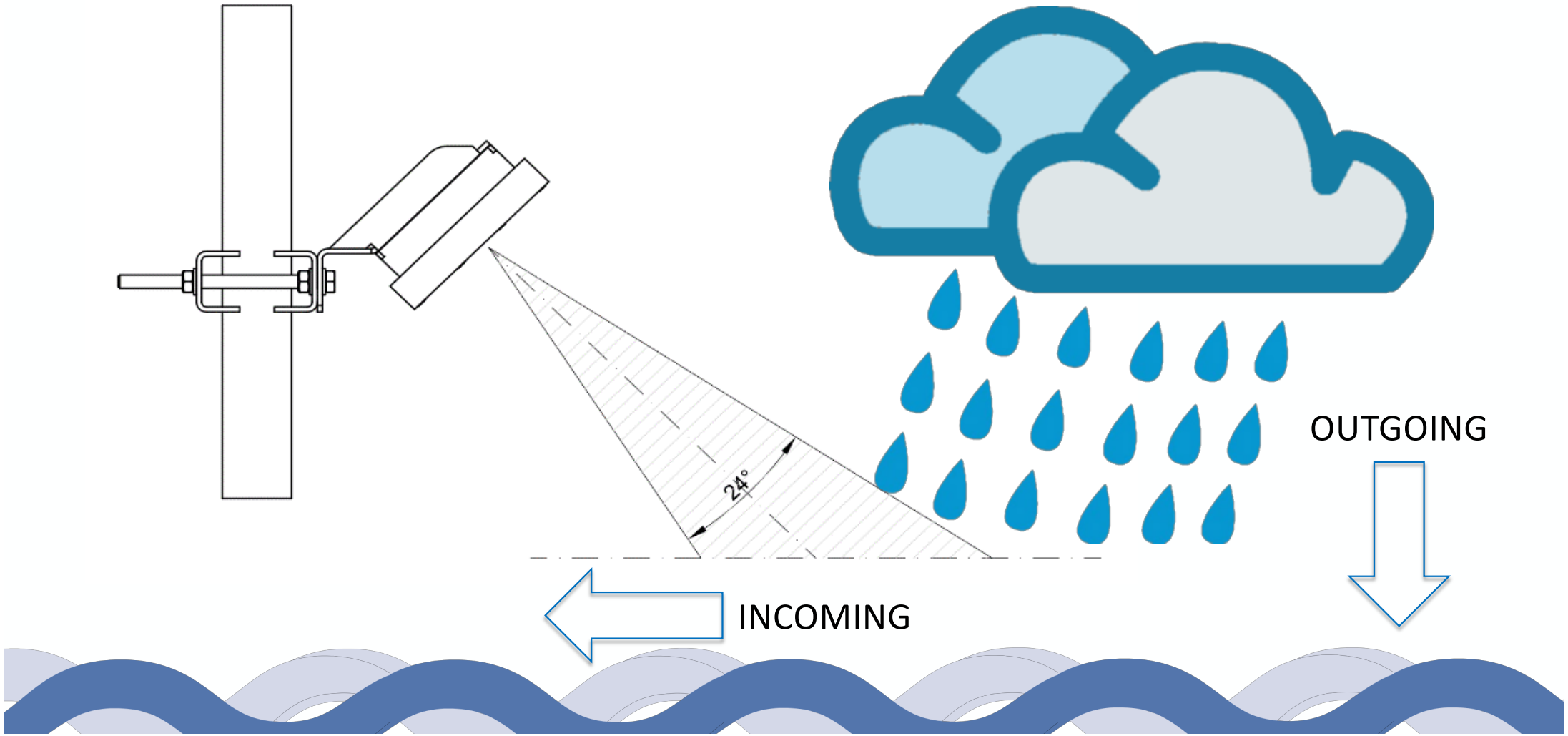


Surface velocity – best practice



Surface velocity – best practice

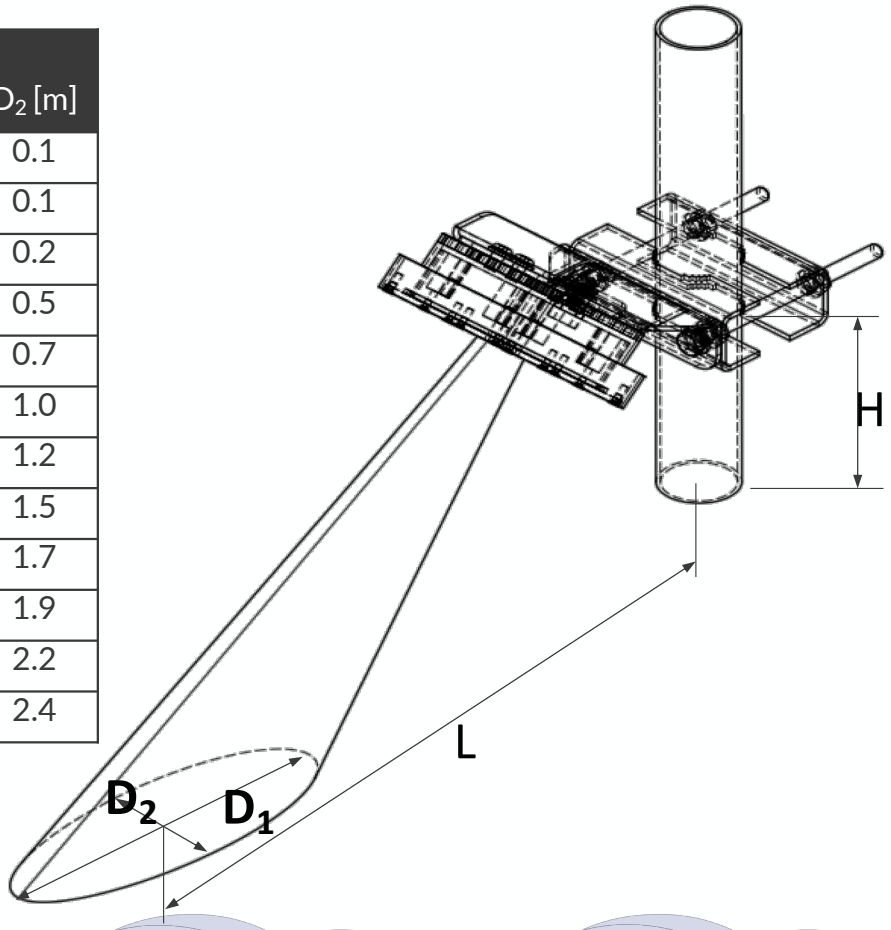
RAIN & WIND



Surface velocity – best practice

ANGLE & FLOW DIRECTION

Angle →	30°			45°			60°		
Height [H]	L [m]	D_1 [m]	D_2 [m]	L [m]	D_1 [m]	D_2 [m]	L [m]	D_1 [m]	D_2 [m]
0.3m	0.5	0.6	0.2	0.3	0.3	0.2	0.2	0.2	0.1
0.5m	0.9	1.0	0.3	0.5	0.5	0.3	0.3	0.3	0.1
1m	1.7	2.0	0.4	1.0	0.9	0.3	0.6	0.6	0.2
2m	3.5	3.9	0.8	2.0	1.8	0.6	1.2	1.2	0.5
3m	5.2	5.9	1.3	3.0	2.7	0.9	1.7	1.7	0.7
4m	6.9	7.9	17	4.0	3.6	1.2	2.3	2.3	1.0
5m	8.7	9.8	2.1	5.0	4.5	1.5	2.9	2.9	1.2
6m	10.4	11.8	2.5	6.0	5.3	1.8	3.5	3.5	1.5
7m	12.1	13.8	2.9	7.0	6.2	2.1	4.0	4.0	1.7
8m	13.9	15.7	3.4	8.0	7.1	2.4	4.6	4.6	1.9
9m	15.6	17.7	3.8	9.0	8.0	2.7	5.2	5.2	2.2
10m	17.3	19.7	4.2	10.0	8.9	3.0	5.8	5.8	2.4



