GRAPHICAL DISPLAY

INTRODUCTION

In conducting ship control at periscope depth, a submarine diving officer relies on a variety of indications, meters, and some verbal reports to maintain the ship within the required depth band. In addition to the displayed parameters, the ship's control party also has their inertial reference, or "the seat of the pants". It is perhaps the inertial reference which differentiates between great ship's control parties, and the merely adequate.

A submarine diving officer must track status of many ship's systems in addition to ship control. The items which the diving officer must monitor include:

- Mast positions
- Proximity of any portion of the ship to broaching (sail, rudder, mast fairing)
- Water depth (general terms)
- Ship's relationship to the submerged operating envelope
- Trim
- Speed
- Water density
- Ship's evolutions (trash disposal, ventilation, etc.)
- Towed array, floating wire antenna

In many cases, the tracking tool most used is the diving officer's mental picture. Unfortunately, the ability to keep a clear status on many issues varies with fatigue and among individuals. This chapter gives the current conditions of the interface between the diving officer and ship's control, and proposes a different display medium to improve operations.

CURRENT DIVING OFFICER INTERFACE

To maintain a complete status, the diving officer has few tools at his disposal. He must rely on looking around at several different panels to get mast status, soundings, and

water density while supervising the planesman. If an unplanned event, for example broaching, occurs the only record for reconstruction is the memory of the operators.

The gauges and meters used for ship control, while designed with generally appropriate time constants, are not adaptable for a given circumstance. For the most part, the same indications are used for high speed transit, periscope depth, and tactical operations. Figure 40 and Figure 41 show some of the indications used on board the USS Nautilus (SSN 571). Although Nautilus is now a museum, the design of submarine ship's control panels has not changed significantly.

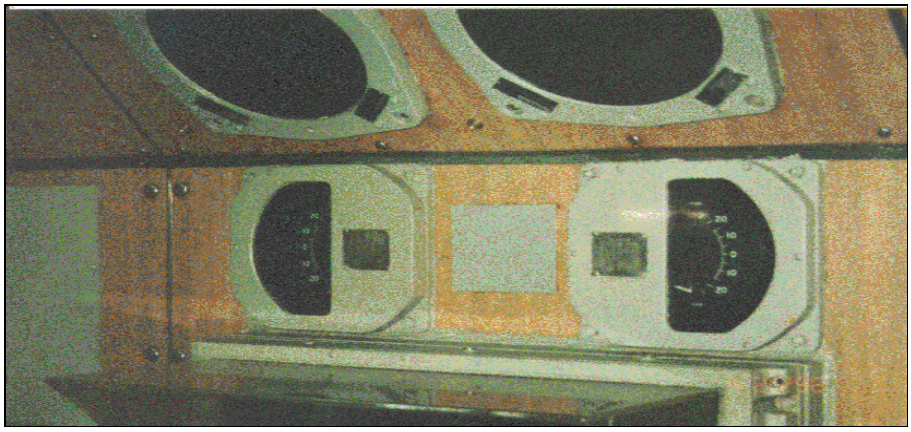

Figure 40. USS Nautilus planes position indications

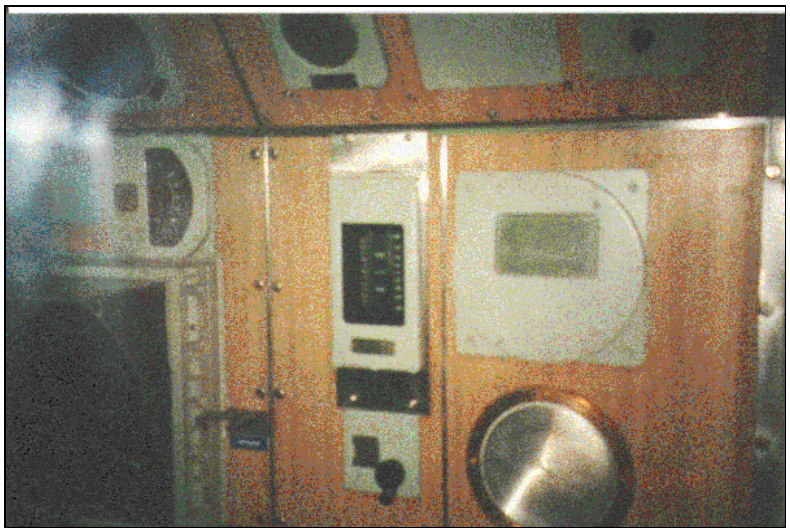

Figure 41. USS Nautilus pitch angle indication

The current system of ship status display is very reliable, with redundant indications for important items and some purely mechanical indicators. It falls short in the area of

