ADCP (Acoustic Doppler Velocity Profiler) flow measurement is currently one of the most advanced river velocity and flow measurement equipment in the world. It uses the Doppler effect principle to measure flow velocity and helps hydrological departments to obtain river flow velocity and flow information online and in real time. By using ADCP, the departmemt can grasp the operation status and changing laws of rivers, provide reliable data for flood prevention and flood control decision-making, so as to minimize or avoid casualties and property losses caused by flood disasters, and ensure the safety of people's lives and property.

Application of iFlow RP600 ADCP in high Sand flow Measurement of Yellow River

Project Background

The Luokou Hydrological Station, located on the south bank of the Yellow River Embankment in Luokou Town, Jinan City, Shandong Province, has been monitoring and reporting water regimes for the National Defense General and the Yellow River General Defense all the year round, providing accurate hydrological data information for flood control and drought relief, water scheduling, engineering construction, and local economic development in the lower reaches of the Yellow River in Shandong. Due to the coming of the flood season, affected by the water and sediment regulation and scouring of the upper reaches of the Yellow River, the river water in the eastern section of the Yellow River has a large sediment concentration, and the flow rate and discharge increase, making the Luokou Hydrological Station always facing the problem of flow measurement in an environment with a large sediment concentration.

Pain Point Analysis

In the environment with large sediment concentration, the current meter and ADCP used in the Luokou hydrological station cannot be tested normally. The flow meter test takes a long time, which takes about 1 hour, and the test method is relatively complicated, and has high requirements for the test section. And the current meter is labor-intensive, requiring operators to drive the test boat for testing, and there are certain hidden dangers to personal safety. However, when ADCP faces a large sediment concentration, the transmitted acoustic signal will be quickly absorbed, and effective echoes cannot be obtained, resulting in the inability to measure bottom tracking information, making it difficult to obtain flow rate and flow data.

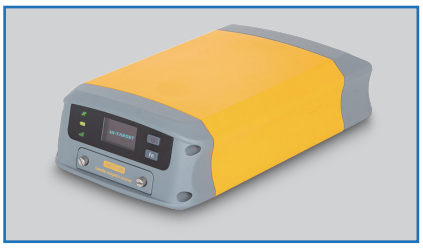
Implementation Program

Due to the harsh conditions of the high sediment concentration in the Yellow River, ADCP has no bottom tracking information and cannot be tested separately. Therefore, Hi-Target provided the solution of iFlow RP600 ADCP equipped with HD-MAX DF dual-frequency echo sounder and K20 high-precision split RTK.

In the scheme, the HD-MAX DF dual-frequency echo sounder is used to measure the water depth information to supplement the water depth parameters in the ADCP bottom tracking information, and the K20 high-precision split RTK is used to measure the speed to supplement the relative ground velocity of the equipment in the ADCP bottom tracking information. The measurement data of each device is output to the iFlow flow measurement software in real time through the matching software of both HD-MAX DF dual-frequency echo sounder and K20 high-precision split RTK, and integrated with the relative flow velocity information measured by iFlow RP600 ADCP, so as to calculate the flow and complete this ADCP flow measurement operation task.

HD-MAX DF dual frequency depth sounder FIG1

iFlow RP600 ADCP FIG2



K20 high precision split RTK FIG3

Workflow

1. Equipment installation

In order to reduce the measurement error caused by the distance between each device during the joint measurement, the iFlow RP600 ADCP is installed on the right front of the steel survey vessel in a sideways installation, the HD-MAX DF dual-frequency echo sounder is installed in front of the iFlow RP600 ADCP for narrowing the distance between the HD-MAX DF dual-frequency echo sounder and the iFlow RP600 ADCP, and the two positioning directional antennas of the K20 high-precision split RTK are installed directly above the fixed bracket of the iFlow RP600 ADCP. Meanwhile, to improve the accuracy and quality of the joint measurement, Hi-Target testers made a deviation correction of -4°between the antenna baseline of the K20 high-precision split RTK and the iFlow RP600 ADCP heading installation angle.

