RQ–30 non-contact discharge system

Technical Information

Abstract

- Conventional discharge measurement
- Features RQ-30
- Measurement principle RQ-30
- Calibration RQ Commander
- Advantages RQ-30
- Range of application
- Set-up of measurement site
- Compare RQ-30 to other systems

Conventional discharge measurement

Conventional discharge measurement

Limits of conventional discharge measurement

Floodwater

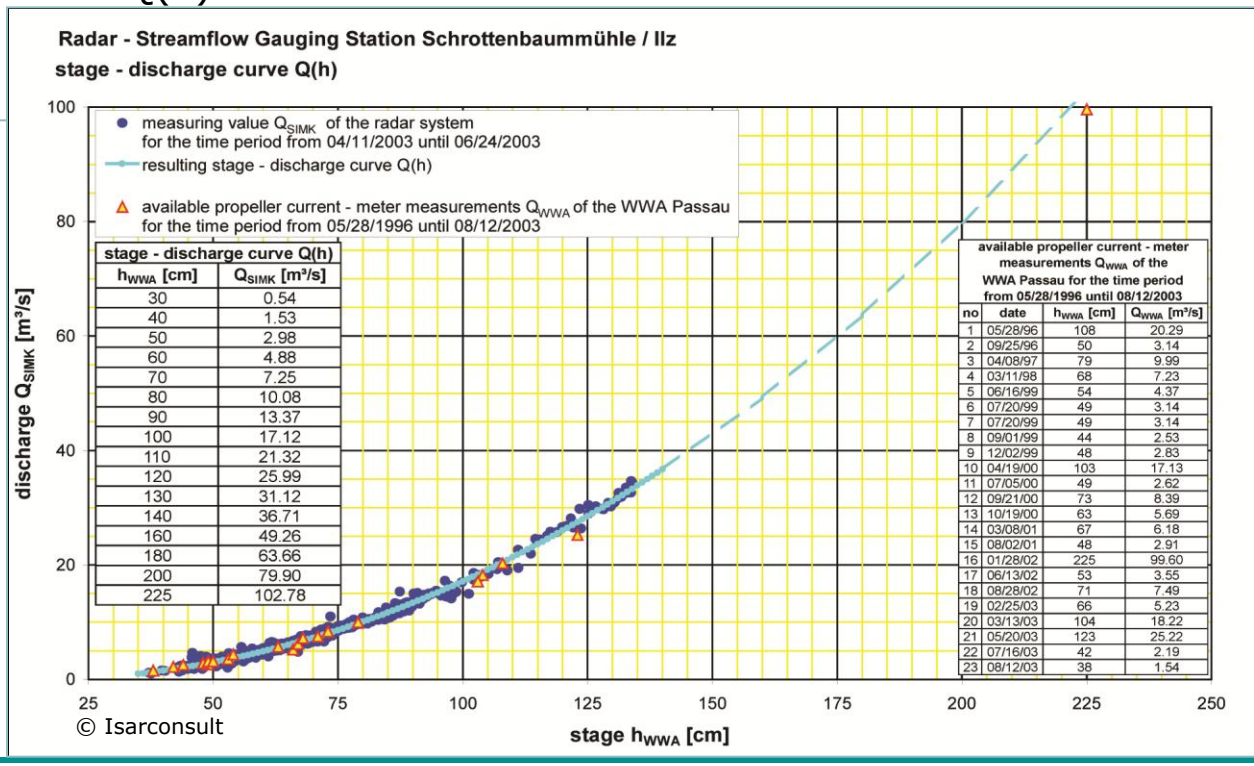
- Manual measurement (current meter, ADCP boat, …) not possible
- Damage of instrumentation by bed load, trees,…
- Danger for employees during manual measurement
- Availability of employees during the flood for measurement jobs
- Low data base for accurate determination of discharge – extrapolation of stage-discharge curve Q(h)

How is conventional discharge measurement done?

- Manual measurement of flow velocity by e.g. current meter or ADCP boat over a long time period
  - Chart: ▲ (yellow triangle)
  - Time period: 7 years
  - Only a few measurement points to create discharge curve
- Generate discharge correlation-curve Q(h)

Method RQ-30

- Continuous measurement of flow velocity
  - Chart: ● (blue circle)
  - Time period: 2 month
  - Many measurement points also at high discharge (floodwater)
- Determination of discharge without discharge curve Q(h)
- Better Quantifying of discharge
  - Relation „discharge / level"
  - Relation „flow velocity / level"
- Discharge curve quicker available



stage - discharge curve Q(h)

h_{WWA} [cm]	Q_{SIMK} [m³/s]
30	0.54
40	1.53
50	2.98
60	4.88
70	7.25
80	10.08
90	13.37
100	17.12
110	21.32
120	25.99
130	31.12
140	36.71
160	49.26
180	63.66
200	79.90
225	102.78

available propeller current - meter measurements Q_{WWA} of the WWA Passau for the time period from 05/28/1996 until 08/12/2003

no	date	h_{WWA} [cm]	Q_{WWA} [m³/s]
1	05/28/96	108	20.29
2	09/25/96	50	3.14
3	04/08/97	79	9.99
4	03/11/98	68	7.23
5	06/16/99	54	4.37
6	07/20/99	49	3.14
7	07/20/99	49	3.14
8	09/01/99	44	2.53
9	12/02/99	48	2.83
10	04/19/00	103	17.13
11	07/05/00	49	2.62
12	09/21/00	73	8.39
13	10/19/00	63	5.69
14	03/08/01	67	6.18
15	08/02/01	48	2.91
16	01/28/02	225	99.60
17	06/13/02	53	3.55
18	08/28/02	71	7.49
19	02/25/03	66	5.23
20	03/13/03	104	18.22
21	05/20/03	123	25.22
22	07/16/03	42	2.19
23	08/12/03	38	1.54

Features RQ-30

Functions

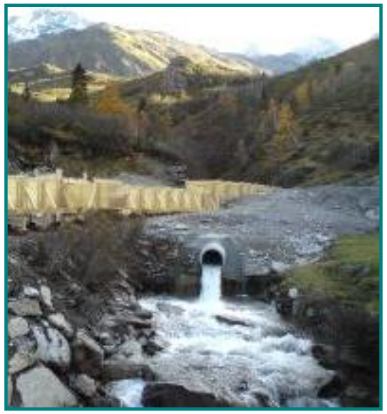
- **Calculation of discharge**
  - Continuous measurement of flow velocity and level
- **Discharge value immediately available after installation**
  - Stage-discharge curve (Q/h) not required
- **Non-contact measurement**
  - Failsafe and reliable
  - Maintenance-free
  - Safe from flood damaging
  - Easy assembling outside/above the river at bridge or arm
- **Easy integration into existing systems**

