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Autonomous Collection of River Parameters Using Drifting Buoys

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Abstract - QinetiQ North America Technology Solutions Group's (QNA) has developed a Lagrangian Riverine Drifter for remote, autonomous collection and transmission of real-time surface velocities and water depth. A discussion of the design and results achieved during deployment of the QNA Riverine Drifter in are provided. Testing was conducted by QNA, the Naval Postgraduate School (NPS) and the University of Southern Mississippi in the West Pearl river in Louisiana, Kootenai River in Idaho and Klamath river in California, Black and Okatoma creeks in Mississippi.

I. Introduction

The physical characteristics of a river are complex, owing to unpredictable snowmelt, precipitation, and wind conditions. River depth, flow rate and course are influenced by such environmental factors. The QNA riverine drifter measures the surface velocity and water depth as a function of position and transmits the data via satellite in near real-time, approximately every three (3) minutes. The drifters collect data at a programmable rate and are able to provide high temporal and spatial resolution data which are essential for military scientific community and commercial groups interested in planning operations, monitoring and modeling river behavior. The objective is to create a lightweight, autonomous, expendable drifting buoy capable of obtaining river measurements and providing up-to-date information on the existing conditions.

II. Drifters

The QNA riverine drifter, shown in Fig. 1, is 15 cm in diameter and contains the following components: GPS receiver, satellite (Iridium) modem and blue tooth communications, depth sounder with temperature transducer, battery pack, dual axis accelerometer and a Gumstix processor running a Linux operating system. The drifter floats low in the water to minimize the profile above the water to reduce exposure and movement of the drifter due to the influence of wind. The drifter weighs approximately 1.8 kg and is easily transported and deployed. Upon removal of the power switch, the drifter performs a self-test. The successful completion of the self-test is indicated by an LED indication. The QNA drifter hosts a web-page that may be accessed via blue tooth to display near real-time data. The short range communications is disabled after a period of time to conserve battery life and data are then broadcast via the Iridium modem. Fig. 2 shows the QNA drifters deployed in the West Pearl river in Louisiana.

Fig. 1 QNA Riverine Drifter

Fig. 2 QNA Riverine Drifters floating in the West Pearl River

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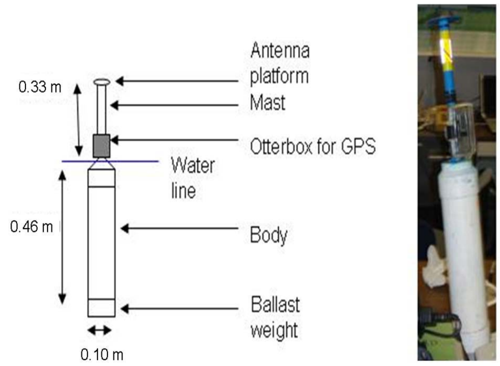

Fig. 3 Schematic of NPS GPS Equipped Drifter

The Naval Postgraduate School (NPS) has developed and demonstrated a low-cost GPS-equipped drifter which consists of a ballasted, subaqueous 0.46m long by 0.10 m diameter PVC central tube connected to a 0.33 m long antenna mast made of a 0.03 m diameter PVC tube, Fig. 3. A hand-held GPS is protected by a wate-proof plastic box attached to the drifter at the waterline. The complete drifter weighs 3.6 kg. The NPS drifters measure position which is then stored on an internal drive [1] since the drifters do not have any satellite or short range communications capabilities. Data are downloaded and processed once the drifters are retrieved.

The QNA and NPS drifters were tested in conjunction on the Kootenai and Idaho rivers in August on 2009. Fig. 4 shows the QNA drifters (pink balls) and the NPS drifters (pink rods) deployed on the Kootenai River.

The spherical shape of the QNA drifter allows the drifter to reduce snags caused by twigs and branches which may lie beneath the water surface. During testing, the QNA drifters demonstrated the ability to roll off tree limbs or duck underneath the limbs when the current provided enough force on the drifter. Future tests are planned in August of 2010 using multiple QNA and NPS drifters, as well as an Acoustic Doppler Current Profiler (ADCP).

