Hydroacoustics in the USGS: From Research to Operational Tools

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Hydroacoustics in the USGS: From Research to Operational Tools

- Experience with Hydroacoustics
- Lessons Learned
- Sustaining Innovation

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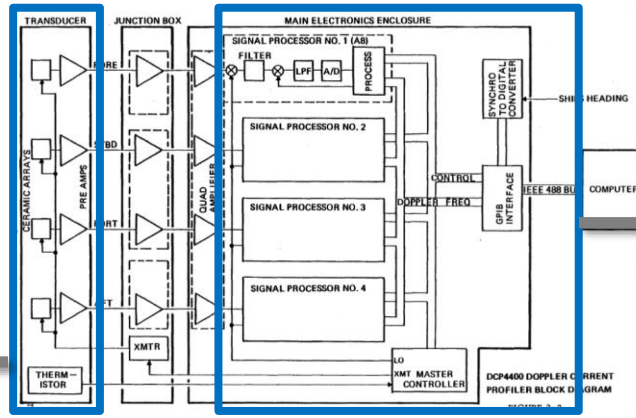
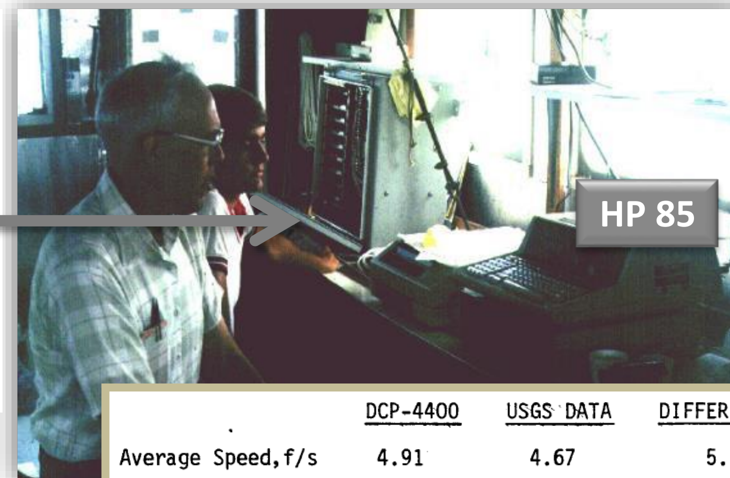
First ADCP River Discharge - 1982

Ametek/Straza
DCP 4400 ADCP





Min bin size (cm)	100
Vel. Std. Dev. (cm/s)	1,100
Update rate (p/s)	8
Depth to first bin (m)	~3.6
Total Weight (kg)	**90**

	DCP-4400	USGS DATA	DIFFERENCE
Average Speed, f/s	4.91	4.67	5.1%
Average Speed, m/s	1.49	1.42	
Average Depth, feet	59.2	54	9.2%
Average Depth, meters	18.05	16.5	
Discharge Area (sq feet)	142,523	150,000	-5.2%
Discharge Area (sq m)	13,252	13,942	
Discharge (cu ft/sec)	701,904	703,916	-0.3%
Discharge (cu m/sec)	19,891	19,948	

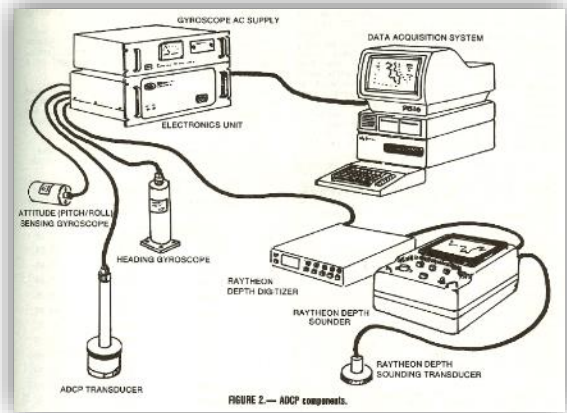
1982

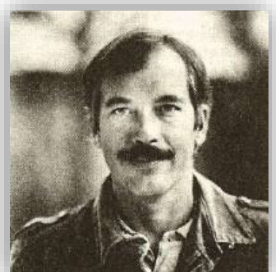
Photos from Steve Blanchard

1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015

RD Instruments Narrowband ADCP

- CA District bought prototype
- Mike Simpson, others tested NB ADCP in SF Bay & Delta.
- Mike wrote software for computing discharge in real time (ADDMS)





<u>Limitations</u>

"Average depths < 4.5 m"

"Irregular cross sections (unless vessel is slowed sufficiently to allow depth definition by ADDMS)"

Min bin size (cm)	**100**
Vel. Std. Dev. (cm/s)	**13.4**
Update rate (p/s)	**8**
Depth to first bin (m)	**~3.6**
Total Weight (kg)	**27**
Length (m)	**1.07**