Features based on the measuring data

- **Recognize dynamic processes such as riverbed changing, backwater, vegetal invasion and hysteresis**
  - Online stage-discharge curve Q(h) to evaluate discharge
  - Correlation „level /flow velocity“ to evaluate discharge

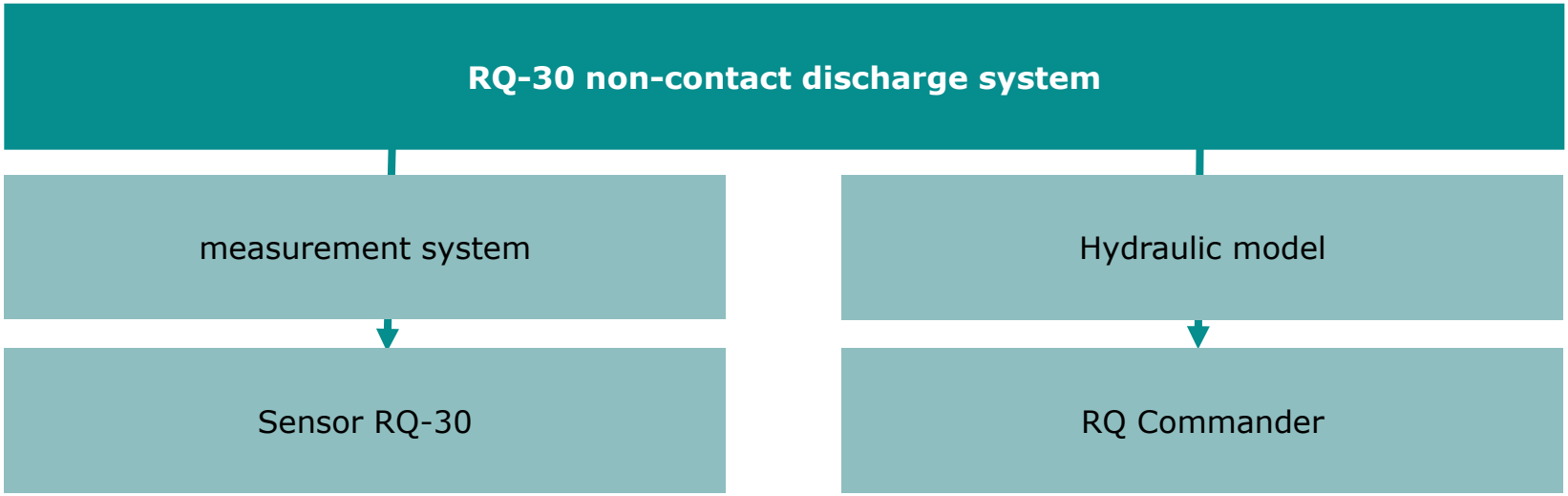
Range of applications

- Rivers, mountain, torrents
  - Hydrographic services
  - Civil service
  - Hydro power plants
- Open channels, canal, drains
  - Hydro power plants
  - Waste water
  - Industry
  - Irrigation
  - Water management

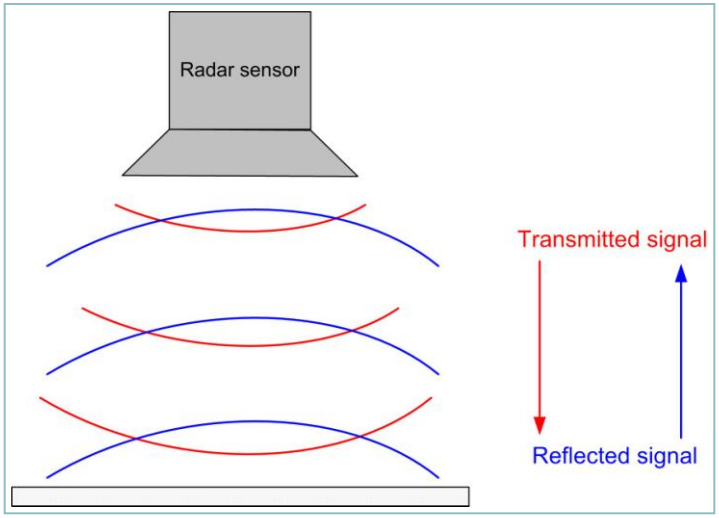


Measurement principle RQ-30

Measurement principle RQ-30

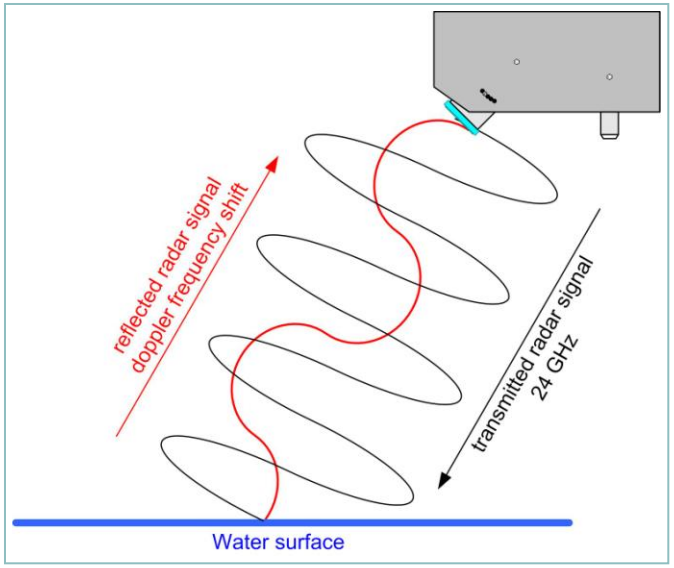


Measurement principle RQ-30



Water level (stage)

- Non-contact
- duration measurement of radar signal
- High accuracy
- Measurement independent from air temperature and medium



Flow velocity

- Non-contact
- Measurement of doppler frequency shift
- 24 GHz – min. detection of 3mm waves
- High accuracy: velocity > 30cm/s
- Measurement independent from air temperature and medium