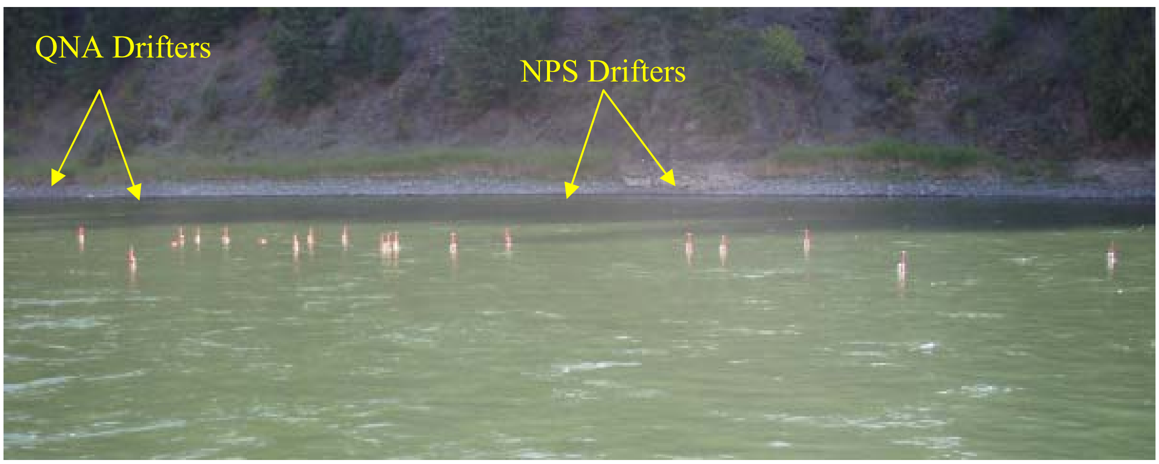

Fig. 4 Picture of river drifter deployment on the Kootenai River. QNA Drifters are pink balls and NPS drifters are pink rods. [1]

III. DRIFTER TESTING

A. West Pearl River Deployment

The QNA drifters were deployed during a set of two tests during July and August of 2009 for three days each, for a total of six days of data collection. The test results from the July deployments are discussed in [2]; a combination of the results from the July and August are presented herein. Five (5) riverine drifters were utilized for testing. In addition, a commercial fishfinder with a depth sounder, temperature sensor and GPS was attached to the support boat to provide ground truth data. The drifters were deployed on two reaches of the West Pearl River. The initial deployment of the drifters was in a wide, slow moving section of the river. The test team decided to move to a more southern reach of the river, where the river was narrower and the current was moving faster. The swifter current made the drifters less susceptible to dead-zones the river. The West Pearl River was approximately 0.48 km wide where the testing was performed. The longest continuous drift trail of a QNA drifter without repositioning was approximately 11 km. The commercial fishfinder data were recorded automatically on a computer which was located on one of the boats during testing. When the commercial fishfinder was utilized, one of the QNA drifters was tied in close proximity in order to collect data over a similar drift pattern. Table 1 depicts which drifters were allowed to float freely, marked by an "X", and which drifter was tied to the boat for comparison with the commercial fishfinder data.

Table 1: Drifter Usage by Test Day

	QNA Drifter Serial Number				
Date	**001**	**002**	**003**	**004**	**005**
July 14	**X**	**X**		**X**	**X**
July 15	**X**		**X**	**X**	Tied to Boat
July 16	**X**	Tied to Boat	**X**	**X**	**X**
August 3		**X**	**X**	**X**	**X**
August 5	**X**	**X**	**X**	**X**	
August 6	Tied to Boat	**X**	**X**	**X**	

The QNA Drifters performed well throughout testing. They quickly attained a GPS fix and began taking data without any issues. The Riverine Drifters were deployed randomly near the center of the river, as well as dispersed laterally across the river. The exhibited drift patterns are shown for two reaches in Fig. 5. The drifters floated together, then would drift apart, and then come back together again. At times, it was observed that drifters that were deployed in close proximity would travel the opposite sides of the river. The test data recorded demonstrate a range of drift patterns that are dependent on the river parameters.

