The Velocity Mapping Toolbox

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User Guide for version 4.09

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Contents

Figures

Tables

User Guide: The Velocity Mapping Toolbox

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Introduction

The Velocity Mapping Toolbox (VMT) is a Matlab®-based software for processing and visualizing ADCP data collected along transects in rivers or other bodies of water. VMT allows rapid processing, visualization, and analysis of a range of ADCP datasets and includes utilities to export ADCP data to files compatible with ArcGIS®, Tecplot®, and Google Earth®. The software can be used to explore patterns of three-dimensional fluid motion through several methods for calculation of secondary flows (e.g., Rhoads and Kenworthy, 1998; Lane et al., 2000). The software also includes capabilities for analyzing the acoustic backscatter and bathymetric data from the ADCP. A user-friendly graphical user interface (GUI) enhances program functionality and provides ready access to two-and three-dimensional plotting functions, allowing rapid display and interrogation of velocity, backscatter, and bathymetry data.

To-date no standardized technique exists for combining velocity data from multiple ADCP transects to produce a composite depiction of three-dimensional velocity fields. To address this important need, the Velocity Mapping Toolbox (VMT) has been developed for processing, analyzing, and displaying velocity data collected along multiple ADCP transects. VMT can be run using either the Matlab® source code or compiled standalone executables. Users with access to Matlab® are encouraged to run the source code for the most versatility. However, some older versions of Matlab®, for example version 7.0.4, are not able to run GUIs like VMT that are created with newer versions of Matlab®. In this case, run the executables rather than the source code. The VMT and utility executables require the Matlab® Runtime Library 2015a 64 bit[1] to be installed prior to running.

The main processing component of the software projects data collected along several irregular ship tracks, or measurement transects, onto a straight-line plane that defines a measurement cross

[1] *http://www.mathworks.com/products/compiler/mcr/index.html*

section. The velocity data from individual transects are then averaged to produce a composite representation of the cross-sectional flow field. For more details see Velocity Mapping Toolbox (VMT): a processing and visualization suite for moving-vessel ADCP measurements, ESPL, by Parsons and others (2013).

Limitations

- Only moving-boat transects are supported. The software does not support stationary profile data.
- Presently (2016) the software accepts input from TRDI ADCPs, including RioGrande 600 and 1200 MHz, RiverRay, StreamPro, RiverPro, and RioPro. VMT will also accept input from SonTek M9 or S5 ADCPs processed with RiverSurveyorLive v3.9 or later.
- The program has not been tested extensively on many platforms. Some issues may result with plotting, saving figures, etc. on platforms with different graphics capabilities and screen resolution. Please report these issues via the VMT forum (*https://simon.er.usgs.gov/smf/index.php?board=38.0*).
- Due to forward compatibility issues, the current version of VMT is not compatible with older versions of Matlab® (for example, v.7.0.4). If you experience issues of Matlab® crashing when running VMT, please either upgrade Matlab® to the newest version or run the compiled version of VMT.

Overview of the VMT User Interface

When starting VMT, you are presented with the Graphical User Interface (GUI) shown in Figure 1. The GUI has a menu bar with access to most functions/operations, and a toolbar allowing quick access to common functions. Processing workflow is organized into procedural panels.

All menus, panels, and options are explained in detail in the next section.

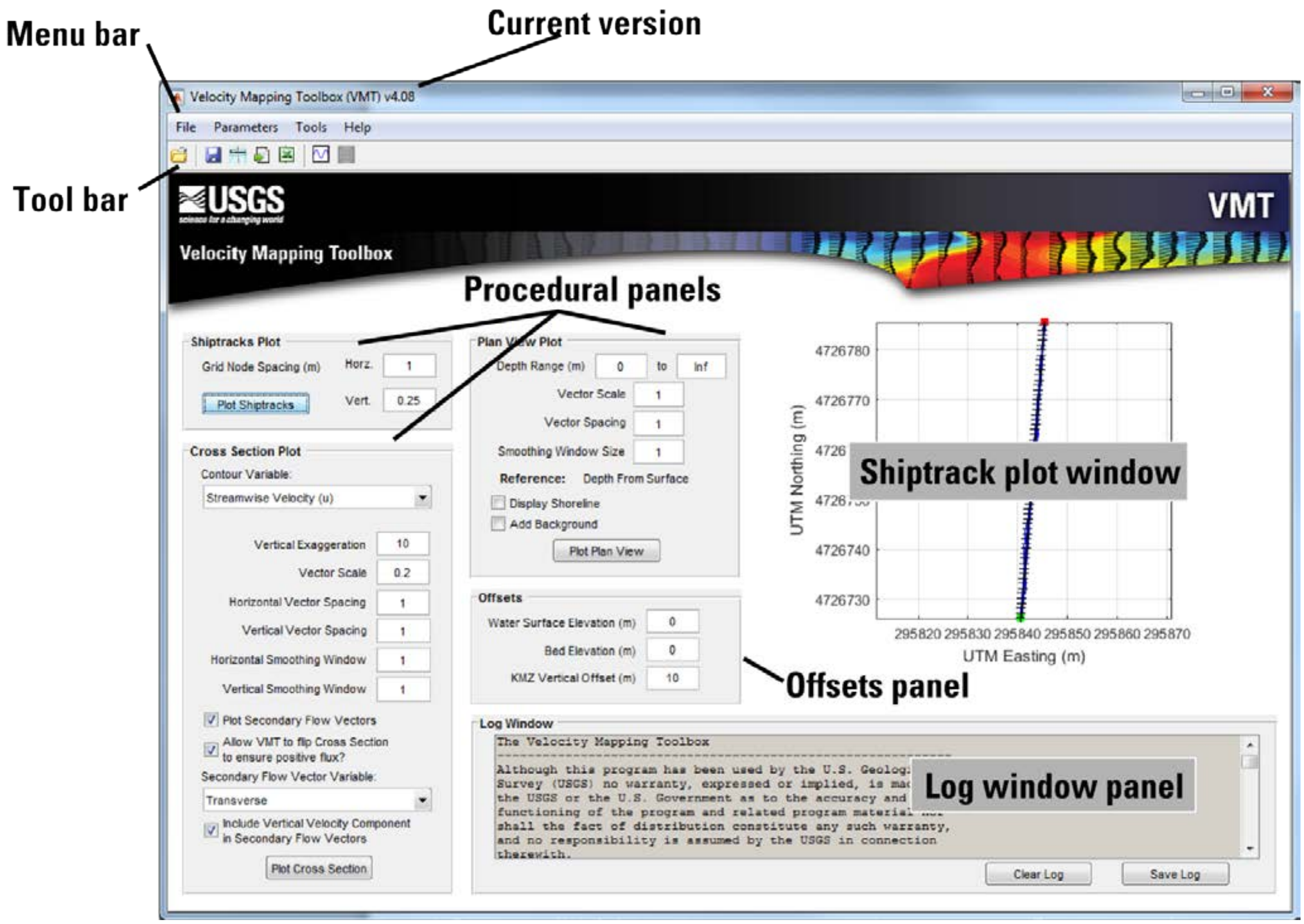


Figure 1. The VMT graphical user interface (GUI).

Menu Bar

File

Provides access to various I/O tools. The following submenus are included:

1. Open

a. TDRI ASCII Files (Ctrl+O): Prompts to load TDRI ASCII output files created by the WinRiver II software package

b. SonTek MAT Files (Ctrl+R): Prompts to load MAT files created from the RiverSurveyorLive v3.9 or newer software package

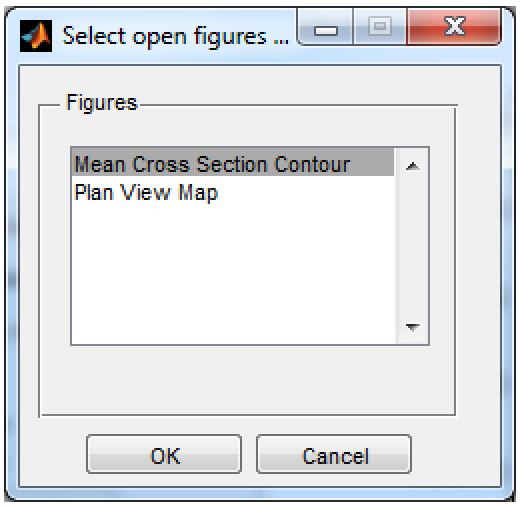
c. VMT MAT File (Ctrl+M): Prompts to load MAT file created by VMT from previously processed data

2. Save MAT File (Ctrl+S)
3. Export

a. Figure Export Settings

i. Print or Presentation: Choose between two standard figure formats

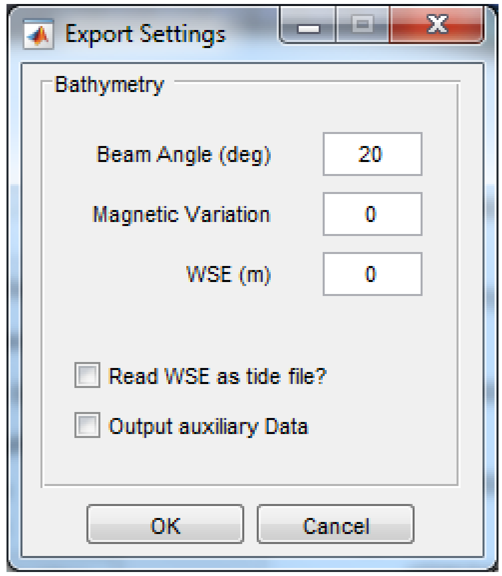
b. Export Figures as Graphics: Prompts to save currently open figures as PNG or EPS graphics files



Choose the desired figure from the list of currently available figures ans press OK to export graphics.

c. Export iRic ANV File: Prompts to save a text file in a format recognizable in the iRic modeling framework. *Note: this feature will be depreciated in a future version.*

d. Bathymetry Export Settings: Opens the following dialog allowing for adjustment of parameters related to bathymetry.



Beam Angle (deg): This is the angle between the beams of the ADCP. The angle is dependent on the ADCP manufacturer.

Magnetic Variation: The modeled or measured magnetic variation from true north in degrees. This is used to correct compass headings if required. (this feature has been depreciated).

WSE (m): Elevation of the water surface in meters.

Read WSE as tide file?: If this box is checked, VMT will prompt the user for a text file containing a time series of water surface elevation data.

Output Auxiliary Data: If this box is checked, VMT will also export an auxiliary file with more information

e. Export Multibeam Bathymety: Prompts to save a CSV file containing the bed elevations measured by all four individual beams (corrected for heading, pitch, and roll, and user-supplied water surface elevation).

f. Export KMZ File: Prompts to save a KMZ file of the processed Mean Cross Section (MCS), using the specified Vertical Offset (KMZ Vertical Offset, in the Offsets Panel). The vertical offset is equal to the height the cross section will be raised above the image plane in Google Earth®.

g. Export Tecplot® File: Prompts to export a Tecplot® DAT file of the processed Mean Cross Section (MCS).

h. Export Excel® File: Prompts to export an Excel® File of the processed VMT data.

i. Export Custom Flat File: Prompts to export a CSV file with user selected variables.

4. Exit: Closes the program.

Settings

Adjust and set parameters used by VMT. The following submenus are included:

1. Units
    a. Metric or English: Metric units are the default. NOTE: all data must be imported in metric units and this feature only controls the units of the figures.Processing
2. Processing
    a. Unit Discharge Correction: Activate or Deactivate the Unit Discharge Correction. The Unit Discharge Correction is deactivated by default (see Parsons et al. 2013 for more information).
3. Plotting
    a. Set Cross-Section Endpoints
        i. Automatic or Manual: Automatic is the default. Manual (fixed) endpoint may be entered by the user.
    b. Style
        i. Print or Presentation: Presentation is the default.
    c. Graphics Renderer: Choose which graphic renderer VMT uses to display plots on the user's monitor. The default is OpenGL, with 2 other options: Painters and Zbuffer. If the user experiences issues with seeing plots on the screen, adjust this option.

    d. Advanced Settings: Opens a dialog box with the following settings:

        i. Offsets:
            1. Water Surface Elevation (m): A user entered water surface elevation. Default is 0 meters.
            2. Bed Elevation (m): A user entered water surface elevation. Default is 0 meters. This setting is only used in the Height above Bed reference.
            3. KMZ Verical Offset (m): Ground clamp distance used when creating a KMZ export file.
        ii. Vertical Reference

1. Depth From Surface: This is the default option. Computation of the MCS assumes that all data are referenced from the water surface (at depth equal to 0 meters)
2. Height Above Bed: Computation of the MCS assumes that all data are refenced from the bed/bottom. Vertical distance/elevation is shown as the distance from the bottom for each grid node. The user can specify a Bed Elevation which is added to each grid node elevation (this feature works best with artificall channels with flat bottoms).

iii. Cross Section Orientation: Choose between letting VMT automatically determine the starting bank of the Mean Cross Section, or choose left or right bank.

Tools

Start standalone tools packaged with VMT. The following tools are included:

1. GIS Export Tool: Opens a new GUI window for exporting the depth- time- or layer-averaged ADCP data to a GIS formatted CSV table. Also allows basic plotting of data.
2. TDRI ASCII to KML: Prompts to save currently loaded TDRI Shiptrack data as line features in a KML file for viewing in Google Earth®.
3. SonTek MAT to KML: Prompts to save currently loaded SonTek Shiptrack data as line features in a KML file for viewing in Google Earth®.
4. Open Batch Mode: Opens a new GUI window that runs the VMT processing engine in a batch mode, enabling you to process multiple transects for multiple cross sections with the click of a button.

Help

Displays help information. The following submenus are included:

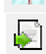
1. Users Guide: Opens the User Guide ADOBE PDF.
2. Function Library: Opens a web-formatted (stored locally) documentation library of all of the functions and files included in the VMT software. This is especially useful for understanding the source code.

3. Check for Updates: Checks the currently running version of VMT against the most recently released version, and alerts you of the status. This feature requires an active internet connection.
4. About: Displays the following information window (your version number may be different).

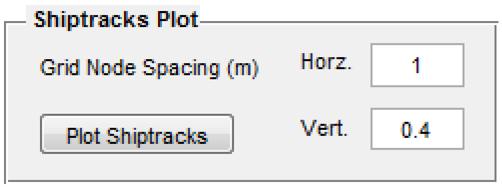
Toolbar

The VMT toolbar allows for quick access to common tasks. Table 1 shows each toolbar item and its function. In addition, tooltips will appear when you hover the mouse over a toolbar icon.

Table 1. VMT toolbar item descriptions.

Icon	Description
	Open ASCII File(s)
	Save MAT File
	Export multibeam bathymetry file
	Export figure(s)
	Export Excel® spreadsheet
	Plotting parameters
	Processing parameters (currently unused)

Shiptracks plot



The Shiptacks Plot Panel is the first panel in the VMT User Interface (Figure 1), and consequently is the typical starting point for any processing you do. There are two items in this panel:

Horizontal Grid Node Spacing (m): This is the horizontal resolution of the Mean Cross Section (MCS). The default is 1 meter, but you may set it to whatever you wish. However, it is recommended that you chose a value representative of the data being processed. VMT will make a suggested spacing, which is displayed in the Log Window (see the Log Window Panel).

Vertical Grid Node Spacing (m): This is the vertical resolution of the MCS. The default value varies depending on the data type currently loaded. For TDRI RioGrande and StreamPro ADCPs, the default is the bin size. For TDRI RiverRays, the default is 0.4 meters.

Plot Shiptracks: This button will process the currently loaded dataset, and display a map in the Shiptracks Plot Window.

Shiptracks plot window

The Shiptracks plot (Figure 1) is intended to be a quick reference tool for viewing the processed Mean Cross Section (MCS) and the original ADCP recorded Shiptracks. When VMT starts, this plot is initialized as an empty chart.

Task: To create a Shiptrack Plot, ensure that data are loaded. VMT will automatically load and process the data to produce the Shiptrack Plot.