1987

1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015

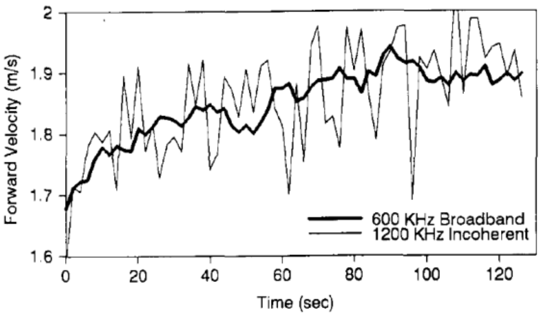
RD Instruments Broadband ADCP

Table C-1. ADCP Input Command Summary

COMMAND	DESCRIPTION	PAGE
?	SHOWS COMMAND MENU	C-7
<BREAK> or	INTERRUPTS OR WAKES UP ADCP AND LOADS LAST SETTINGS USED	C-9
BAnnn	BT EVALUATION AMPLITUDE MINIMUM (1-255 counts)	C-10
BCnnn	BT CORRELATION MAGNITUDE MINIMUM (0-255 counts)	C-10
BDnnn	BT DELAY BEFORE REACQUIRE (0-999 ensembles)	C-10
BEnnnn	BT ERROR VELOCITY MAXIMUM (0-9999 mm/s)	C-11
CPnnn	TRANSMIT POWER (0-255 counts)	C-19
CQnnn	TRANSMIT DELAY SELECT (0-127 counts) {NOTE: NOT FULLY IMPLEMENTED	C-19
CRn	RETRIEVE PARAMETERS (0 = user, 1 = factory)	C-20
CS or T	START PINGING	C-20
CTn	TURNKEY OPERATION (0 = off; 1 = Turnkey)	C-22
CXn	TRIGGERED TRANSMIT (0=off: 1=on)	C-22
CY	CLEAR ERROR STATUS WORD	C-23
CZ	POWER DOWN ADCP	C-24
DA	ATMOSPHERIC PRESSURE CORRECTION	C-25
DI	IDENTIFY THE SVP	C-25
DQ	SENSOR POWER ON/OFF TOGGLE	C-26
DS	SAMPLE/DISPLAY DATA SCAN	C-26
EA±nnnnn	HEADING ALIGNMENT [PHYSICAL] (LSD = ±0.01 ; -179.99 to 180.00)	C-27
EB±nnnnn	HEADING BIAS [ELECTRICAL/MAGNETIC] (LSD = ±0.01 ; -179.99 to 180.00)	C-28
ECnnnn	SPEED OF SOUND (1400-1600 m/s)	C-30
EDnnnnn	DEPTH OF TRANSDUCER (0-65535 decimeters)	C-30
EHnnnnn	HEADING (LSD = 0.01 ; 000.00 to 359.99)	C-30
EP±nnnn	PITCH (LSD = 0.01 ; -20.00 to +20.00)	C-31
ER±nnnn	ROLL (LSD = 0.01 ; -20.00 to +20.00)	C-31
ESnn	SALINITY (0 to 40 parts per thousand)	C-32
ET±nnnn	TEMPERATURE (LSD = 0.01 C; -5.00 C to +40.00 C)	C-32
EXnnnnn	COORDINATE TRANSFORMATION (type,type; tilts; 3-beam; bin mapping)	C-32
EZnnnnnnn	SENSOR SOURCE (EC; ED; EH; EP; ER; ES; ET); (0=manual, 1=transducer, 2=synchro)	C-35
PAn	PRE-DEPLOYMENT TESTS	C-36
PCnnn	BUILT-IN TESTS (0=help)	C-36
PDnnn	DATA STREAM SELECT (0 = actual, 1 = simulated, 3=ADCP1, 4=ADCP2, 5=ADCP3, 6=ADCP4, 7=NMEA)	C-38
PInnnnnn	BUILT-IN TESTS (repeat; CPU; clock; timing; demod; loop)	C-38
PM	DISTANCE MEASURING FACILITY	C-39
PSn	SHOW SYSTEM PARAMETERS (0=hard/firmware;1=fxd ldr;2=var ldr;3=xdcr mtrx;4=ping seq)	C-41

EX1011	Coordinate transformation
WS25	Cell size (cm)
WV170	Ambiguity velocity (cm/s)
BA30	Bottom amplitude

Performance of a Broad-Band Acoustic Doppler Current Profiler
Blair H. Brumley, Ramon G. Cabrera, Kent L. Deines, and Eugene A. Terray



Min bin size (cm)	**25**
Vel. Std. Dev. (cm/s)	**6.5**
Update rate (p/s)	2
Depth to first bin (m)	**~1.8**
Total Weight (kg)	**27**
Length (m)	1.0

Cost: $55,000

1992

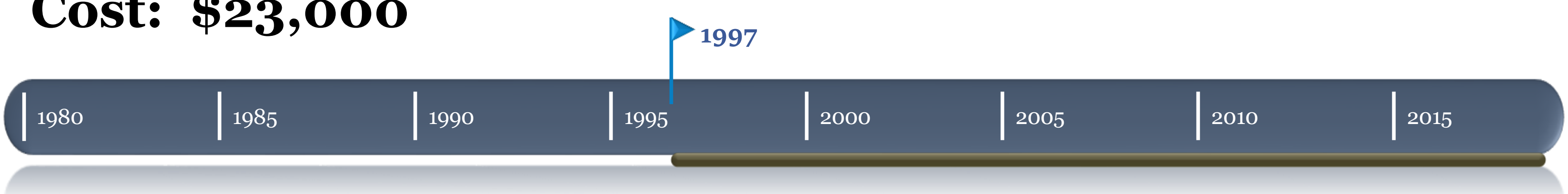
1980 1985 1990 1995 2000 2005 2010 2015

RD Instruments Rio Grande ADCP

- First 12-volt ADCP
- Based on Workhorse technology

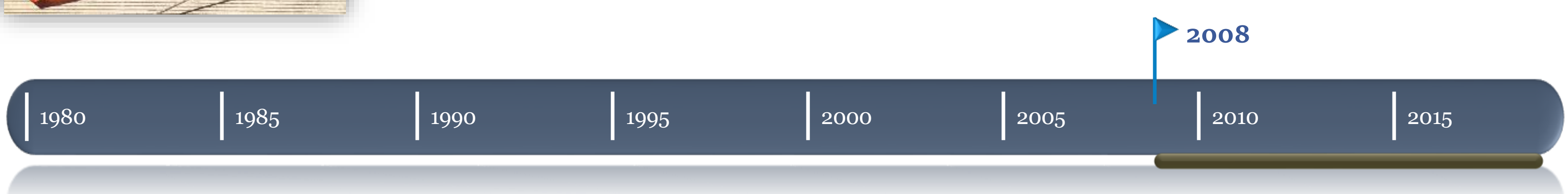
	WM1	WM5
Min bin size (cm)	25	**10**
Vel. Std. Dev. (cm/s)	10	**.60**
Update rate (p/s)	2	3
Depth to first bin (m)	~1.8	**0.5**
Total Weight (kg)		**6.8**
Length (m)		**0.20**

