

# Operational Glider Monitoring, Piloting, and Communications

Bryan Mensi, Rosemary Rowe, Sean Dees,  
Danielle Bryant

Naval Oceanographic Office

Glider Operations Center, Observation Systems Branch  
Stennis Space Center, MS 39522-5001, USA

David Jones and Robert Carr

Applied Physics Laboratory  
University of Washington  
Seattle, WA 98105, USA

**Abstract**— The Glider Operations Center (GOC) at the Naval Oceanographic Office (NAVOCEANO) is responsible for operating a fleet of autonomous unmanned systems, including ocean gliders, in the collection of physical oceanography data. The data collected include ocean temperature, salinity, and optical properties, which are profiled at depth and used by ocean modelers to forecast future environmental ocean conditions. NAVOCEANO then provides these forecasts in near-real time to support strategic, operational, and tactical Navy fleet requirements and activities.

The Glider Monitoring, Piloting, and Communications (GLMPC) interface is a tool used by the GOC for command and control of ocean gliders and other unmanned surface vehicles. Vehicles controlled by GLMPC include the Littoral Battlespace Sensing-Glider (shallow and deep varieties), Kongsberg Seaglider, and Liquid Robotics Wave Glider. GLMPC provides the glider pilot with the ability to change and adjust missions, plan and adjust routes, review vehicle data profiles and statistics, compare dives and profiles of multiple vehicles in one area, and view vehicle diagnostics. Each type of autonomous vehicle is produced by the respective manufacturer with its own user interface, complete with a special set of commands only that type of vehicle can understand. GLMPC provides a pilot the ability to communicate with multiple types of vehicles simultaneously via a graphical user interface (GUI). GLMPC converts the GUI instructions into the specific commands expected by each vehicle type. This significantly reduces the number of commands a pilot is required to manually issue to vehicles and increases the number and types of vehicles that can be effectively operated at once.

Future enhancements to GLMPC are planned to include Glider Observation Strategies (GOST) software, developed by the Naval Research Laboratory, which will automate the generation of planned vehicle tracks to be ingested by GLMPC. Other enhancements to GLMPC include the ability to display quality-controlled data and raw data for comparison purposes. Currently only raw data are displayed. Display of real-time weather and/or wind forecast data is also being explored.

**Keywords**—gliders; piloting; Littoral Battlespace Sensing-Glider; Autonomous; communication; integration; graphical user interface

U.S. Government work not protected by U.S. Copyright

## I. INTRODUCTION

The Glider Operations Center (GOC) at the Naval Oceanographic Office (NAVOCEANO) began as a small group of scientists utilizing three types of ocean glider systems to collect physical oceanographic data. The three systems initially employed were the Seaglider developed by the University of Washington, the Slocum glider developed by Teledyne Webb Research, and the Spray glider developed by Scripps Institution of Oceanography. A later addition to this list—and the only surface system used by the GOC—was the Wave glider developed by Liquid Robotics, and the APEX profiling float developed by Teledyne Webb Research. The Glider Monitoring, Piloting, and Communications (GLMPC) system was developed by the Applied Physics Laboratory, University of Washington (APL-UW) for the U.S. Navy as a common means of interfacing with the different systems while maintaining the proprietary communications specific to each [1].

## II. NAVY GLIDERS

### A. Background

Knowledge of the environment in which the U.S. Navy operates is important for maintaining strategic and tactical advantages. NAVOCEANO collects relevant physical oceanographic data and uses these data to provide forecasts to the warfighter. Profiles of ocean temperature and salinity are used to characterize the acoustic environment, and profiles of optical properties such as beam attenuation are used to characterize the optical environment. Traditionally these profiles have been collected by vessel-mounted systems that require the vessel to hold station while a profiler is slowly lowered to the ocean floor and retrieved. This process is very time consuming and expensive, and the necessary temporal and spatial sampling density is less than optimal. Ocean gliders are capable of sampling greater areas at higher temporal and spatial resolution at a lower cost and are operated independent of the deployment platform. The profile data collected autonomously by ocean gliders are also made available for assimilation into ocean models near-real time [2].



Fig. 1. Littoral Battlespace Sensing Gliders

The Littoral Battlespace Sensing–Unmanned Undersea Vehicle (LBS UUV) program of record will deliver a variant of the Teledyne Webb Research Slocum gliders to NAVOCEANO (Fig. 1). These LBS Gliders (LBS-G) will be launched and recovered from NAVOCEANO survey vessels and vessels of opportunity. LBS-G will expand the survey capability of NAVOCEANO while increasing the spatial and temporal fidelity of the data collected to meet fleet requirements. A total of 150 LBS gliders are scheduled to be delivered to NAVOCEANO by FY 2015 [3].

