3-DIMENSIONAL FIELD MEASUREMENTS IN SHORT INTAKES USING AN ACOUSTIC DOPPLER PROFILER

Juergen Skripalle
Managing Director
Hydrovision GMBH
Gewerbestraße 61A, 87600 Kaufbeuren, Germany
Email: j.skripalle@hydrovision.de

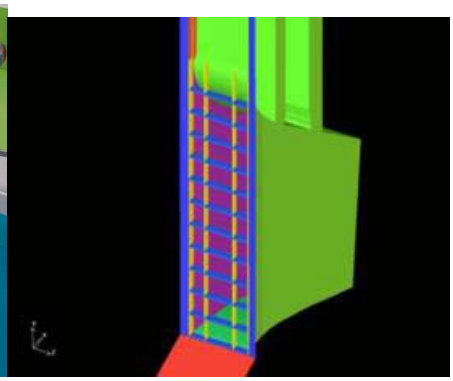
Content

- Motive
- Acoustic Doppler profiler
- Comparative tests
- System components
- Case studies

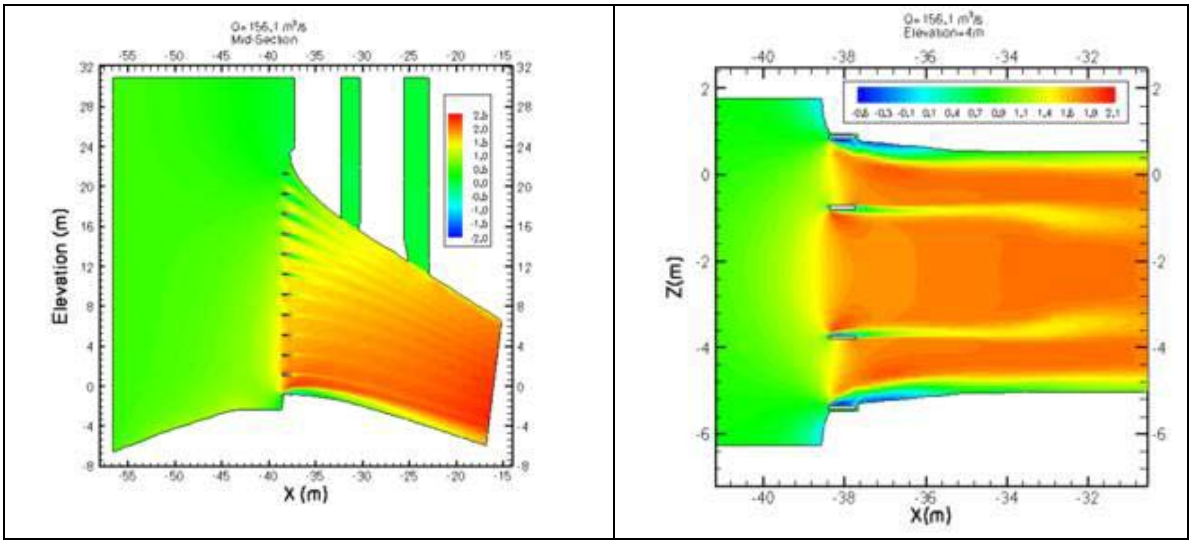
Motive:

- Site Conditions Low Head Turbine
  - Complex 3D-Flow
  - Limited Space

Picture: www.strom-online.ch



3D CFD of La grand-1



Mean Horizontal Velocity Distribution in the Middle Cross Section of the Intake and in a Lateral Section

Source:
Comparison of discharge measurement by current meter and acoustic scintillation methods at la grande-1
Gilles proulx, eric cloitier, hydro-québec, essais spéciaux de production, 5655 de marseille, montréal, canada
Latif bouhadji, david lemon, asl-aqflow, inc., 1986 mills road, sidney, bc, canada

- Measurement Methods
  - Current Meter Method
  - Acoustic Time-Of-Flight Method
  - Acoustic Scintillation Method
  - Acoustic Doppler Profiler Method