Cost: $23,000



RiverRay and RiverPro & M9/S5

- Multi-frequency
- Auto-adaptive configuration
- Smaller footprint
- Vertical beam for depth measurement
- Bluetooth radio support
- Geo-location info (some models)

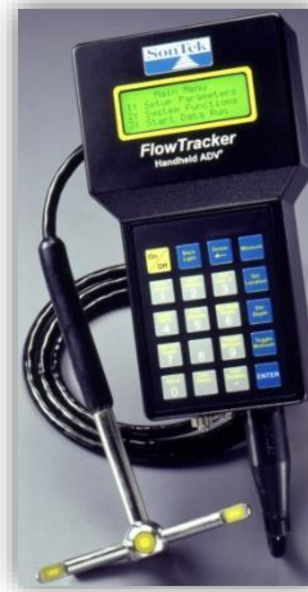


SonTek FlowTracker ADV

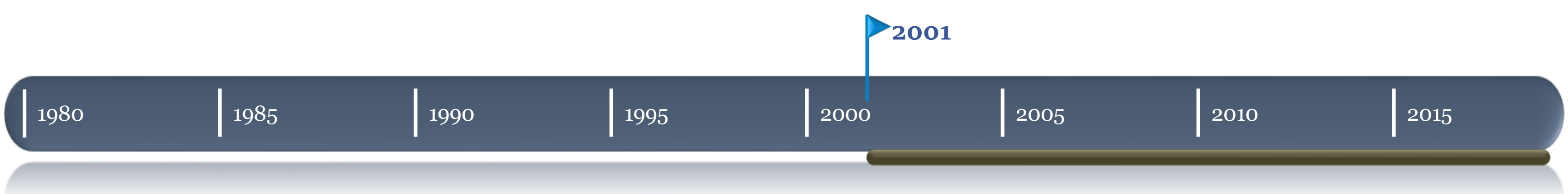
ADV

Proof of concept

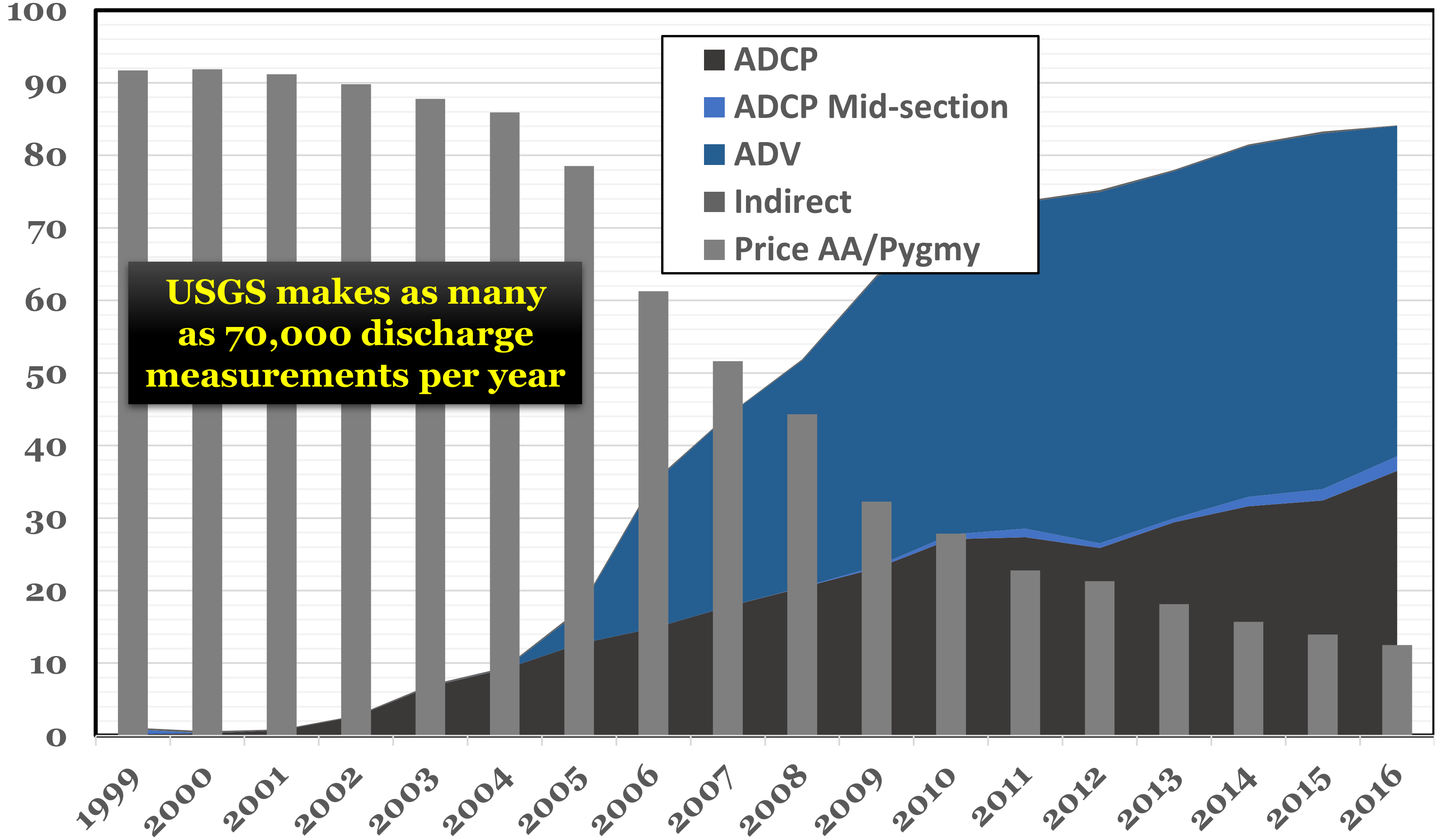
2nd generation



Flowtracker



Impact of Hydroacoustics in USGS



Lessons Learned

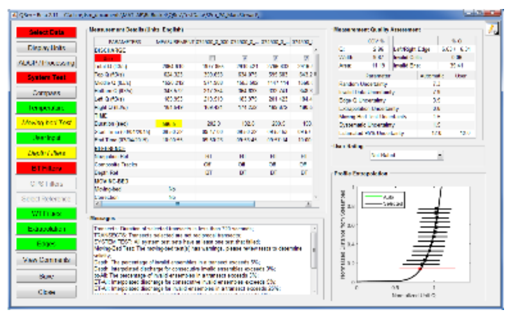
What lessons can be learned?

1. Technological Innovation
2. Incentives
3. Standardized Training / Standard Operational Procedures
4. Vendor Interaction & Collaboration
