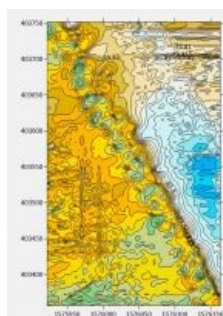*TECHNIQUES IN BATHYMETRIC SURVEY*

Using the Apache Unmanned Survey Vessel

This paper explores the various features of the Apache USV series for efficient seafloor-level mapping. The CHCNAV hydrographic survey software is used for data recording and analysis. It provides results in the form of 3D models of the ground, contours and depth.

(This story is brought to you by CHCNAV)
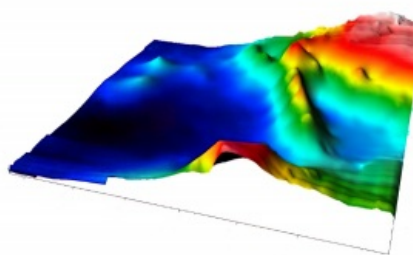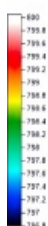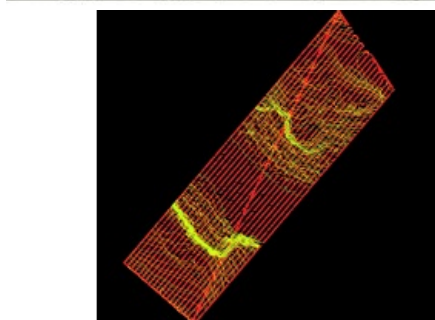
Bathymetry is the study and mapping of the seabed or lake bed. It consists of obtaining measurements of the depth of the ocean or lakes and is equivalent to the mapping of the Earth's topography. In general, only limited information is known about the seabed and lake beds. Existing maps of the seabed are often low-resolution or obsolete.
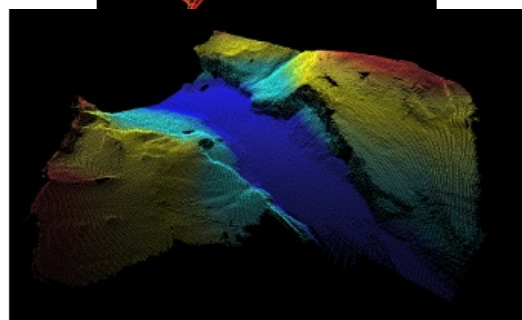
In the case of dams, the bottom is mapped during construction. Time series data is not recorded as depths will be difficult to measure. Due to the water inflow, a large amount of silt will settle in the dam, reducing the depth of the stored water. In this application, the Apache series is suitable technology as it can measure depths of up to 300m and provide exact GNSS positioning. The data can be used to estimate silt deposits that scour the channel bottom, etc.

The seabed level must be accurately measured to determine whether a vessel can make it to the berthing area or whether dredging is required to create adequate depth. The depth level is required in dam and reservoir areas to calculate the capacity of the dam year after year. Due to the constant movement of water through dams, siltation causes the bed level to rise, which reduces their overall capacity.

Figure 1: CHCNAV Apache3 river survey.

The Apache unmanned surface vehicle (USV) series is a self-contained hull vessel, made of carbon-fibre macromolecular polyester. Carbon ï¬bre is widely used in the manufacture of advanced materials due to its excellent properties, such as high strength and modulus speciï¬c, low expansion coefï¬cient and relative ï¬‚exibility.

Autonomy is a central aspect in unmanned marine applications. The objective is to increase the range and complexity of underwater tasks that can be automated while reducing the need for operator supervision. Two of the most important issues for the implementation of unmanned vehicles on a large scale and in a tight timeframe are system reliability and manufacturing costs. Compared to the field of drones, such as UAVs or remotely operated vehicles (ROVs), less R&D has been carried out in the field of marine USVs. However, in recent years, significant progress has been made in several aspects, such as hardware design, system development, collision avoidance, trajectory planning, platform design, collision avoidance, controllers, modelling, stability and energy management.

The Apache series features a differential GNSS to provide centimetre-accurate position data. The rover's GNSS is attached to the marine drone and the base station is installed on the ground. It is equipped with an RF communication system for data transfer to the ground station and has a live PTZ video camera.

Integrated hydrographic system

The Apache USV series

The Apache series integrates unmanned navigation and topographic survey technology, providing a stand-alone, integrated, motorized and networked hydrographic solution.