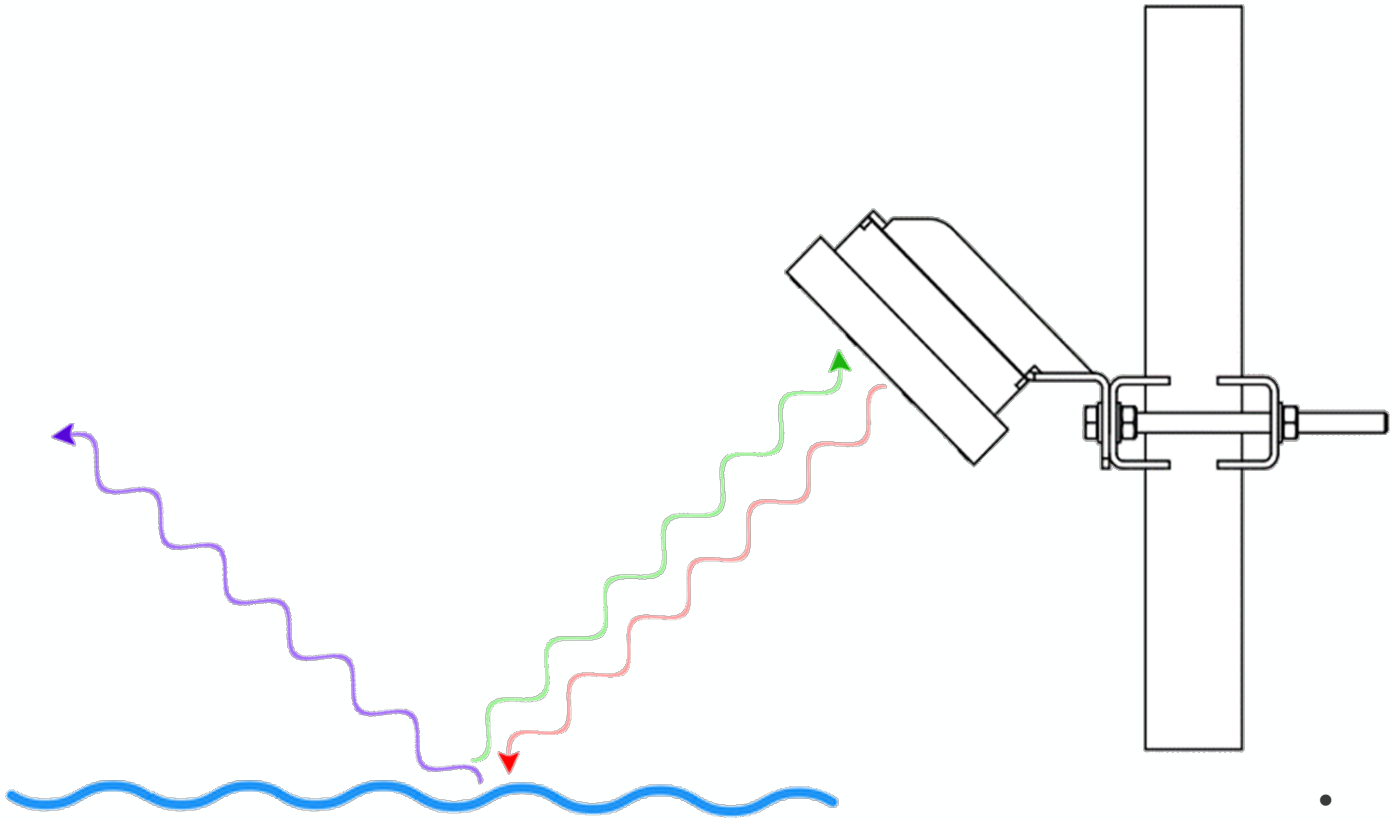
Surface velocity – best practice

F_c = 24.125 GHz
v = 15 m/s → ≈4 kHz

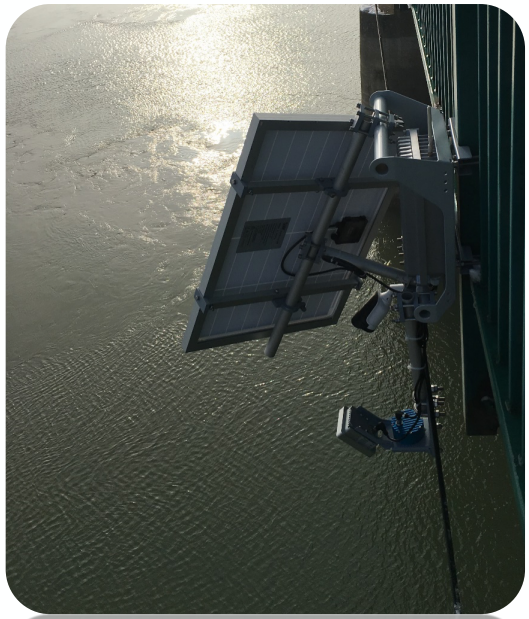
Tolerance ≈ 0,00005%

Surface velocity – best practice

SIGNAL STRENGTH



→ Radar TX signal
→ Inbound reflection
→ Outbound reflection



- Internal AGC
- 20x oversampling for better SNR
- I/Q 16bit ADC + SDR

Radar Level Meter – best practice

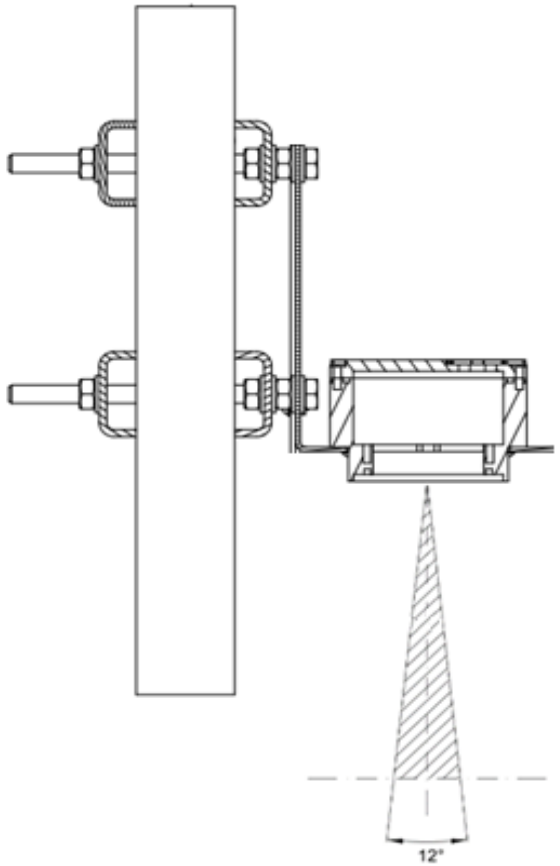
ADVANTAGES & MEASURING PRINCIPLE

- FMCW – 77 GHz to 81 GHz
- SDR design – flexibility, adaptability
- High precision – up to ±1mm on 35m range
- Low power consumption
- **Low maintenance**
  - measurements are not affected by sediments, mud or driftwood
  - ideal for hydrological, industrial and wastewater applications
  - possible measurement through non-conductive materials (plastic)
