Shipboard ADCP data acquisition systems: VmDas and UHDAS

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For the common shipboard ADCP systems made by Teledyne RD Instruments, there are two data acquisition systems in general use: VmDas, from the manufacturer, and UHDAS, developed at the University of Hawaii. This document is a comparison from the point of view of the UHDAS developers. For additional background and references on the oceanographic application of shipboard ADCPs, see Firing and Hummon (2010).

The most basic functions of a shipboard ADCP data acquisition system are:
1. To control the configuration and operation of the instrument.
2. To record the raw data stream from the ADCP, along with ancillary data streams including the ship's heading and position.

Additionally, a data acquisition system may:
3. Perform data processing steps including editing, coordinate transformation, and averaging.
4. Provide graphical display of the data as well as access to the numbers.
5. Provide mechanisms for remote monitoring of the system.

Although both VmDas and UHDAS perform the first 4 of these functions, we will argue that for the purposes of oceanographic research, UHDAS performs all of them substantially better than VmDas. The fifth function, remote monitoring, is provided only by UHDAS. To summarize the most important advantages of UHDAS:
1. Operation: UHDAS presents a very simple interface to the operator, minimizing the opportunity for error.
2. Data presentation: UHDAS provides a shipboard web site with full access to the data, both raw and processed; to documentation; to the processing software; and to automatically generated plots in styles familiar to oceanographers.
3. Monitoring: UHDAS sends out a daily email message with a subset of the data and with extensive diagnostic information about the system. Ashore, an automated system updates a web site with plots and diagnostics as each email message arrives.

In the following we give a more detailed comparison between VmDAS and UHDAS.

User interface: instrument configuration and control.

- UHDAS presents a simpler interface to the operator; typically all the operator needs to do is, at the beginning of a cruise, press "Start Cruise", specify the cruise name, and press "Start Logging"; and at the end, press "Stop Logging", and "End Cruise" (Figure 1).   A minimal number of widgets for changing instrument setup parameters are provided on the same panel; in our experience, there is nothing to be gained and much to be lost by frequently changing instrument parameters, so we recommend setting good defaults and sticking with them. The defaults are loaded automatically from a simple text file, which can be customized for each ship. In contrast, VmDas presents a bewildering array of options, with unclear interactions