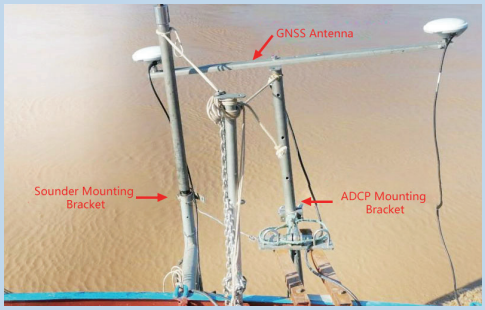
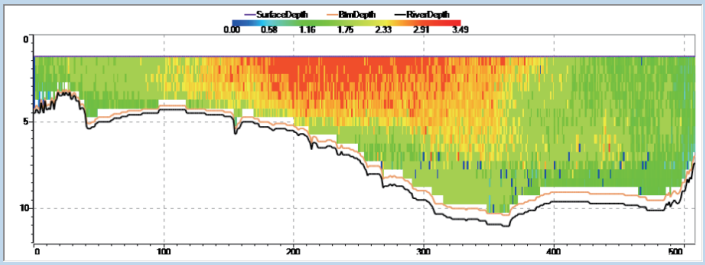


Diagram of equipment installation FIG4

Measurement Round	Course	Equipment Model	Measurement Time	Data File Name
1	Right	iFlow RP600 ADCP	15:48:44~16:02:28	154930_Right.PD0
2	Left		16:03:01~16:11:30	160347_Left.PD0
3	Right		16:16:45~16:29:42	161645_Right.PD0
4	Left		16:29:49~17:07:17	162949_Left.PD0

Two Course Data FIG5



Overall flow velocity profile of the Yellow River section at Luokou FIG6

2. Data collection

In this flow measurement, the iFlow RP600 ADCP performed 2 measurement rounds (a total of 4 and a half measurement rounds). The start time and recorded data files of each test are shown in the table on the right.

3. Data analysis

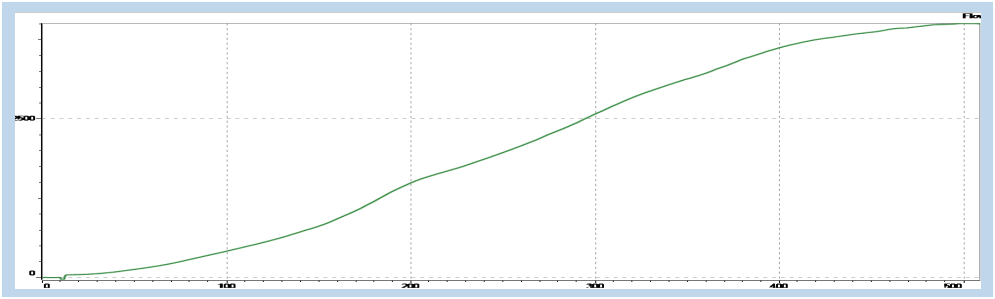
Based on the iFlow flow measurement software, various information such as the overall flow velocity profile of the test section of the Luokou section can be obtained.
Based on the iFlow flow measurement software, it is possible to obtain the flow, velocity, area, river width and other parameter values obtained from the current measurement of the cross-section and the statistical analysis and calculation of the data.

Selected Lines: 2 Pieces

All	MeasureName	StartEdge	Ensemble Number	StartTime	Total Discharge(m^3/s)	Total Area(m^2)	AverageDischarge(m/s)	FlowRate(m/s)	FlowDirection(°)	MaxFlowRate
☑	20-09-02 154930_Right	Right	825	2020-09-02 15:48:44	4015.045	1805.16	2.224	2.325	87.44	3.241
☑	20-09-02 160347_Left	Left	509	2020-09-02 16:03:01	3995.196	1813.01	2.204	2.177	84.95	3.192
	Average				4005.121	1809.082	2.214	2.251	86.20	3.217
	Standard Deviation				14.035	5.549	0.015	0.104	1.76	0.035
	Standard Deviation / Average				0.004	0.003	0.007	0.046	0.020	0.011

Statistical analysis table **FIG7**

Based on the iFlow flow measurement software, it is possible to obtain a schematic diagram of the curve of the measured flow of the entire section as a function of the measurement time, thereby clearly obtaining the trend of the flow change with time.