5. Validation and Quality Assurance
6. Dedication of Resources (Staff and $$)

(1) Technological Innovation

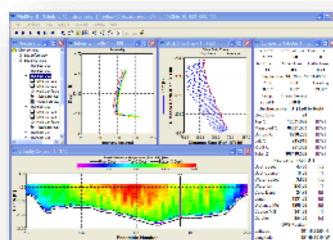






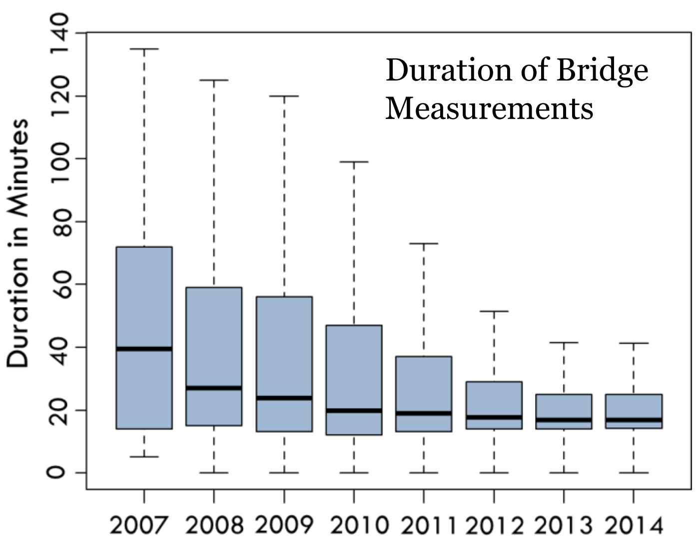






(2) Incentives are Necessary

- **Economic**
- **Capability**
- **Accuracy**
- **Safety**

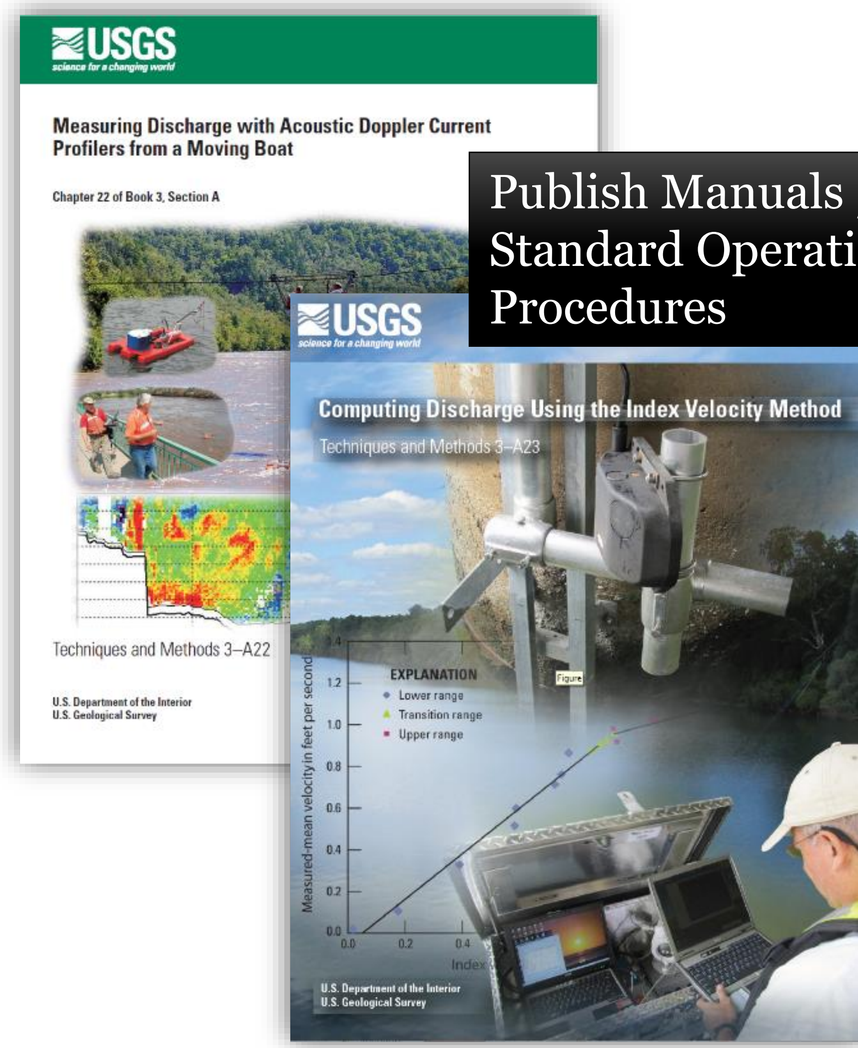


- ADCP usage
  - Cost less (less staff / Qm time)
  - Measure in conditions that were previously not possible
  - More Qms/time
  - Enabled use of in-situ ADCPs (estuaries, unsteady flow, etc.)
  - Moving boat measurements are more accurate than with mechanical meters
  - Safer to use in many situations (e.g. less time on bridges)