Measurement principle RQ-30

- Continuous measurement
- Determined once at measuring site
- Calculated by RQ-30

Water level h

Local velocity v_i

Profile

Cross section A(h)

Mean velocity v_m

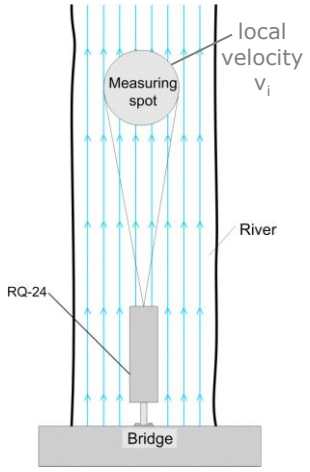
Calibration: factor $k = v_m/v_i$

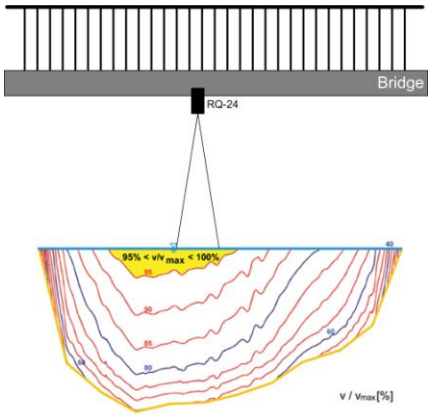
Discharge Q

1. Measure flow velocity at spot and level

2. Calibration (e.g. Hydraulic model RQ Commander) and discharge calculation in RQ-30

3. Output Discharge Q





5.2 m³/s

Continuity equation

$$Q = v_m \cdot A(h)$$

$$V_m = v_i \cdot k$$

$$Q = A(h) \cdot v_i \cdot k$$

RQ Commander

Spectrum | Profile | Time Series

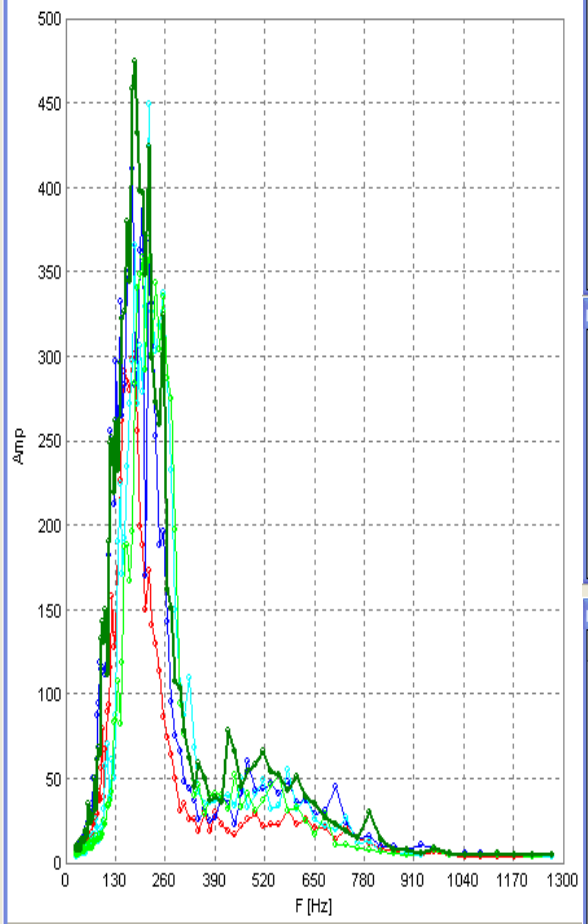
File Information

File Name	Rhein.xml
File Size	21,8 KB
File Date	09.10.08 11:14
Count	6
Description	Bad Tölz Testspektrum

Spectrum Information

Index	3
Color	
Vel	1873
EmV	70
Add	1
MCo	0
Amp	1
Tbl	4
SNR	197
SCR	
NAv	
Min	4476
Max	0
Dur	153
Lev	

Spectrum Graph



1-5 | 1 Spectrum

Spectrum | Profile | Time Series

Profile Informationen

File Name	Branzoll.xml
Title	
Unit	m
Distortion	☑
Height Corr. [m	0
Width Corr. [m	0
Distance to Wa	☐
Roughness ks [	50
Slope [%]	0,017
Radar Position	30
Max. Vel. [m/s]	3,35

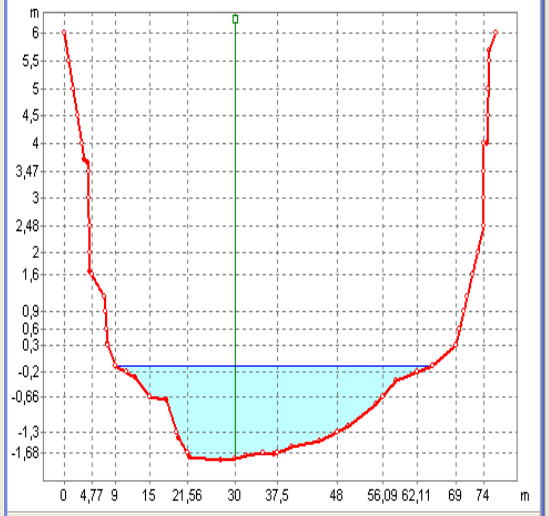
Profile Item

Type	Point
Number	30
Height [m]	6
Width [m]	76

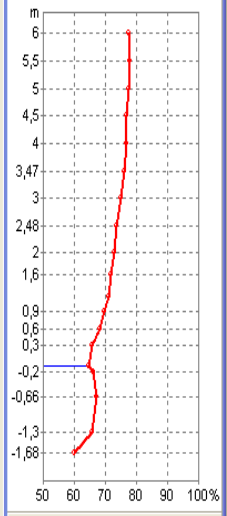
Profile List

No	Type	Height	Width [m]
1	Point	6	0
2	Point	3,7	3,5
3	Point	3,65	4,1
4	Point	1,65	4,5
5	Point	1,19	7
6	Point	0,32	7,5
7	Point	-0,08	9
8	Point	-0,3	12,5
9	Point	-0,66	15
10	Point	-0,7	18
11	Point	-1,4	20
12	Point	-1,76	22