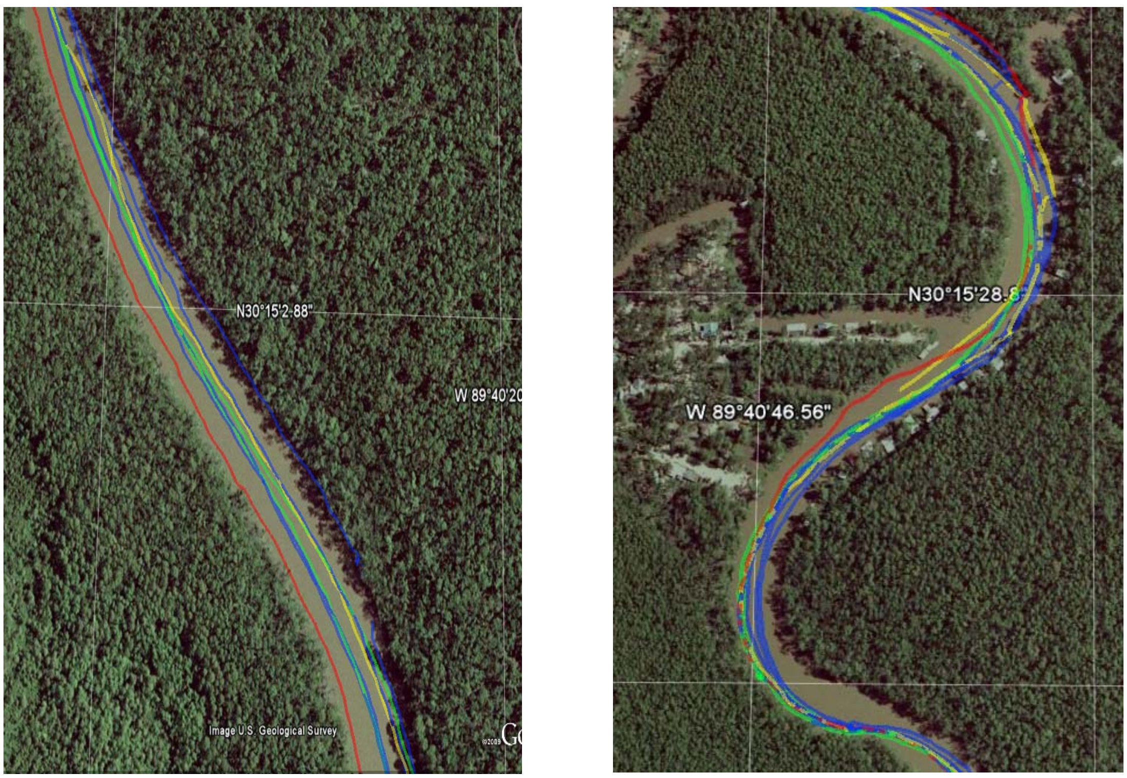

Fig. 5 Riverine Drifter Patterns over Six (6) Days Testing in West Pearl River

Several times during the course of the testing the drifters would become snagged on a limb or tree and, given enough time, they would be able to roll their way back into the main river current. It was observed that if there was sufficient current, the drifters were able to continue progress down stream after being snagged. In conditions where the drifter became entrapped in an eddy, or in the Y of a tree limb, the drifters were unable to become free moving again. During the first three days of testing, the drifters were only repositioned if they were stopped and it did not appear that they would be able to make any additional progress. During the second three days of testing, if the drifters appeared to be moving toward a location where the test team would not be able to retrieve them, the drifters were retrieved and redeployed. The likelihood of the drifters being trapped or stalled is diminished by a substantial river current. Table 2 shows the number of times that the drifters were manually repositioned during the tests. When the drifters were repositioned, they were redeployed at the center of the river.

Table 2: Times the Drifters were Redeployed

	QNA Drifter Serial Number				
Date	**001**	**002**	**003**	**004**	**005**
July 14	**X**	**X**		**X**	**X**
July 15	**1**		**2**	**0**	Tied to Boat
July 16	**X**	Tied to Boat	**X**	**X**	**X**
August 3		**1**	**1**	**2**	**1**
August 5	**2**	**2**	**2**	**3**	
August 6	Tied to Boat	**3**	**1**	**4**	

Fig. 6 shows a plot of the depth recorded by the QNA Riverine Drifter attached to the boat plotted with the data collected from the commercial fishfinder data, labeled "hum", with respect to position. Fig. 7 shows the depths as a function of position for the August 6th test using the data from three (3) drifters.