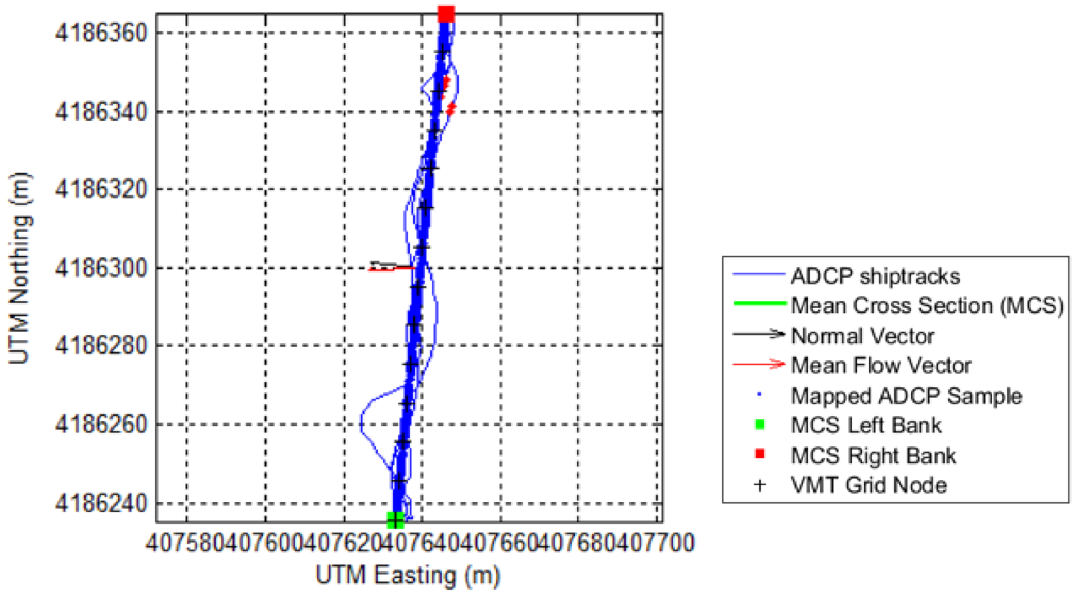
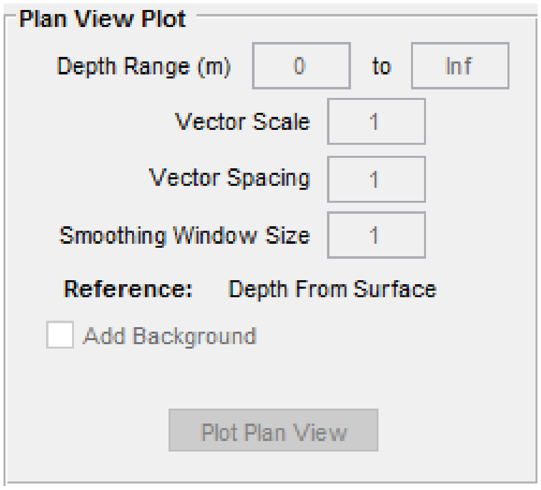


Figure 2. VMT shiptracks plot explanation.

Plan view plot panel



The Plan View Plot Panel (Figure 1) allows you to control the depth- or layer-averaged parameters used to produce the Plan View Map Figure. In includes the following options:

Depth Range (m): You may select the vertical depth range over which VMT will average the East and North velocity components used to produce the Plan View Map Figure. The default is the full depth range (that is, depth of 0 to infinity). VMT use the following equation to determine layer-averaged quantities:

$$V_{la} = \frac{1}{d_2 - d_1} \int_{d_1}^{d_2} V dz \qquad (1)$$

where V Velocity component being averaged (typically East and/or North components)

d_1 minimum depth for layer-averaging

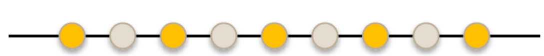
d_2 maximum depth for layer-averaging

V_{la} layer-averaged velocity

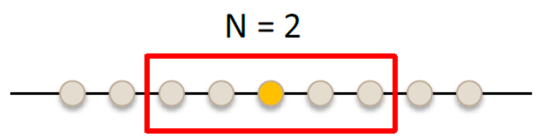
Vector Scale: You can adjust the length of plotted vectors in the Plan View Map Figure with this parameter. Vector lengths are determined using an autoscaling procedure. The Vector Scale quantity is a simple multiplier of the vector lengths. For example, to produce a vector twice the length as the default, set Vector Scale to 2. The default is 1.

Vector Spacing: This is the “index skip factor” (VS) used by VMT to plot only particular vectors along the Mean Cross Section (MCS). Setting Vector Spacing to 2 will make VMT plot only every other vertical in the MCS. The map distance between vectors is the Vector Spacing multiplied by the Horizontal Grid Node Spacing. For example, with a node spacing of 2.5 meters and vector spacing of 2, VMT will plot vectors which are 5 meters apart. The default Vector Spacing is 1, and this value must be an integer greater than 0.

$$VS = 2$$



Smoothing Window Size: This sets the window size (N) which VMT uses to apply a 1-D moving average to the layer-averaged velocities. The window size specifies the number of nodes on either side of the central node which is used in the average. VMT ignores any missing data in the computation. The default Smoothing Window Size is 1, and this value must be an integer greater than 0.



Reference: Displays the current depth reference as set in Settings→Advanced Settings→Vertical Reference. The default is Depth From Surface. VMT also supports the Height Above Bottom reference.

Add Background: If selected, VMT will prompt you to load one or more georeferenced image files, to be added as a background of the Plan View Map Figure. NOTE: the background imagery or file must have a UTM projection to plot properly. Several programs, including ArcGIS®, are available to change projections and coordinate systems of georeferenced images and shapefiles.

Tip: Though the intent of the Add Background functionality is to display image files (e.g., GeoTiff, TIFF/JPEG/PNG with a world file), VMT will recognize the following spatial data types:

- Shapefiles (point, line, or polygon classes)
- ARC ASCII GRIDs
- SDTS Rasters

Plot Plan View: This button will process the currently loaded dataset, and display the Plan View Map Figure.

Plan view map figure

The Plan View Map figure (Figure 3) is a planform plot of depth- or layer-averaged velocity vectors produced by the averaging procedure of VMT. When processing for a single cross section, the Plan View Map figure will contain only one set of vectors along the mean cross section (Figure 3A). Multiple cross sections can be viewed at once and all referenced to the same scale by loading several previously processed VMT transects (MAT files) (Figure 3B). You may also visualize a vector shoreline (Figure 3C) and/or aerial imagery (Figure 3D). A colorbar provides the scale for the planview vectors. The title displays the range over which vectors have been averaged, and the units designation. All planview plots in VMT are in UTM coordinates.

Task: To create the Plan View Map figure, ensure that data are loaded, adjust parameters in the Plan View Plot panel as desired, and press. 

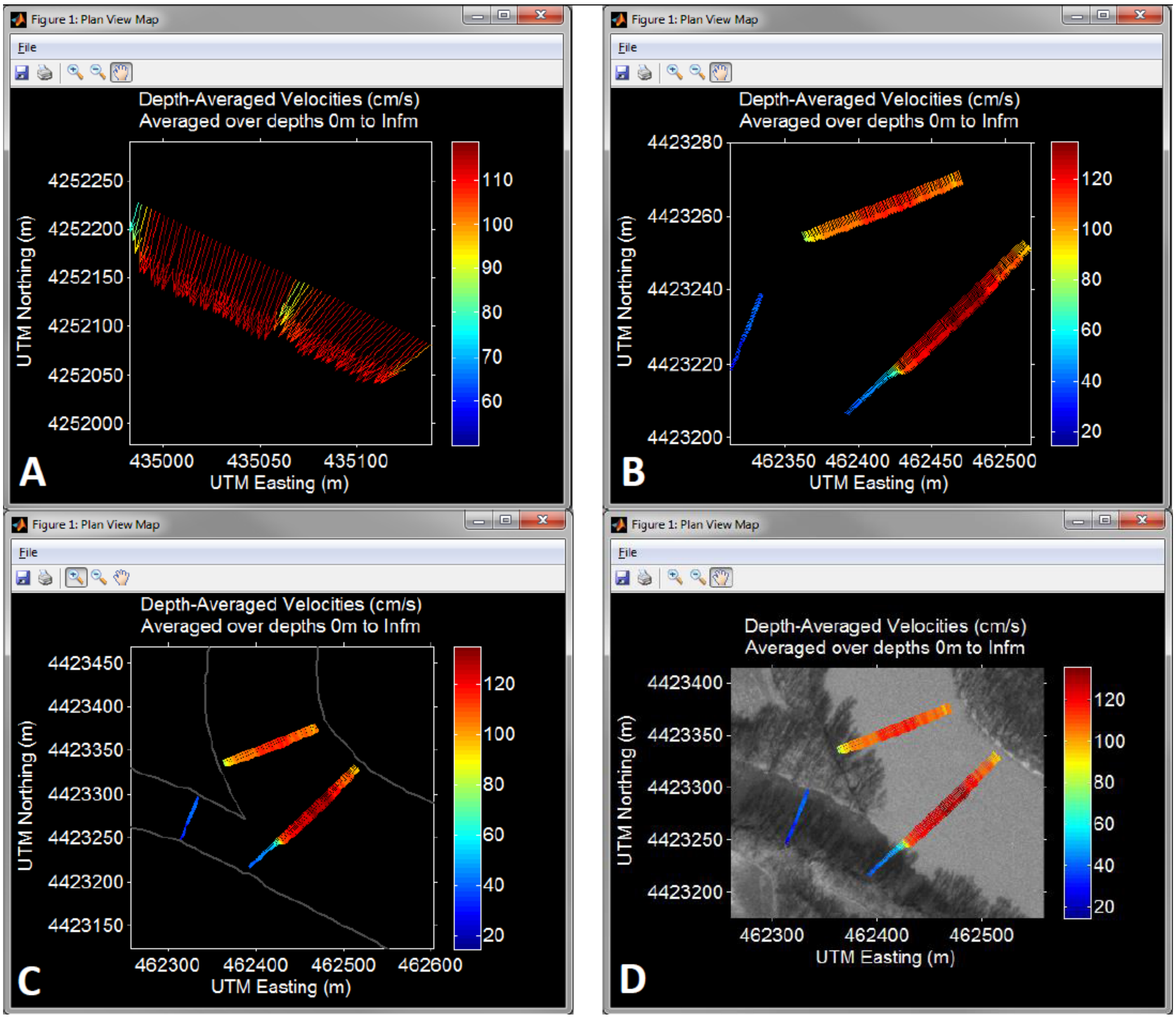
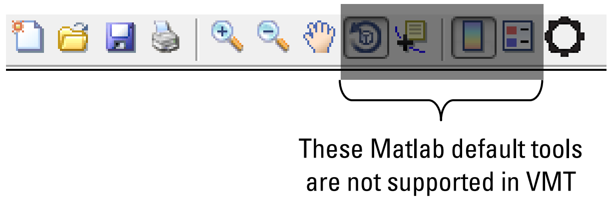


Figure 3. Layout of the Plan View Map figure in VMT.

The Plan View Map figure can be manipulated by several means to produce a plot suitable to your needs. To resize the figure, Left click-hold on any edge of the figure and drag to desired dimensions. Use the figure window toolbar to zoom in or out, and pan the viewable extent of the figure.

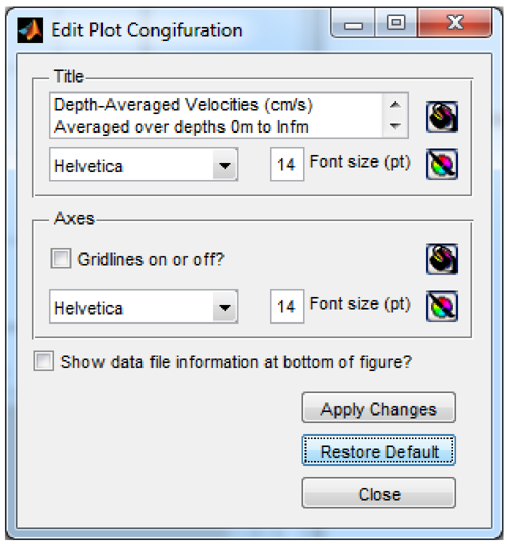
You may also save a Matlab® native file of the figure (*.fig file), or print the figure using the Matlab® default export settings, all from the toolbar.

The Figure Toolbar:

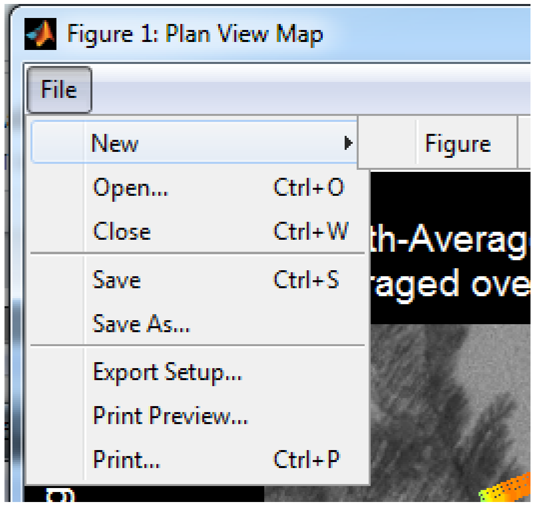


Tip: Once you have setup a figure the way you want it to look, use the Save feature in the File menu to create a *.fig file. Then, you can use the Open… figure menu item to reload the figure. VMT will still recognize the reloaded figure.

The gear icon  on the Figure Toolbar may be used to customize the VMT plots further, or reset them to the original formatting:

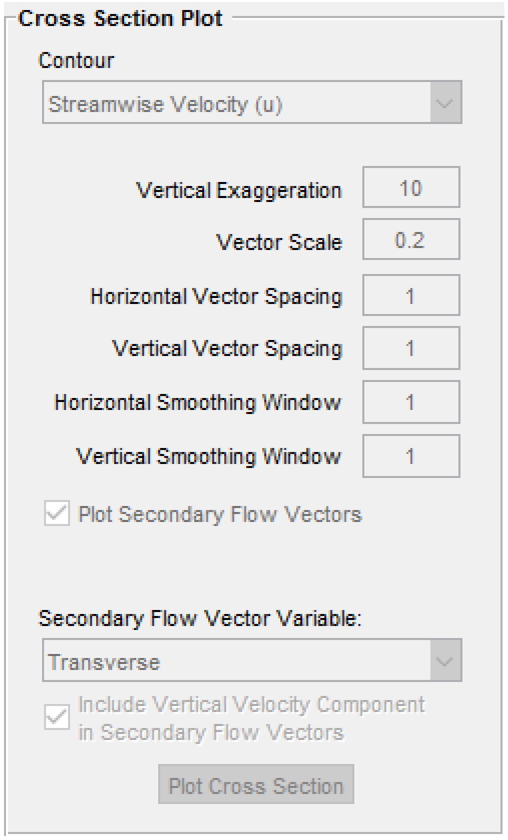


Using the File Menu, you may perform other optional actions, some of which are not technically part of VMT, but are included within the Matlab® MCR environment VMT was compiled in.



Note: Though it is possible to export the figure from the File→Export Setup… dialog, it is recommended that you use the Export Figure functionality within the Main VMT User Interface. If the predefined export settings in the VMT interface are not sufficient for your purposes, the File→Export Setup… option provides customizable export files.

Cross section plot panel



The Cross Section Plot Panel (Figure 1) allows you to control the parameters used to produce the Mean Cross Section Figure. In includes the following options:

Contour Variable: This is the primary variable used to create a colored contour rendering in the Mean Cross Section Contour Figure. There are several options (Table 2).

Vertical Exaggeration: This is the ratio of the horizontal to vertical axes that VMT uses in the Mean Cross Section Contour Figure. The default is 10.

Vector Scale: You can adjust the length of plotted vectors in the Mean Cross Section Contour Figure with this parameter. Vector lengths are determined using an autoscaling procedure. The Vector Scale quantity is a simple multiplier of the vector lengths. For example, to produce a vector twice the length as the default, set Vector Scale to 2. The default is 0.2.