between settings via the gui and via a text file.
- A single instance of UHDAS running on a single machine can control any number of ADCPs, starting and stopping them at the same time; VmDas requires one program instance per ADCP.
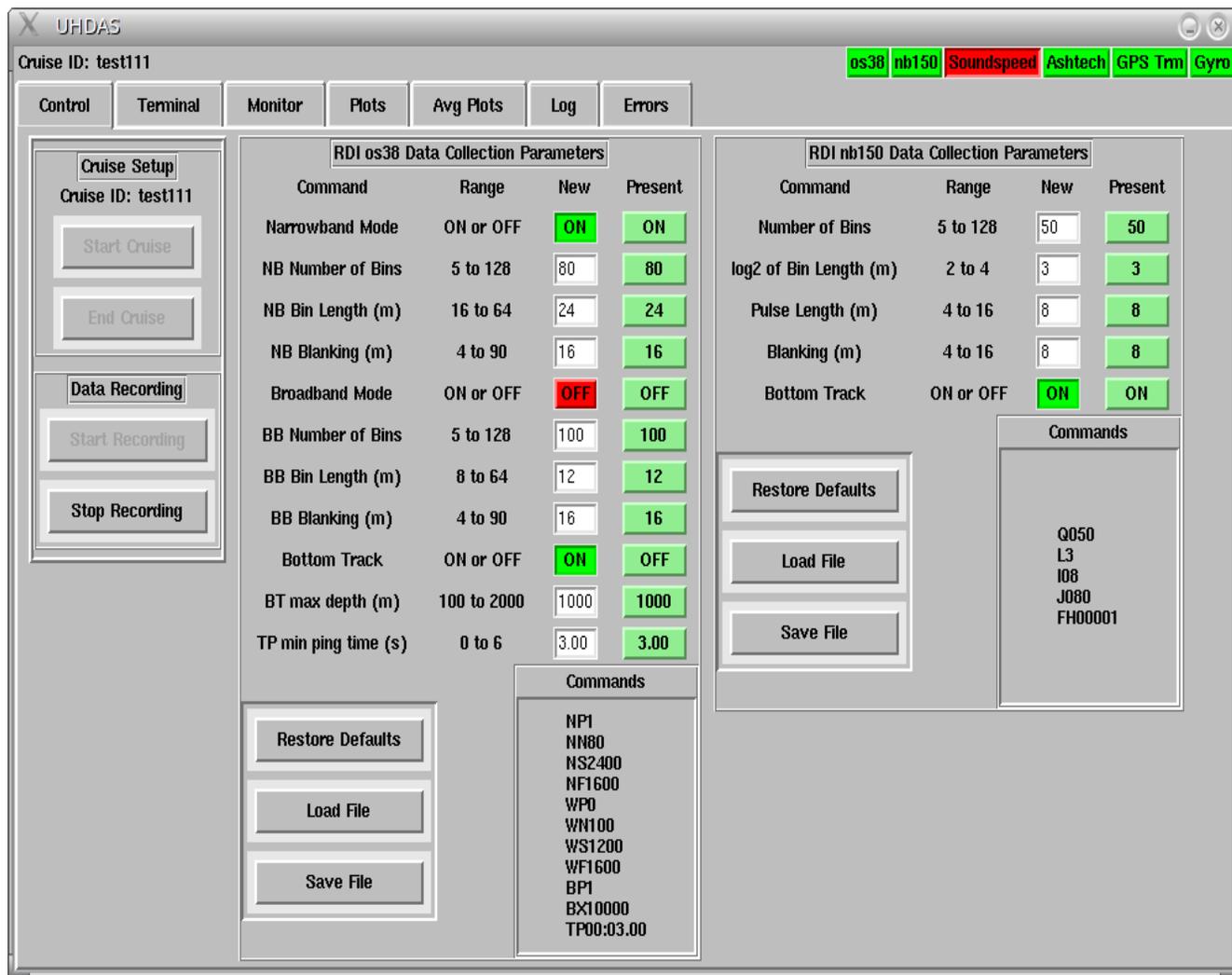
Figure 1: UHDAS control tab, showing control and setup parameters for two ADCPs: an OS38, and the original Narrowband 150. (VmDas cannot be used with this early instrument from RDI, which is still in use on some ships.) All other tabs in the UHDAS GUI are for information only; all operator actions are controlled solely by the Control tab shown here. For more information, see http://currents.soest.hawaii.edu/docs/adcp_doc/UHDAS_techdoc/UHDAS_GuiTour.html.

Raw data recording.

- For reliability, UHDAS separates the control GUI from the logging, using a separate Linux process, compiled from C code, for each data stream. Each process can handle a high data rate. In contrast, VmDas serial data logging often suffers from buffer overrun and lost data when confronted with a heavy stream of NMEA messages.
- UHDAS can handle any number of serial ports, so there is great flexibility in logging backup sensors for position and heading. Modern VmDas can handle only 3 serial ports for NMEA data

streams. (Earlier VmDas versions could only handle 2 NMEA streams.)