(3) Training & SOPs (Manuals)

Training in the Use of the Technology is Essential

10-15 classes per year in USGS

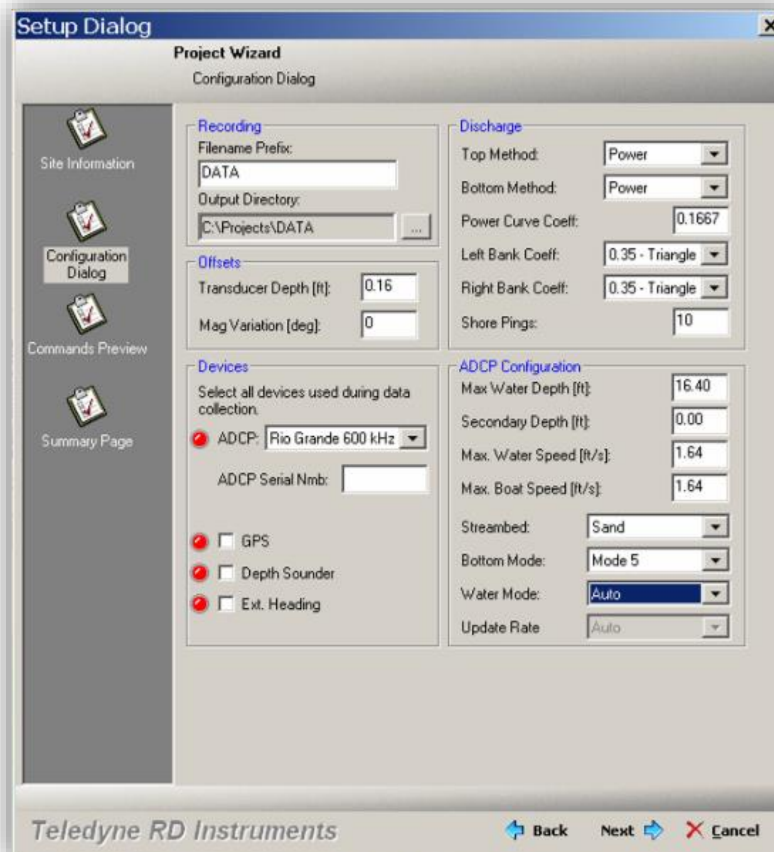


Publish Manuals / Standard Operating Procedures

(4) Work with Manufacturers

Regular Meetings

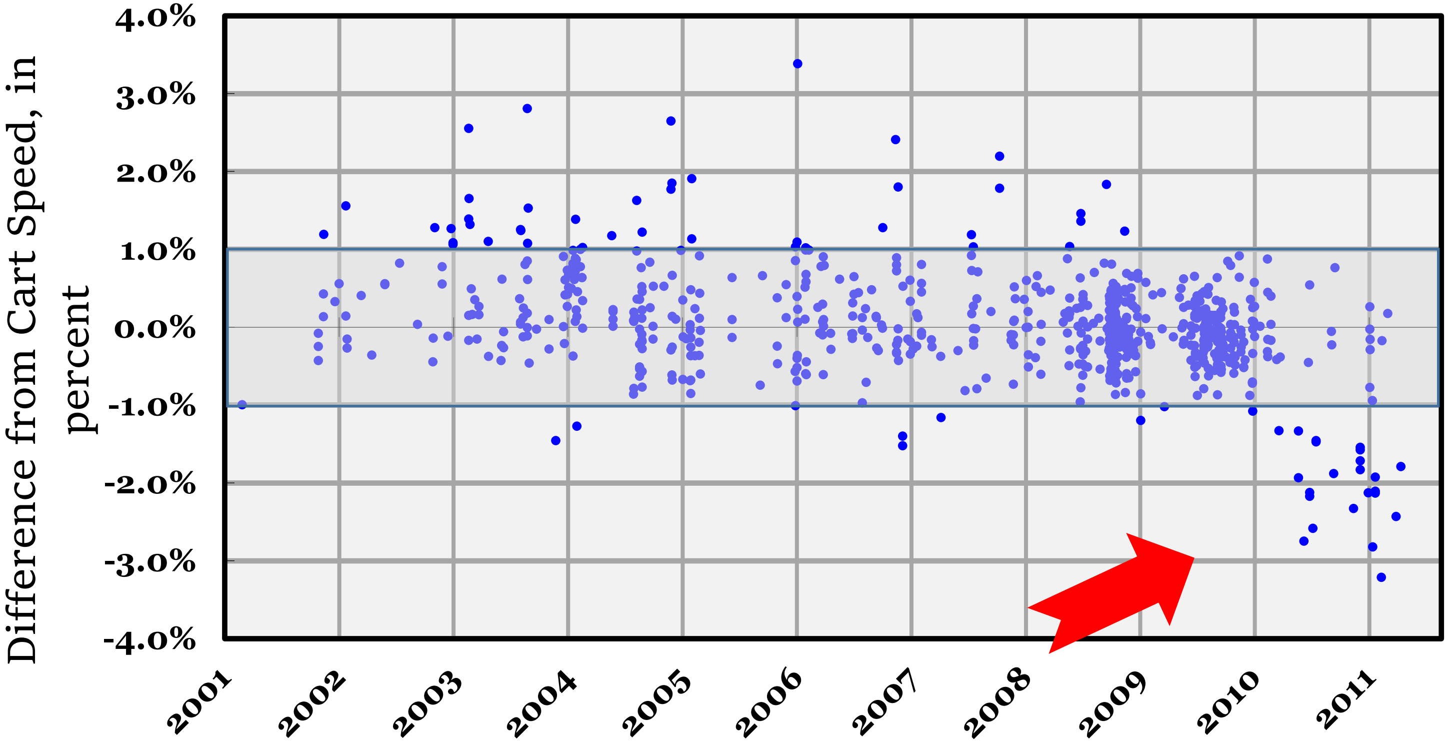
- Discuss requirements
- Learn the technology
- Share problems/bugs



Collaborate to improve the product

Example: USGS developed the logic for an ADCP configuration wizard

(5) Testing is Essential – Field and Lab



- Error was introduced into manufacturer's calibration facility
- USGS QA program identified the problem

Trust but Verify!