Horizontal Vector Spacing: This is the “index skip factor” used by VMT to plot only particular vectors along the horizontal axis of the Mean Cross Section Contour Figure. Setting the Horizontal Vector Spacing (HVS) to 4 will make VMT plot only every fourth horizontal grid node location in the MCS. The map distance between vectors is the Horizontal Vector Spacing multiplied by the Horizontal Grid Node Spacing (for example, with a node spacing of 2.5 meters and horizontal vector spacing of 2, VMT will plot vectors which are 5 meters apart in the horizontal. The default Horizontal Vector Spacing is 1, and this value must be an integer greater than 0.

Vertical Vector Spacing: This is the “index skip factor” used by VMT to plot only particular vectors along the vertical axis of the Mean Cross Section Contour Figure. Setting the Vector Spacing (VVS) to 2 will make VMT plot only every other vertical grid node location in the MCS. The map distance between vectors is the Vertical Vector Spacing multiplied by the Vertical Grid Node Spacing (bin size) For example, a bin size of 0.1 meters and vertical vector spacing of 2 will produce a plot of vectors which are 1 meter apart in the vertical. The default Vertical Vector Spacing is 1, and this value must be an integer greater than 0.

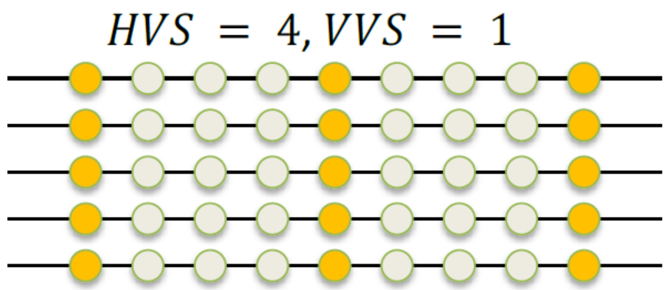


Table 2. Contour Variable options for the Mean Cross Section Contour Figure (see Parsons and others 2013 for more information on primary and secondary flow definitions).

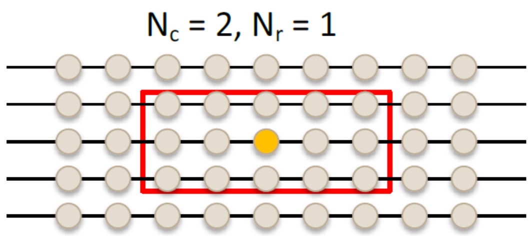
Contour variable	Description
Streamwise Velocity (u)	Component of velocity perpendicular to the MCS
Transverse Velocity (v)	Component of velocity parallel to the MCS
Vertical Velocity (w)	Component of velocity in the vertical axis
East Velocity (E)	East component of velocity ENU frame of reference
North Velocity (N)	North component of velocity ENU frame of reference
Error Velocity	Vertical error velocity as reported by the ADCP[1]
Primary Velociy (zsd)	Primary component of velocity after zero net secondary discharge rotations
Secondary Velocity (zsd)	Secondary component of velocity after zero net secondary discharge rotations
Primary Velociy (Roz)	Primary component of velocity after Rozovskii discharge rotations
Secondary Velocity (Roz)	Secondary component of velocity after Rozovskii discharge rotations
Prim. Vel. (Roz, downsream component)	Component of primary velocity in the streamwise (u) direction computed from Rozovskii discharge rotations
Prim. Vel. (Roz, cross-stream component)	Component of primary velocity in the cross-stream (v) direction computed from Rozovskii discharge rotations
Sec. Vel. (Roz, downsream component)	Component of secondary velocity in the streamwise (u) direction computed from Rozovskii discharge rotations
Sec. Vel. (Roz, cross-stream component)	Component of secondary velocity in the cross-stream (v) direction computed from Rozovskii discharge rotations
Backscatter	Backscatter intensities as reported by the ADCP[2]
Flow Direction (degrees)	Flow direction in geographic degrees (compass heading)
Flow Vorticity (v,w)	Cross stream-lateral vorticity (curl) of the flow
Flow Vorticity (zsd)	Cross stream-lateral vorticity (curl) of the flow using the Zero Secondary Flow lateral component
Flow Vorticity (roz)	Cross stream-lateral vorticity (curl) of the flow using the Rozovskii lateral component

[1]Error velocity is reported in the same manner as it is output by the ADCP software

[2]Backscatter can be decibels or counts, depening on options chosen in ADCP software. Backscatter from SonTek ADCPs is not currently supported.

Horizontal Smoothing Window: This in tandem with the Vertical Smoothing Window sets the horizontal window size (Nc) which VMT uses to apply a 2-D moving average to Mean Cross Section (MCS) velocities. The window size specifies the number of nodes on either side of the central node which are used in the average. VMT ignores any missing data in the computation. The default Horizontal Smoothing Window Size is 1, and this value must be an integer greater than 0.

Vertical Smoothing Window: This in tandem with the Horizontal Smoothing Window sets the vertical window size (Nr) which VMT uses to apply a 2-D moving average to Mean Cross Section (MCS) velocities. The window size specifies the number of nodes on above and below of the central node which are used in the average. VMT ignores any missing data in the computation. The default Vertical Smoothing Window Size is 1, and this value must be an integer greater than 0.



Note: To determine the spatial extent of the smoothing window, multiply the Horizontal Smoothing Window by the Horizontal Grid Node Spacing times 2, and the Vertical Smoothing Window by the Vertical Grid Node Spacing (that is bin size) times 2. For example, with a bin size of 0.25 meters, horizontal grid size of 1 meter, and horizontal and vertical smoothing window size of 3 and 2 respectively, VMT will perform a 2-D moving average of a region 6 meters wide, by 1 meter deep, centered on a node.

Plot Secondary Flow Vectors: when selected, VMT will add superimposed cross-stream and vertical vectors to the Mean Cross Section Contour Figure. The default is checked.

Secondary Flow Vector Variable: this is the secondary variable used to create superimposed vertical and cross-stream vectors on the Mean Cross Section Contour Figure. There are several options (Table 3). The default variable is Transverse.

Table 3. Secondary Flow Variable options for the Mean Cross Section Contour Figure (see Parsons and others 2013 for more information on primary and secondary flow definitions).

Secondary flow variable	Description
Transverse	Component of velocity parallel to the MCS
Secondary (zsd)	Secondary component of velocity after zero net secondary discharge rotations
Secondary (Roz)	Secondary component of velocity after Rozovskii discharge rotations
Secondary (Roz, cross-stream component)	Component of secondary velocity in the cross-stream (v) direction computed from Rozovskii discharge rotations
Primary (Roz, cross-stream component)	Component of primary velocity in the cross-stream (v) direction computed from Rozovskii discharge rotations

Include Vertical Velocity Component in Secondary Flow Vectors: when selected, VMT will include the Vertical Velocity (w) component in the vectors. When unchecked, only the selected Secondary Flow Vector Variable is used to create the vectors. The default is checked.

Plot Cross Section: This button will process the currently loaded dataset, and display the Mean Cross Section Contour Figure.

Mean cross section contour figure

The Map Cross Section Contour plot (Figure 4) displays the transect-averaged data in both a color-coded contour plot and a vector field. You can control what variables are plotted for both the contour plot and the vector field. In addition, you have the option to not include the vertical velocity component in the vector field. Unmeasured area near the surface and bed is shown and no data is interpolated into these regions. A colorbar provides the scale for the contour plot and a reference vector is provided for the vector field. The title displays the currently plotted velocity components (both contour and vector) and units designation.

Task: To create the Map Cross Section Contour figure, ensure that data are loaded, adjust parameters in the Cross Section Plot panel as desired, and press Plot Cross Section.

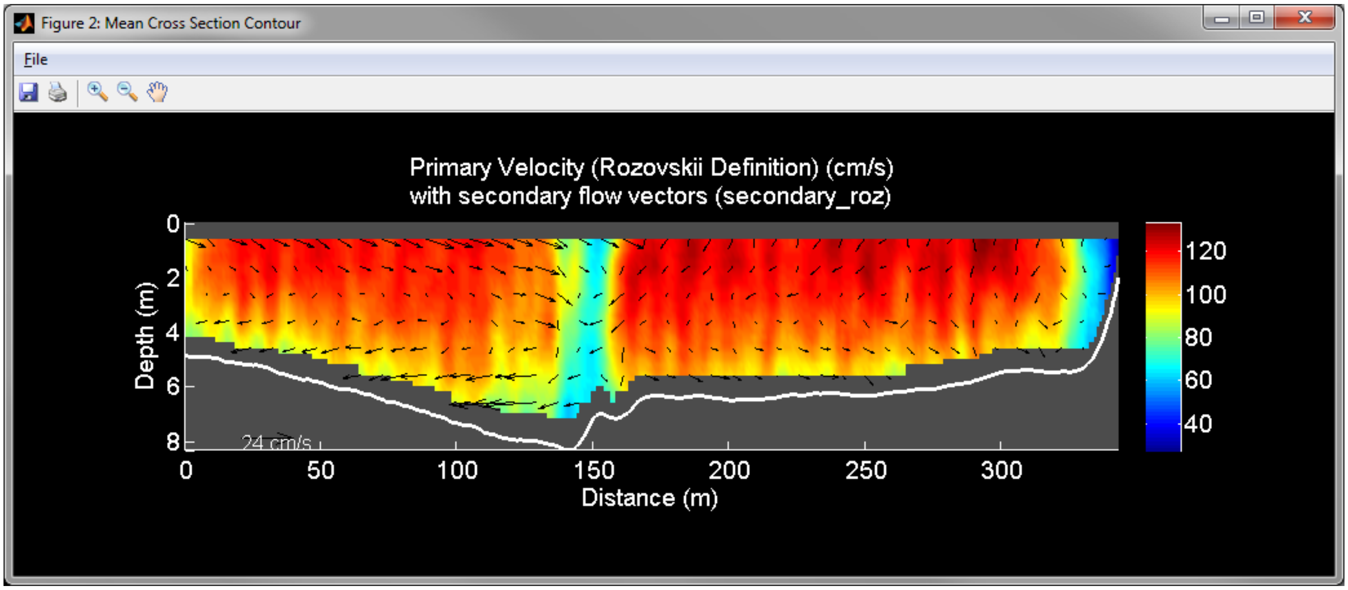


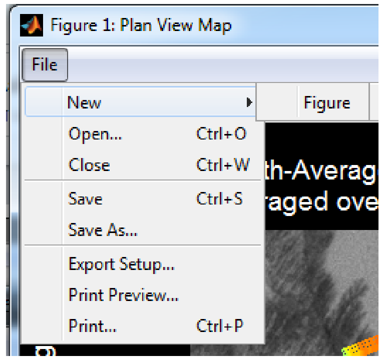
Figure 4. Layout of the Mean Cross Section figure in VMT.

The Map Cross Section Contour figure can be manipulated by several means to produce a plot suitable to your needs. To resize the figure, Left click-hold on any edge of the figure and drag to desired dimensions. Use the figure window toolbar to zoom in or out, and pan the viewable extent of the figure. You may also save a Matlab® native file of the figure (*.fig file), or print the figure using the Matlab® default export settings, all from the toolbar.

The Figure Toolbar: 

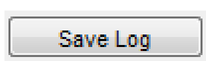
Tip: Once you have setup a figure the way you want it to look, use the Save feature in the File menu to create a *.fig file. Then, you can use the Open… figure menu item to reload the figure. VMT will still recognize the reloaded figure.

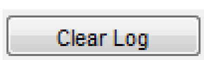
Using the File Menu, you may perform other optional actions, some of which are not technically part of VMT, but are included within the Matlab® MCR environment VMT was compiled in.



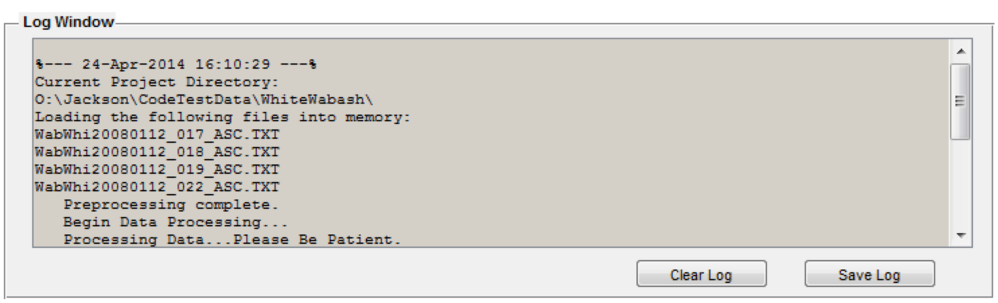
Note: Though it is possible to export the figure from the File→Export Setup… dialog, it is recommended that you use the Export Figure functionality within the Main VMT User Interface. If the predefined export settings in the VMT interface are not sufficient for your purposes, the File→Export Setup… option provides customizable export files.

Log window panel

The Log Window Panel displays helpful information about processing and plotting parameters in VMT. You may scroll through previous messages generated during the current session. To save the log of the current session to a text file, press 

. Conversely, you may clear the current log by pressing 

.



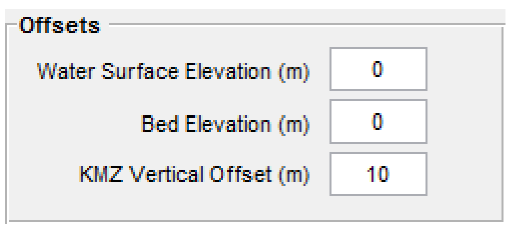
Tip: When processing a large dataset it is very helpful to save your logs. In this way, you can recall the settings and parameter used to produce a particular figure and/or dataset at a later time.

Advanced Settings

Generally, the default settings are sufficient for most cases. However, VMT also offers some other options, found in Settings→Advanced Settings in the menus.

Offsets

The Offets Panel displays the various vertical elevation offset option available in VMT. These offsets are used to modify VMT outputs and data exports.



Water Surface Elevation: Set a constant water surface elevation for the loaded MCS. This elevation is used to compute bed elevations (in Depth From Surface reference) for each vertical in the MCS. These results are output in the various data export functionalities.

Bed Elevation: Set a constant bed elevation for the loaded MCS. This elevation is used to compute elevations (in Height Above Bed reference) for each vertical in the MCS. These results are output in the various data export functionalities. Notice that this is a constant value for *each* grid node, thus this offset is most useful when working with artificial channels with flat bottoms.

KMZ Vertical Offset: This is a distanced used by VMT when exporting the Mean Cross Section to a Google Earth KMZ file. By Default, Google Earth will “clamp” the Cross Section to the surface of the earth. To be able to correctly visualize the cross section(s), you must specify some offset distance here. As a rul of thumb, set the vertical offset distance to about or just greater than the deepest depth in your VMT processed cross section(s).

Vertical Reference

This panel allows users to set how VMT computes bed elevations and depths.

Depth From Surface: this is the default option, and most appropriate for natural channels. The datum for computations of depth is the water surface elevation.

Height Above Bottom: this option is handy if producing outputs you wish to compare to a “boundary clamped” model, or when the channel geometry is flat (for example, a rectangular cross section). The datum for computations of depth is the channel bed, as determined from ADCP beam depths.

Cross Section Orientation

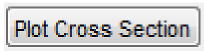
This panel allows users to set how VMT sets the starting and ending banks for computations.

Automatic: this is the default option. VMT will compute a rough net flux of streamwise discharge in the mean cross section, and flip the orientation of the cross section such that it starts from the left bank and ends on the right bank (as if viewed from upstream). This is appropriate for rivers and unidirectional flows.

Start bank (Left or Right): the user can override the automatic start bank determination if needed. When selected, VMT forces the mean cross section start bank to be as selected. This is useful if collecting velocities in bidirectional or stratified flows, or if the user must have stationing (chainage) start at one side or the other.