Time series chart of iFlow flow measurement software **FIG8**

Based on the iFlow flow measurement software, the flow velocity and echo intensity measured by the iFlow RP600 ADCP corresponding to the 4 beams at each measurement time can be obtained.
Based on the iFlow flow measurement software, the GNSS information corresponding to each burst time can be obtained.

Velocity Magnitude | Time sequence | Velocity Profile | Profile Table | **Time Sequence Table** | GNSS Table | Profile average table

PingNum	Time	Duration	WaterDepth	ValidCellNum	CurWaterVel	CurWaterDir	MeanWaterVel	MeanWaterDir	CurBoatVel	CurBo
1	16:03:01	0	4.50	0	---	---	0.000	0.00	---	---
2	16:03:02	1	4.30	5	1.634	73.13	1.634	73.13	0.058	317.
3	16:03:03	2	4.30	5	1.542	88.03	1.575	80.36	0.056	311.
4	16:03:04	3	4.50	6	1.200	83.73	1.434	81.42	0.057	297.
5	16:03:05	4	4.50	6	1.157	85.47	1.358	82.36	0.058	280.
6	16:03:06	5	3.90	4	1.458	100.19	1.364	85.25	0.061	268.
7	16:03:07	6	4.30	5	1.022	86.64	1.309	85.42	0.067	260.
8	16:03:08	7	4.50	6	1.262	81.77	1.301	84.85	0.062	250.
9	16:03:09	8	3.80	4	1.630	80.77	1.333	84.36	0.064	249.
10	16:03:10	9	4.30	4	1.396	78.28	1.338	83.80	0.056	242.
11	16:03:11	10	4.30	5	1.305	90.10	1.334	84.41	0.058	243.
12	16:03:12	11	4.20	5	1.217	95.23	1.321	85.32	0.067	237.
13	16:03:13	12	4.30	5	1.366	87.32	1.325	85.49	0.078	229.
14	16:03:14	13	3.80	4	1.799	81.68	1.354	85.17	0.086	223.
15	16:03:15	14	3.90	4	1.664	72.73	1.370	84.29	0.095	217.
16	16:03:16	15	4.30	5	1.376	82.75	1.371	84.18	0.096	216.
17	16:03:17	16	3.80	4	1.698	84.82	1.388	84.22	0.132	209.
18	16:03:18	17	3.70	4	1.598	85.67	1.398	84.31	0.148	209.
19	16:03:19	18	3.30	3	1.784	76.61	1.411	83.96	0.168	198.
20	16:03:20	19	3.50	4	1.771	74.93	1.427	83.45	0.165	194.
21	16:03:21	20	3.50	4	1.396	79.57	1.425	83.29	0.168	188.

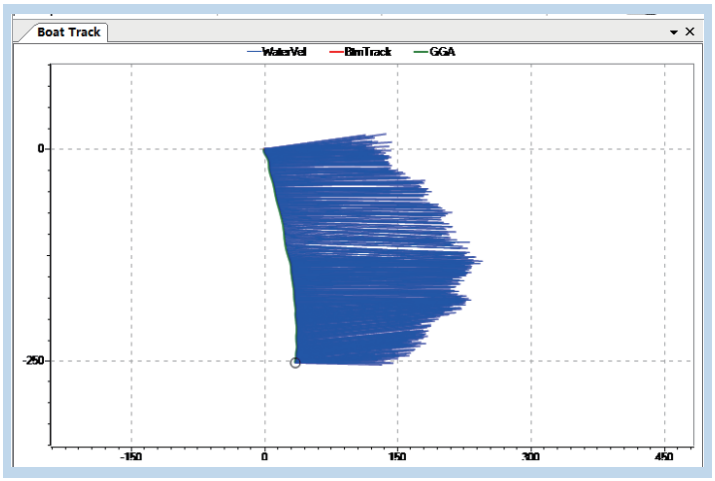
iFlow flow measurement software displays ADCP profile information **FIG9**

Velocity Magnitude | Time sequence | Velocity Profile | Profile Table | Time Sequence Table | GNSS Table | Profile average table