Profile Graph



k-Factor Graph

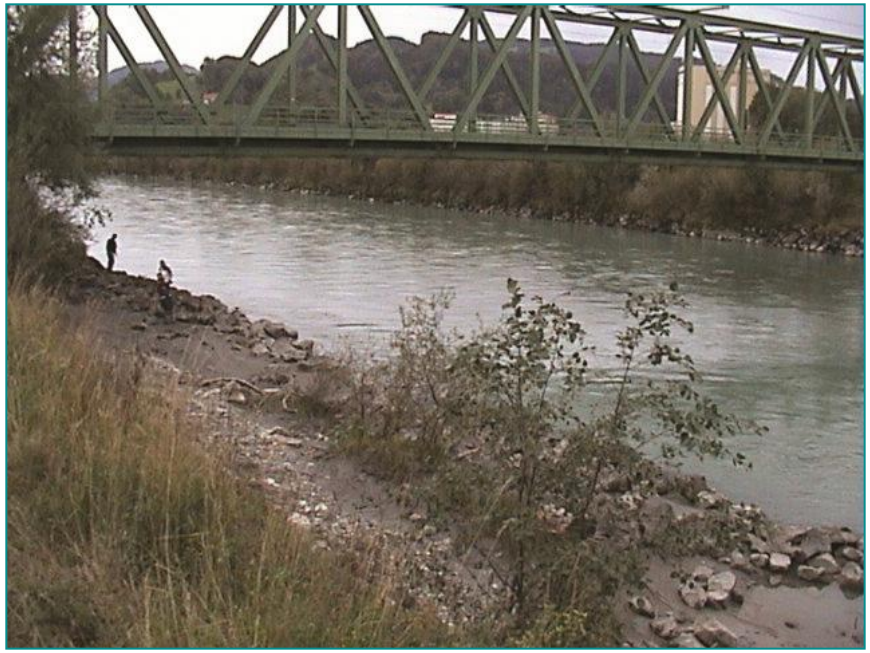


frmDischargeList

19	☐	M	0	63,0	64,9
18	☑		-0,08	58,5	64,6
17	☑	M	-0,2	52,1	66,0
16	☐		-0,3	47,1	67,5
15	☐		-0,35	44,8	68,1
14	☑		-0,66	31,4	67,1
13	☐		-0,7	29,8	68,5
12	☐		-0,8	26,1	68,0
11	☐		-1,2	12,6	66,2
10	☑		-1,3	9,7	65,8
9	☐		-1,4	6,9	64,7
8	☐		-1,45	5,7	63,8
7	☐		-1,58	2,8	64,1
6	☑		-1,68	1,1	60,1