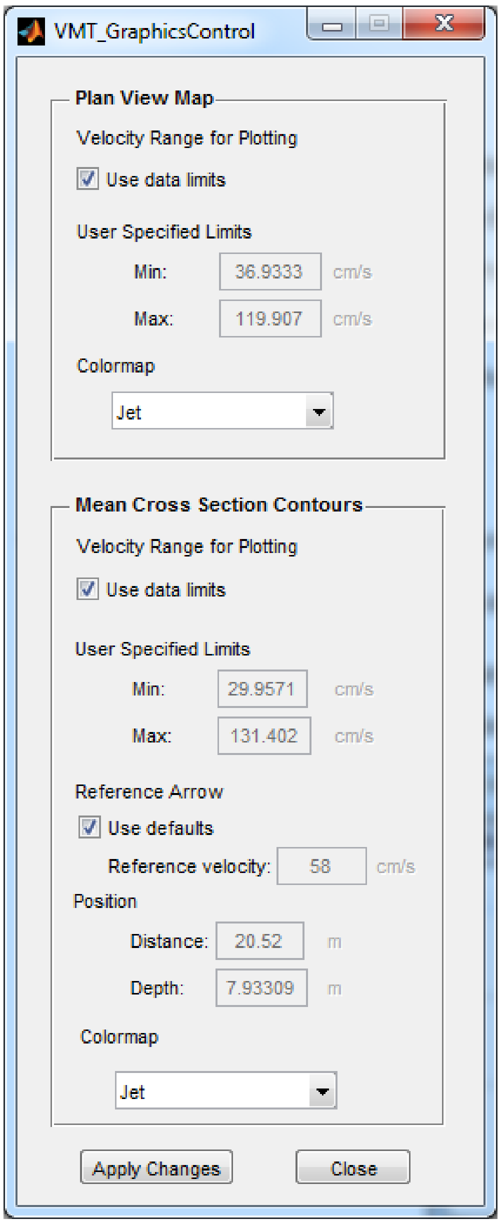
Graphics control sub-GUI (VMT_GraphicsControl)

The Graphics Control Sub-GUI gives you more flexibility in the feel and appearance of the Plan View Map and Mean Cross Section Contour Figures. The Sub-GUI automatically opens whenever either the 

or 

buttons are pressed.

Fields in the Sub-GUI are automatically populated by the limits and default parameters in the currently loaded dataset. The following options, grouped by panel are included:



Plan View Map Panel

User Specified Limits: You can adjust the limits of the velocity range plotted in the plan view figure by changing the Min and Max values. The boxes remain greyed out until you uncheck Use Data Limits.

Colormap: Choose from a variety of built in colormaps (Figure 5), or browse for a custom colormap specified in the CPT file format.

Mean Cross Section Contours Panel

User Specified Limits: You can adjust the limits of the velocity range plotted in the contour figure by changing the Min and Max values. The boxes remain greyed out until you uncheck Use Data Limits.

Reference Velocity: You can adjust the magnitude of the reference vector by changing this value. The box remains greyed out until you uncheck Use defaults.

Position: You can specify the location of the tail of the Reference Vector by adjusting the Distance and Depth Values. The boxes remain greyed out until you uncheck Use defaults.

Colormap: Choose from a variety of built in colormaps (Figure 5), or browse for a custom colormap specified in the CPT file format.

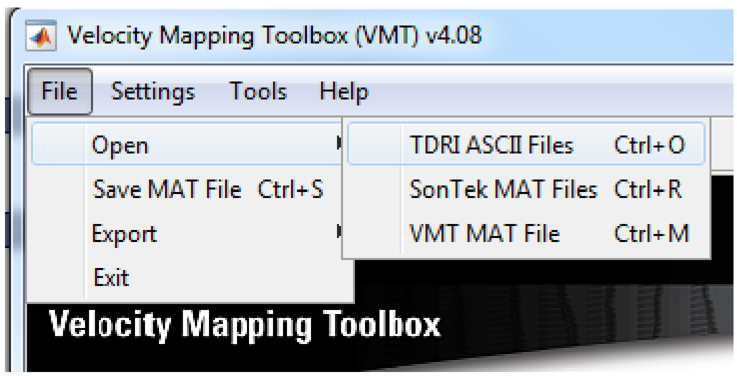
Figure 5. Built in VMT colormaps.

Procedures and typical workflows

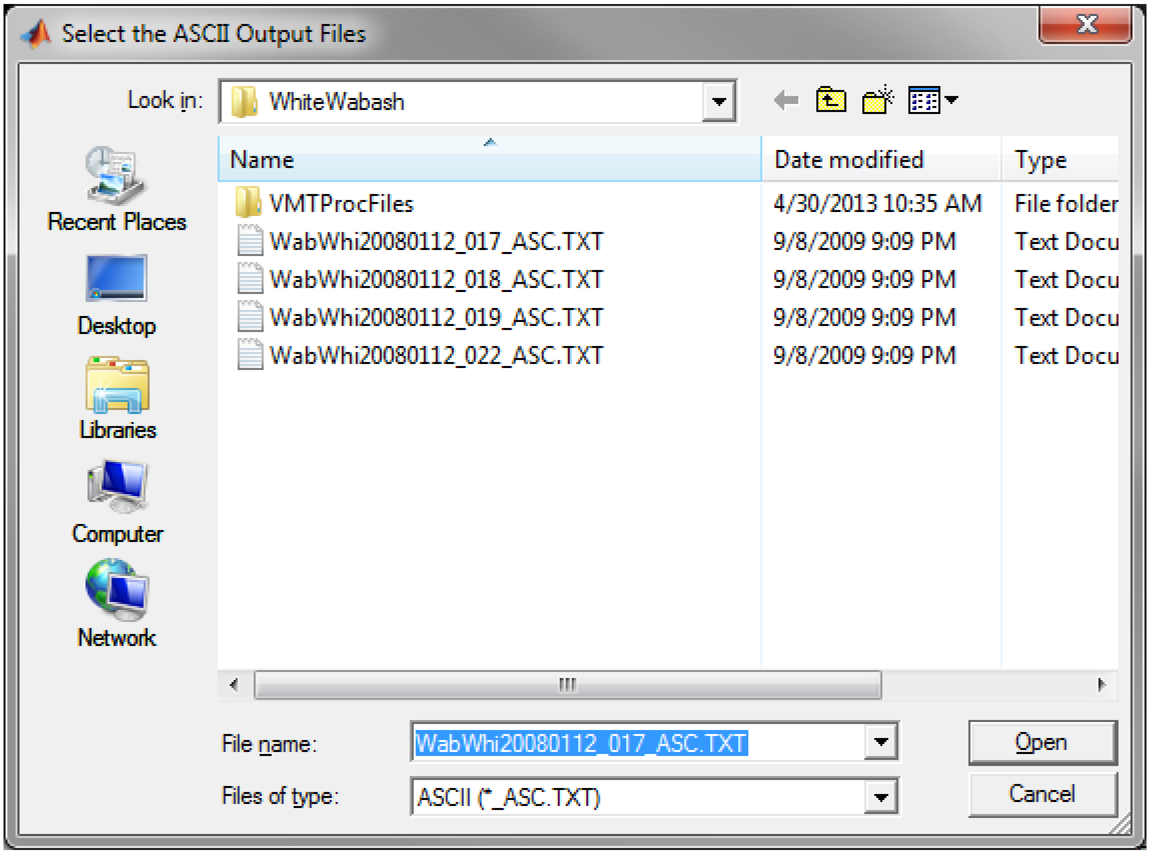
This section is organized into a set of tasks typically performed when analyzing data in VMT. It follows a logical progression similar to what you might use in your own work.

Loading raw ASCII data from WinRiver II®

VMT can read data exported in WinRiver II® using the Classic ASCII option. To load raw ASCII data (see note about formatting below), choose File→Open→TDRI ASCII Files. (Conversely you can press Ctrl+O, or click the  button).



You will be prompted to navigate for ASCII (*._ASC.TXT) files. If you have used VMT before, it will remember the last folder you loaded ASCII files from. NOTE: VMT looks for files with the (*._ASC.TXT) format, so if you rename your ASCII files after producing them in WinRIver II® (for example adding an additional text to the end of the filename), VMT will not recognize your ASCII files. Make sure your files all end in “_ASC.txt”.



Select the ASCII files corresponding to one cross section (i.e., all transects which were on the same tag line or cross section in the river) by holding the Shift or Ctrl keys and Left Clicking the file names. Press Open. VMT will load the files (you will see a progress bar), and push information to the Log Window Panel about the current processing session.

Tip: Loading the files is not the same as processing the data. To process the data, you must press one of the plot buttons. After loading, processing, and plotting the ASCII files, it is recommended that you save your work for future reference. See Creating a figure that suites your needs is an iterative process. Explore how changing parameters affects the plot. See the sections titled Planview Map Figure and Mean Cross Section Figure for details about the various adjustments you can make to the figure.

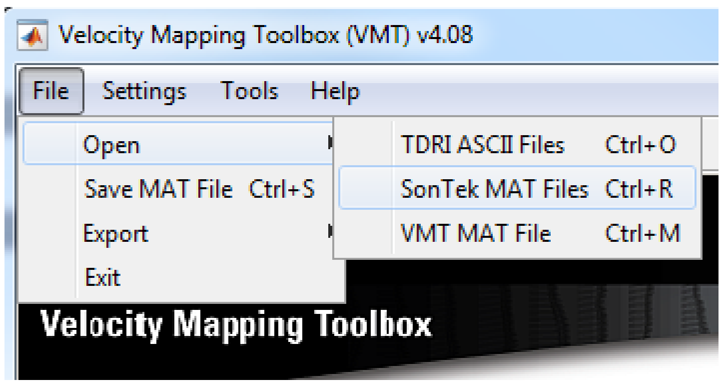
Note: There are some specific data input requirements.

1. WinRiver II® ASCII data must be “Classic ASCII Output Format” using the “Output Backscatter Data” option.
2. *SI Units (metric) must be used.* VMT will warn you if you attempt to import an ASCII file using English units.
3. It is recommended that there be no spaces in the file names, though this is no longer required. If you have trouble loading ASCII data, this is a first thing to check
4. Files should have the standard naming convention format (“*_ASC.TXT”) for easiest browsing.
5. Data must include valid GPS data within the ASCII file (VMT currently does not read the *GPS.txt files).
6. Google Earth® must be installed if outputting KMZ files (free download from Google®).
7. VMT is best suited for repeat transects at a single cross section (they will be used to compute an average cross section and velocity distribution). The software will handle a single transect however. Note that transects at a site with significant variation in the channel bathymetry and/or variation in the position of the transect may result in unusual averaging for the bathymetry and water velocities. Processing single transects in this case is recommended and will preserve bathymetry and flow variation.
8. It is helpful for to know the maximum depth within a study reach for setting the vertical offset and vertical exaggeration. When multiple cross sections are mapped in a reach, the user should set these values for the transect with the maximum depth and keep these values constant for the remaining transect sites in the reach. This ensures that vertical scaling and offsets are consistent throughout the reach (especially true for the KMZ offset—see below).
9. Occasionally, WinRiver II® will produce ASCII files with errors. If an ASCII file will not load into VMT, try exporting the ASCII file again in WinRiver II® (you may need to restart WInRiver II®) and importing into VMT again. This can usually solve the problem.

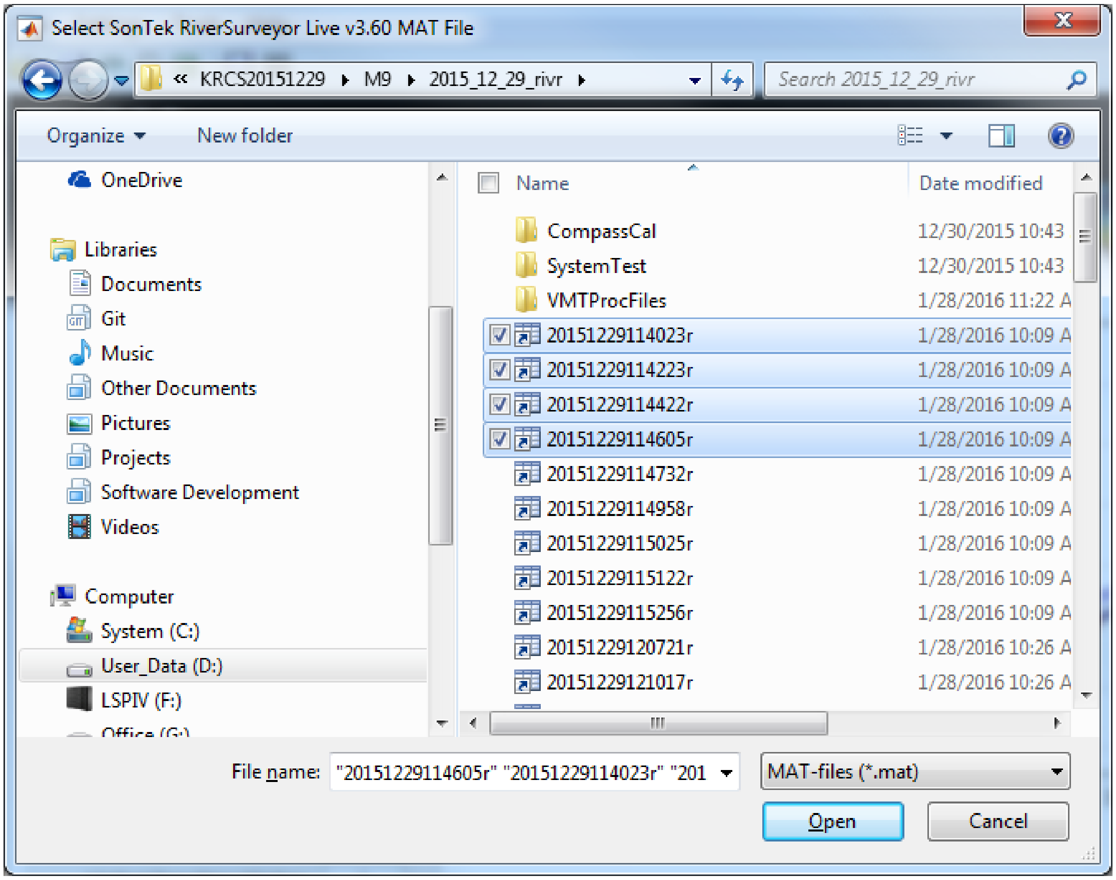
The user should have notes handy that list the repeated transects at each cross section. The user will be asked to select these ASCII output files at each cross section to determine the average cross section and velocity field for the cross section. If filed notes are poor, the user can determine the spatial locations of each transect by using the ASCII2KML_GUI utility (generates a Google Earth® KML file for each transect shiptrack for easy identification of spatial positions).

Loading M9/S5 data from RiverSurveyorLive®

VMT can read data exported in RiverSurveyorLive® versions 3.9 and newer using the MAT-file export options in RiverSurverorLive. To load M9/S5 data into VMT choose File→Open→SonTekMat Files. (Conversely you can press Ctrl+R).

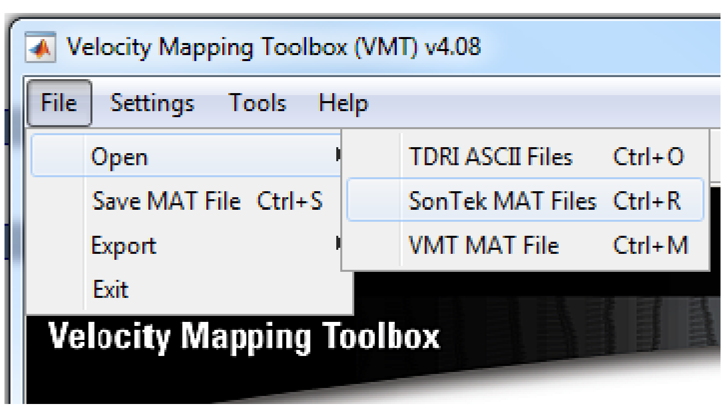


You will be prompted to navigate for MAT-files (*.mat) files. If you have used VMT before, it will remember the last folder you loaded SonTek MAT files from. Select the desired MAT-files associated with one cross section, and press Open.