### B. Command and Control of Navy Gliders

The communication system utilized by U.S. Navy gliders is the Iridium global satellite phone system, which transmits at a frequency of ~1600 MHz and power of ~1.1 Watts [4]. All U.S. Navy glider communications as well as all sensitive data stored in nonvolatile memory within the glider are encrypted using the Advanced Encryption Standard algorithm to Federal Information Processing Standard Publication 140-2. Each of the systems of gliders employed by the GOC at NAVOCEANO has its own native command and control commands and protocols, which become confusing for a common user. The GLMPC system was developed by the APL-UW as a tool for glider pilots to interface with the multiple systems. GLMPC is used to guide, direct, and control U.S. Navy glider systems through a distributed, server-based web application that uses existing web browsers in the GOC to enable piloting of Navy glider systems.

## III. GLMPC

GLMPC was designed to control multiple gliders of different manufacturers via a common user interface through map and data visualizations. The targeted user for GLMPC is a well-trained technician with experience piloting various types of gliders.

### A. Tasking

Managing a fleet of gliders via GLMPC consists of two basics tasks: monitoring and commanding. GLMPC provides the user the ability to monitor gliders by presenting glider position, historical track, sensor data, and engineering data. This information is used by the pilot to determine the health of the glider and the quality of the data collected. The commanding task is available in GLMPC via setting waypoints on a map as well as sending instructions for sensor use, data sampling frequency, and dive parameters [5]. Useful during monitoring and commanding, GLMPC has the ability to ingest and display NAVOCEANO ocean model data. The model output is displayed as an overlay, which helps pilots analyze glider responses to the environment and aids in predicting future responses.

### B. Interface

The GLMPC Console contains six tabs across the top of the main screen, each of which corresponds to a different page: Tracks, Reports, Profiles, Diagnostics, Control, and Routes (Fig. 2).

1) *Tracks*: This page is presented in a map view and displays glider position, previous track, planned route, and depth-averaged currents.

2) *Reports*: This page is presented in a tabular format and includes information received during each surfacing of a glider. This information is different for each type of glider system but in general includes vehicle health information and sensor data.

3) *Profiles*: This page provides a method for viewing the science and engineering data graphically (Fig. 3a).

4) *Diagnostics*: This page presents glider graphically also, this time over the entire mission and as a function of time (Fig. 3b).

5) *Control*: This page is heavily dependent on the glider system due to the uniqueness of the control framework for each glider system. Each type of glider system will have a different control page that provides an interface to set parameters and control scripts for that particular system of gliders (Fig. 3c).