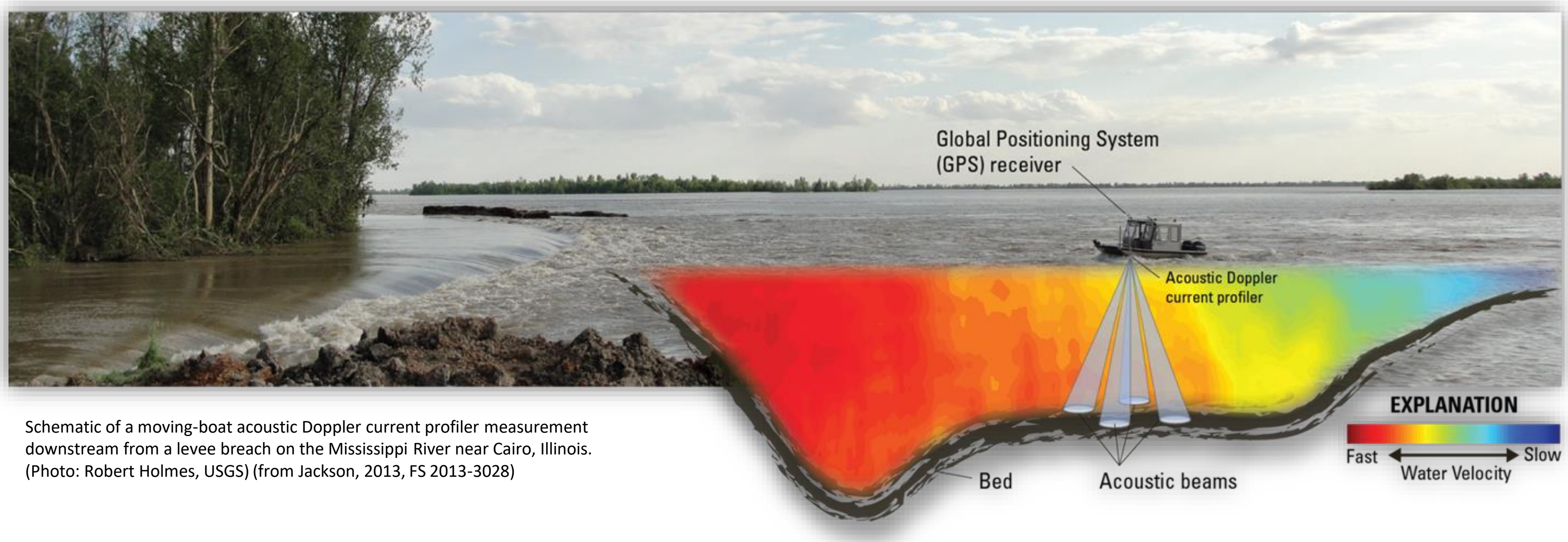
(6) Resources

- Necessary to have staff dedicated to ensure that the things get done
    - **Field Support** (trouble shooting problems via phone, email, etc..)
    - Implement **Training** and Standard Procedures
    - **Validate** Instrument and software
    - **Interact and collaborate** with vendors consistently
- Funding needed to facilitate desired software and hardware enhancements

Sustaining Innovation

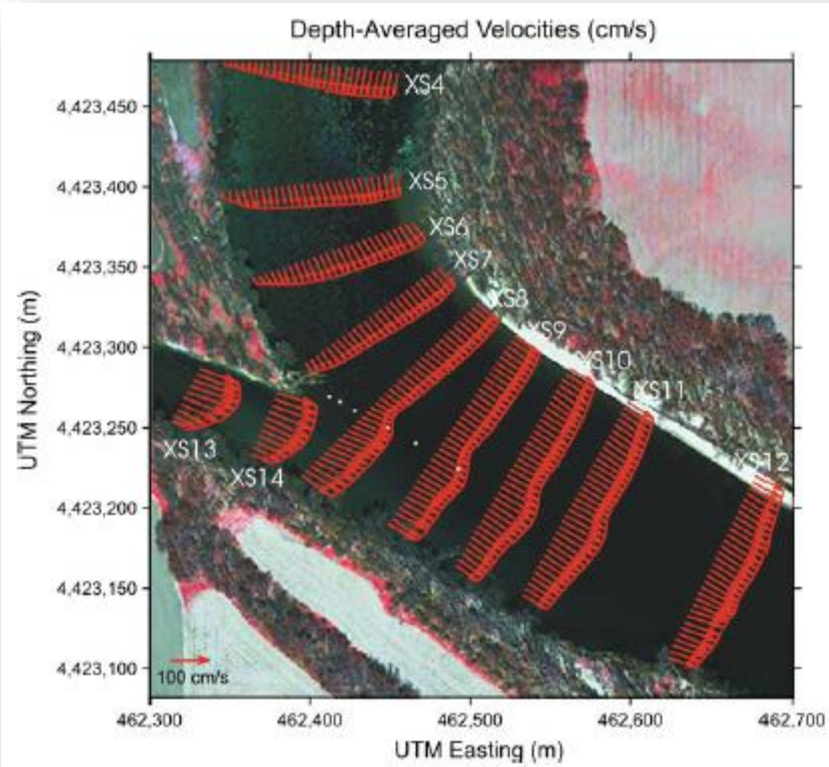
Untapped Potential?