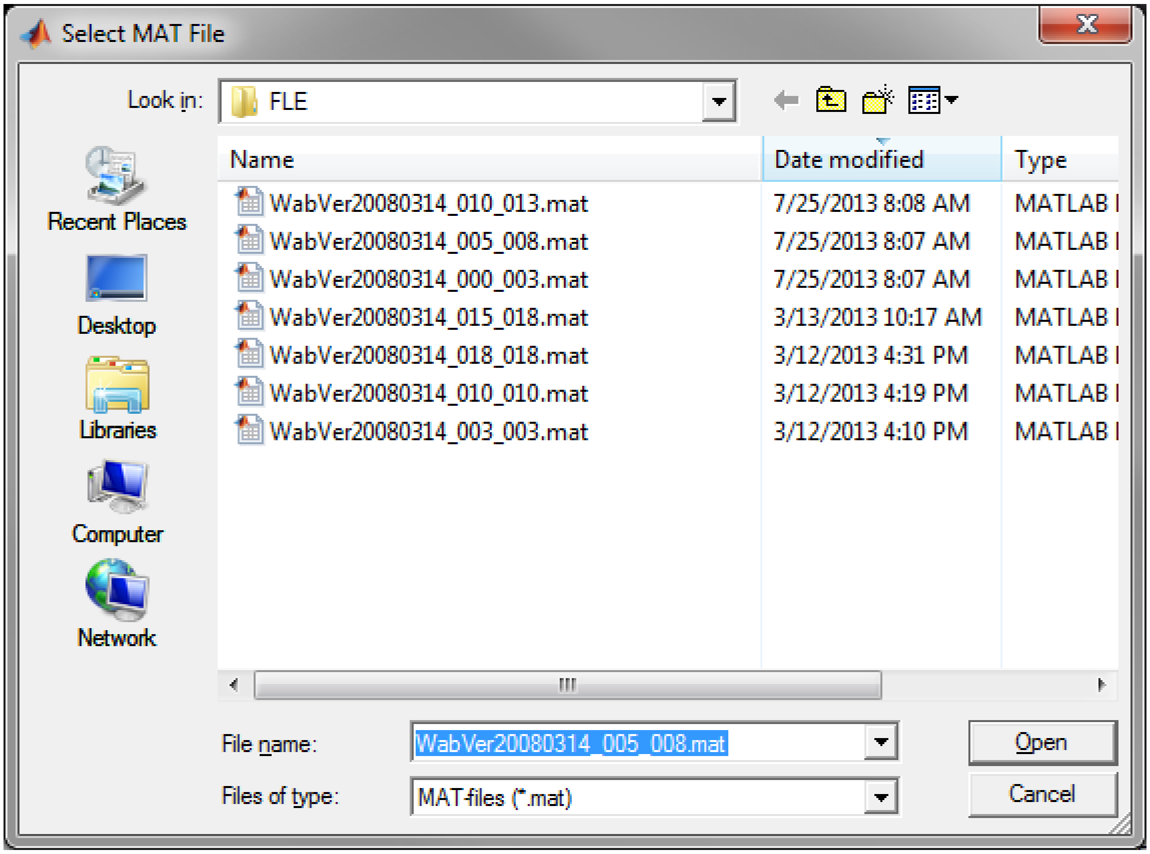


Loading previously processed VMT data

VMT can load previously processed results for reanalysis and/or plotting of multiple transects (in the Plan View Map Figure). To open previously processed VMT data files, choose File→Open→VMT MAT File



You will be prompted to navigate for MAT-files (*.mat). If you have used VMT before, it will remember the last folder you loaded MAT files from. You can either chose one MAT file, or multiple MAT files. VMT behaves differently depending on your choice.



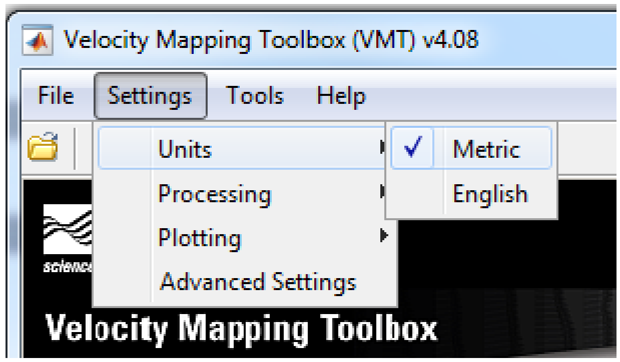
Loading a Single MAT File: This is analogous to loading several raw ASCII Output files for a single cross section. Once the MAT file is loaded, you may reprocess the data, create plots, or export results.

Loading Multiple MAT Files: This option is used to create a Plan View Map Figure which contains multiple Mean Cross Section (MCS) results (e.g., for an entire study reach). Also, you may export the depth- or layer-averaged MCS results for an entire study site in batch by loading multiple MAT files.

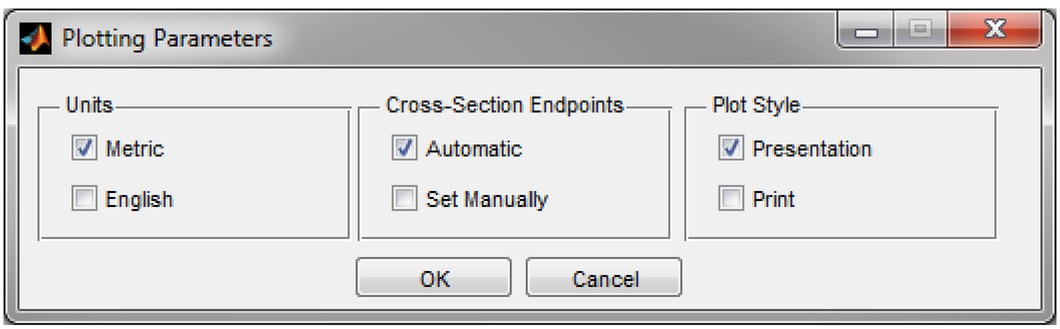
Changing the default units

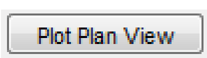
By default, VMT uses SI units in all plots. You can switch between SI and English units by a couple of different methods.

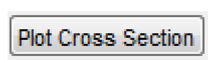
Method 1: Choose Settings→Units→Metric (or English)



Method 2: Click the  on the toolbar to open the Plotting Parameters dialog. Toggle the check boxes and press OK.

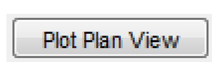


Note: You must click either 

or 

to reflect any changes in units.

Creating and manipulating a plot of planview vectors

Once data are loaded (Raw ASCII Output, SonTek MAT files, Single or Multiple MAT files), you can create a Plan View Map plot. Choose the parameters in the Plan View Plot Panel to suite your needs, or use the defaults as a starting point. Press 

to process the currently loaded data and create (or refresh) the figure.

Creating a figure that suites your needs is an iterative process. Explore how changing parameters affects the plot. See the sections titled Planview Map Figure and Mean Cross Section Figure for details about the various adjustments you can make to the figure.

Note: If you load multiple MAT files, the Plan View Map (and the Plan View Plot Panel) are the only options available. Though you can export data, you cannot create the Mean Cross Section Contour figure.

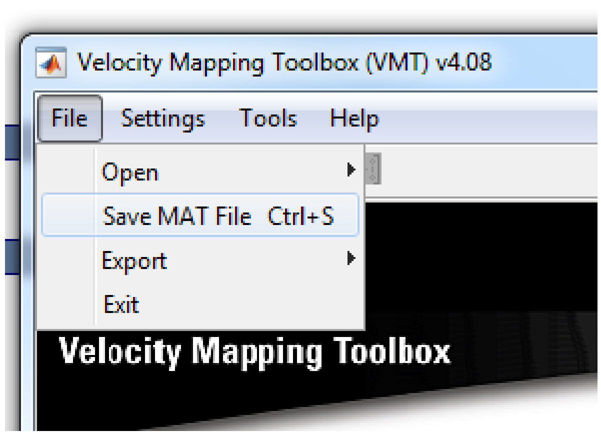
Creating and manipulating a plot of the mean cross section

Once data are loaded (Raw ASCII Output, SonTek MAT files, Single VMT MAT file), you can create a Mean Cross Section Contour plot. Choose the parameters in the Cross Section Plot Panel to suite your needs, or use the defaults as a starting point. Press Plot Cross Section to reprocess the loaded data and create (or refresh) the figure.

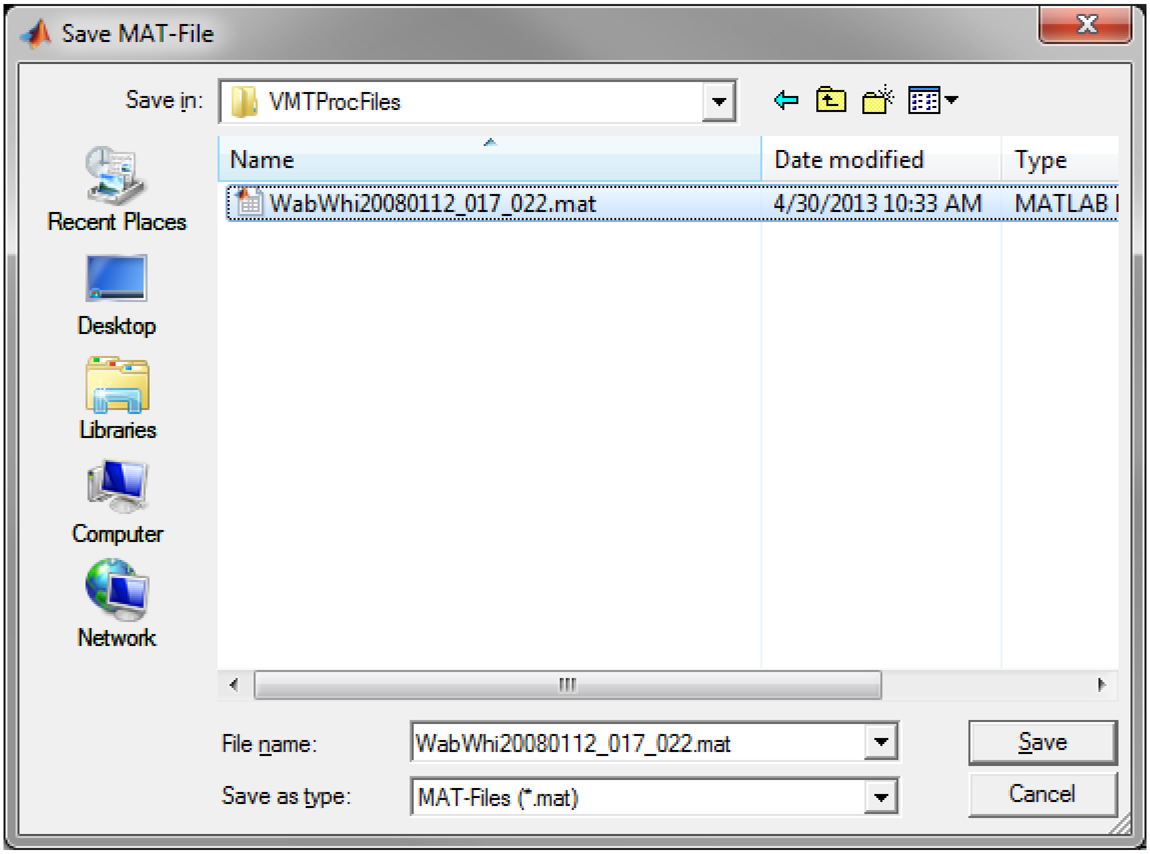
Creating a figure that suites your needs is an iterative process. Explore how changing parameters affects the plot. See the sections titled Planview Map Figure and Mean Cross Section Figure for details about the various adjustments you can make to the figure.

Saving VMT results for later use

When you have processed a dataset, you may wish to save the result for later use. To save the processed data choose File→Save MAT File (conversely you can press Ctrl+S, or click  from the toolbar)



VMT will prompt you to navigate to a location and save the file. VMT will attempt to construct a filename for you based on the standard naming convention used in WinRiver II® (BaseFileName_startingtransectnumber_endingtransectnumber).

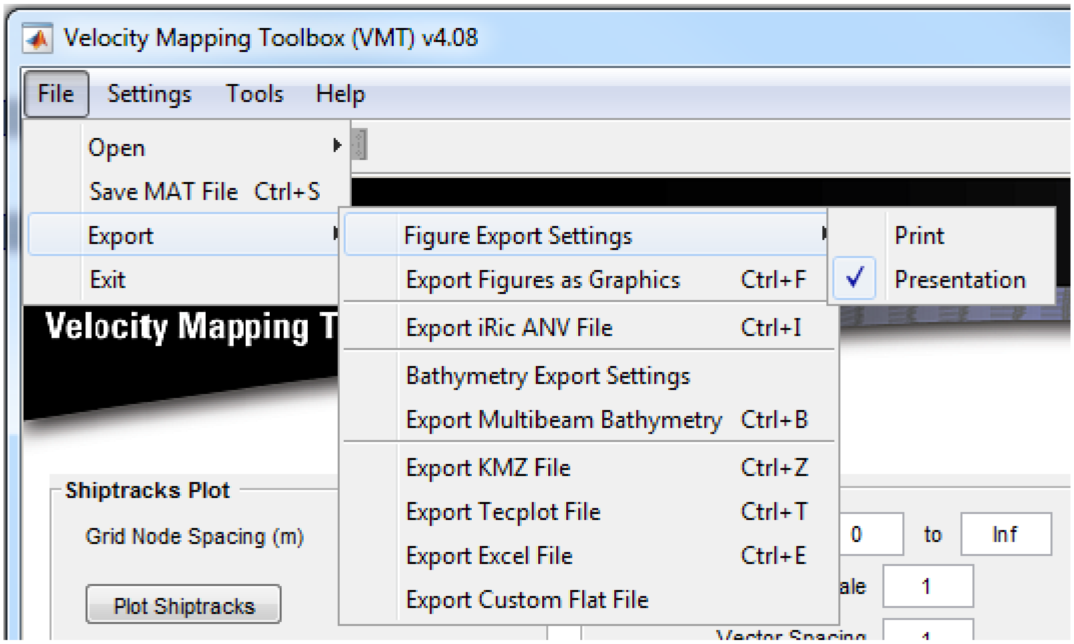


If you have used VMT before, it will remember the name and location of the last saved MAT file.

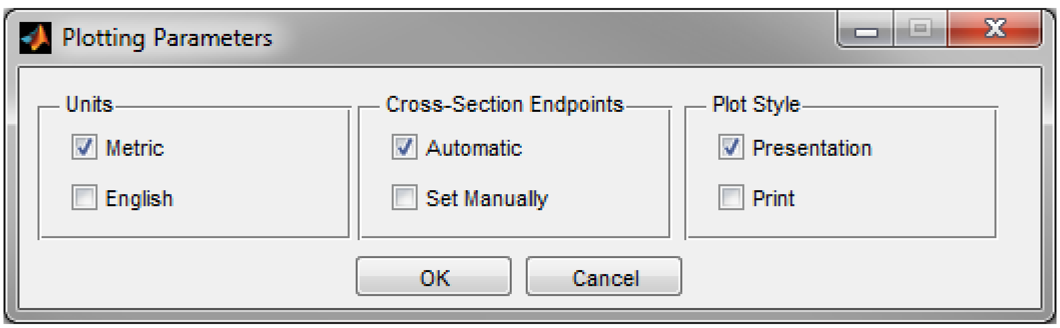
Note: The MAT file is a native Matlab® binary file format. You can view the contents of this file in Matlab®. See Appendix 2: Output File Specifications for details about the MAT file structure.

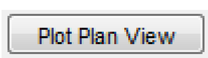
Exporting VMT figures

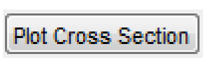
Once you have created and adjusted the VMT figures you wish, you can export these figures to either PNG or EPS image files. VMT comes with two figure presets (Print and Presentation), which you can switch freely between. The Print format is designed to work well with color printers, whereas the Presentation format is ideal for use in Microsoft PowerPoint® (or other presentation software). To choose the figure style, choose File→Export→Figure Export Settings→Print (or Presentation). The figure(s) will be automatically updated.



Conversely you can click  on the toolbar to open the Plotting Parameters dialog.



Note: you can also adjust the plotting units for the figures, however you must click either 

or 

to reflect the changes.