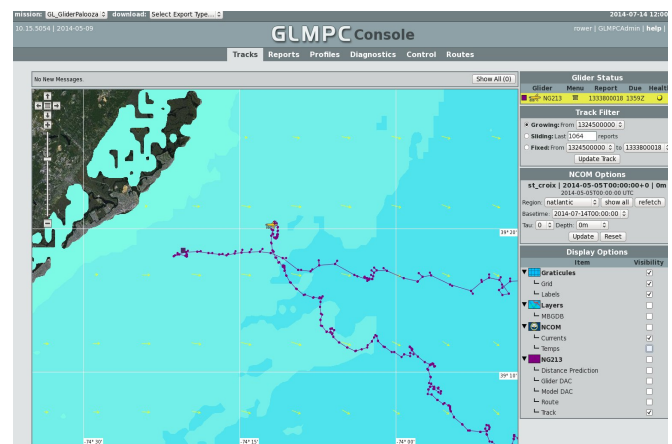


Fig. 2. GLMPC Main Screen

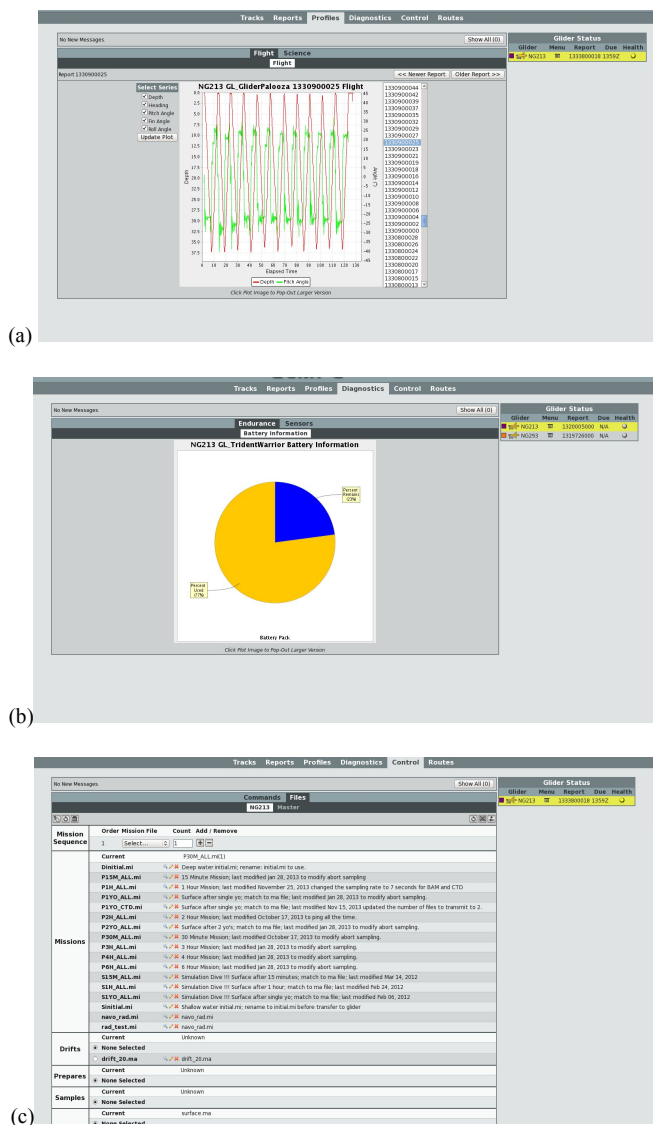


Fig. 3. (a) Profile, (b) Diagnostic, and (c) Control Screens

6) *Routes*: This page is used to construct new routes or planned tracks. These planned tracks are made up of waypoints that are selected by the user.

#### IV. FUTURE ENHANCEMENTS

GLMPC is currently highly dependent on the users, or glider pilots, and efforts are underway to mitigate some of interaction by employing automation algorithms. Developed by the Naval Research Laboratory, Glider Observation Strategies (GOST) is one such automated system that will provide waypoints such that observations made by gliders are optimized. Forecasts of the ocean currents and model uncertainty are used to develop cost functions. These cost functions are used to generate waypoints that form routes, along which gliders collect data [6] (Fig. 4).

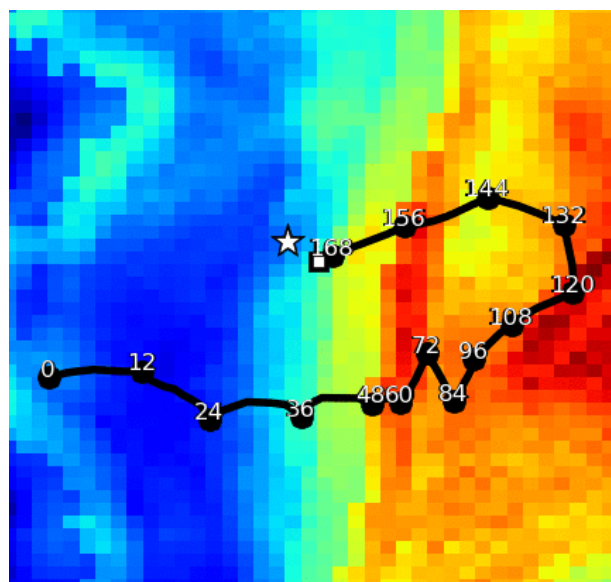


Fig. 4. GOST Cost Function and Route

Other future enhancements include the ability to display quality-controlled sensor data and raw data simultaneously to make comparisons. At present, only the raw data are displayed.

The ability to display real-time overlays of weather data and forecasts is also being explored.

#### ACKNOWLEDGMENT

The authors would like to thank the GOC pilots and leads who use GLMPC every day to collect data for the Navy.

#### REFERENCES

- [1] Applied Physics Laboratory University of Washington GLMPC, Glider Monitoring, Piloting, and Communications System Summary Webpage [http://www.apl.washington.edu/projects/GLMPC\\_html/glmcp\\_summary.html](http://www.apl.washington.edu/projects/GLMPC_html/glmcp_summary.html), obtained 6 August 2014.
- [2] U.S. Navy, The Navy Unmanned Undersea Vehicle (UUV) Master Plan, 9 November 2004, <http://www.navy.mil/navydata/technology/uuvmp.pdf>, obtained 6 August 2014.
- [3] U.S. Navy Program Guide 2012, <http://www.navy.mil/navydata/policy/seapower/npg12/top-npg12.pdf>, obtained 6 August 2014.
- [4] Teledyne Webb Research, Slocum G2 Glider Operators Manual, P/N 4343, Rev. B, January 2012.
- [5] David W. Jones, Robert J. Carr, and Benji Schwartz-Gilbert, "GLMPC: an integrated system for glider command and control." OCEANS 2011, vol., no., pp.1,7, 19-22 Sept. 2011.
- [6] Charlie N. Barron, Lucy F. Smedstad, Jan M. Dastugue, Germana Peggion, and Emanuel Coelho, "Implementing glider observation strategies for Navy ocean observing systems." 17th IOAS-AOLS Conference, 6-10 January 2013.