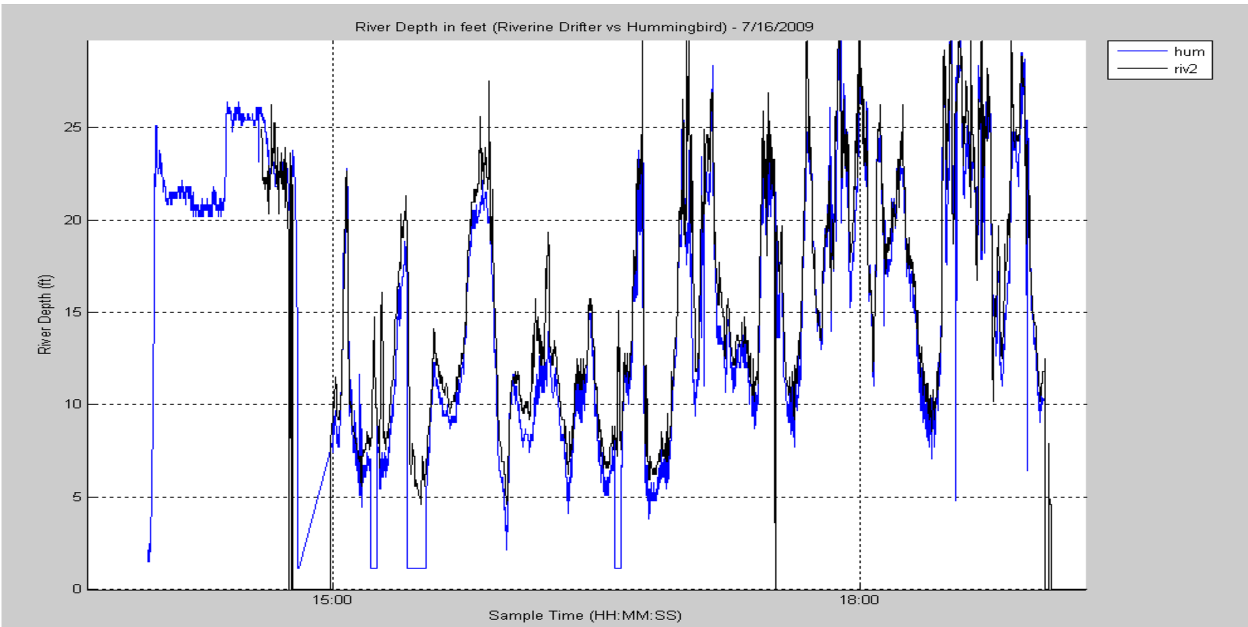

Fig. 6 Riverine Drifter Data compared to the commercial depth sounder depths show close correlation

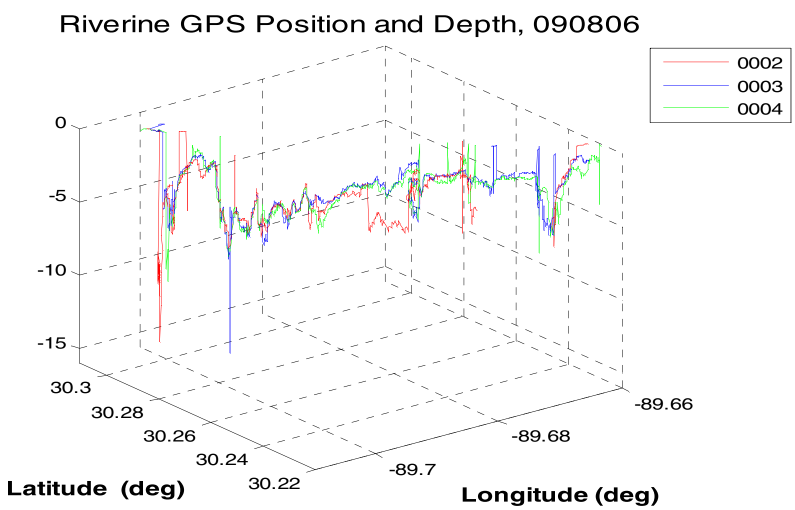

Fig. 7 Riverine drifter depth vs position for three drifters

The current speed calculated by the drifter based on GPS positions appears to be consistent with the data recorded by the commercial GPS utilized during the tests. The commercial GPS was located on the test boat which was floating unpowered down the river. The river current for the West Pearl River averaged 0.75 – 1.75 knots on the days which testing was performed. Fig. 8 shows the recorded current speeds from the four (4) QNA drifters deployed on August 6, 2009.

