Drone-based Bathymetric Mapping Platform

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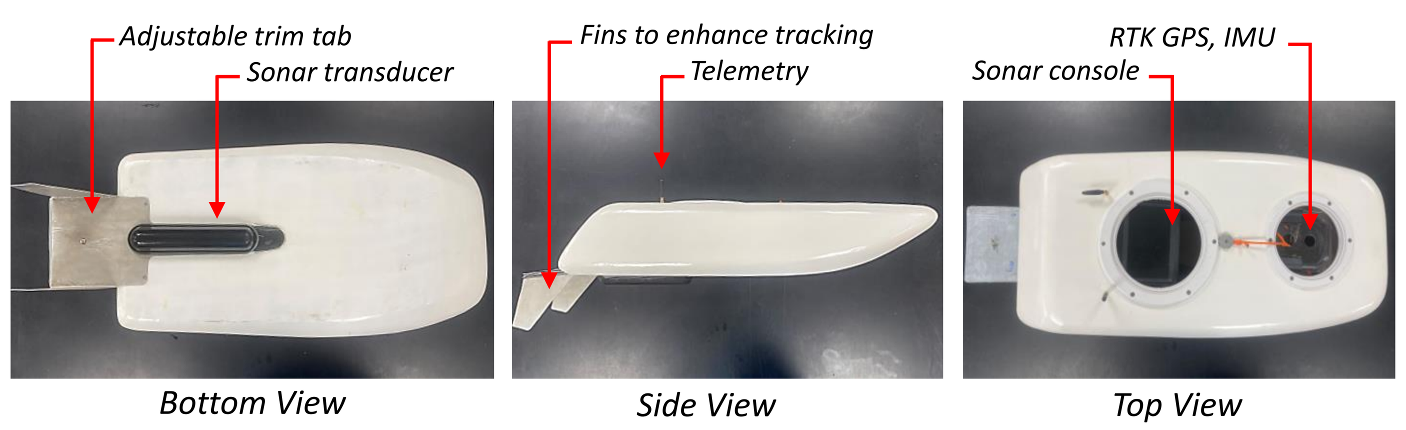
Introduction

The University of Florida (UF) has developed a unique, unmanned bathymetric mapping system that can be used for a variety of underwater survey and mapping applications. The objective was to develop a system capable of autonomous surveys in difficult to access, turbid waters. Prototyped by a team of researchers in the UF Unmanned Aircraft Systems Research Program (UASRP), the system utilizes modern drone and autopilot technology with applications in natural resources and civil infrastructure. It consist of an independent payload vessel which is lifted to the water, and then pulled by an unmanned aircraft via a tether. The system represents a cost effective, efficient, and accurate solution.

Bathymetric System Test in Citra Retention Pond UF/IFAS Plant Science Research and Education Unit (left). Survey Deployment in C11 Canal, Fort Lauderdale, FL (right).



Bathymetric System consists of a vessel with a COTS sonar transducer mounted on the bottom . The sonar console is housed in the vessel along with RTK GPS and an IMU. A telemetry system is used to communicate with the ground station.

