Project to Refine a Prototype Unmanned, Tethered ADCP Platform for Measuring Streamflow

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The Indiana District office developed a prototype tethered platform for making ADCP measurements from bridges and other structures.This prototype has been used successfully by a number of USGS district offices. The Kentucky District office also had developed a remote-controlled boat for conducting bridge-scour investigations. The Texas District office and the Corps of Engineers built remote-controlled boats based on the Kentucky design. Both of these platforms have invited much interest in the USGS because of the potential they offer in reducing exposure to hazards, particularly during streamgaging activities.

At the request of the USGS Chief Hydrologist, the Office of Surface Water Hydroacoustics Workgroup prepared a proposal for refining the design of the tethered and remote boats. This proposal was submitted to the USGS Instrumentation Committee (ICOM) and was funded.

The primary objective of the project is to develop and test designs for tethered and remote-controlled boats for increasing safety during streamgaging activities. The project included the following major tasks:

- develop specifications based on a survey of user needs;
- investigate various models of radio modems for wireless data telemetry;
- investigate commercial availability of boat hulls;
- test and evaluate prototype hulls;
- make designs available to USGS district offices.

Development of Specifications:

A written survey of user needs was sent to all USGS district offices and to other federal agencies known to use ADCP's. The survey asked users to specify desired features such as maximum boat length and weight.

Based on the 30 responses received, the following specifications were developed for a tethered platform:

- maximum weight with payload: 40 pounds;
- maximum length: 5 feet; maximum beam: 3 feet;
- maximum water velocity of rivers where the platform would be used: 12 feet per second;
- minimum acceptable time between battery replacement or recharge: 2 hours.

Investigation of various models of radio modems for wireless data telemetry:

To safely and efficiently acquire ADCP data from a tethered platform, data needed to be wirelessly transmitted from the ADCP to a laptop computer. It had previously been determined that a 900-MHz spread spectrum data modem could be used for this purpose. Approval from the USGS Water Resources Division radio liaison was obtained to use radios operating in the 900-MHz frequency range if the radios are license free under Part 15 of the FCC code. To use a licensed frequency in a government band will probably take 2 years (1 year for radio certification and 1 year for frequency assignment). However, the method used in initializing communication between the acquisition software and the ADCP caused limited compatibility with most wireless modems. After the problem was discussed with the manufacturer of the ADCP (RD Instruments), an alternate initialization method was implemented in the latest versions of Rio Grande firmware (10.07 and greater) and latest version of data-acquisition software (WinRiver 10.00).

A list of desired features then was developed for the radio modems. The desired features included

- reliably communicate with the ADCP, using the ADCP data-acquisition software provided by the manufacturer;

- have rugged, environmental housing;
- operate on 12-volt DC power; and,
- have 115,200-baud data-communication capability with the ADCP to maximize data throughput.

For a complete list of modems tested and for information on using radio modems with ADCP's, please see Use of Radio Modems with Acoustic Doppler Current Profilers.

Currently, the Freewave Model DGR-115 is the only modem tested that has met all of the desired specifications. More modems may be evaluated as they are made available for testing.

Investigation and testing of hull designs:

A review of possible off-the-shelf products that could easily be modified to meet the specifications was completed. Boat-builder literature, marine-supply catalogs, and the Internet were used in the literature search for off-the-shelf products. The research resulted in the purchase of a small, plastic catamaran designed to float a single person. The catamaran was modified for use with an ADCP and tested.

Hobie Floatcat modified for use with Rio Grande ADCP.

Discharge measurements in the field were completed to test this platform. The field tests revealed some major deficiencies: the platform exceeded the design-specification weight limit; the platform was difficult to control in the water; and the platform did not readily orient itself with the flow. These operational deficiencies were primarily a result of trying to apply a product designed for slow propulsion on a lake to use in faster river velocities. Recognizing these deficiencies led to having hulls built specifically for the tethered-platform application.

Private vendors were commissioned to construct prototype hulls specifically designed for making ADCP discharge measurements. The hulls acquired from the vendors for testing included two catamaran designs, two mono-hull designs, and three trimaran designs. The hull testing included tow-tank tests preformed at the USGS Hydraulics Laboratory at Stennis Space Center and field tests in which the platforms were used to make ADCP discharge measurements over varying flow conditions.

Field tests of the platforms included testing below a U.S. Army Corps of Engineers (USACE) Reservoir. The USACE increased the release of water from the reservoir during the testing to create higher flow conditions with velocities up to 7 ft/sec. During these tests, each platform was fitted with an RD Instruments Rio Grande ADCP and wireless 900-MHz spread spectrum modems. ADCP data were acquired using RD Instruments WinRiver software.

Field testing some platforms.

For the tow-tank tests, each platform tested was fitted with an RD Instruments Rio Grande ADCP and towed the length of the tank at varying speeds. Drag was measured for each platform with a strain-gage meter, which measured the force on the towrope. The drag each platform produced while being towed was recorded. The platforms were towed through the tank at speeds varying from 1 to 12 ft/sec to simulate the desired flow rates in which the platform might be used. During some of the tow-tank tests, wireless 900-MHz spread spectrum modems were used to acquire ADCP data that included the pitch and roll of the ADCP.