  - robust sensors in IP68-rated enclosure

Radar Level Meter – best practice

INSTALLATION & MAINTENANCE

- Mounting above water surface
- Minimal distance – 0,1 m (10 cm)
- Maximal distance – up to 35m
- Measurement frequency – 1 Hz (10 Hz opt.)
- Measurement duration – < 5s from power up
- **Location selection**
  - infrastructure
  - water level fluctuation
  - vegetation
  - vibrations



Radar Level Meter – best practice

RAIN & WIND

- FMCW operation – low sensitivity to rain
- Minimal wind sensitivity – almost no wind impact

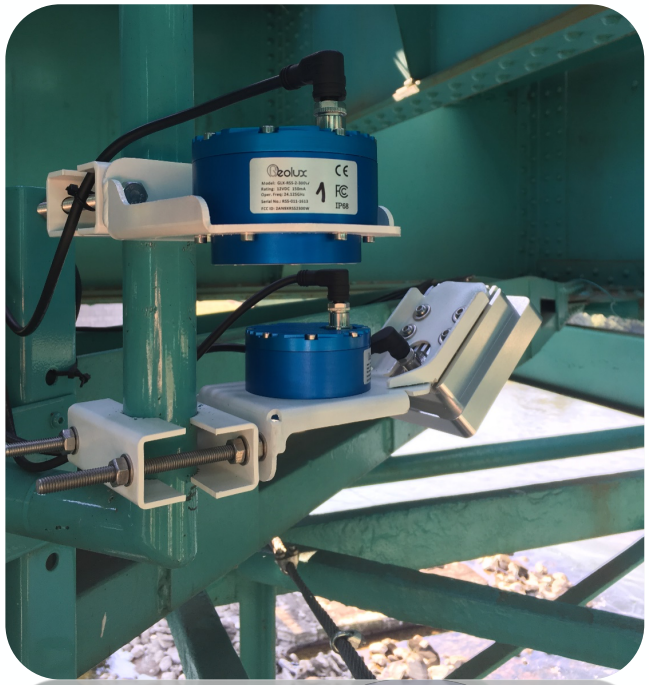
MEASUREMENT THROUGH MATERIALS

- Microwave signal – passing through dielectric (non-conductive) materials
- Materials used in industry and buildings:
  - ABS, PVC, Nylon
  - Teflon, Polycarbonate, Plexiglas
  - Polyamide, Polypropylene