- Every ADCP measurement contains high-resolution 3D velocity data
- Most ADCPs are only used for discharge



Schematic of a moving-boat acoustic Doppler current profiler measurement downstream from a levee breach on the Mississippi River near Cairo, Illinois. (Photo: Robert Holmes, USGS) (from Jackson, 2013, FS 2013-3028)

“Other” Data & the Velocity Mapping Toolbox



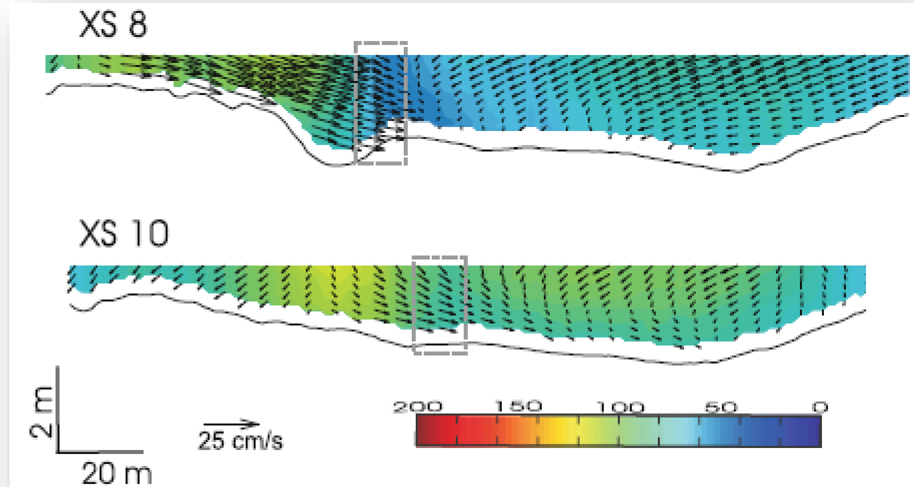
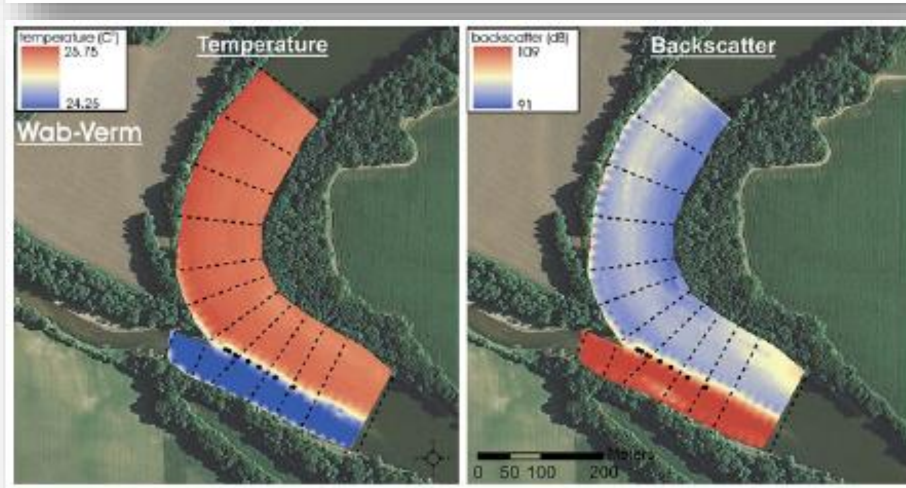


Fig. 15 Primary (contours) and secondary (vectors) velocity components using a zero net discharge frame of reference for cross sections at Wab–Verm confluence (looking upstream). *Grey boxes* indicates approximate locations of stationary ADCP within the mixing interface