Advantages RQ-30

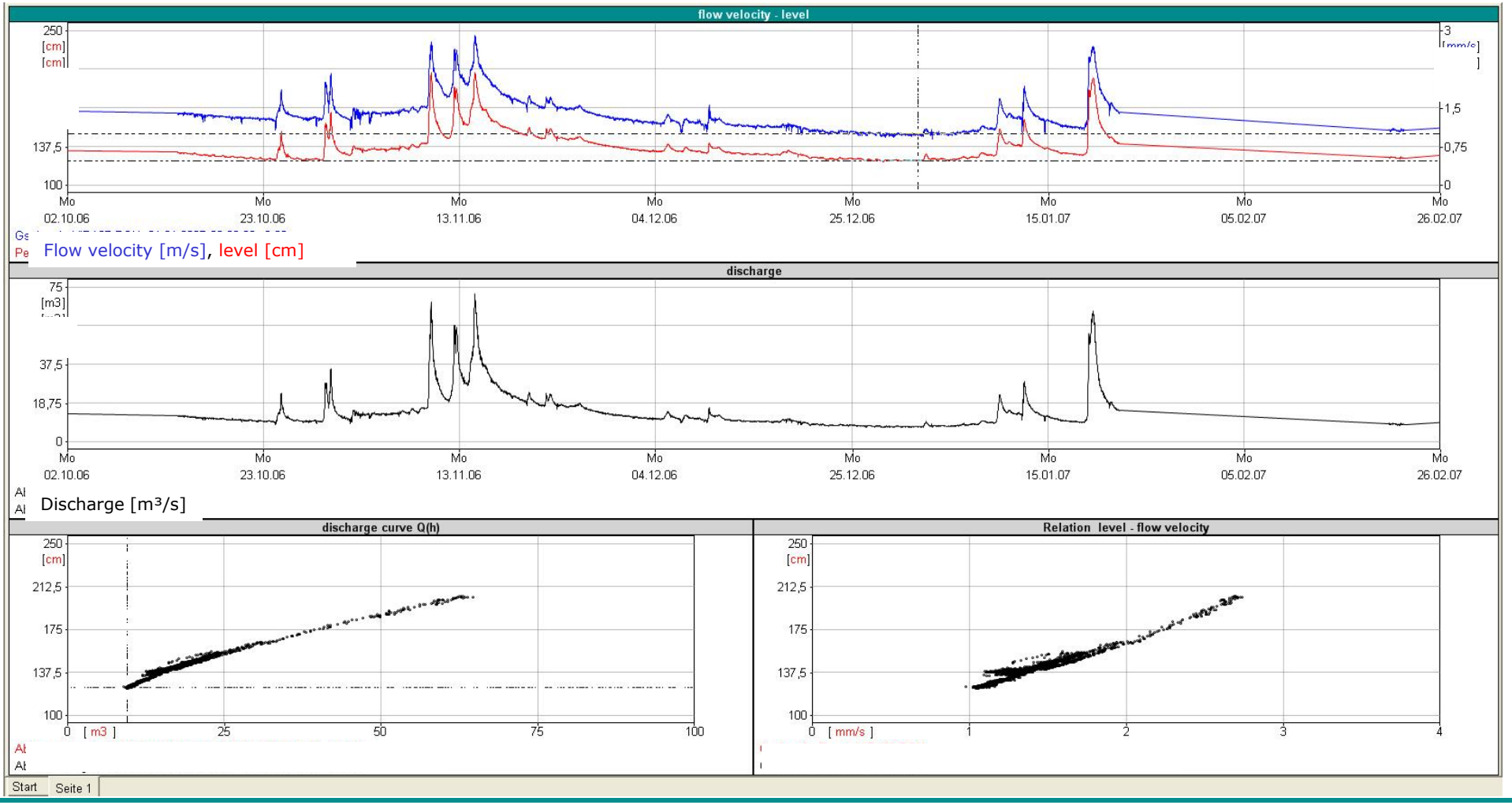
Non-contact measurement



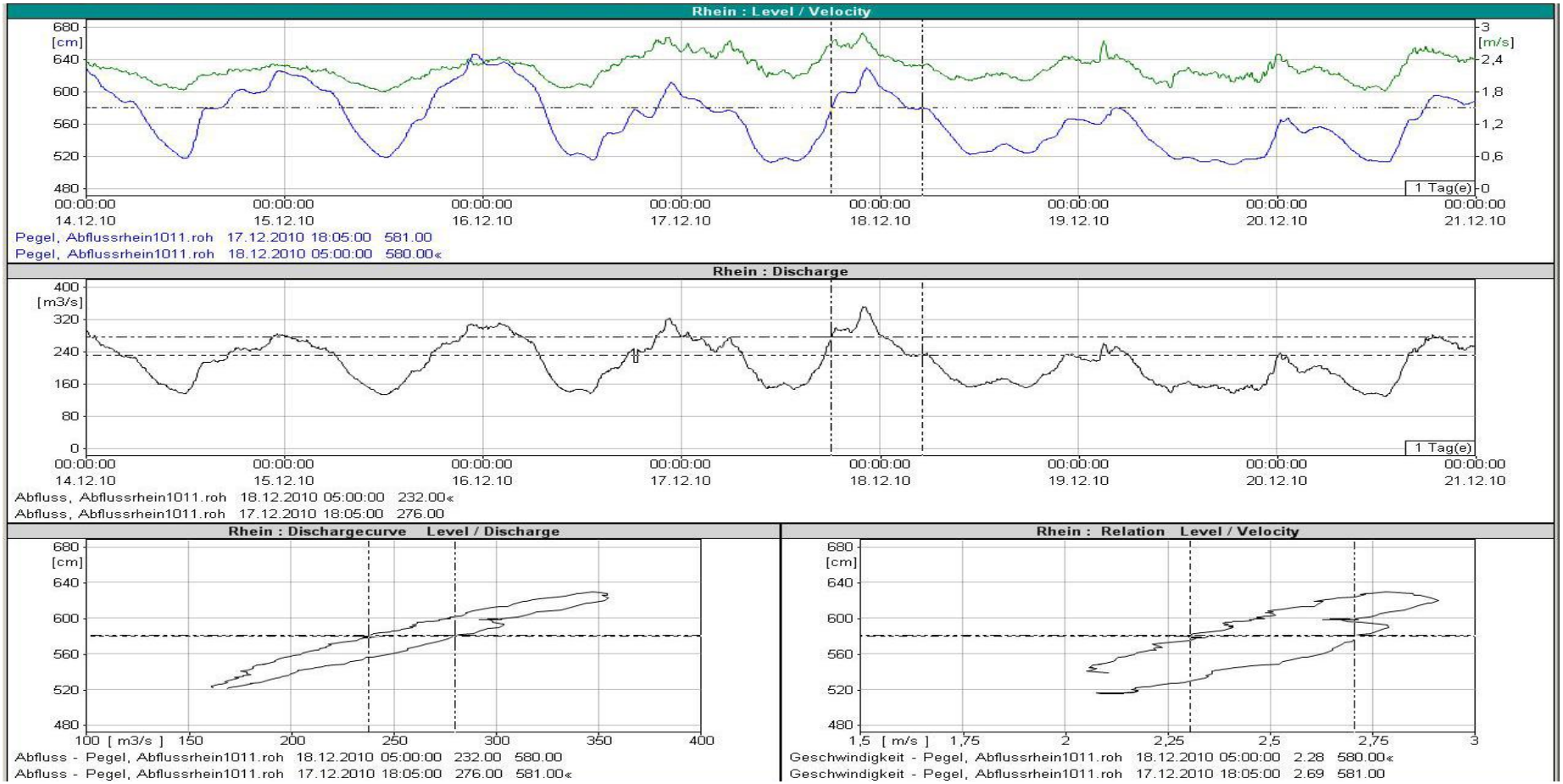
- Installation outside/above the river
  - High reliability / failure safety at floods
  - Maintenance free (No cleaning of Sensors necessary)
  - No damage of sensor by flotsam, trees, debris, bed load,…

Continuous measurement of water level and flow velocity

» Control of quality of measurement and measuring site through generating the discharge curve