Radar Level Meter – best practice

FOGGING & EVAPORTAION

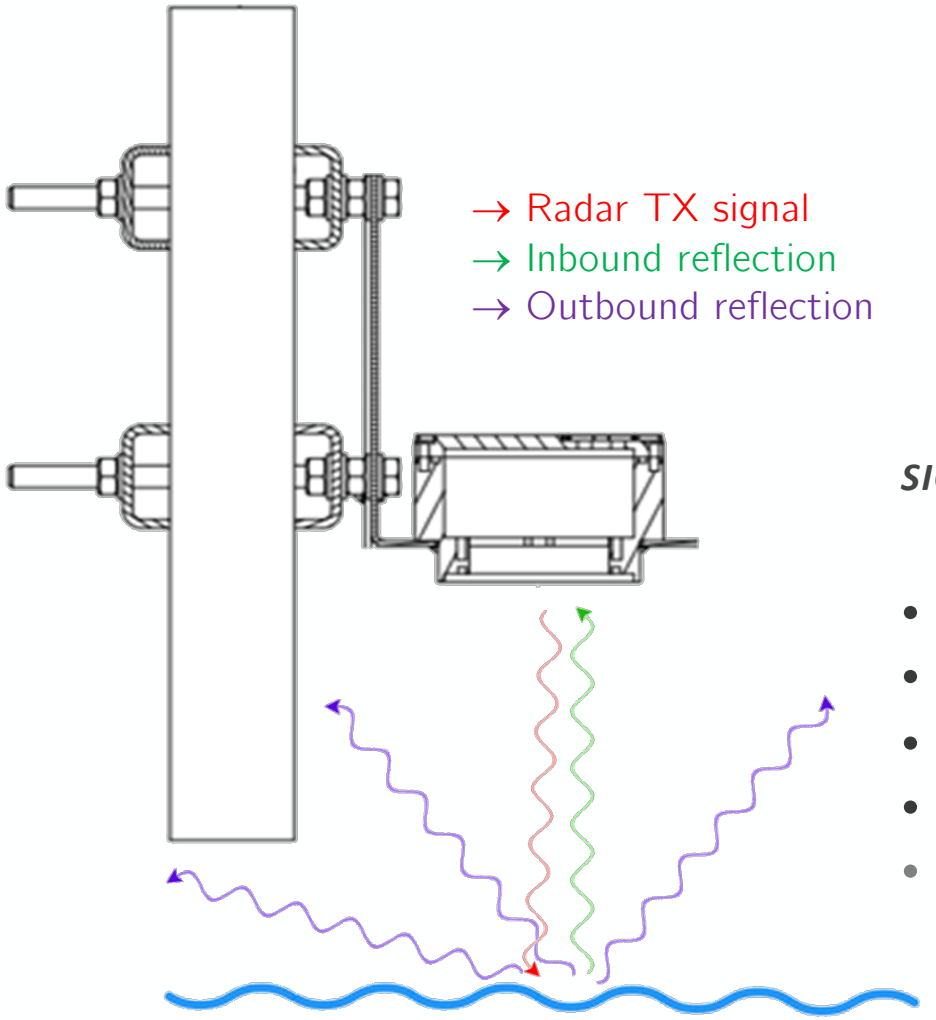
- Fog & evaporation density – much lower than water
- Lower signal reflection – increased averaging solves problem