Current Meter Method:

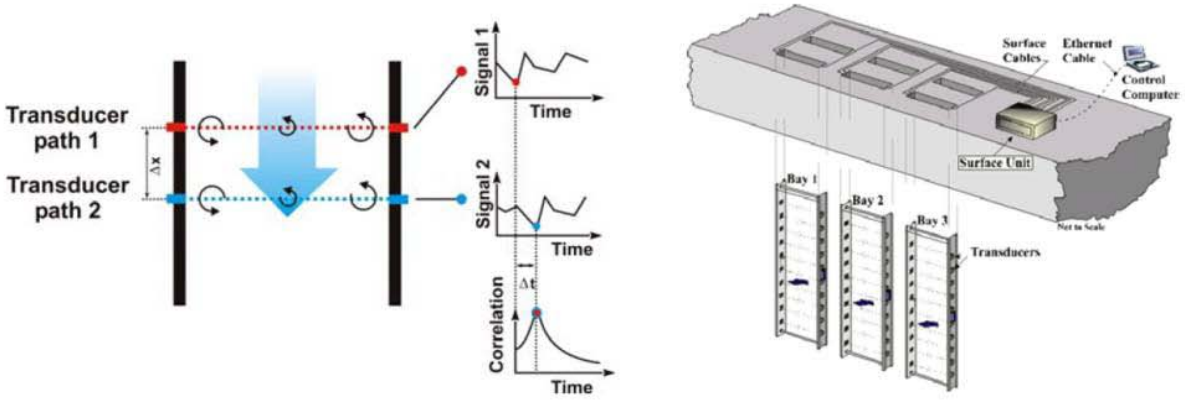
Source:
Performance Testing Of The St. Lawrence Power Project Using Current Meters
Albert F. Mikhail, P.Eng., Ontario Power Generation And Robert J. Knowlton, P.E., New York Power Authority

Current Meter:

General View Of The Current Meter Setup

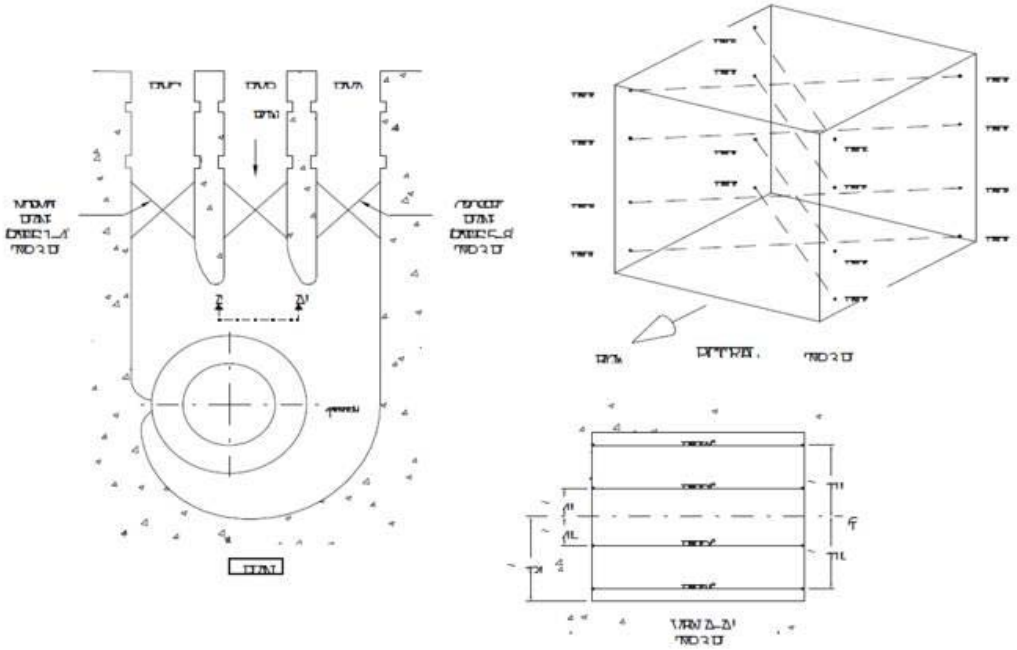
Source:
Performance Testing Of The St. Lawrence Power Project Using Current Meters Albert F. Mikhail, P.Eng., Ontario Power Generation
Robert J. Knowlton, P.E., New York Power Authority