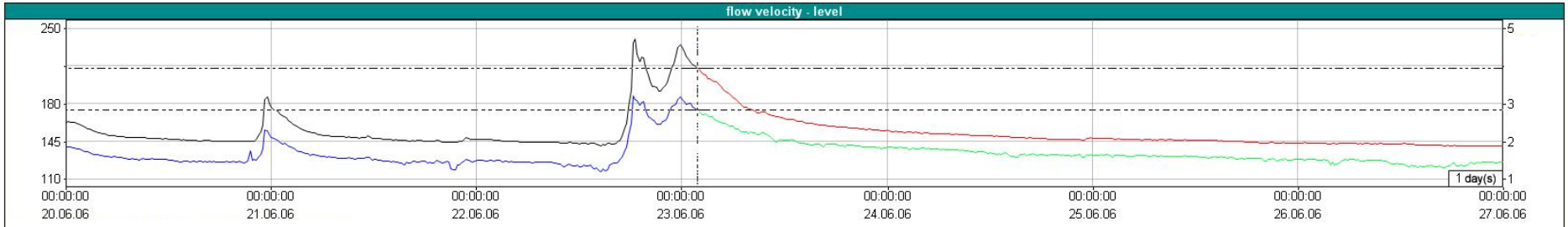


Recognition of flow hysteresis

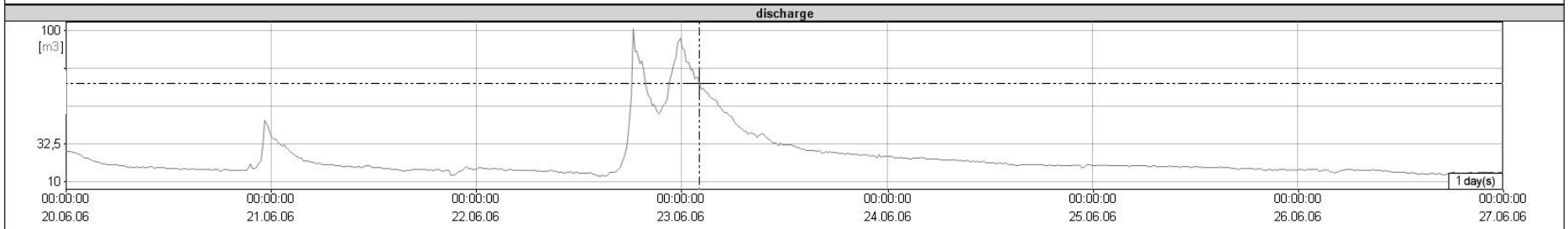


Recognition of dynamic processes: At the same level change of flow velocity

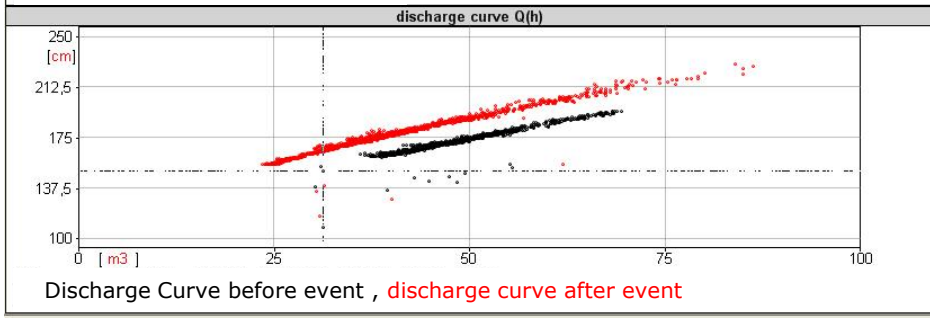
- The cross surface sections change, but not the hydraulic model (k – dimensionless factor)!
  - Vegetal invasion, bed loads, changes of profile and river bed



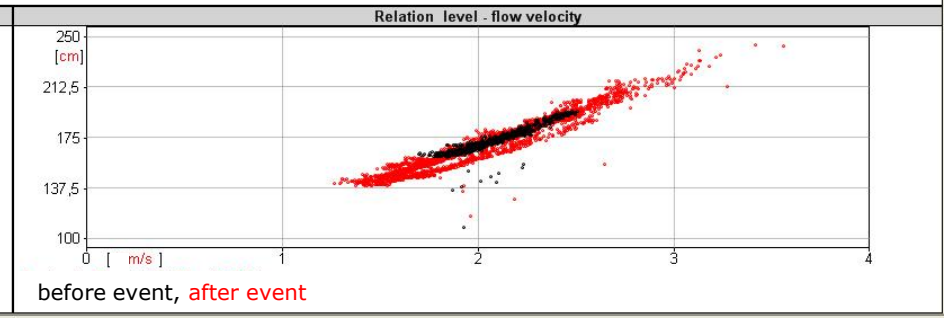
Level before [cm], Level after [cm], flow velocity before [m/s], flow velocity after [m/s]



Discharge [m³/s]



Discharge Curve before event , discharge curve after event



before event, after event

Easy and economic installation

- »No installation underwater
- »No construction at river necessary
- »Installation all-the-year possible
- »Mounting height from 0.5 to 35m
- »Independent from flow direction
- »Mobile and fixed installation
- »Mounting at bridge without drilling
- »Safe of vandalism

Range of application

Structure of water surface

- Minimum detectable wave height: 3 mm
- Measuring spot contain no rocks, falls or gullies

Floodwater:
– high waves
– perfect measuring

Flat water surface:
– low waves
– perfect measuring

Very flat water surface:
– very low waves
– difficult measuring

Limits of RQ-30

- Flow velocity < 0,3m/s and > 15m/s
- Distance sensor – water surface < 0,5m and > 35m
- Broad and slow rivers with behavior like a lake
- Detectable wave height > 3mm
- At measurement spot flow velocity: NO stones, swirls, standing waves
- Measurement time between 10 to 240 sec (recommended 30 sec)
- Disturbance of wave pattern at water surface

Technical specification

Technical specification

General data

Dimesions (mm):	Appr. 200 x 190 x 130 mm
Protection:	IP 68
Power supply:	5.5 V … 30 V
Power consumption:	Sleep modus … 1mA
	Active … appr. 130 mA (measurement 10 … 60 sec)
Operating temperature:	-35° to 60° C
Storage temperature:	-40° to 60° C
Lightning protection:	Integrated lightning protection with discharge capacity 0.6 kW Ppp

Connector 1 (12 pin)

Interface:	1x RS 485
	1x SDI - 12
	Transmission rate (1.2. KBaud to 115 KBaud)
Analog Output:	Water level
	Velocity
	Discharge
	Ext Input (AUX sensor)
Digital Output:	1x Switching output (max. 1.5 A)
Digital Input:	1x Trigger input (0=0 – 0.6V) (1=2 – 30V)

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Technical specification

Level Measurement

Depth measurement:	0 to 15 m standard operation range
	0 to 35 m optional extended operating range
Resolution:	1 mm
Accuracy:	+/- 5 mm; +/- 0.025 % FS (15 m)
Measurement frequency:	K-Band (26 GHz)

Velocity Measurement

Range:	0.3 to 15 m/s
Accuracy:	+/- 0.02 ms; +/- 0.5 %
Resolution:	1 mm/ s
Direction recognition:	+/-
Measurement duration:	10 to 240 sec
Measurement period:	Min 2 sec (active 10 … 60 sec)
Frequency of sampling:	2 khz
Measurement interval:	Min 5 sec … max 5 h
Distance to water surface:	Min 0.5 m … max 15 m/ 35 m

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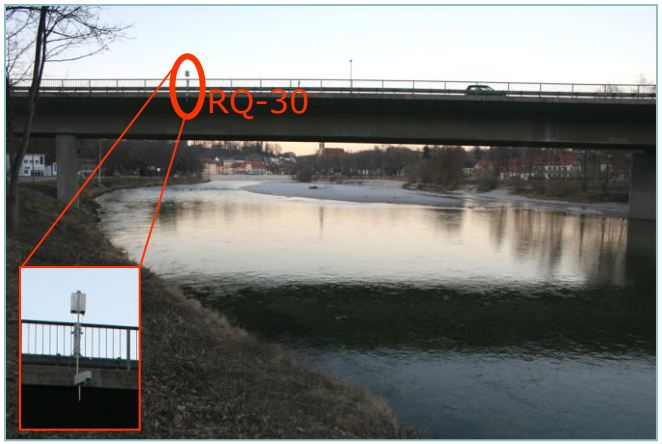
Comparison RQ-30 to other systems