- UHDAS handles more types of NMEA message, and support for additional messages can be added if needed.
- VmDas inserts ping-labeled time tag messages into the serial streams whenever the ping occurs, with no line buffering, so that they are often found in the middle of an NMEA message. UHDAS writes a time tag as a separate line preceding each NMEA message. (See Figure 2, end of document.)
- Although in UHDAS a separate process handles each serial port, they are synchonized so that they all use a common file naming scheme, and they all open and close files at the same time, at 2-hour intervals. VmDas files are rolled over based on size, so there is no way to match data from different streams at a given time based on their file names within a given data recording interval (that is, between start and stop commands).
- UHDAS file names are guaranteed to sort lexically in time order for a given cruise; the date and time of the start of the file are encoded in the name. VmDas file names have no date or time information, and are guaranteed to sort lexically only within a recording interval.
- When UHDAS is controlling more than one instrument, the ancillary data are recorded only once; because VmDas requires separate instances for each ADCP, the logging of ancillary data is duplicated.
- UHDAS records the raw data stream from each instrument exactly as it is received; VmDas overwrites the instrument's clock time with the PC clock time.
- Apart from optional backups, UHDAS writes the voluminous raw single-ping data once; VmDas writes three versions of single-ping data (*.ENR, *.ENS, *.ENX).
- VmDas records each entire NMEA stream; UHDAS records only the desired NMEA messages, with optional subsampling (e.g., if gyro compass headings are coming in at 10 per second, one may record every fifth record), and with optional gzip compression. UHDAS does require additional space, however, for saving the NMEA data in a fast-random-access binary format in full-resolution and ping-gridded versions.
- VmDas stores all data, raw and processed, in a single flat directory. The VmDas ASCII configuration file is stored in a different location from the data, making it easy to lose. UHDAS data (raw and processed) and configuration files are all stored in one directory per cruise, with a tree of subdirectories used to organize the categories of files.

Data processing

- VmDas applies very basic editing criteria before averaging; UHDAS uses the full CODAS data processing system, with single-ping editing algorithms developed at UH based on experience with data from around the globe.
- VmDas can use only a single heading source at a time; UHDAS uses two, continually correcting the reliable but insufficiently accurate gyro compass headings with readings from a more accurate but less reliable gps-based attitude sensor. (Heading accuracy is often the limiting factor in overall shipboard ADCP velocity accuracy.) UHDAS has algorithms for editing the data from such unreliable sensors.
- Ocean Surveyor instruments can interleave two ping types: uncoded ("narrowband"), providing maximum range, and coded ("broadband"), providing higher resolution or short-term accuracy at the cost of depth range. Although VmDas can configure the instrument to interleave these two ping types, it can process and display only one of them at a time. UHDAS processes and displays the two ping types simultaneously and independently.

Data display and access

- UHDAS automatically generates oceanographic-style vector plots (current vectors on a map with color-contoured bottom topography), and contour plots of the velocity components as functions of depth and latitude, longitude, and time, at 15-minute intervals, along with diagnostic plots.
- Additional UHDAS displays are provided for use on the bridge; these have been developed based on requests from ships' officers.
- UHDAS runs a web server on which these plots are displayed, so they are available anywhere on the ship's network. VmDas provides a more limited set of plots, available only on the screen.
- UHDAS data are available via the ship's network, using NFS or Samba (Windows shares), at all stages of processing, and with the processed data provided in Matlab and NetCDF formats. VmDas can provide Windows shares access to all its files, but none are in a standard format ready for data analysis.

Remote monitoring

- VmDas has no facilities for remote monitoring.
- UHDAS composes a daily email message with extensive system status information, together with subsampled processed data. The email can be sent to any who wish to receive it; for the ships that we monitor, we have an automated system for receiving and processing these messages, posting their contents and plots made from the data snippet on our web site: http://currents.soest.hawaii.edu/uhdas_fromships.html.

General aspects.

- VmDas is a typical Windows *application*; UHDAS is a Linux *system configured with many software components*. Consequently, VmDas is easier to install but very limited; UHDAS is more complicated to set up, but much more powerful and flexible, and easy to operate once it is in place.
- VmDas is entirely proprietary: a closed-source executable. UHDAS is entirely open source, and built on open source tools; there are no proprietary components or requirements. Our code is maintained in a set of Mercurial repositories. It is written in C, Python, and Cython, taking advantage of numpy for numerics and matplotlib for graphics.
- VmDas is developed by a hardware company to provide an off-the-shelf interface to their instruments. UHDAS is developed by physical oceanographers to meet the needs of the seagoing oceanographic community.
- VmDas has been very stable over the years since it was introduced; UHDAS has been evolving continuously. With the removal during 2011 of its original dependence on MATLAB for processing and plotting, UHDAS has reached an important milestone, but we expect its evolution and improvement to continue.