presenting an integrated status. It is the writers opinion that the display system degrades the performance of the ship's control party. With some parameters not displayed and others not conditioned for the ship's operating mode, operation near the surface in heavy sea states is extremely difficult. Skilled operators rely upon the existing indications, as well as "the seat of their pants" to maintain depth. Even so, it is a solid accomplishment to keep from broaching during extended periscope depth operations.

Even more complex are operations in shallow water. The proximity to grounding complicates all aspects of ship control. The diving officer must be constantly aware of the water beneath the keel available for casualty recovery. Because nonzero pitch angles will cause one end of the ship to be deeper than indicated, this must also be accounted for.

PROPOSED DISPLAY

To incorporate the desired indications in a single display, a radically different approach is taken. Rather than rely on meters and gauges for the state of the ship, a screen is used. Figure 42 shows the proposed display. A crude version of this display was developed using the SIMULINK® Animation Toolbox® (Figure 43).

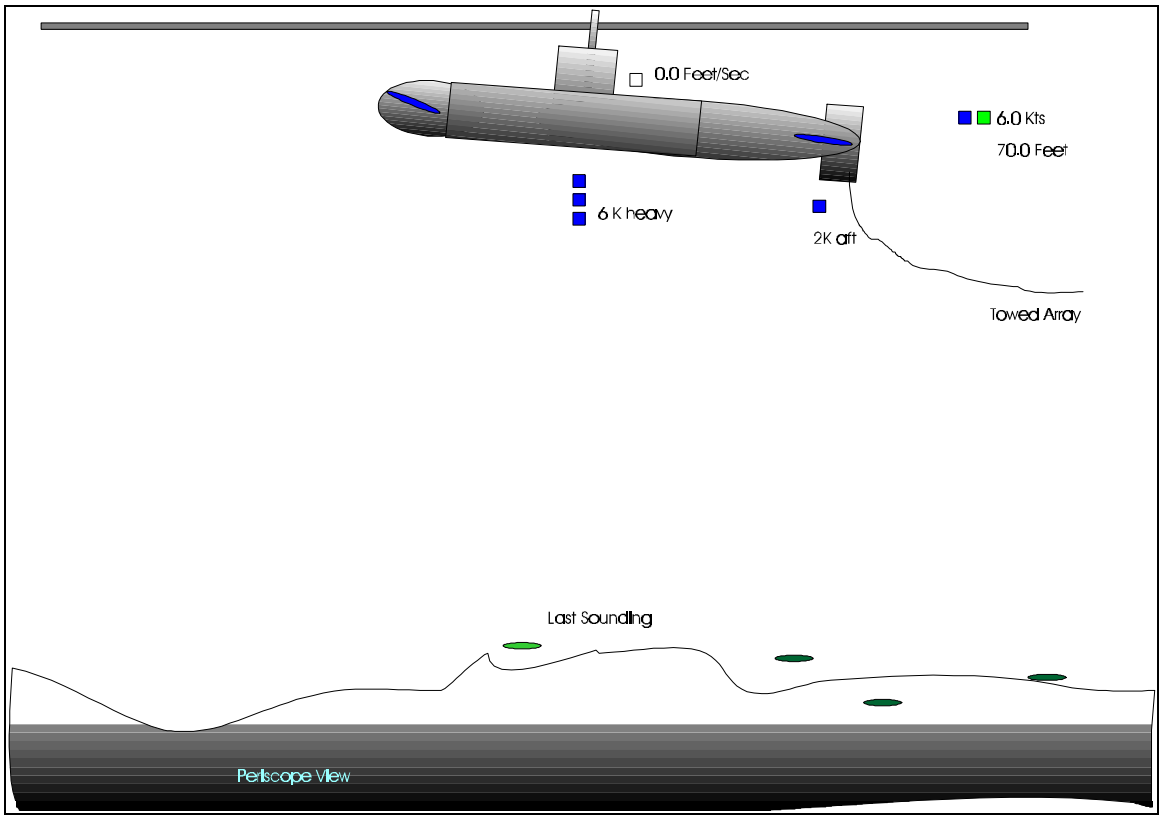

Figure 42. Proposed graphical display of submarine control status

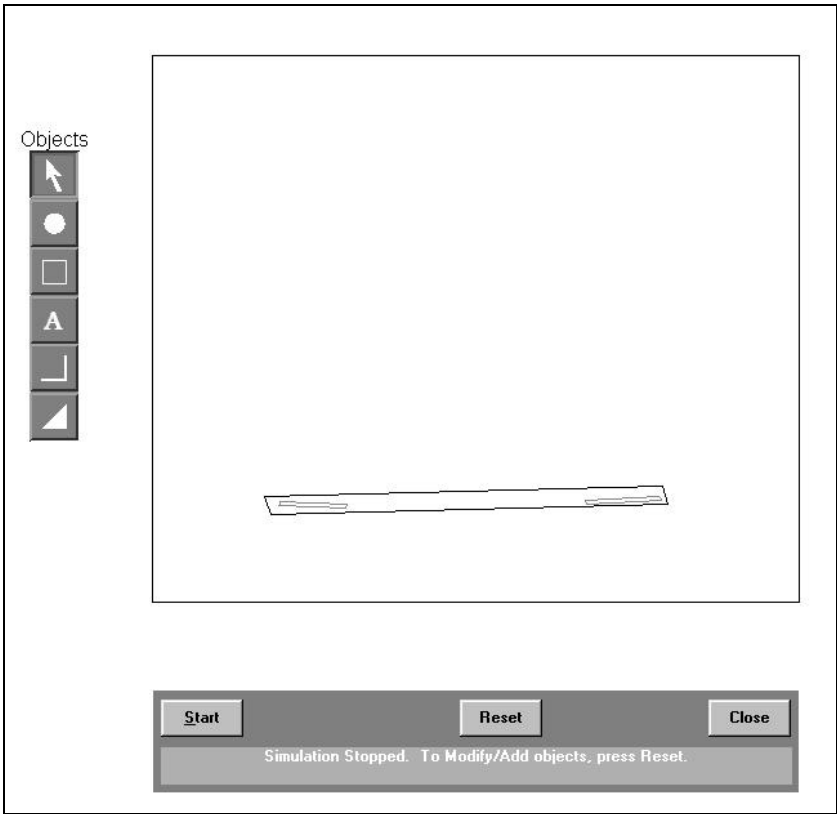

Figure 43. SIMULINK® animation of depth, pitch angle, and planes angles

By integrating the ship status into one display, numerous improvements can be realized. The relationship of the submarine to the bottom and the surface is clearly shown. With the bottom contour information from a database, the diving officer has a continuous sense of the ship's proximity to grounding. In addition as sounding data is obtained, it can be displayed.

The use of a digital display paradigm allows the display to be modified to support different operating modes. Because of the relationship between ship control and safety, the settings would be chosen based on a commanding officer approved doctrine. This would allow the operators to adjust the display system to best fit needs, and adapt it to new circumstances or missions. Alerts and alarms could readily added as the situation warranted.

To assist the diving officer in maintaining status on the wave forces, several bar graphs were added to show the net force that the ship's angle and planes were applying at a given time. These quantities would be filtered to provide a relevant average. Provided the

averaging interval was appropriate, this would queue the diving officer to order trim changes in response to changing environmental conditions.

The periscope video in the bottom left hand corner would provide critical feedback for the dive. This would make the scope's position relative to the surface apparent (another indication of depth), and allow the diving officer to be somewhat aware of the tactical situation. A close or new contact would prompt the diving officer to review mast exposure, which is also on the same display.

Safety of shallow water operations would be enhanced by presenting a clear picture of the ship's relationship to the bottom. During evasive action, the ship's control party and the Officer of the Deck would be working with common knowledge of available water beneath the keel, and the contour ahead of the ship.

Ship's status could be recorded, to allow playback for the reconstruction of unplanned events. Figure 44 shows a possible data architecture to support the display.