INTERFERENCE & MULTIPLE RADARS

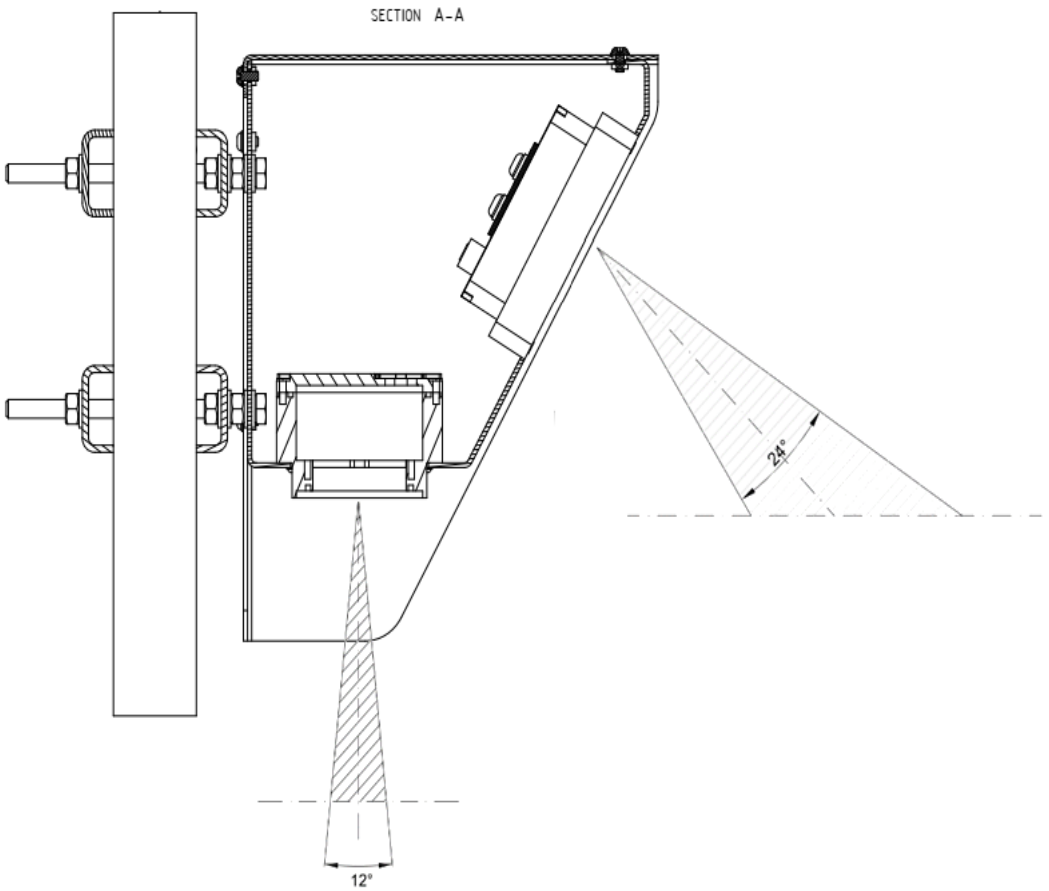
- FMCW linear modulation – 77 GHz to 81 GHz
- Baseband filter – up to 500 kHz
- Required synchronization – better than 25 ns
- Very low interference probability

Radar Level Meter – best practice



SIGNAL STRENGTH

- Internal AGC
- Narrow beam angle
- Advanced SDR signal processing
- Basic classification of materials
- Ice & snow depth measurement (coming soon)



Radar Flow Meter – best practice

COMBINED RSS-2-300W & LX-80

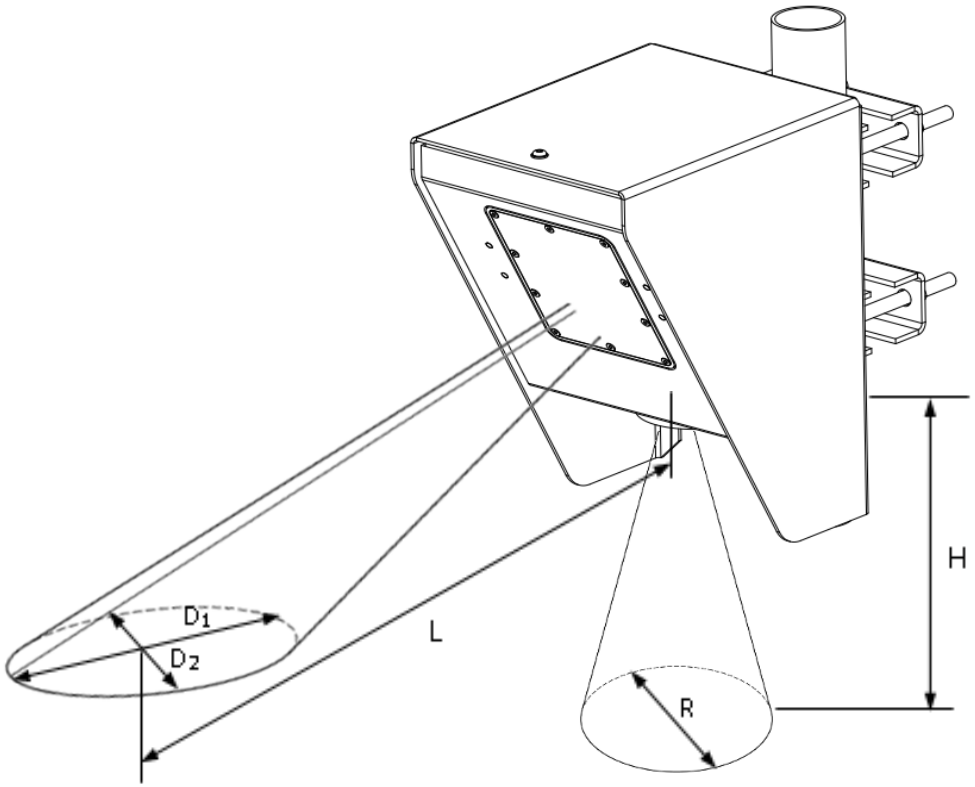
- Mounting above water surface
- Level & Surface Velocity sensor
- Flow calculation – internally
- River profile – defined with setup application, internal flow calculation
- Measurements: level, velocity & flow