PingNum	UTC Time	Longitude	Latitude	Number of satellites	GNSSQuality	Altitude	GNDSpeed_kn	GNDSpeed_kmh	Heading
1	8:03:46	116:59:13.406	36:43:36.263	30	G_Q_Dif_co...	30.72	0.131	0.243	268.81
2	8:03:47	116:59:13.405	36:43:36.264	30	G_Q_Dif_co...	30.73	0.109	0.202	268.01
3	8:03:48	116:59:13.403	36:43:36.265	30	G_Q_Dif_co...	30.72	0.111	0.205	267.24
4	8:03:49	116:59:13.401	36:43:36.266	30	G_Q_Dif_co...	30.72	0.114	0.211	266.39
5	8:03:50	116:59:13.399	36:43:36.267	30	G_Q_Dif_co...	30.72	0.116	0.214	265.58
6	8:03:51	116:59:13.396	36:43:36.267	30	G_Q_Dif_co...	30.71	0.126	0.233	264.64
7	8:03:52	116:59:13.394	36:43:36.266	30	G_Q_Dif_co...	30.71	0.134	0.248	263.80
8	8:03:53	116:59:13.391	36:43:36.266	30	G_Q_Dif_co...	30.71	0.124	0.230	262.69
9	8:03:54	116:59:13.389	36:43:36.265	30	G_Q_Dif_co...	30.70	0.124	0.230	261.82
10	8:03:55	116:59:13.387	36:43:36.264	30	G_Q_Dif_co...	30.71	0.108	0.201	261.11
11	8:03:56	116:59:13.385	36:43:36.263	30	G_Q_Dif_co...	30.70	0.117	0.217	260.42
12	8:03:57	116:59:13.382	36:43:36.262	30	G_Q_Dif_co...	30.70	0.137	0.254	259.88
13	8:03:58	116:59:13.380	36:43:36.260	30	G_Q_Dif_co...	30.69	0.160	0.297	259.06
14	8:03:59	116:59:13.378	36:43:36.258	30	G_Q_Dif_co...	30.69	0.172	0.319	258.32
15	8:04:00	116:59:13.375	36:43:36.256	30	G_Q_Dif_co...	30.69	0.197	0.364	257.73
16	8:04:01	116:59:13.373	36:43:36.253	30	G_Q_Dif_co...	30.67	0.195	0.361	256.87
17	8:04:02	116:59:13.370	36:43:36.250	30	G_Q_Dif_co...	30.68	0.292	0.541	255.93
18	8:04:03	116:59:13.367	36:43:36.245	30	G_Q_Dif_co...	30.66	0.288	0.533	254.81
19	8:04:04	116:59:13.365	36:43:36.240	30	G_Q_Dif_co...	30.67	0.335	0.619	253.32

GNSS information sheet FIG10

Based on the iFlow flow measurement software, the current track trajectory line of the steel measurement vessel and the corresponding flow velocity vector can be obtained.



Steel survey boat track and flow vector FIG11

Based on the iFlow flow measurement software, the flow result table can be automatically generated, and the configuration information of the current measurement, flow parameter measurement results and measurement average results can be automatically recorded.

Luokou Acoustic Doppler Current Profiler Discharge Record Form

Date: 9月2日	Year:	Wheather:		Wind power and direction:	
Measurement Times:		Survey Boat:		Computer Name:	LAPTOP-DM1HHCKE
Start Time:	15:48	End Time:	9/4/2020 16:11:46 AM	Average Time:	9/4/2020 16:00:40 AM
ADCP Model:	iFlow RP600	Firmware Version:		Software Version:	iFlow V3.3.1
GNSS Model:		Compass Model:		Echo Sounder:	
Data File Path:	C:\Users\86134\Desktop\zbd\Flow Measurement Data\Data		Configuration File Name:	Discharge Measurement Data	
Transducer Depth:	0.50 m	Blanking Distance:	0.50	Depth Cell Size:	0.50
Salinity:	0	Water tracking ping number:	3	Bottom tracking ping number:	0
				Number of Depth Cell:	60
				Exponent: b	0.1667

Measurement Round	Course	Shore Distance(m) L	Shore Distance(m) R	Data File Name	Half round Q(m^3/s)	Average Q of one whole round(m^3/s)	Remarks
1	Right	3.00	10.00	20-09-02 110530_Right	4020	4010	
	Left	10.0	10.00	20-09-04 111351_Left	4000		
2							