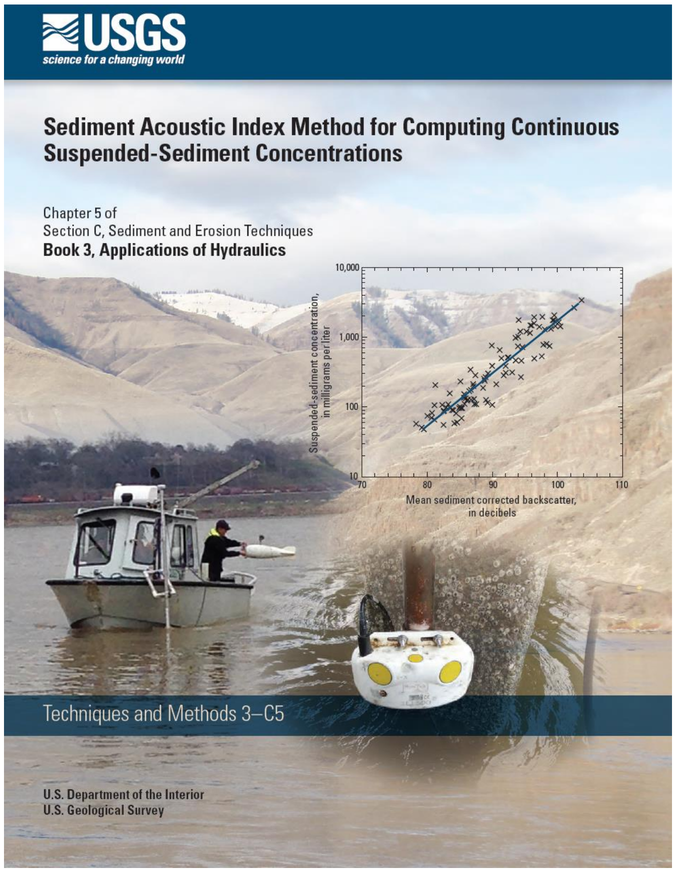


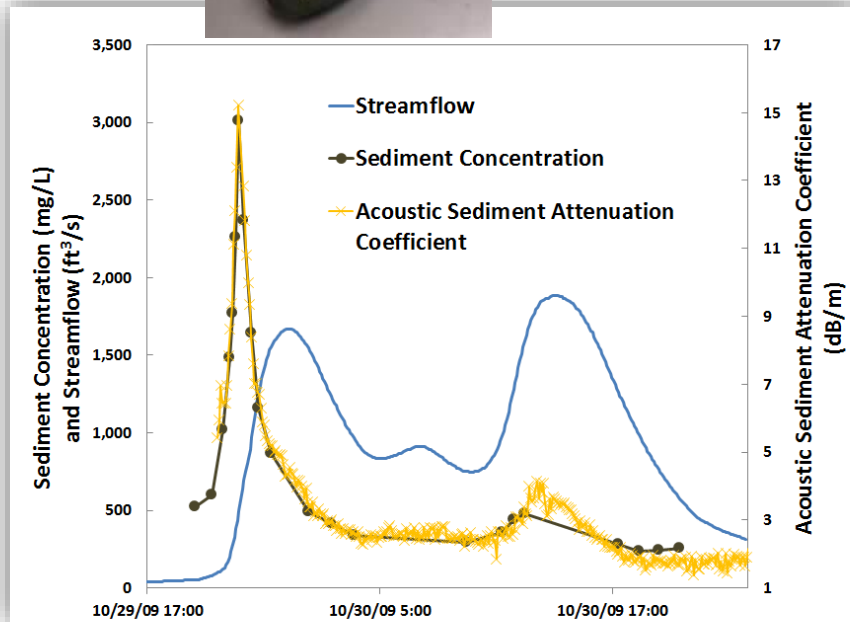
Velocity Mapping Toolbox (VMT): a processing and visualization suite for moving-vessel ADCP measurements https://doi.org/10.1002/esp.3367

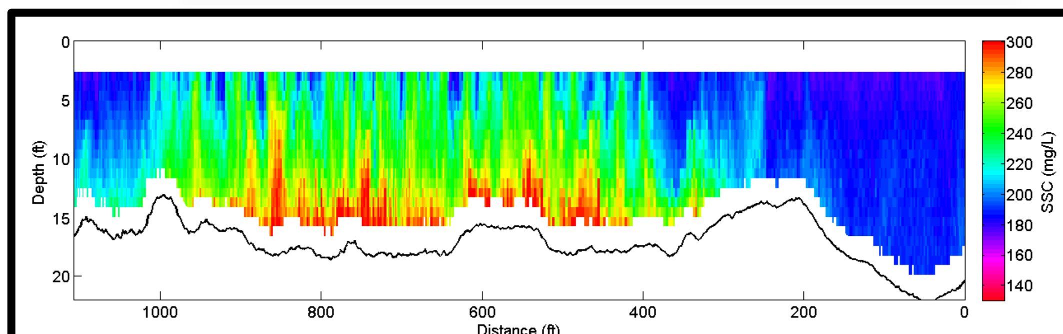
VMT software available at:
hydroacoustics.usgs.gov/movingboat/VMT/VMT.shtml

Konsoer, K. M., & Rhoads, B. L. (2011)

New Uses for “Old” Data: Sediment Acoustics

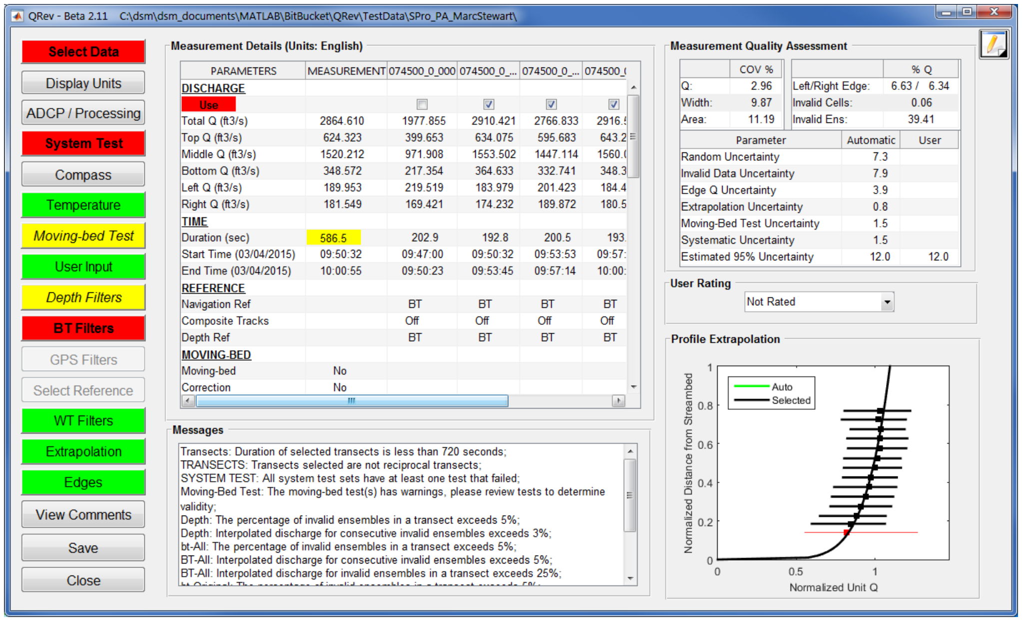






SSC

Develop New Tools: QRev Software



QRev is used by many agencies around the world for processing ADCP discharge measurement data.

- Manufacturer independent
- Improve efficiency of data review and ensure consistency
- Automate data screening algorithms, better data interpolation
- Automate data quality checks and feedback
- Assist user with uncertainty estimation
- Finalize Qm in the field

QRev User's Manual

https://hydroacoustics.usgs.gov/software/QRev_Users.pdf


Thanks for listening!
Thanks also to whoever shared this photo!

Questions?

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