- **Location selection**
  - infrastructure
  - all recommendations for each instrument apply

Radar Flow Meter – best practice

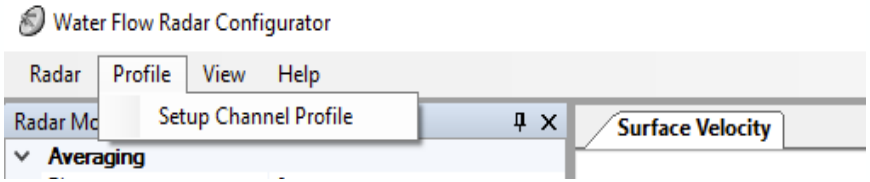
COMBINED RSS-2-300W & LX-80

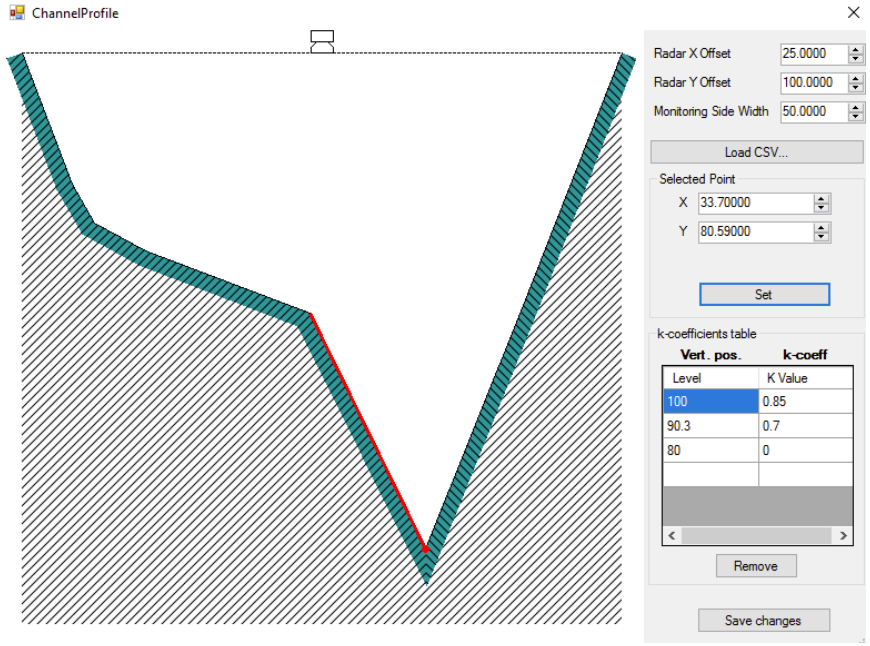
Height [H]	L [m]	D_1 [m]	D_2 [m]	R [m]
0.3 m	0.3	0.3	0.2	0.06
0.5 m	0.5	0.5	0.3	0.11
1 m	1.0	0.9	0.3	0.21
2 m	2.0	1.8	0.6	0.42
3 m	3.0	2.7	0.9	0.63
4 m	4.0	3.6	1.2	0.84
5 m	5.0	4.5	1.5	1.05
6 m	6.0	5.3	1.8	1.26
7 m	7.0	6.2	2.1	1.47
8 m	8.0	7.1	2.4	1.68
9 m	9.0	8.0	2.7	1.89
10 m	10.0	8.9	3.0	2.10
11 m	11.0	9.8	3.3	2.31
12 m	12.0	10.7	3.6	2.52
13 m	13.0	11.6	3.9	2.73
14 m	14.0	12.5	4.2	2.94
15 m	15.0	13.4	4.5	3.15