The Apache USVs are portable to enable bathymetric surveying and mapping, channel surveys, underwater geological exploration, etc., even in remote locations. The system reduces risks to human safety and improves the flexibility and efficiency of underwater surveillance and hydrographic surveys. The hull uses anti-corrosion sealing technology, which is suitable for different types of mission environments. It sails autonomously to complete the task according to the mission plans.

Singlebeam and multibeam echosounders

The echosounder is a type of sonar used to determine water depth by transmitting sound pulses into the water. The time interval between the transmission and return of a pulse is recorded and is used to determine the depth of the water as well as the speed of sound in the water at that time. Distance is measured by multiplying half the time between the outgoing pulse of the signal and its return by the speed of sound in the water [T÷2×(4,700ft per second or 1.5km per second)].

The Apache series is equipped with a singlebeam echosounder to find the depth and calculate the level of the seabed. The Norbit multibeam echosounder (MBES) for oceanographic operations is also available in the Apache 6 series, providing not only a reliable bathymetric chart, but also a backscatter resistance (BS) profile of the seabed. This information is used in various applications, such as seafloor segmentation and characterization, and inversion of geophysical parameters.

GNSS RTK + Inertial positioning and navigation

The Apache series integrates a GNSS real-time kinematics (RTK) system to provide improved positioning accuracy from the nominal GNSS accuracy of several metres to about 2-3cm. RTK uses a network of fixed ground reference stations to broadcast the difference between positions given by GNSS satellite systems and known fixed positions.

Simplified mobilization, higher productivity

The Apache USVs are compact and light to facilitate transportation. A ground communication system is installed and connected to a computer for the transfer of data from the marine drone. A RTK base station is set up to allow precise positioning. The navigation plan with the survey limits is generated and uploaded onto the Apache navigation system.

Once on autopilot, the Apache USV follows the mission plan and collects data at predetermined points, transmitting it to the ground station where it is stored on a computer. This data can then be processed using the CHCNAV HydroSurvey software, and 3D models of the subsurface, contours and depth graphs are generated. In port areas, the seabed level is measured to determine where a ship can go to berth and where dredging is required.

In dams, the bed level is measured to calculate the capacity of the dam. The level of the dam bed is raised during monsoon days due to siltation caused by the arrival of heavy water in the dam area. This can cause serious changes in the capacity of the dam. De-silting must be carried out whenever it exceeds an amount that would limit the operation of the dam.

Figure 2: Seabed contour map.

A versatile bathymetric solution

In the following cases, the projects were uploaded to the Apache USV using a radio bridge, with the data collection rate set at one point every metre and GNSS set to output NMEA at 1Hz.

Project 1: To map the seabed in the existing port area with a 10m line spacing. The echosounder and GNSS receiver were connected to the HydroSurvey software. The data acquisition procedure was started, and the autonomous mission was defined. The Apache USV navigated to the start location and began capturing points along the predefined course line. Once the mission was completed, it returned to its original location.

The processed data was used to prepare a 3D model of the seabed and the generated contours. Figures 2 shows an example of a contour map.

Project 2: Extraction of the cross-section of the riverbed along a watercourse. The Apache was manually operated along the given cross-section to obtain the depths at every one-metre interval. Depths at different cross-sectional positions were used to generate a complete cross-section.

Figure 3: Riverbed cross-section.

Project 3: Mapping of the bed levels of a lake. The processed data was extracted and used to prepare a 3D model that will be used as a baseline reference to verify the amount of silt removed. The area will be re-mapped with the USV after completion of the lake de-silting. Both layers will be used to compare and estimate the amount of silt removed.

Figure 4: Riverbed cross-section.

Conclusion

Various methodologies have been used in these projects to effectively map riverbed and seafloor levels. The proposed methods have a variety of applications such as calculating the capacity of dams and de-silting riverbeds and reservoirs. The results accurately represent the depth and level of the seabed using 3D terrain models, contour lines and depth maps.

The use of marine USVs allows bathymetric survey operations to be carried out in automated mode without having to mobilize a traditional survey vessel, thus increasing the productivity of bathymetric surveys. Their portability allows their use in remote and hard-to-reach locations. The continuous development of technologies embedded in marine drones such as the Apache series, combined with their affordability, has triggered their adoption and widespread use by marine surveying professionals.

Figure 5: 3D model.