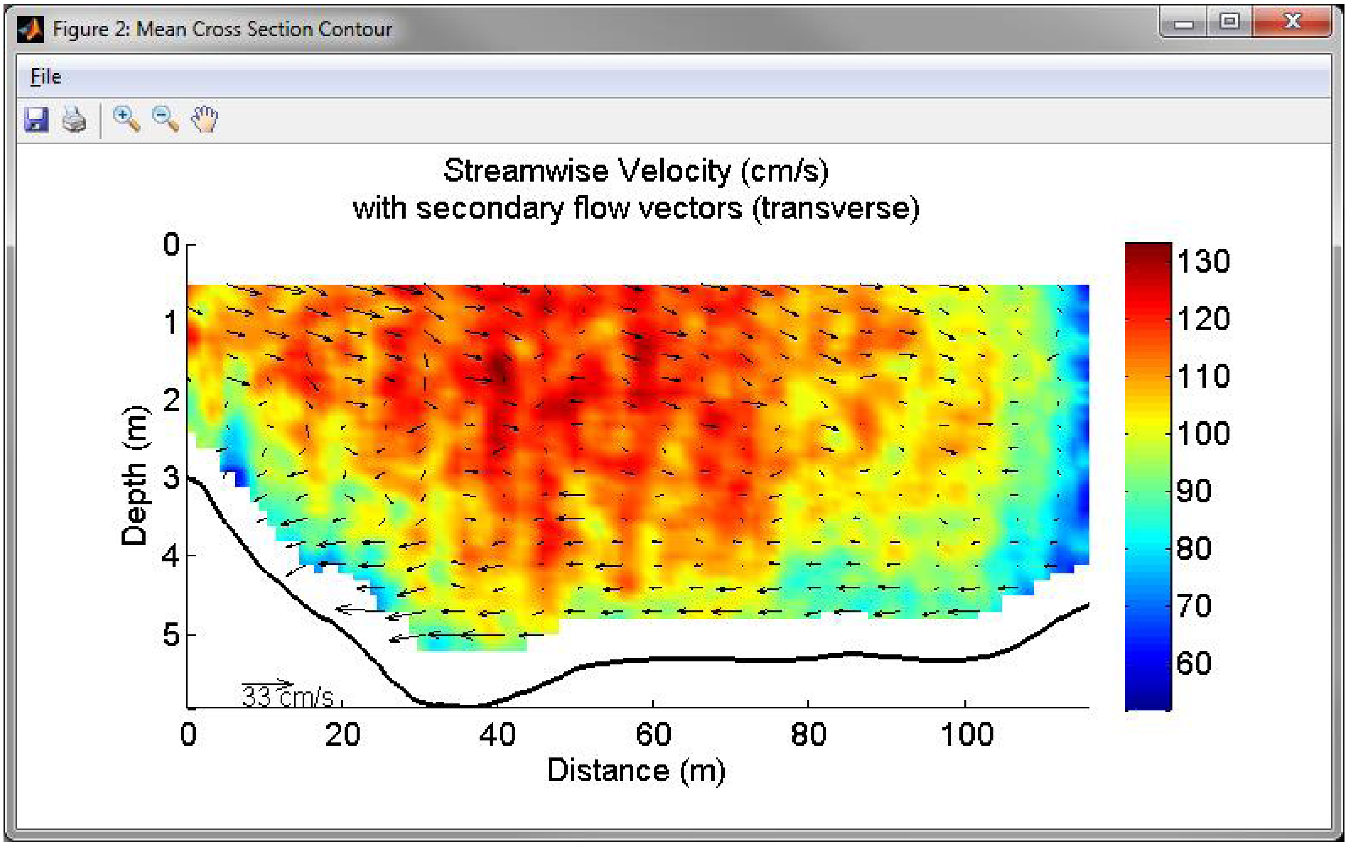
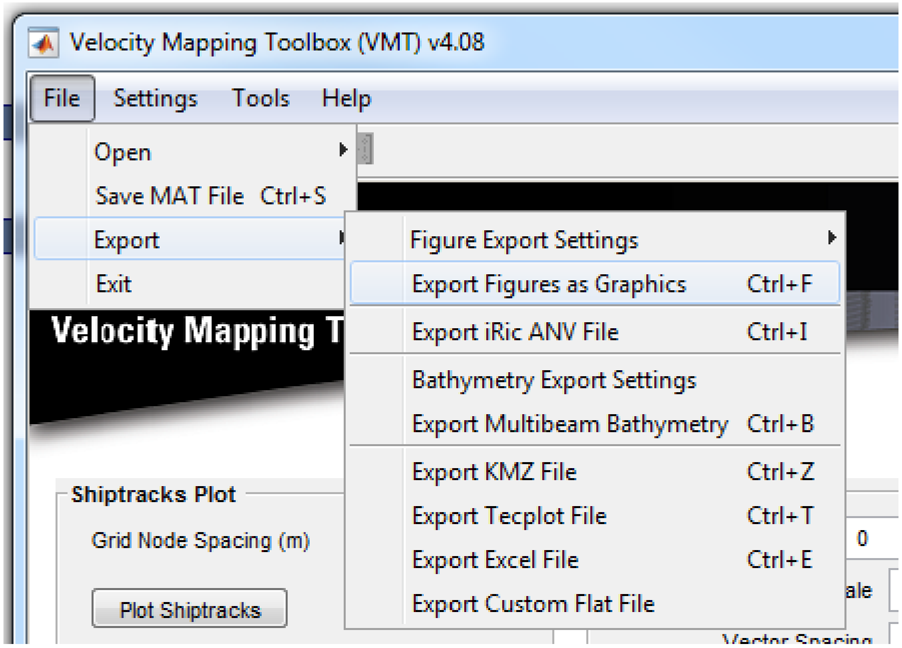
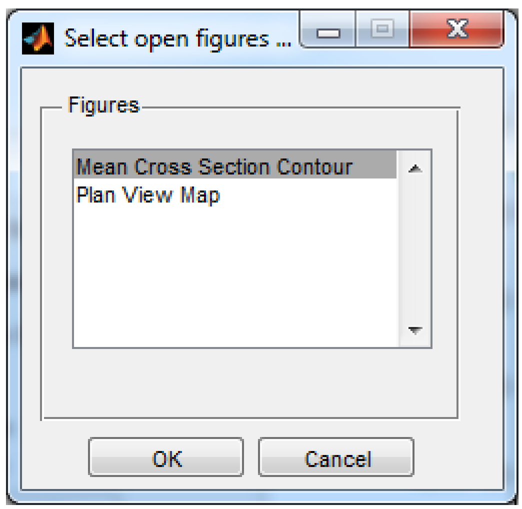


Figure 6. Example Mean Cross Section Contour figure using the Print figure style.

To Export the figures, choose File→Export-Export Figures as Graphics. Conversely, you can click  on the toolbar.



Then select the figures you wish to export from the list and click OK.



Choose either PNG or EPS format and VMT will prompt you to save a file in the location of your choosing. If you have used VMT before, it will remember the last place you save an image export file.

Exporting data for use outside of VMT

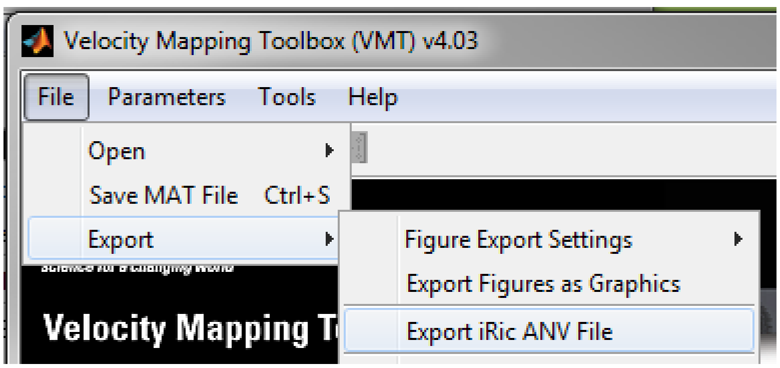
Once you have processed the input data according to your specifications, you may export the results to a variety of file formats. The details for each output file format are described in Appendix 2: Output File Specifications. A brief overview is given here.

iRic©

The iRic© river modeling interface allows input of vector velocity data for model calibration and validation (2-D) in the form of ANV files. VMT will export ANV files from the ASCII2GIS utility (depth-averaged velocity along the curvilinear boat path) and ANV files containing the depth- or layer-averaged velocity as displayed in the plan view plot with vector spacing and smoothing applied.

Before exporting an iRic© ANV file, you must load and process raw data, and produce a Plan View Map Figure. VMT will export the depth- or layer-averaged vectors as specified in the figure (i.e., spacing, depth range, and smoothing are applied prior to the creation of the ANV file).

To create an iRic© ANV file, choose File→Export→Export iRic ANV File. VMT will prompt you to save the file in the desired location. If you have used VMT before, it will remember the name and location of the last saved file.



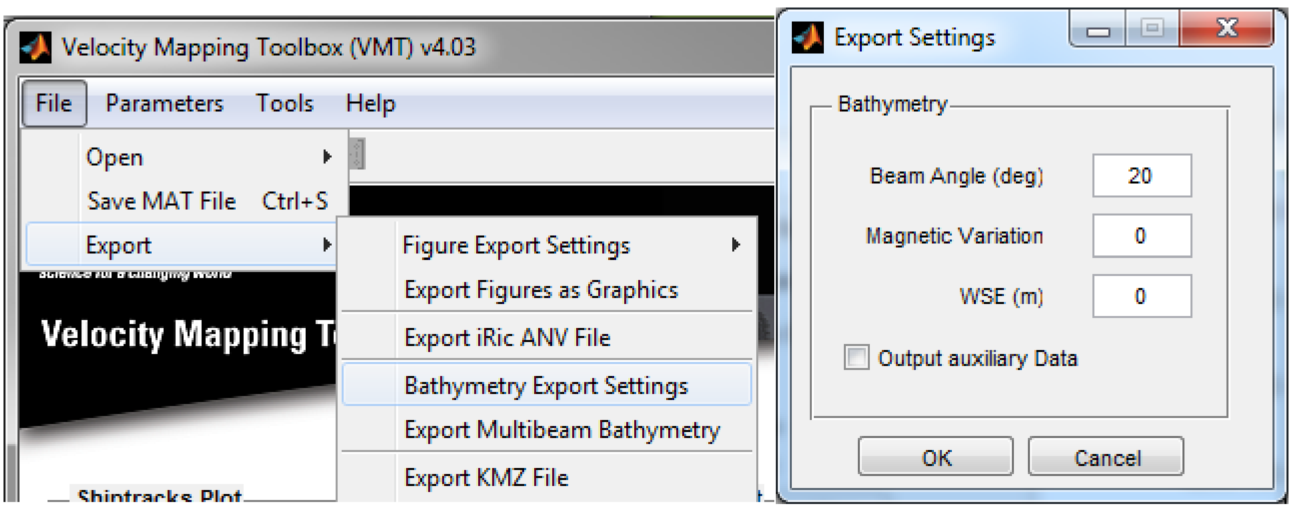
Multibeam bathymetry

These files contain the bathymetry data from the four individual beams of the ADCP, corrected for heading, pitch, and roll. This functionality works for both 4 beam and 5/9 beam ADCPs. The data is formatted as a simple CSV (comma-separated value) file that is easily imported into ArcGIS® using the XY data import tool. The user has the option to add ancillary data to the data file.

To create the Multibeam Bathymetry file, first choose File→Export→Bathymetry Export Settings. Select the appropriate parameters, paying close attention to the beam angle (Table 4). Choosing Output auxiliary data will add several handy computation to the resulting file (See Appendix 2: Output File Specifications for more details). Press OK when you are finished setting the Bathymetry Export parameters.

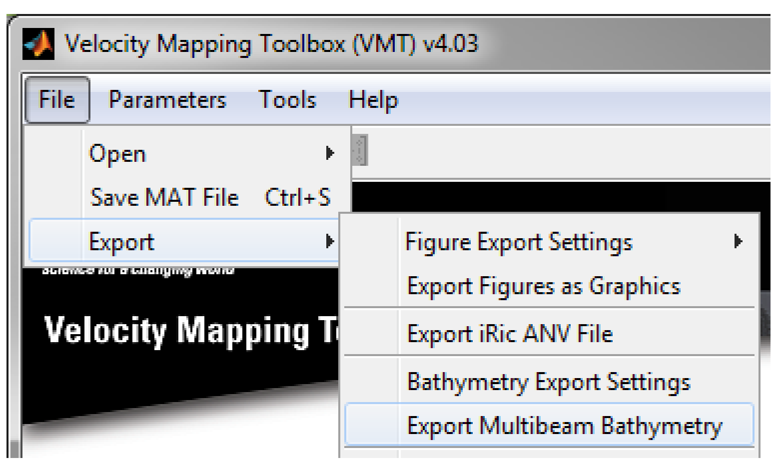
Table 4. Some common ADCP sensors and their beam angles.

ADCP Type	Manufacturer	Beam Angle in degrees
Rio Grande	Teledyne RDI	20
Stream Pro	Teledyne RDI	20
River Ray	Teledyne RDI	30
River Pro	Teledyne RDI	20
Rio Pro	Teledyne RDI	20
M9	SonTek	25
S5	SonTek	25



Tip: It is common to collect velocity data near stream gages, or other stage records. By entering a water surface elevation (WSE), you can correct bed depths to know elevations.

Next, choose File→Export→Export Multibeam Bathymetry



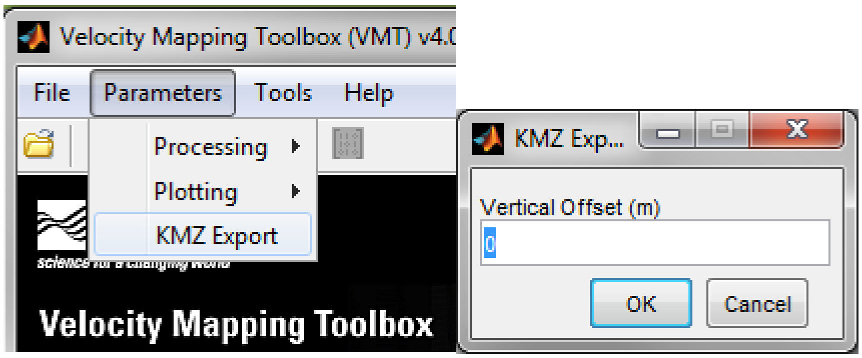
VMT will prompt you to save the file in the desired location. If you have used VMT before, it will remember the name and location of the last saved file.

Google Earth® KML and KMZ files

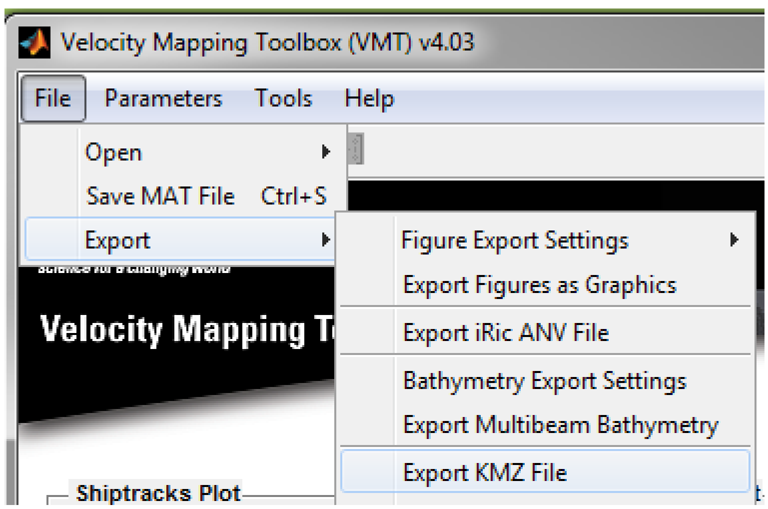
These files are generated to allow the user to display the transect shiptracks (*.kml) and mean cross sections (*.kmz) in Google Earth®.

The KMZ files are generated at the request of the user in the VMT interface and will open automatically in Google Earth® through a request in the VMT code.

To create KMZ files, first set the vertical offset in the Offsets Panel.



Next, choose File→Export→Export KMZ File



VMT will prompt you to save the file in the desired location. If you have used VMT before, it will remember the name and location of the last saved file.