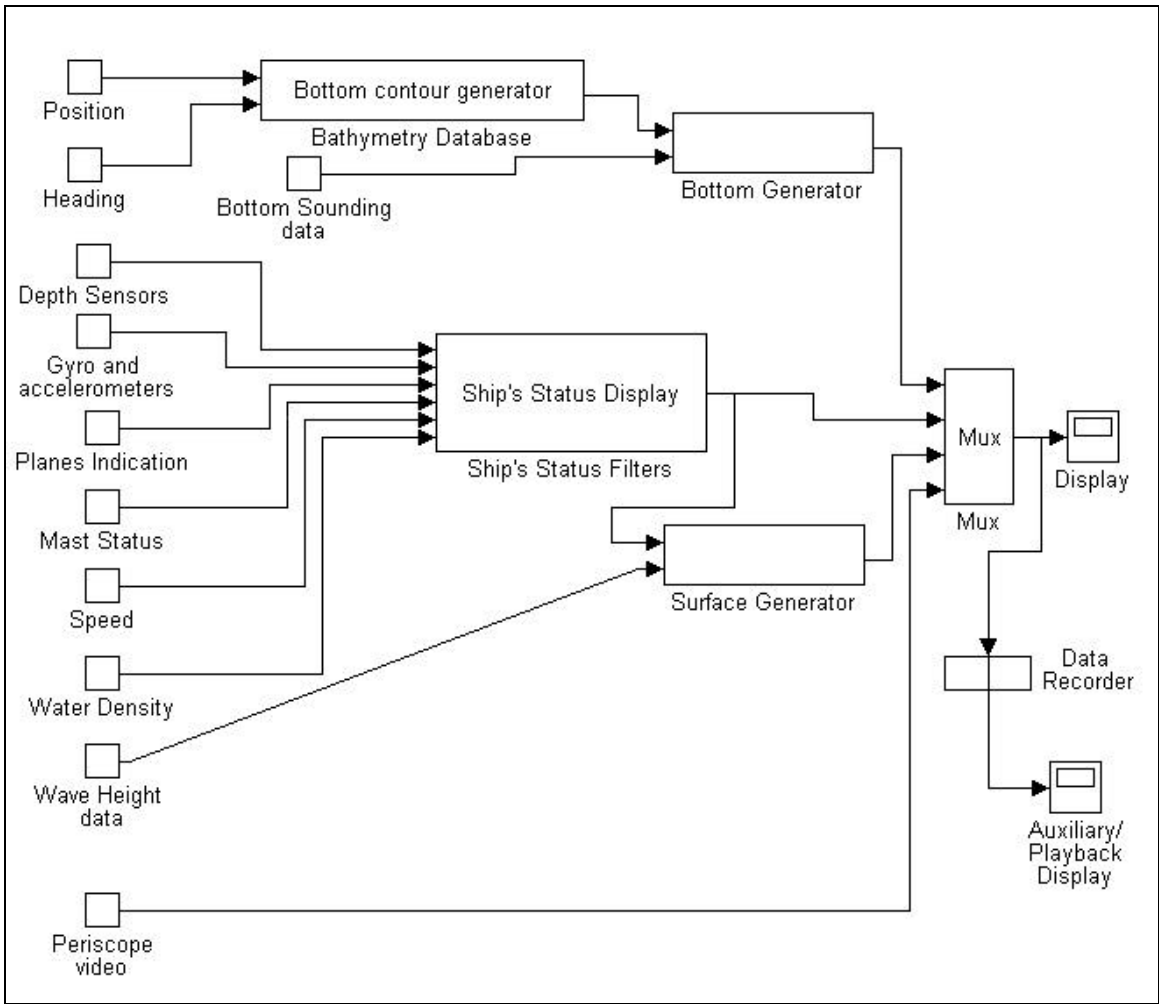

Figure 44. Graphical display data paths

CONCLUDING REMARKS

The integration of the pertinent ship parameters in one display should yield dramatic improvements in submarine periscope depth operations. The diving officers improved awareness should reduce fatigue levels, allow for slightly lower speeds for a given sea state (reducing mast feather), and enable a much more complete environmental picture for the ship's control party. This awareness should increase the confidence of the ship's control party during demanding shallow water operations, reduce the likelihood of grounding or broaching, and provide an improved level of support for the Officer of the Deck.