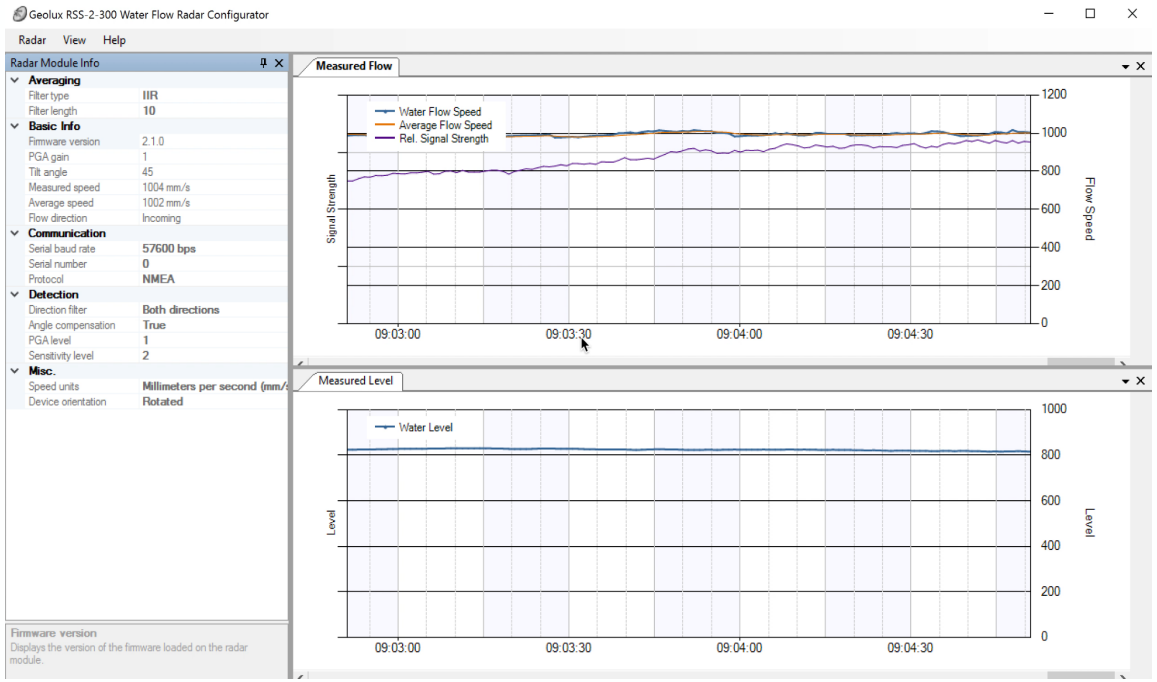


FLOW MEASUREMENT

Radar Flow Meter – best practice







- Profile geometry definition
- K coefficient definition
- Calibration points for K coefficient

Examples

Tributary flow could affect velocity measurement

Pipe in front of radar, vibrating in the wind ;)

Examples

Curved water flow, lower accuracy and vegetation in front of sensors

Specific case:

- surface flat as mirror for level < 0,6m
- surface velocity not measured below 0,6m
- flow calculation from V notch equation and level
- above level 0,6m velocity measurement is correct
- above level 0,6m flow is calculated from level and velocity

Examples

Straight flow after bridge
Surface waviness for smaller flow

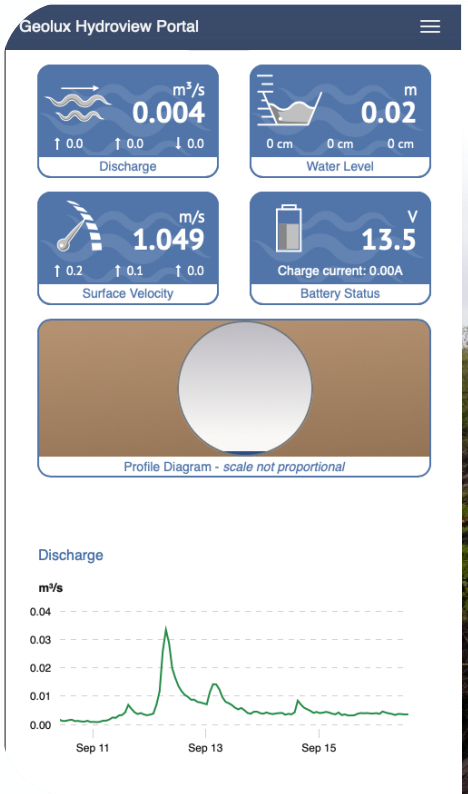
Good location, enough water waviness, no vegetation in from of sensors

Examples

Good location, enough water waviness, no vegetation, proper installation

High distance to water – would prefer smaller distance
Surface very flat, but still correct measurements

Examples



Drainage pipe discharge measurement
Close distances for sensors
Fast flow changes

Shallow water, enough surface roughness, installed on the middle of the river

Thank You!

Geolux success story @ Altium booth on EmbeddedWorld 2017

Geolux success story presented by European Commission in 2018

Geolux selected among most innovative companies in Croatia by Croatian SME agency HAMAG-BICRO