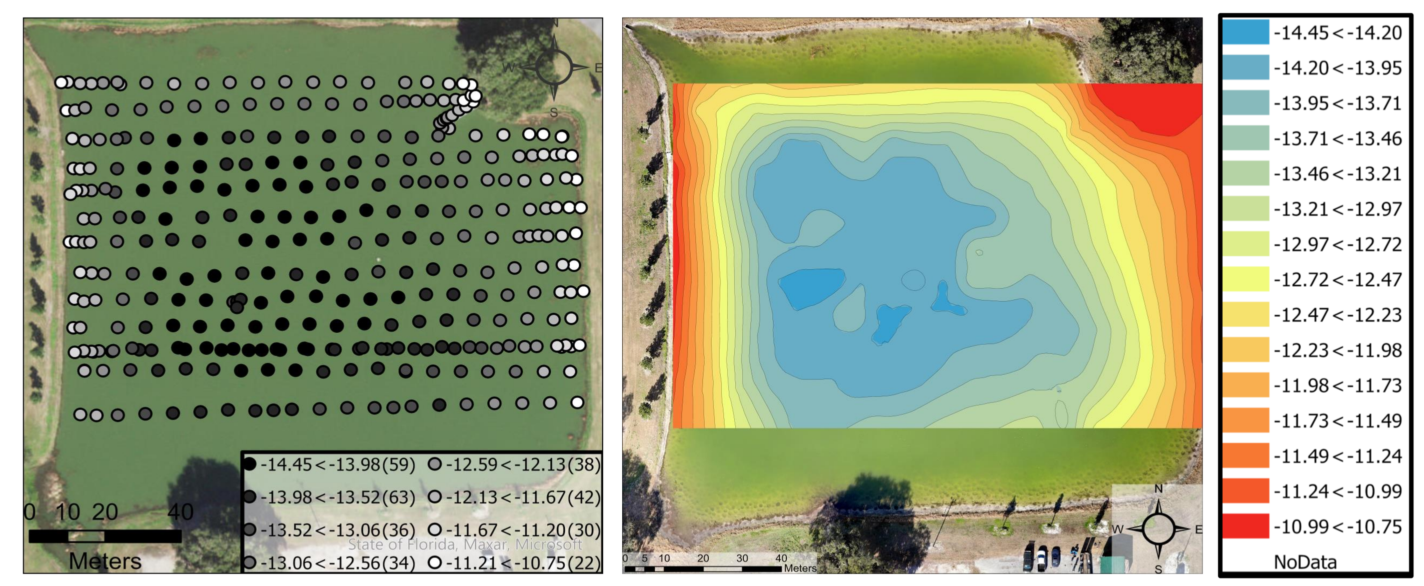
Attributes and Advantages

- *Quick, high-resolution solution for small areas, such as construction sites, inlets, retention ponds, bridge inspections, post storm damage assessment, and rivers.*
- *Easy to deploy (one man operation) with no boats or boat ramps required for nearshore applications but is capable of being launched from a boat.*
- *Easy to transport to the site since it is compact and lightweight.*
- *Cost effective compared to traditional methodologies. (Crew time and resources are minimized; e.g., level pole, 8 hours – Bathymetric System, 30 minutes)*
- *Large range of operating speeds (0 – 10 mph) and easy path planning. (20 acres covered per battery charge in less than ½ hour, depending on depth)*
- *Can be deployed a mile away (line of sight) from launch location*
- *Can be used in waterways with significant current (inlets and rivers)*
- *Won't snag on floating vegetation or run aground on sand bars (no propellers)*
- *Can be used in very shallow water with minimal stirring of the bottom sediment*
- *Communication with the system is robust since the vessel and drone portions are above the waterline*
- *Additional sensors integration; optical, temperature, salinity, and turbidity, etc.*
- *All electric and minimal effect on environment (no fuel or load noise)*
- *Can easily merge land topo maps and underwater isobaths together*

Ground Truthing

The bathymetric system has been ground-truthed at the UF Citra Plant Science Research and Education Unit (PSREU). This facility has a variety of retention ponds ideal for system testing. Level-pole measurements with RTK GPS were taken in over 300 locations on the pond which served as a comparative reference for the drone-based measurements, to assess the system accuracy.