Comparison RQ-30

Water Gauge Station

- Parameter
  - Continuous water level
  - Manual flow velocity
- Stage - discharge curve Q(h) required
  - Time and cost intensive measurement campaign
  - Less measurement data at flood situation
  - Extrapolation of Q(h) curve at high discharge
  - Measuring during flood at high risk
- Damage at flood
  - Bed load / trees / flotsam
- No direct detection of riverbed changing
- Expensive setup of measurement site
  - Structural measures in the river
  - Assembly costs



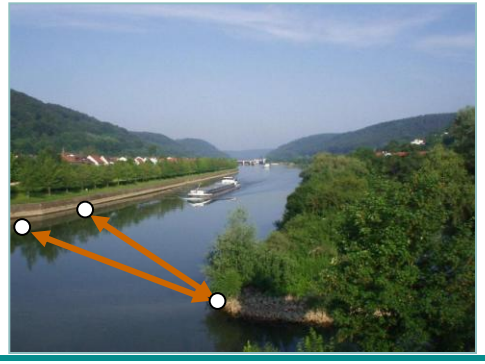
RQ-30

- Parameter
  - Continuous water level
  - Continuous flow velocity
- Discharge correlation-curve Q(h) NOT necessary
  - Calibration by hydraulic model
  - Discharge immediately available after installation
- Reliable even during floods
  - Non-contact – fail-safe - low maintenance
  - Sensor above / outside the river
- Detection of dynamic processes (riverbed changes, vegetal invasion, hysteresis, …)
- Economic and simple assembling
  - No structural measures in the river
  - Low assembly costs

Comparison RQ-30

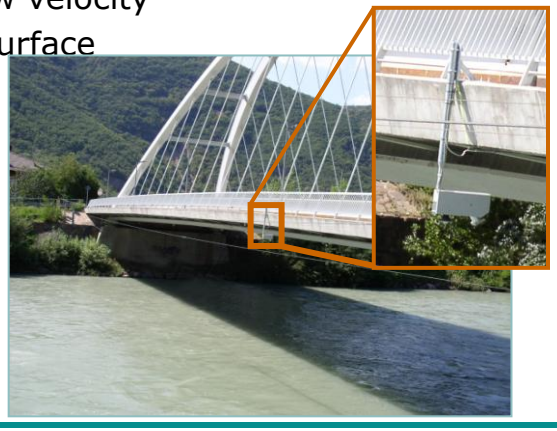
Ultrasonic - transit time

- Contact measurement
  - Flood: troubles with bed load
  - Damage of measurement system (trees, …)
  - Sediments and airbubbles
- Flow velocity
  - Down to 0 m/s
  - Flood: measurement close to river bed
- Minimum water depth
- Expensive setup
  - Underwater installation
  - Construction in the river
  - Installation of several operating time analysis
  - Maintenance-intensive
- Limits
  - Bed load, suspended load, turbidity
  - Minimum water depth
  - High velocity



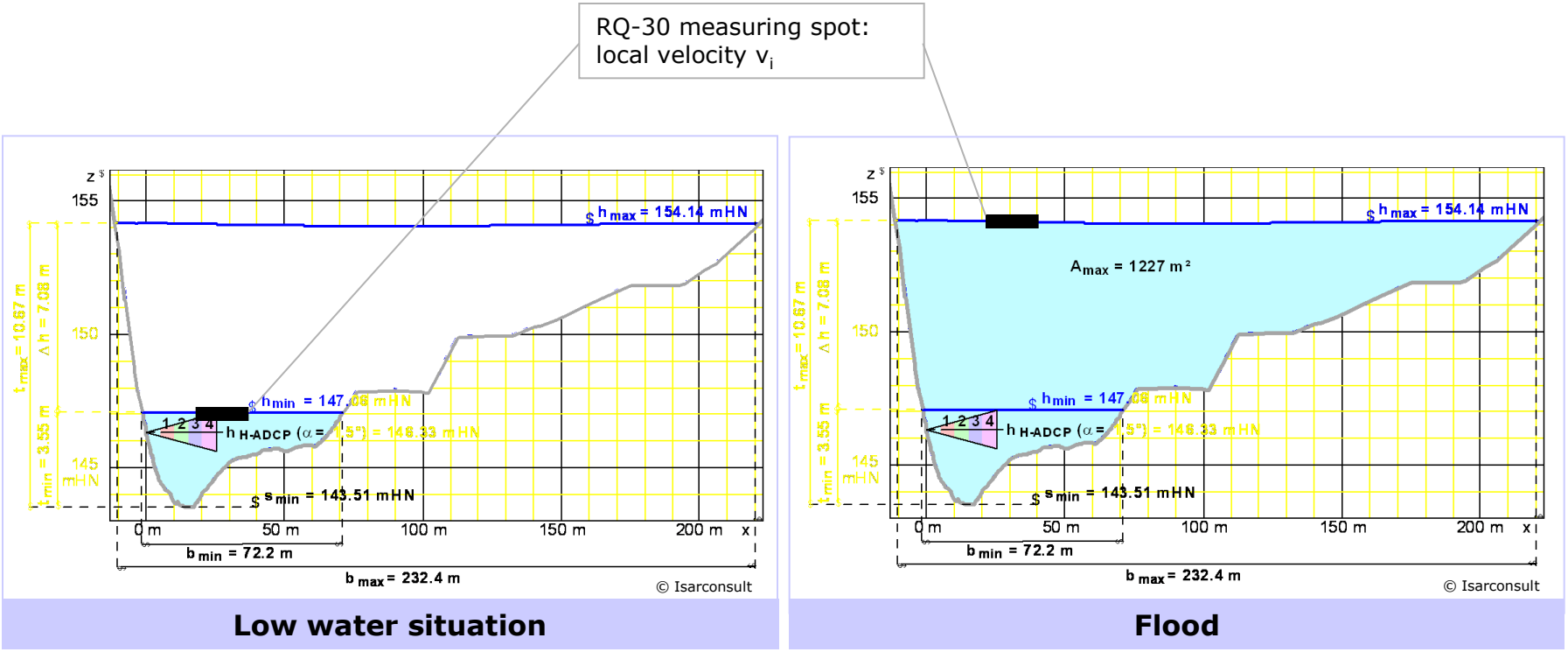
RQ-30 – radar system

- Non-contact measurement
  - Reliable measurement even during flood
  - Setup above of river – no damage
  - Maintenance-free
- Flow velocity
  - >0.30 m/s and <15 m/s depending on the river characteristics
  - Flood: Always measurement of v_{max} at surface
- No minimum water depth
- Simple setup
  - Easy and cost-saving mounting
  - Setup above river - No construction in the river
- Limits
  - Very slow flow velocity
  - Calm water surface



