Project Number: **200105**

Project START year: **2003** Project END year: **2003**

Project Manager: David Caress

200105 Core Navigation - MDUC

1) Abstract (new and continuing projects)

This MDUC project provides for the institutional support of “core” navigation data from MBARI ships and ROVs. This is a continuing project since 2001.

The usual elements of this project are:

- Maintenance and minor development of software used for the processing and archiving of ROV and ship navigation.
- Data archiving and dissemination through the expedition database.
- Data validation through Science data “champion”.

In addition, for 2003 we propose a significant development and testing effort for ROV navigation:

- Shipboard testing of realtime ROV navigation and logging of raw (pre-Winfrog) navigation data.
- Development of new algorithms for processing USBL + DVL ROV navigation
- Extension of the Expedition database to support multiple versions of processed ROV navigation.

2) Proposal

Introduction

ROV and ship navigation have been designated as core data streams, which means that support for the collection, processing, and archiving of the data is provided on an institutional basis rather than through individual projects or divisional budgets. The 2001 and 2002 Core Navigation projects were intended to maintain a more or less stable set of navigation data streams. The budgets included some IAG time and some of David Caress’ time (13 days each in 2002) to support processing and validation of ROV and ship navigation data and maintenance of the software used to move the data from the ships through processing and into the data archives.

We have discovered and experienced some major difficulties with ROV navigation over the past few months. In particular:

- We found that the Tiburon navigation logged prior to 2001 was actually ship navigation. This problem was due to erroneous settings for the Winfrog realtime navigation package, probably introduced during software version updates.
- We've experienced significant real-time operational difficulties with Tiburon navigation following the integration of a DVL with the USBL in April. These are continuing on the present expedition.

Through 2000, we simply archived the Kalman filtered USBL navigation as our best ROV navigation. Starting in 2001, we began to reprocess the navigation using an algorithm that fits the USBL fixes while minimizing speed and acceleration. The advantage of this approach is that it produces a plausible, self-consistent model for the navigation.

Now that both USBL and DVL are being input to Winfrog, the behavior of the real-time navigation output has changed. The real-time position estimate no longer "bounces" along with the USBL fixes, but now moves slowly as constrained by the DVL. One consequence seems to be that the position estimate can drift while the vehicle is stationary. We do not understand how this behavior relates to Winfrog settings, or whether there is also some undiagnosed problem(s) with the USBL or DVL.

These issues have prompted us to reconsider how best to approach ROV navigation over the long term. In order to implement a new ROV navigation and processing scheme, we are proposing increased effort for Core ROV navigation during 2003.

A Revised Approach to ROV Navigation

We have come to realize that real-time ROV navigation and post-processed ROV navigation do not serve the same needs, and so the latter does not have to derive from the former. Our goal for real-time navigation should be to provide the best possible instantaneous estimate of the vehicle's position. Our goal for the primary archived navigation should be to provide the best possible self-consistent model for the navigation of the whole dive. Both types of navigation are important, but it needs to be recognized that they are different.

The use of Kalman filtering as provided by Winfrog is entirely appropriate for real-time navigation. However, Kalman filtering is always one-sided in time (in real-time one doesn't know the future) and focused on the present best estimate. This has the consequence that new information can produce rapid shifts in the position estimate. In some cases, these shifts may seem unreasonable, but they really reflect the filter design. We propose to work with the ROV pilots in testing and verifying the Winfrog based realtime ROV navigation system. The goal will be to fully understand the behavior of the ROV navigation output, to communicate this understanding to the science users, and to document optimal software and hardware settings. This testing will require dedicated-dive testing with both ROVs. We will continue to log and archive the realtime ROV navigation.

Once a dive is completed, the use of Kalman filtering to model the navigation is inappropriate. A better method is to consider all of the constraints on ROV navigation simultaneously, and to solve for a navigation model that is consistent with the USBL fixes while fitting the DVL estimates for vehicle speed. We propose to log “raw” USBL fixes and DVL velocity over ground values. An initial effort to log the raw navigation sensor data has been undertaken in 2002 and was only partially successful due to changes made to the DVL. Also, it is not yet clear whether we are logging truly raw USBL positions or positions that have been Kalman filtered by the USBL software prior to Winfrog. Once we are sure that we are logging the desired values (and that we understand those values), we will then develop and test new software for obtaining optimal ROV navigation solutions from the raw sensor data. We will implement this new algorithm as the primary source of processed ROV navigation. Finally, we will update the Expedition Database scripts so that the raw navigation sensor data, the realtime Winfrog navigation, and the post-processed optimal ROV navigation are all accessible via the usual web interface.

The Plan

The following tasks for this project during 2003 include:

- Maintenance of existing software used for the processing and archiving of ROV and ship navigation.
- Data archiving and dissemination through the expedition database.
- Data validation through Science data “champion”.
- Monthly reports on data quality from data champion to MDUC.
- Modification to navprocessor software to restore proper DVL data handling.
- Modifications to Winfrog to fix known vulnerabilities and newly discovered problems.
- Shipboard testing and validation of Winfrog realtime navigation.
- Routinely log and archive USBL positions and DVL speed-over-ground prior to any filtering by Winfrog
- Develop and implement algorithms for obtaining optimal navigation solutions from the raw USBL and DVL data
- Update the Expedition database to include links to raw navigation sensor data, to realtime Kalman filtered navigation, and to processed optimal navigation.

The MDUC Chair (David Caress) will serve as both project manager and lead scientist for this project.

The core navigation data team includes:

- David Caress (Data Champion, MDUC, Science)
- John Graybeal (IAG)
- Rich Schramm (IAG, MDUC)
- Doug Au (Support Engineering)
- Buck (Tiburon chief pilot)
- T.C. Dawe (Ventana chief pilor)

3) Budget Justification

The 2003 budget includes the following:

- Routine navigation data validation
    - 8 days IAG
    - 4 days Caress
- Support of existing software
    - 17 days IAG
    - 1 days Caress
- Restore DVL/datamanager software on navprocessor
    - 5 days (Au)
    - 3 days (IAG)
- Contract with Thales/Pelagos to fix known and discovered problems with Winfrog
    - 3 days (Au)
    - 2 days (IAG)
- Characterization/calibration of DVLs, USBL and vehicle gyros.
    - 5 days (Caress)
    - 10 days (IAG)
- Modification and testing of realtime navigation systems
    - 20 days IAG
    - 5 days Caress
- Development of new post procesing algorithms and software
    - 20 days Caress
    - 15 days IAG
- Update to expedition database software to handle all ROV navigation products
    - 8 days IAG
    - 2 days Caress

The labor totals are:

- 37 days Caress
- 83 days IAG
- 8 days Support Engineering

We request $10K to contract with Thales/Pelagos (formerly Racal/Pelagos) to consult and make necessary modifications to the Winfrog navigation software.

We also will require one dedicated dive day on each vehicle to characterize the DVL and vehicle compasses and an additional (possibly shared) dive day on each vehicle to test changes (2 dive days total on each vehicle).

4) Milestones (new and continuing projects)

- End of each month: Data champion review of ship and ROV navigation data quality.

	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Milestone 5	**Total Resources** [1] for each resource category for all milestones listed here
Milestone date	March 2003	May 2003	June 2003	July 2003	August 2003	
Milestone description	Complete testing and modification of realtime ROV navigation	Complete development of new post processing	Complete update to expedition database	MDUC budget recommendations for 2004	Finalize 2004 proposal	
EE						
SE						
ME						
IAG	35	15	8		25 (spread over year)	83
Machine Shop						

[1] This number should be same as the number you entered on the resource requests for this particular resource