Acoustic Scintillation Method:



Source: Turbine flow measurement for low-head plants – owners' options for the 21st century
Josef Lampa And David Lemon Pierre Lamy John Taylor

Acoustic Time-Of-Flight Method:



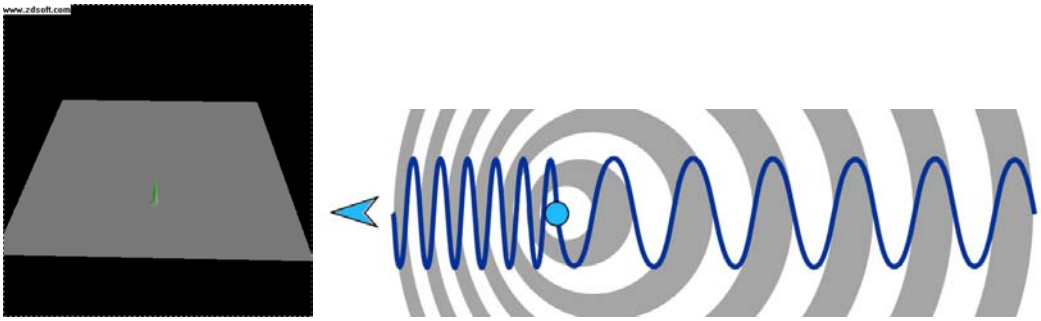
Source: Ultrasonic flow measurement for unit testing and Performance monitoring at low-head hydroelectric plants
Terrance l. Burch and James t. Walsh Accusonic technologies, inc.

Acoustic Doppler Profiler:

Measurement principle

- Doppler phenomenon
- Profiling technology
- Blanking
- Beam characteristic
- Reflections

Doppler Phenomenon:

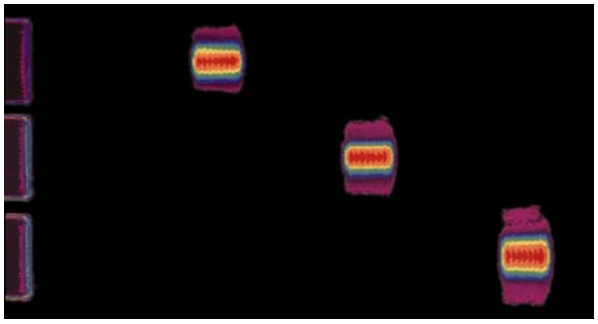


$V_P = (C * F_{DOPPLER})/(2*F_0)$

with V_P = Local Velocity In Beam Direction
C = Velocity of Sound F(T)
$F_{doppler}$ = Doppler Shift Frequency
F_0 = Basic Frequency of The Transducer

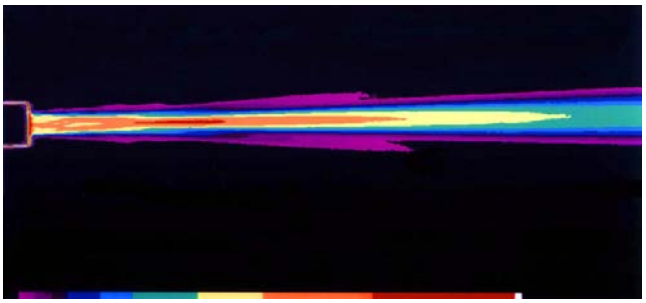
Profiling Technique:

Transducer



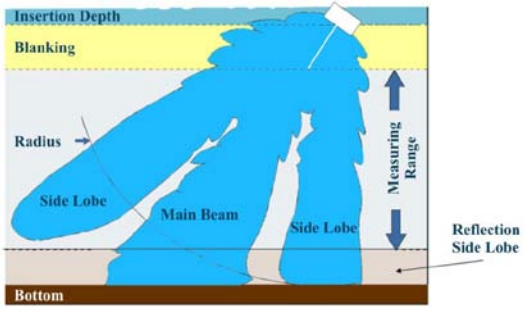
Visualized Burst

Beam Characteristic:

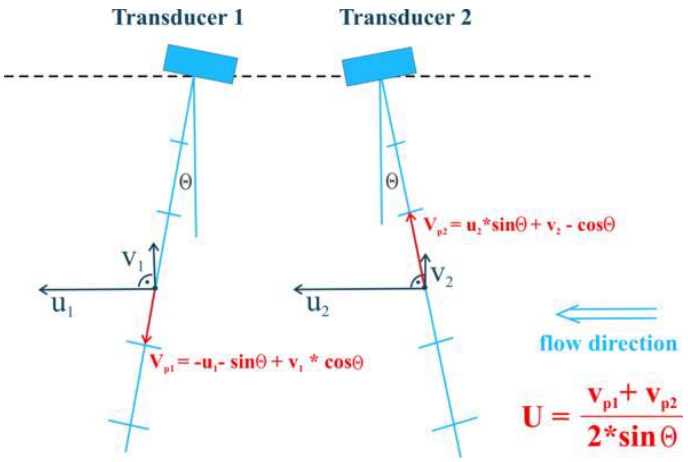


Visualized Pressure Distribution

Side Lobe Influence:

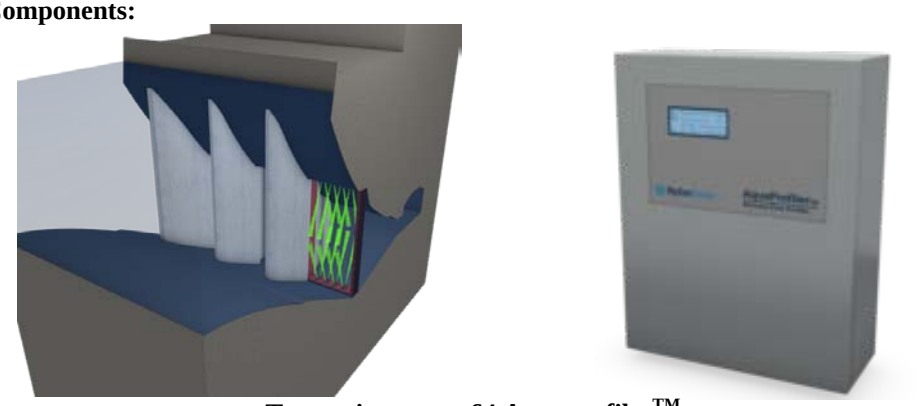


Flow Computation:



One transducer measures one velocity profile vector projection into transducer axis.
For a complete 2d measurement in a point at least two transducers are necessary.

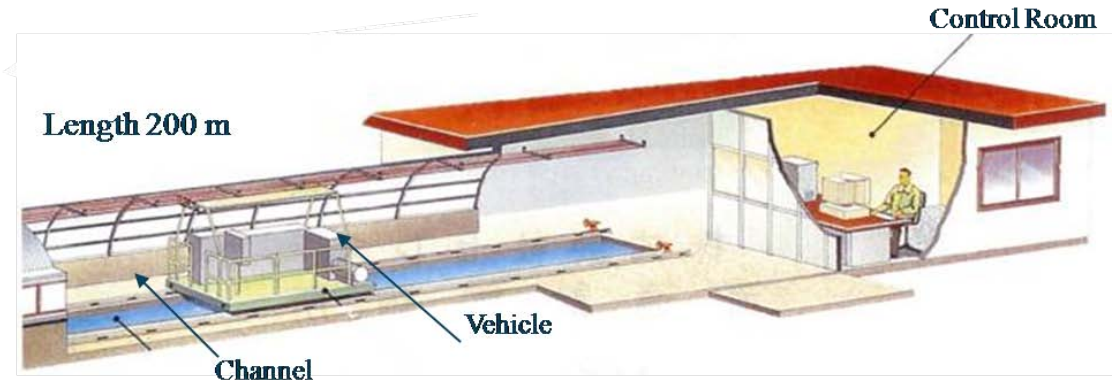
System Components:



Transmitter upto 64 Aquaprofiler™

Sensor Aquaprofiler™
Long Range: 0,25 To 20 M, #Cells Up To 64
Short Range: 0,01 To 3 M, #Cells Up To 128

Overview Test Rig:



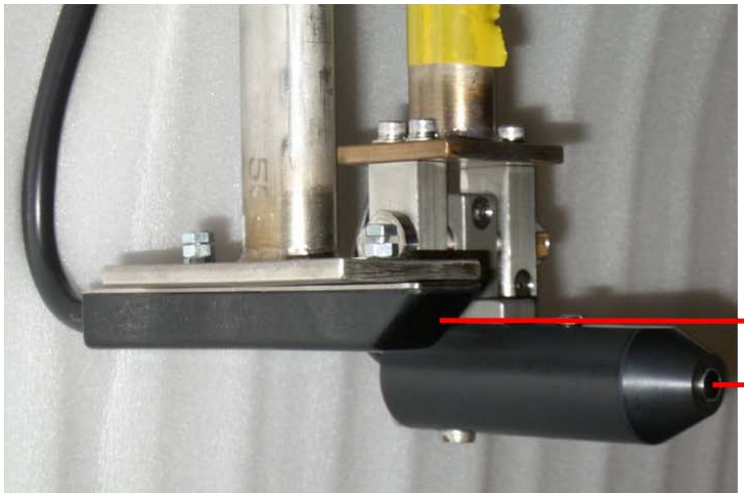
Cross section

Test Rig:

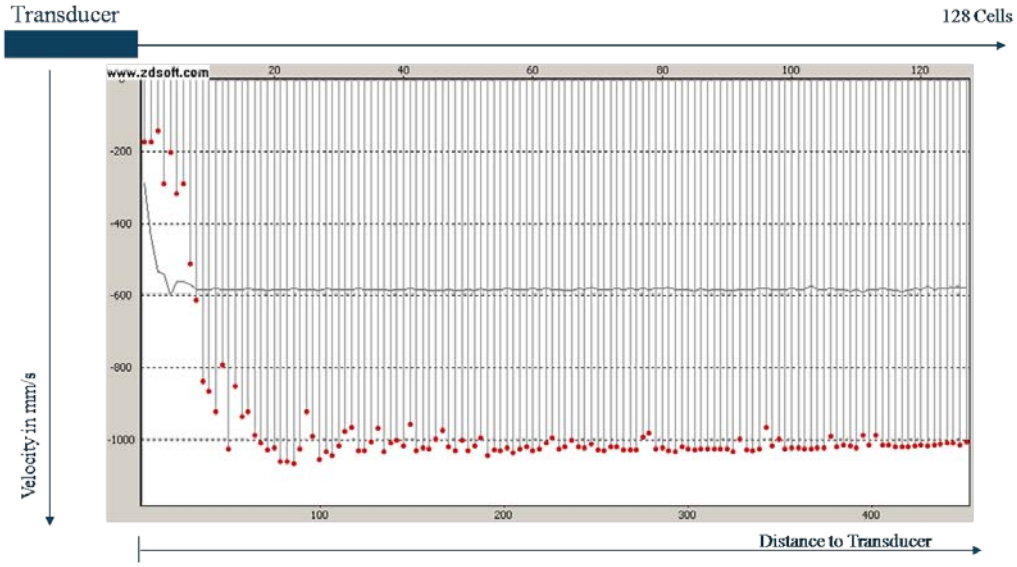
Channel

Vehicle

Sensor Installation:

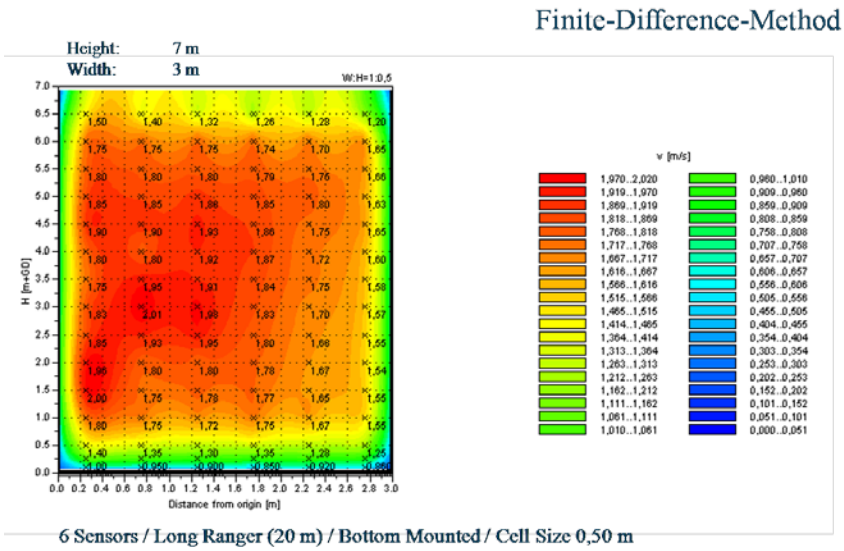


Test High Resolution Doppler Profiler:



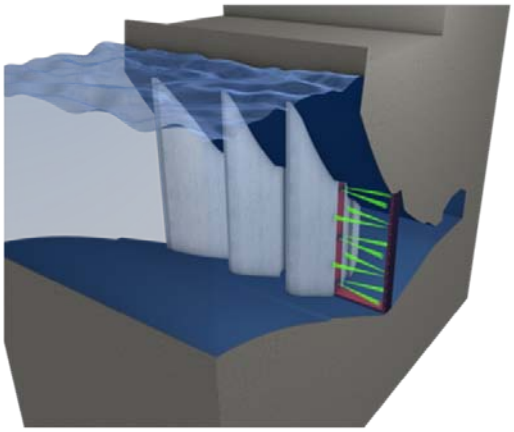
Test Low Resolution Profiler:

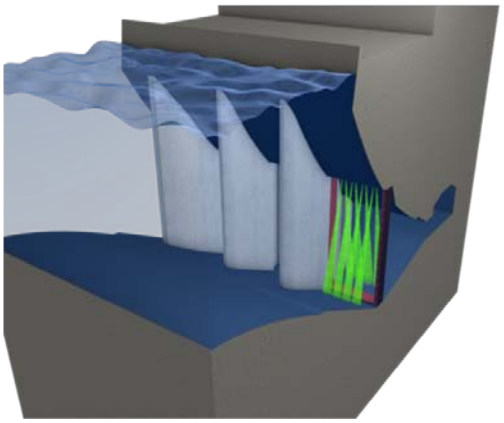
Case Study 1:



Case Studies:

Horizontal and/or vertical beams





Comparison Flow Measurement Methods:

Stationary	Current Meter (stationary support)	Time-Of-Flight (wall mounted)	Scintillation (wall mounted)	Doppler Profiler (wall mounted)
Dewatering	YES	YES	YES	YES
Continuous Monitoring	NO	YES	YES	YES
Installation Time	VERY HIGH	HIGH	HIGH	LOW
Suitable for very short intakes	YES	LIMITED	YES	MEDIUM
Relative Cost	HIGH	HIGH	HIGH	MEDIUM
Moving Frame	Current Meter	Time-Of-Flight	Scintillation	Doppler Profiler
Suitable for very short intakes	YES		YES	MEDIUM
Portable between intakes	YES		YES	YES
Code approved for short intakes	NO		NO	NO
Measuring Time	VERY HIGH		HIGH	VERY LOW
Relative Cost	LOW		MEDIUM	MEDIUM