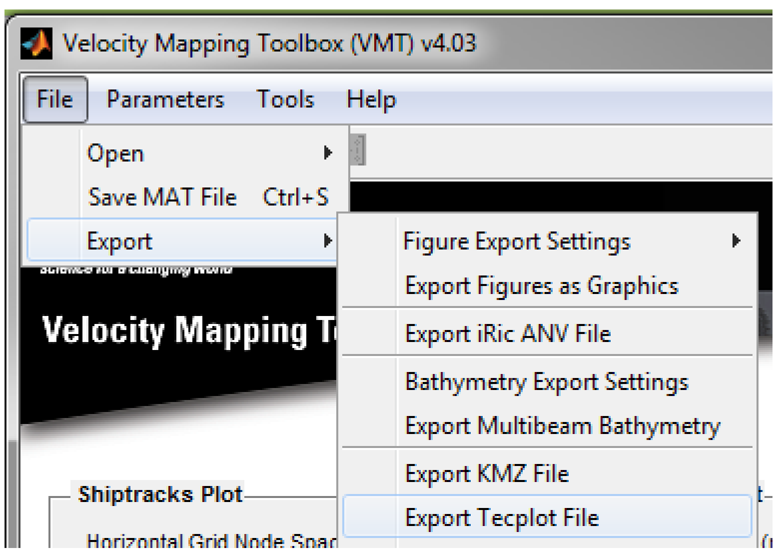
Note: The KMZ files are best viewed as 3-D cross sections so the user should adjust the view in Google Earth® to get the best display of the cross section. To display each KMZ file as a 3-D cross section, enter an offset in the VMT interface that is greater than or equal to the max depth in the reach. This will ensure the cross section is fully displayed above the image plane in Google Earth®.

The KML files are generated using the VMT utility ASCII2KML and the KML files must be loaded into Google Earth® for display.

Tecplot® DAT files

Files contain processed and averaged ADCP data formatted for direct import into Tecplot®. Choosing the Tecplot® export option will export the average cross-section data only with no smoothing or data reduction (vector spacing) applied. Data files contain a header with all necessary information. One data file (*_TECOUT.dat) contains the velocity and backscatter data array for the cross section while the other data file (*_TECOUT_XSBathy.dat) contains the georeferenced bed depth and bed elevation data.

To create the TecPlot® files, choose File→Export→Export Tecplot File. VMT will prompt you to save the file in the desired location. If you have used VMT before, it will remember the name and location of the last saved file.



Excel® files

VMT will produce an Excel® (*.xlsx) file of the processed results when prompted. There are two version of the file: Typical, single cross-section output; and, multiple transects loaded (i.e., plan view) output.

VMT writes 5 worksheets in the Excel® File:

VMTSummary: this contains an overview of the data processed, including several parameters related to the MCS, and the raw ASCII Files associated with the processed data.

Planview: this contains the UTM coordinates, elevation, and depth- or layer- averaged velocities of the MCS. Data are organized in rows (one vertical per row). If you have selected a particular depth range, in the Plan View Plot Panel, VMT will output the resulting velocities for that layer only. The depth range used in the computation is appended to the name of the velocity fields for reference.

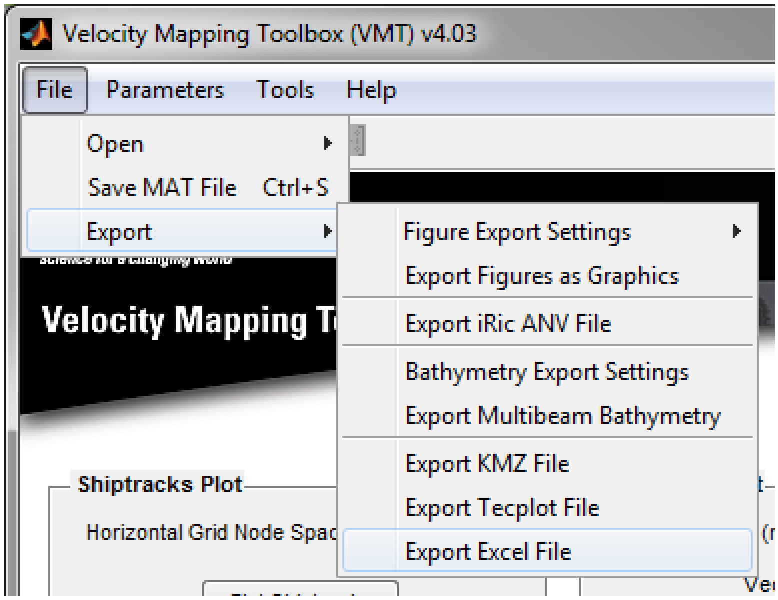
MeanCrossSection: this contains the UTM coordinate, distance along transect (stationing), elevations, bed elevations, and a suite of various velocity variable for every grid node of the MCS. Data are organized in block format, with rows representing vertical locations. Missing/non-data locations are denoted by a value of -9999.

Smoothed_Planview: this contains the UTM coordinates, distance (station), and depth- or layer-averaged velocities of the MCS using the same spacing and smoothing as is employed in the Plan View Map figure (i.e., the data are the same as the vectors in the figure). Data are organized in rows (one vertical per row). If you have selected a particular depth range, in the Plan View Plot Panel, VMT will output the resulting velocities for that layer only. The depth range used in the computation is appended to the name of the velocity fields for reference.

Smoothed_MeanCrossSection: this contains the distance along transect (stationing), depth from surface, and the currently plotted countour and vector components in the Mean Cross Section Contour Plot. Data are organized in block format, with rows representing vertical locations. Missing/non-data locations are denoted by a value of -9999.

Note: If multiple MAT files are loaded, the worksheets MeanCrossSection and Smoothed_MeanCrossSection will not be written, and the worksheets Planview and Smoothed_Planview will contain all transect data.

To create the Excel® file, choose File→Export→Export Excel File. VMT will prompt you to save the file in the desired location. If you have used VMT before, it will remember the name and location of the last saved file.



Exporting VMT Data to GIS

The GIS Table Creation Utility can be accessed by going to Tools→GIS Export Tool, or pressing Ctrl+G. This tool will allow the user to export a CSV table which can be loaded into a GIS for further plotting and analysis (fig. 7). The main benefit of this tool is the ability to process velocities and bathymetry for non-transect based data.

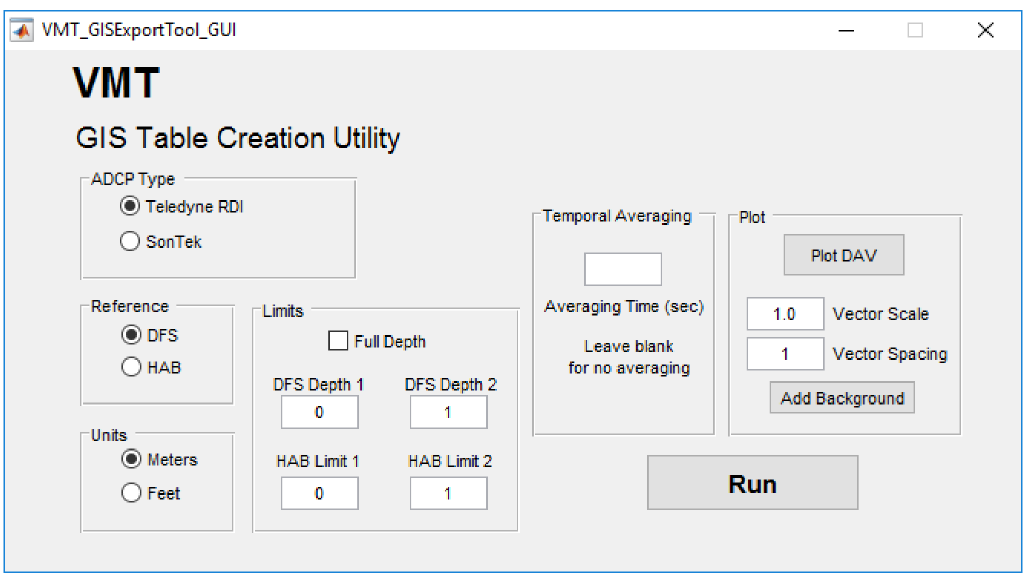
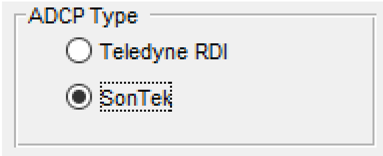


Figure 7. The GIS Export Tool interface.

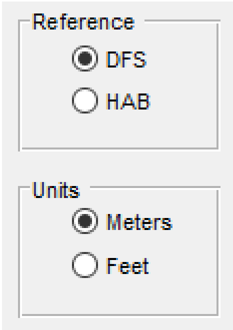
Users can select the type of input ADCP data (either Teledyne RDI or SonTek probes), the depth reference desired (DFS: Depth from surface; HAB: Height above bed), units, and several averaging parameters. Additionally, users can chose to output data for either the full depth, or a specified depth-range (DFS Depth or HAB Limit 1 & 2). Temporal averaging can be applied to reduce measurement noise by specifying an averaging time in seconds. Finally, the tool can be used to create some simple plots of the processed velocity vectors.

A basic workflow follows these steps:

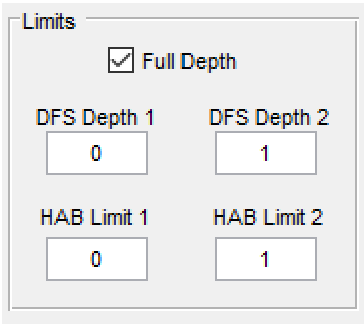
1. Select the appropriate ADCP type. Note that this tool can only process one ADCP type at a time.



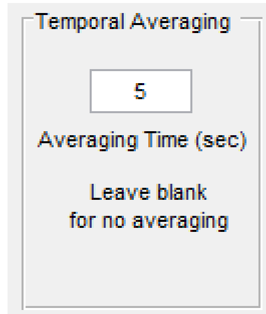
2. Chose the Vertical Reference and desired output Units



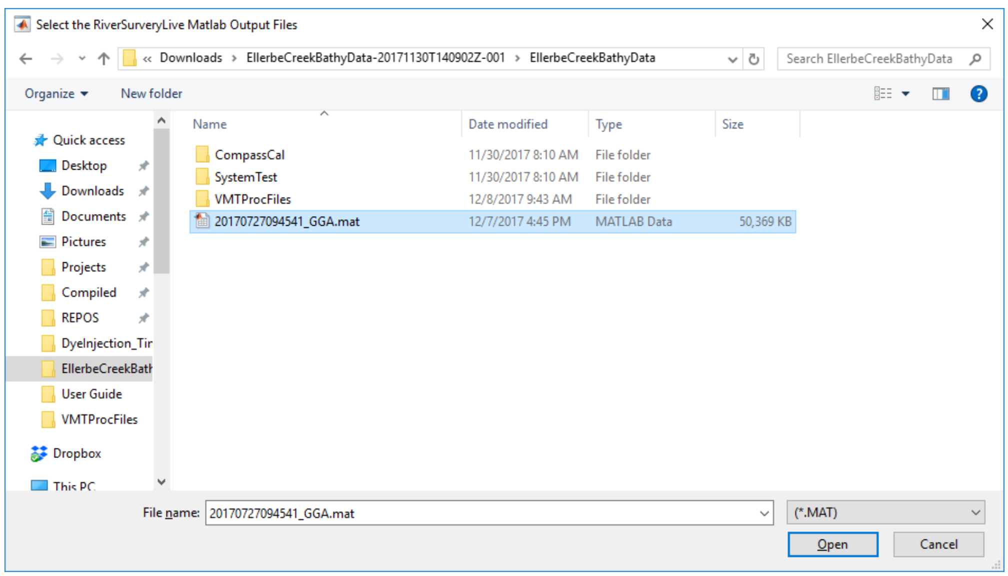
3. Chose the depth range desired for layer-averaging (entering nothing will cause the program to process the entire depth range.



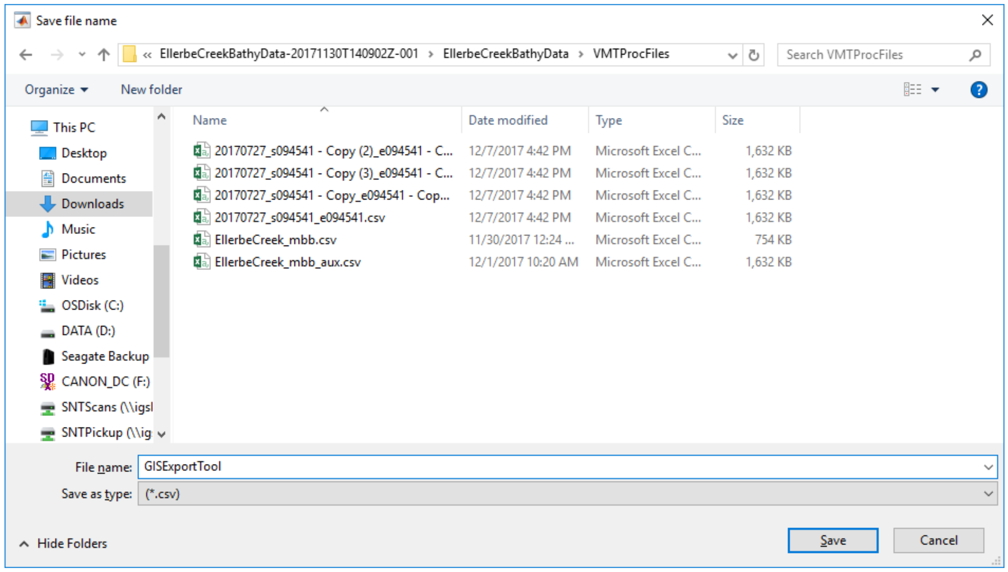
4. And select a temporal averaging window. Leave the value blank for no temporal averaging.



5. Once all the parameters have been set, press the Run button. You will be prompted to load the input ADCP files. If you selected Teledyne RDI, this will be the WinRiver II ASCII Output Files. If you selected SonTek, this will be the MAT-files exported by RiverSurveyorLive.



6. Choose a destination and filename for the output CSV file.



7. The selected ADCP data will be loaded and processed. When the GIS Export Tool finished, it will display a status message indicating the process was successful.
8. Two files will be created. The *.anv file is a headerless tab-seperated text file with UTM Easting, Northing, Elevation, and East and North Velocity components.

```
692595.25   3989557.16   0.00   -0.008   -0.033
692595.51   3989556.95   0.00   0.014   0.004
692595.75   3989556.69   0.00   0.059   -0.004
692595.93   3989556.57   0.00   0.002   0.011
```

Whereas the CSV file will be a labeled flat file suitable for input into a GIS Software. It will contain the following fields (columns):

EnsNo	First ensemble or sample Number
Year	Average year for sample
Month	Average month for sample
Day	Average day for sample
Hour	Average hour for sample
Min	Average minute for sample
Sec	Average second for sample
Lat_WGS84	Latitude of averaged location, in WGS84
Lon_WGS84	Logitude of averaged location, in WGS84
Heading_deg	Averaged heading in degrees
Pitch_deg	Averaged pitch in degrees
Roll_deg	Averaged roll in degrees
Temp_C	Averaged probe temperature in degrees Celsius
Depth_m	Four (or Five) beam averaged depth
B1Depth_m	Beam 1 depth, in meters
B2Depth_m	Beam 2 depth, in meters
B3Depth_m	Beam 3 depth, in meters
B4Depth_m	Beam 4 depth, in meters
B5Depth_m	Vertical beam depth, in meters
BackScatter_db	Averaged backscatter intensity in decibels
DAVeast_cmps	Depth or layer-avg East Velocity component
DAVnorth_cmps	Depth or layer-avg North Velocity component
DAVmag_cmps	Depth or layer-avg Velocity magnitude
DAVdir_deg	Depth or layer-avg Velocity direction, geographic coordinates (0° is North)
DAVvert_cmps	Depth or layer-avg Vertical Velocity Component
U_star_mps	Shear velocity computed from a log-law fit in meters per second
Z0_m	Roughness height computed from a log-law fit in meters
COD	Coeffiecient of determination of the log-law regression

Notes:

- The time averaging window affects all variables, thus the positions (Lat/Lon) as well as times output by the tool represent the result of averaging the positions and times of each input ensemble or sample that is contained in the averaging window.
- The log-law fits should be viewed with caution. No attempt to validate the fits other than reporting the COD are done in the software. Use at your own risk, and with the understanding of what quality (or lack therof) may be present.