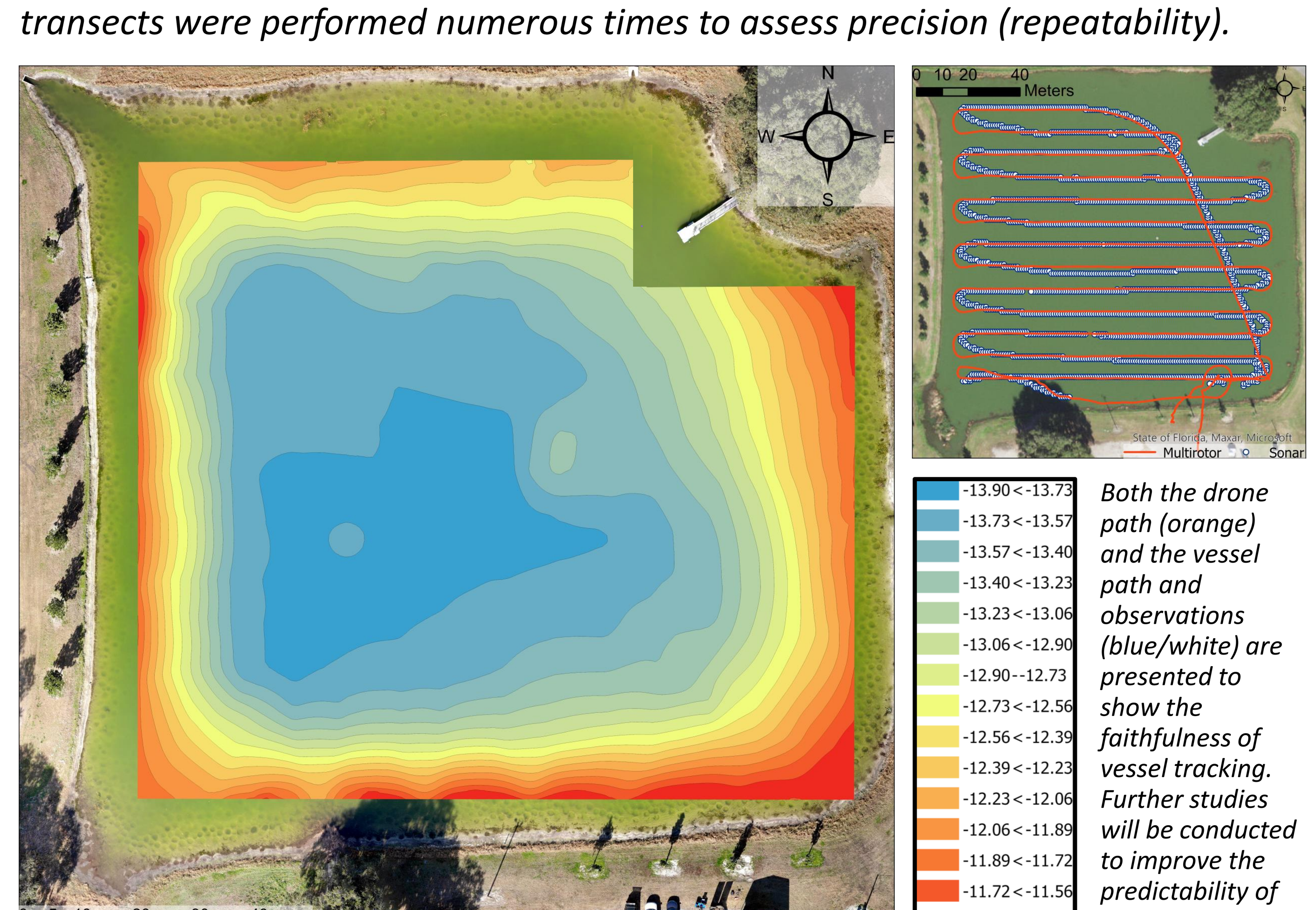
A stable barge suspended across the retention pond allowed for equal point distribution (left). A custom 3d printed topo-boot prevents the level pole from penetrating the silt during observation (center). GNSS base station (right).



Ground-truth data consisting of 324 RTK corrected points (left). Local Polynomial Interpolation of the ground truth data (right). Horizontal and vertical coordinate are NAD 1983 (2011) State Plane Florida West FIPS 0902 (Meters).