Measurement Result

Measurement Item	Measuring Round 1 Forward measurement	Measuring Round 1 Back measurement	Measuring Round 2 Forward measurement	Measuring Round 2 Back measurement	Measuring Round 3 Forward measurement	Measuring Round 3 Back measurement	Average of Rounds
Cross-sectional Q (m^3/s)	4020	4000					4010
Cross-sectional Area(m^2)	1810	1810					1810
Average Current Velocity(m/s)	2.22	2.21					2.22
Maximum Current Velocity(m/s)	3.24	3.19					3.24
Average Water Depth(m)	6.8	6.6					6.7
Maximum Water Depth(m)	11.1	11					11.1
Water Surface Width(m)	265	274					269

Water level at the beginning: m	Water level at the end: m	Average Water Level: m	Corresponding Water Level: m
Remarks:			
Operation Record:	On Site Review:		Approved:

iFlow RP600 ADCP flow results table FIG12

Result

The maximum relative deviation of the 4 half measurement rounds of the iFlow RP600 ADCP is 2.12%, and the self-deviation (standard deviation) of the cross-section average flow velocity, flow direction, river width and cross-sectional area parameters are all between 0.6% and 2.7%, meeting the measurement specifications accuracy requirements, and achieve high test accuracy. Among them, the relative deviation between the average flow rate measured by the iFlow RP600 ADCP and the flow rate at the Luokou Hydrological Station released by the official forecast of the day is 1.01%. It can be concluded that the data measured by iFlow RP600 ADCP under the condition of relatively large sediment concentration has high precision and accuracy, and this joint test has been a complete success.

Measurement Round	Flow rate	Average flow rate	Average flow direction	River width	Cross-sectional area
1	4020	2.22	87.5	265	1810
2	4000	2.21	84.9	274	1810
3	3960	2.16	86.5	268	1830
4	4100	2.28	85.7	268	1800
Average	4020	2.22	86.2	269	1810
Standard deviation	62.081	0.061	1.10	3.70	11.395
Average /Standard deviation	0.015	0.027	0.013	0.014	0.006

iFlow RP ADCP Flow Test Results **FIG13**

Project Summary

The joint test conducted by Luokou hydrological station and Hi-Target shows that the joint use of Hi-Target iFlow RP600 ADCP, HD-MAX DF dual frequency sounder and K20 high precision split RTK can overcome the influence of the harsh conditions of large sand content and complete the measurement task of ADCP, which provides more means and methods to measure the flow in the environment of the Yellow River with large sand content.

The quiz also demonstrated the excellent performance of the iFlow RP600 ADCP in terms of peripheral expansion, installation and commissioning, support software, and flow measurement results.

In terms of peripheral expansion, iFlow RP600 ADCP can be used for ADCP flow calculation by inputting other peripheral parameters reasonably according to demand, and the device has good peripheral compatibility.

For installation and commissioning, the installation and commissioning process of iFlow RP600 type ADCP is convenient and quick, and the connection with HD-MAX DF dual frequency echo sounder and K20 high precision split RTK is reliable and can be used in environments with large sand concentrations.

For the supporting software, the iFlow flow measurement software can present a wealth of measurement information during the testing process and the data analysis process after the measurement is completed, and has a good user experience.

For the flow measurement results, the self-deviation (standard deviation) of the data such as flow, flow velocity, bottom velocity, and cross-sectional area measured by the iFlow RP600 ADCP is within 2.7%, and the measurement accuracy meets the requirements of the ADCP flow inspection specification.

More information at https://en.hi-target.com.cn/become-our-partner/

About Hi-Target

Established in 1999, Hi-Target is the first professional high-precision surveying and mapping instrument brand to be successfully listed in China.

Hi-Target provides a wide range of surveying equipment including GNSS receivers, CORS stations, Total Stations, 3D Laser Scanners, GIS Data Collectors, UAV/UAS, and Hydrographic products to offer complete commercial solutions for various industries.

As the leading brand in the geospatial industry, Hi-Target invests heavily in research and development, on top of collaborating with more than 100 universities globally to bring the latest positioning technology and innovation for product development.

For over 20 years, Hi-Target has approximately 2,500+ employees worldwide, with an established network of 20+ subsidiaries, 28 branches and more than 200 partners in 100+ countries / regions to service and support our customers.

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