Flood – compared to H-ADCP / transit time

- RQ-30 measures always the maximum flow velocity at every water level (stage)
  - The maximal flow velocity produces the highest discharge quantity
  - Transformation from maximum to mean velocity is more accurate



Check list

- □ Are there any waves – at least 3 mm ?
- □ Is the hydraulic situation qualified for a RQ measurement site?

  There should not be any …
  - □ Curves
  - □ Bridges or piers which influences the river flow
  - □ Backwater
  - □ Dam
  - □ Confluence of rivers
  - □ Boulders
  - □ Underwater construction
  - □ Other influences of river flow
- □ What is the min./ max. water depths (e.g. 100 year flood)?
- □ What kind of power supply is needed?
- □ Is an installation at the bridge possible or is an extension arm needed?

Helpful documents for evaluation of a measuring site

- □ Several pictures of measurement site
  - □ Upstream
  - □ Downstream
  - □ Water surface – whole river and detail
  - □ Bridge from the side, piers
- □ Map of the measurement site (e.g. Google map in good resolution)
- □ Estimated min. flow velocity/ max. flow velocity
- □ Profile / cross section of the measurement site

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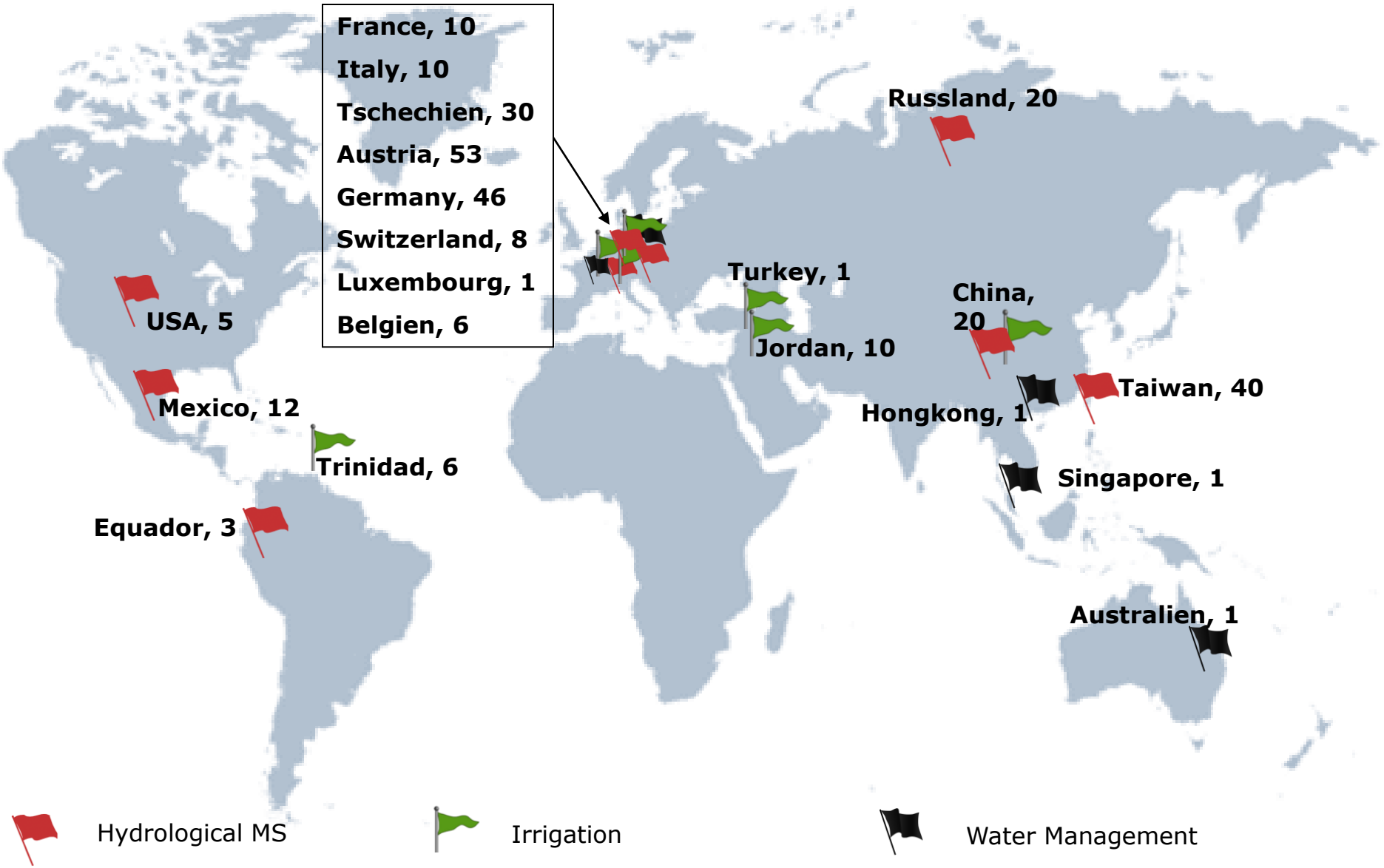
> 300 Measuring sites worldwide



Conclusion

- Non-contact = failsafe = maintenance free (no damage, cleaning of sensor)
- Accurate measurement after installation especially in case of flood incl. floodplains
- Continuous measurement of flow velocity
- No problems with suspended sediments in the water
- Stage-discharge curve Q(h) not required
- Detection of riverbed changing
- No limit of minimum water depth
- Easy and economic set-up outside the river

Thank you for your attention!
Questions?

Rhine, Vorarlberg, Austria

Loisach, Bavaria, Germany

Inn, Upper Austria, Austria

Some measurement sites in Austria and Germany.

For further information

» Contact: elscolab@elscolab.com