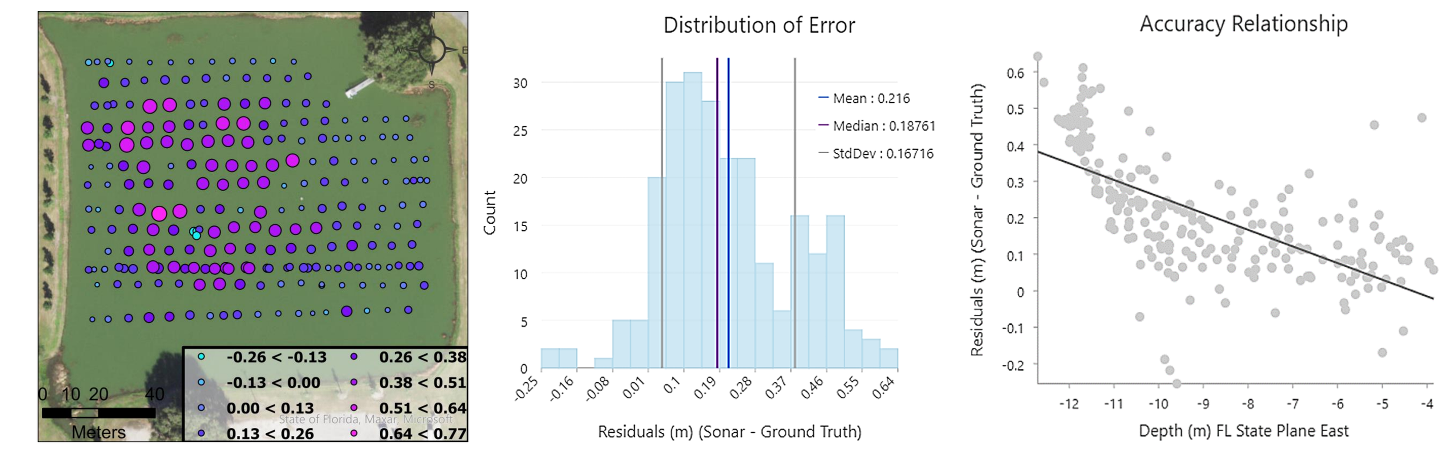
Drone Bathymetry Results

The drone was flown in a boustrophedonic (raster) grid pattern achieving near full sonar coverage of the pond. The flight lasted 15 minutes and consumed 50% drone battery scanning the 5-acre pond. Both north-south and east-west transects were performed numerous times to assess precision (repeatability).

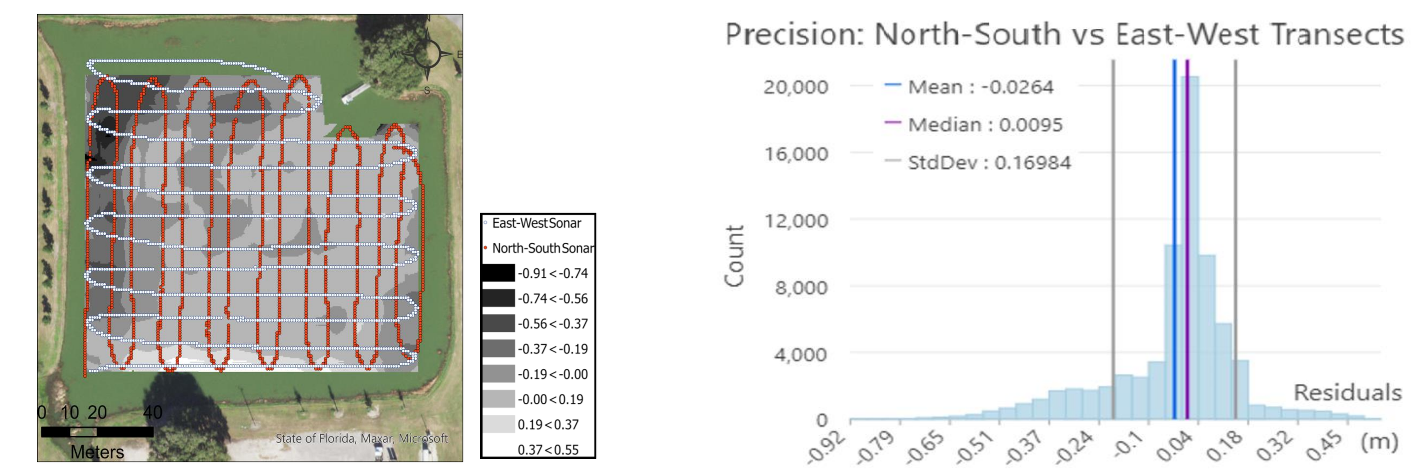


Bathymetric System Test in Citra Retention Pond, horizontal and vertical coordinate are NAD 1983 (2011) State Plane Florida West FIPS 0902 (Meters) (left). Flight lines of multirotor compared to sonar (right).

Assessment of Accuracy and Precision



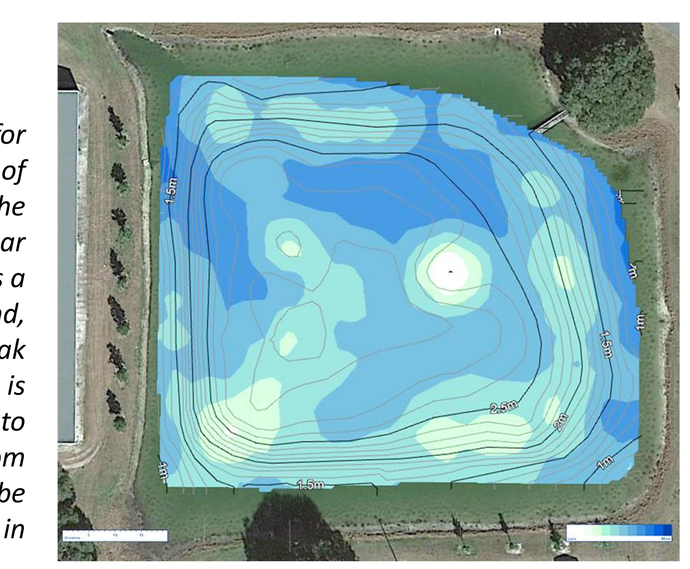
Map of residuals between interpolated sonar and ground truth data (left). Histogram and summary statistics of residuals (center). Scatterplot of residuals and the relationship with depth (right).