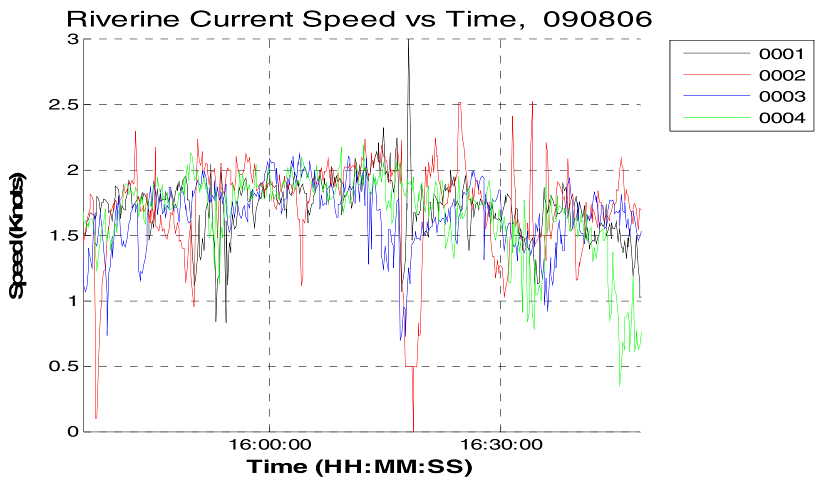

Fig. 8 QNA Riverine Drifter Current Speeds for four (4) drifters along the West Pearl River

B. Black Creek Deployment

In cooperation with the University of Southern Mississippi, one (1) QNA Drifter was provided for deployments in the Black Creek (Camp Dantzler to Brooklyn, MS) and twice in the Okatoma Creek (Seminary to Sanford, MS). In all three instances the rivers were at flood stage. The fast water condition of the creeks enabled the drifters to float continuously down stream, free from snags and eddies. The drifter has a tendency to follow the fastest current thread and will therefore attempt to stay in the thalweg (the deepest part of the river) for most of the time. The drifter became trapped in some back eddies and in log jams, but in most instances was able to free itself or was retrieved with a little effort. Fig. 9 below shows the GPS location data plotted as a KML file on Google Earth. The drifter traveled more than 13 km on the Black Creek and collected data over a period of 6.5 hours. The average river depth for the reach of the Black River was 1.75 m and the drifter speed had a mean of 1.56 knots as shown in Fig. 10. The recorded depths and speeds for the Black Creek reach are shown in Fig. 11.

Fig. 9: Drifter location during the Black Creek deployment.