Conclusion

UHDAS has been developed by and for the oceanographic research community, based on more than 25 years of experience working with shipboard ADCPs. It is designed for ease of operation, for robustness of data logging, and for maximizing the usefulness of ADCP observations at sea as well as their long-

term value for research. This is achieved by providing easy access to automatically processed data sets via plots and files, by facilitating remote monitoring so that system problems can be detected and corrected early, and by recording data flexibly and reliably with an orderly scheme for file naming and formats. First deployed in 2003, UHDAS is now in use on 20 ships in the US research fleet, with more installations planned.

Reference:

Firing, E. and J. M. Hummon, 2010. Ship-mounted acoustic Doppler current profilers. In *The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines*. Hood, E.M., C.L. Sabine, and B.M. Sloyan, eds. IOCCP Report Number 14, ICPO Publication Series Number 134. Available online at: http://www.go-ship.org/HydroMan.html.

UHDAS serial timestamping

```
$UNIXD,87.6667280,12.9128355
$AGHDT,092.0,T
$UNIXD,87.6667395,12.9128470
$AGHDT,092.0,T
$UNIXD,87.6667511,12.9128586
$AGHDT,092.4,T
$UNIXD,87.6667627,12.9128701
$AGHDT,092.4,T
$UNIXD,87.6667743,12.9128817
$AGHDT,092.0,T
$UNIXD,87.6667858,12.9128933
$AGHDT,091.7,T
$UNIXD,87.6667974,12.9129049
$AGHDT,091.7,T
$UNIXD,87.6668090,12.9129164
$AGHDT,092.0,T
$UNIXD,87.6668206,12.9129280
$AGHDT,092.2,T
$UNIXD,87.6668321,12.9129396
$AGHDT,092.4,T
$UNIXD,87.6668437,12.9129512
$AGHDT,092.0,T
$UNIXD,87.6668553,12.9129627
$AGHDT,091.7,T
$UNIXD,87.6668668,12.9129743
$AGHDT,091.7,T
$UNIXD,87.6668784,12.9129858
$AGHDT,092.0,T
```

VmDAS serial feed: a common problem

```
$HEROT,008.7,A*24
$HEHDT,157.1,T*2D
$HEROT,010.6,A*2C
$HEHDT,157.3,T*2F
$HEROT,010.9,A*23
$HEHDT,157.4,T*28
$HEROT,011.0,A*2B
$HEHDT,1$PADCP,1,20111111,154915.01,0.00
57.7,T*2B
$HEROT,014.2,A*2C
$HEHDT,157.9,T*25
$HEROT,014.0,A*2E
$HEHDT,158.2,T*21
$PADCP,2,20111111,154917.04,0.00
$HEROT,015.6,A*29
$HEHDT,158.4,T*27
$HEROT,016.7,A*2B
$HEHDT,158.7,T*24
$HEROT,015.5,A*2A
$HEHDT,159.0,T*22
$PADCP,3,20111111,154920.06,0.00
$HEROT,015.0,A*2F
```

Figure 2: On the left is an example of a gyro compass data stream logged by UHDAS, with a time tag message ($UNIXD) preceding each heading message ($AGHDT). The time tag includes the system time in days from the start of the year, and the monotonic time in days since the system was last booted. On the right is a similar example from VmDas, with the $PADCP time tag being inserted with each ping. This is done without proper line buffering, so the $PADCP message is often inserted in the middle of another message, as seen for the first $PADCP record here.