A measure of precision by comparing the interpolation of North-South versus East-West flight lines (left). Histogram of the residuals from the subtraction of the two sonar surfaces generated from distinct flight paths (right).

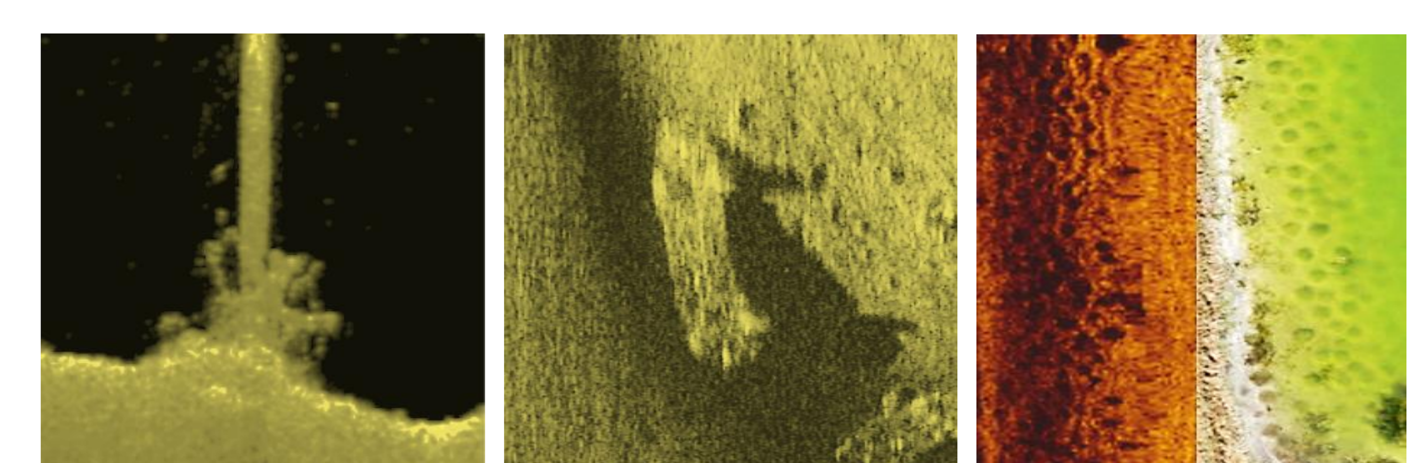
Bottom Hardness

One of the interesting benefits of using sonar for bathymetry is the potential for the measurement of bottom hardness. Backscatter is the measure of the intensity of the sound return that is reflected to the sonar from the measured surface. The figure to the right shows a Bathymetric System test in the Citra retention pond, demonstrating bottom hardness contours using the peak backscatter return in Reefmaster software. The image is qualitative and is not calibrated. In the future we plan to perform soil hardness tests to calibrate the output from the sonar to specific, known hardness data. This can be used to quantify sedimentation deposited during storms in river inlets.



Future Work

The off the shelf sonar system features a basic GPS receiver and lacks an Inertial Measurement Unit (IMU). By adding an RTK capable GNSS + IMU positioning system, we will account for angular orientation changes while obtaining centimeter level positions. Integrating environmental monitoring sensors such as salinity and temperature can better calibrate acoustic transmission properties at each study site. Improved sonar sensor and data processing will allow for 3D point cloud reconstructions from side scan sonar.



Sonar of a C-11 Canal bridge pile showing accumulated vegetation and scour undermining the pile (right) This shows the potential for the drone bathymetry system to be used for inspection of civil infrastructure. Side-scan sonar of submersed vehicle in a quarry (center). Side-scan sonar of tilapia nesting beds at the Citra pond compared with photogrammetry (right).