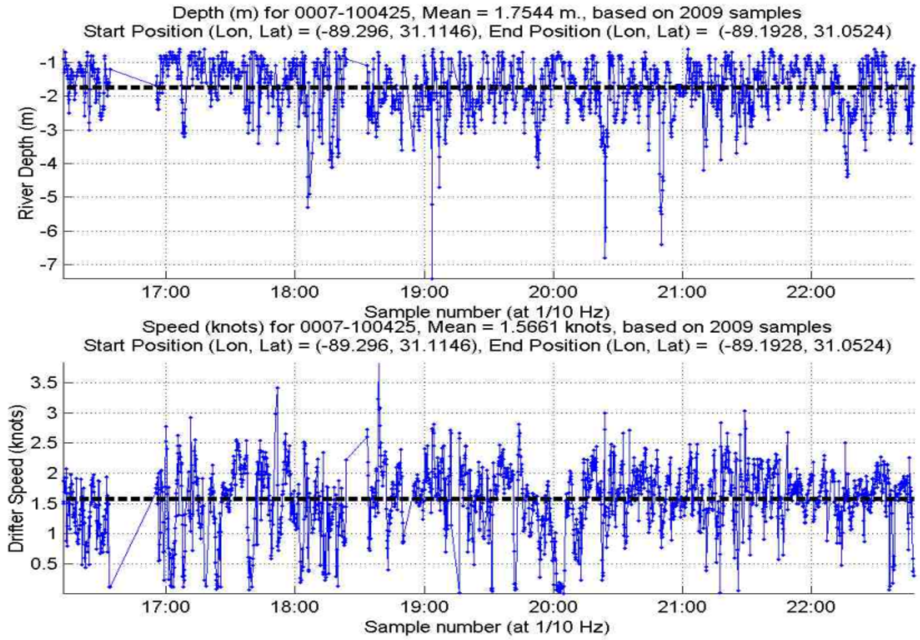

Fig. 10 River depth and speed with calculated mean collected over 13km of Black Creek

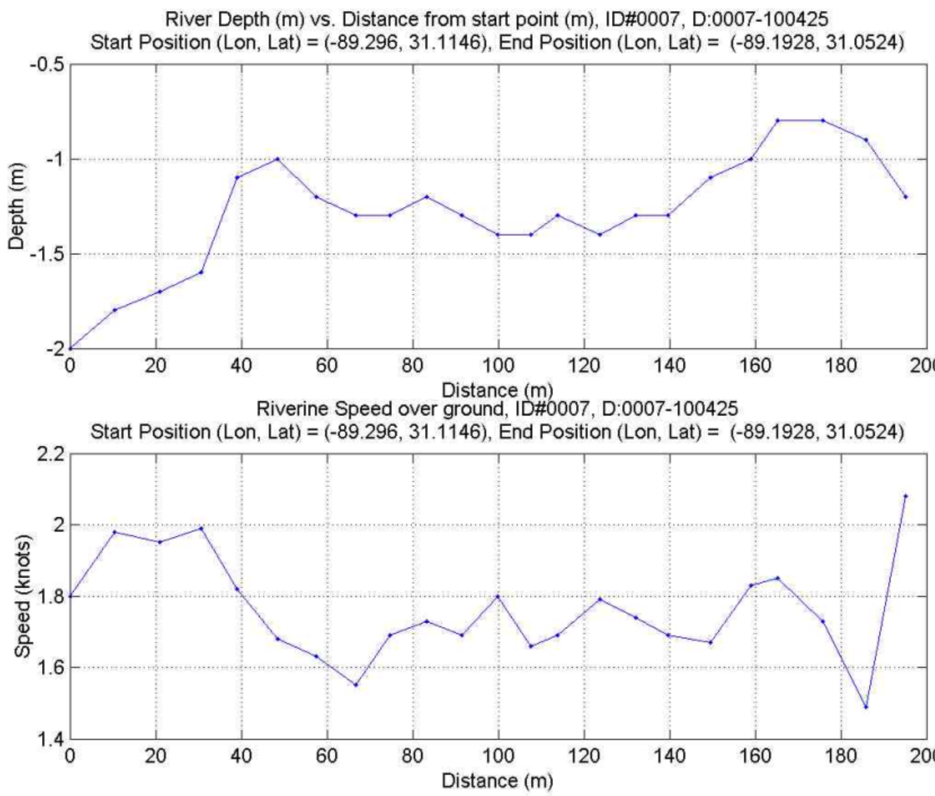

Fig. 11 Subset of the river depth and speed collected during the Black Creek deployment.

IV. CONCLUSION

The QNA Riverine Drifter provides a low-cost, easy-to-use tool for the scientific and other communities to remotely gain access and insight into the dynamic features of riverine environments. The information discerned from the drifter data can be used to provide a better understanding of parameters which can lead to significant and/or sudden changes in a river's morphology, current and/or course. The preliminary test results indicate that the Riverine Drifter is capable of floating freely in a river current and is capable of accurately collecting and transmitting data worldwide via satellite communications. The drifter datasets will prove useful for a variety of end users, including the Army Corps of Engineers, local area water districts, academic researchers, and military operational forces.

REFERENCES

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