Platforms ready for testing at the USGS Hydraulics Lab.

Table 1
. Results of platform drag test in pounds [ft/sec, feet/second; N/A, not available]

Velocity (ft/sec)	Catamaran #1	Catamaran #2	Catamaran #3	Trimaran #1	Trimran #2	Trimaran #3	Monohull #1	Monohull #2
2	1.4	2.3	1.6	0.6	0.9	0.6	0.9	0.9
4	3.8	4.9	5.9	2.7	2.6	1.5	3.5	2.1
6	14.6	11.3	14.6	7.2	8.3	3.6	12.4	5.2
8	18.0	14.8	N/A	9.3	10.9	4.5	19.5	N/A
10	24.3	24	27.3	N/A	13.5	6.6	N/A	7.3
12	33.2	29.5	N/A	N/A	16.9	8.9	29.4	9.2

Brief description of platforms tested:

Catamaran #1 is the original prototype catamaran platform as designed by the Indiana District office. This platform is constructed of polystyrene-foam floats built from a composite of several layers of 2-inch-thick standard insulation cut into a semi-vee shape.

Catamaran #2 is a catamaran platform built by Wanamaker Pontoon and Paddle Company. This platform is constructed

of molded ABS plastic and is close in size and hull shape to the original prototype platform (Catamaran #1).

Catamaran #3 is a catamaran platform built by The OceanScience Group. This platform is constructed of shaped foam covered in a thin layer of fiberglass.

The OceanScience Group built all three trimaran platforms. All of the trimarans had large center hulls with small outriggers. The same outriggers were used on all three platforms. The outriggers were constructed of molded fiberglass. The center hull for Trimaran #1 was constructed of shaped foam covered in a thin layer of fiberglass. The fore and aft of this hull were symmetrical, coming to a thin edge at the ends of the hull. The center hull for Trimaran #2 was constructed of molded fiberglass and had more of a wedge or triangle shape. Trimaran #3's center hull was constructed of molded fiberglass and was longer than the center hull of Trimaran #2.

Mono-hull #1 was a single-hull platform built by Kann Marine. The platform was constructed of aluminum and had a flat-bottom-hull design with three fins on the bottom of the hull for added directional stability.

Mono-hull #2 was a single-hull platform built by The OceanScience Group. This platform was constructed of fiberglass with a vee-shaped-hull design and two fins on the bottom of the hull for added directional stability.

Summary of test results:

The results of the testing indicate that while any of the designs could be used under certain conditions, the best all-around performance under a range of conditions resulted from the trimaran designs.

The ADCP was mounted in the hull of the mono-hull platforms. The vee-shaped mono-hull platform (Mono-hull #2) performed well in the drag test (Table 1) but stability results were less than optimal. Both mono-hull platforms had more erratic motion and were more sensitive to flow disturbances or turbulence in the water than the other platform designs.

The ADCP was mounted between the two hulls of the catamaran platforms. A higher drag resulted at higher velocities when compared to the mono-hull designs (Table 1) because of the shape of the ADCP. The catamaran platforms were more stable than the mono-hull platforms.

The ADCP was mounted in the center hull of the trimaran platforms. The trimaran platforms had lower drag while still retaining the stability of the catamaran designs (Table 1). The trimaran's advantage is realized by combining the drag efficiency gained by placing the ADCP in a hull with two outer hulls that give added stability. Placing the ADCP in a hull also has the observed advantage of lowering the flow disturbance around the head of the ADCP.

Current testing and evaluation has focused on platforms with an RD Instruments profiler because 95 percent of the profilers in use by USGS for streamgaging are RD Instruments units. Sontek also manufactures an acoustic Doppler profiler (ADP) designed to make moving-boat discharge measurements. Similar results are expected with the Sontek units when used with the tested platforms, except that the overall drag may be less for the smaller size ADP's. If funding is available, additional testing of such units may be done.

Also, it is recognized that other brands or models of river-discharge-measurement devices that can use a tethered platform may become available. Current tethered-platform designs may need slight modifications in order to be used with new devices, or new tethered-platform designs may be more desirable.

Platforms available for purchasing:

The OceanScience Group, the manufacturer of the three trimaran platforms tested, has indicated that they will begin production of a fiberglass trimaran platform by the first quarter of 2001. This platform will be based upon the trimaran prototypes tested and specifically will be designed for use as a tethered platform for use with a Rio Grande ADCP. The center hull of the trimaran will have access ports where a wireless modem and a 12-volt battery used for powering the ADCP and the modem will be housed. OceanScience Tethered Boat Pictures.

Wanamaker Pontoon and Paddle Company, the manufacturer of Catamaran #2, has indicated that they are beginning production of a molded ABS plastic catamaran platform. This platform will be based upon the design tested and specifically will be designed for use with a Rio Grande ADCP. The two hulls will have access ports where a wireless

modem and a 12-volt battery used for powering the ADCP and modem will be housed. While the catamaran design has higher drag, it should prove to be a good low-cost alternative for use in conditions with velocities below 6 ft/sec.

Sontek offers a catamaran system designed for use with their Mini-ADP. This package includes an aluminum catamaran-type platform and wireless modems. The Sontek platform has not yet been tested as part of this project.

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