Batch Processing ADCP Transect Data

VMT includes a Batch Processing Tool which can be used to rapidly process larg ADCP datasets for velocity mapping or exporting multibeam bathymetry. To start the Batch Tool, go to Tools→Open Batch Mode (Ctrl+C) (fig. 8).

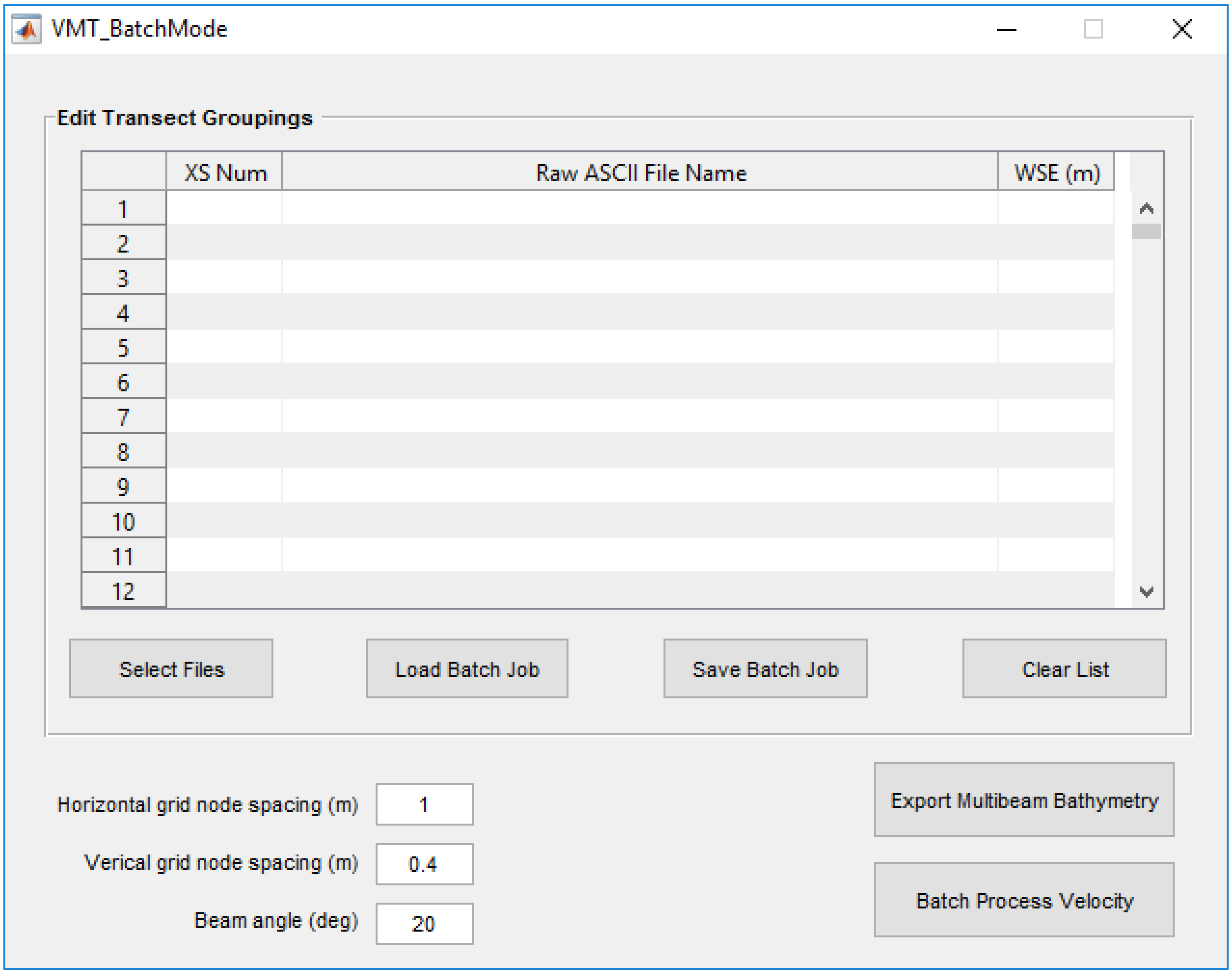
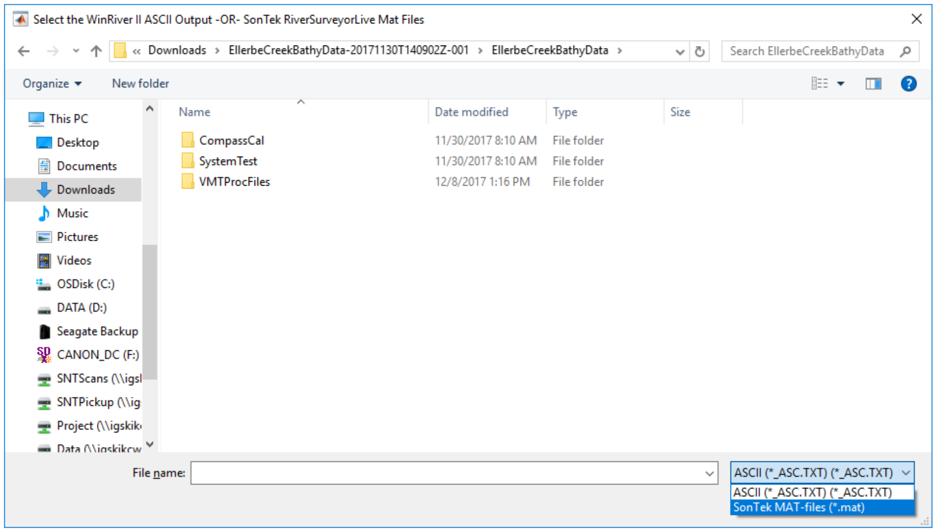


Figure 8. Figure 1. VMT Batch Mode interface.

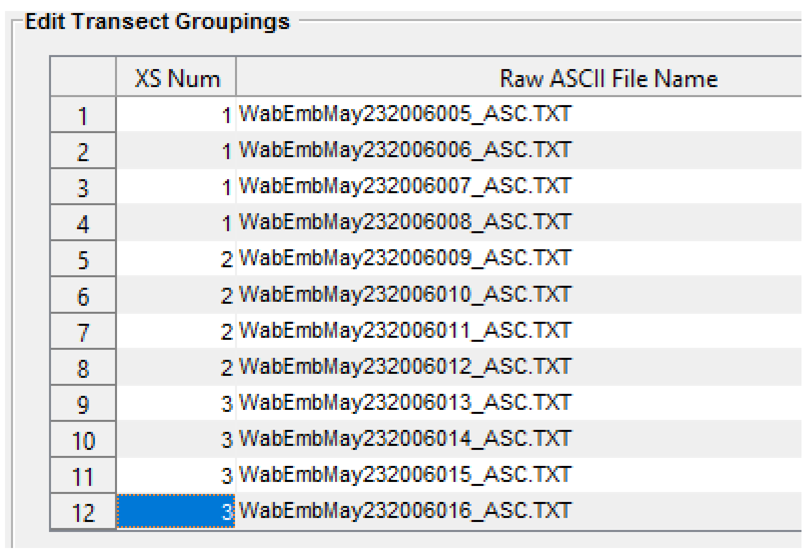
The basic workflow for the Batch Tool is to load the desired transects (either Teledyne RDI or SonTek ADCP output files), group them into cross sections, and process them into VMT Mat Files or into a CSV file containing the multibeam bathymetry corrected for slant, heading, pitch and roll (see section titled, "Multibeam bathymetry").

Workflow to export VMT Mat Files

1. Press Select files, and navigate to either WinRiver II ASCII or RiverSurveyorLive Mat files. You can change the file type selector to show the files within the dialog.



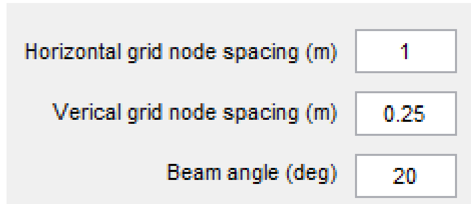
2. Once your desired files are selected, the table in the interface will populate. Initially, all trasects will show a XS Num of 1. Edit the XS Num rows to group data into mean cross sections. Cross sections should start with 1 and increment in increasing order:


Edit Transect Groupings

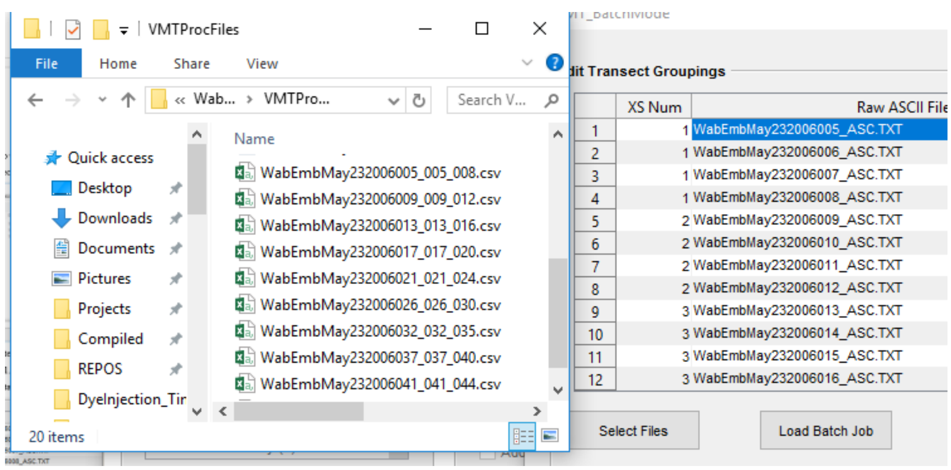
	XS Num	Raw ASCII File Name
1	1	WabEmbMay232006005_ASC.TXT
2	1	WabEmbMay232006006_ASC.TXT
3	1	WabEmbMay232006007_ASC.TXT
4	1	WabEmbMay232006008_ASC.TXT
5	2	WabEmbMay232006009_ASC.TXT
6	2	WabEmbMay232006010_ASC.TXT
7	2	WabEmbMay232006011_ASC.TXT
8	2	WabEmbMay232006012_ASC.TXT
9	3	WabEmbMay232006013_ASC.TXT
10	3	WabEmbMay232006014_ASC.TXT
11	3	WabEmbMay232006015_ASC.TXT
12	3	WabEmbMay232006016_ASC.TXT

3. If desired, you can also enter a water surface elevation in meters for each transect. This number can be the default (0), a constant for all transects, or varied by transect. This is a handy feature if the transects were collected over a changing stage. VMT will assume the water surface elevation was constant *for each transect*.

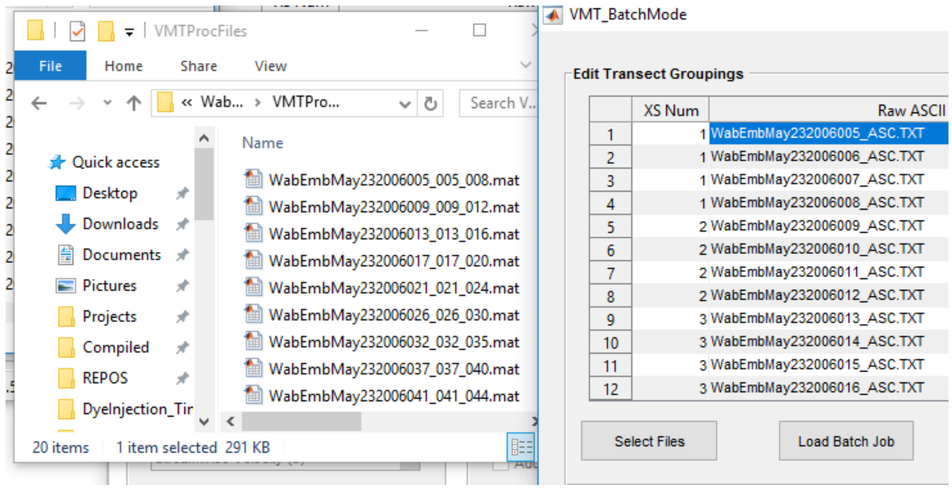
4. Choose horizontal and vertical grid node spacings. This is the same spacing as used in the main VMT interface, but it will be applied to all transects in the table. Set the beam angle as well (see Table 4).



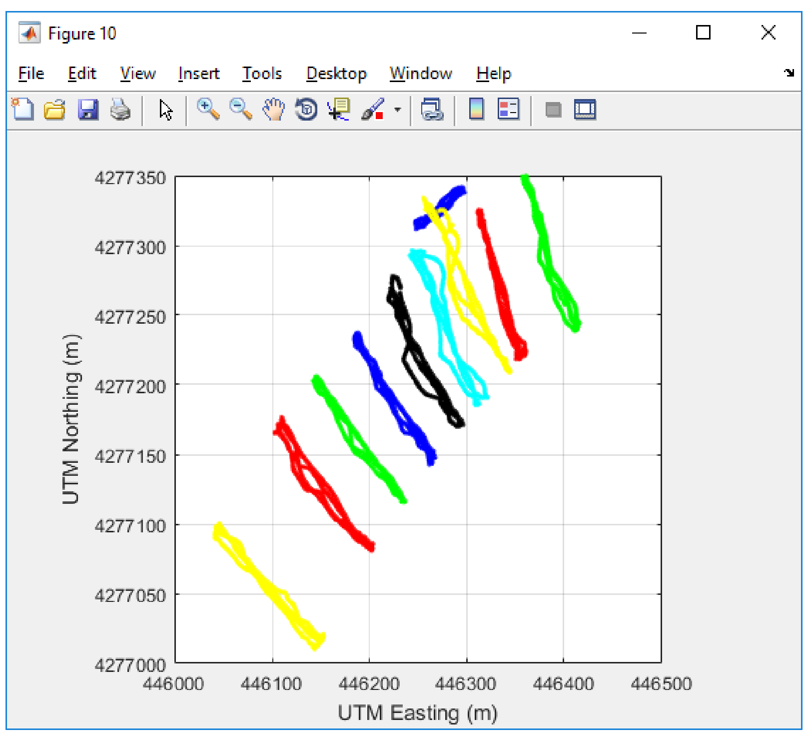
5. At this point you can Save a Batch Job, which will create an Excel file with the contents of the Transect Groupings Table, Load a previously created Batch Job Excel File, or Clear the list.
6. To process the grouped transects into Multibeam Bathymetry CSV files, pres the Export Multibeam Bathymetry button. VMT will load each input ADCP file and create a corresponding CSV output file for each XS Num Grouping (XS Num 1 below corresponds to file *WabEmbMay232006005_005_008.csv* for example). Notice that the files are saved in a folder called VMTProcFiles within the original data folder.



7. To process the grouped transects into VMT Mat files press the Batch Process Velocty button. VMT will load each input ADCP file and create a corresponding VMT MAT output file for each XS Num Grouping (XS Num 1 below corresponds to file *WabEmbMay232006005_005_008.mat* for example). Notice that the files are saved in a folder called VMTProcFiles within the original data folder.



When the processing is complete, a plot showing the individual transect shiptracks, colored by mean cross section grouping will be plotted as a reference that the XS Num grouping was correct.



The VMT Mat Files can be loaded individually or together into VMT for further processing (see section titled, “Loading previously processed VMT data” for more details).

Getting help

User guide

This User Guide is avaialbe via VMT by choosing Help→User Guide

Velocity mapping forum (USGS Office of Surface Water)

The USGS Office of Surface Water (OSW) maintains a Hydroacoustics User Community forum. There is a child forum for velocity mapping, including VMT, that can be found at (*https://simon.er.usgs.gov/smf/index.php?board=38.0*). This is a great place to share news and ideas, request help, or report software issues. You are strongly encouraged to participate in the forums!

The OSW forum requires users to register.

- Registration Instructions (*http://hydroacoustics.usgs.gov/software/Forum_Reg1.html*)
- Link to OSW Forum Registration (*https://simon.er.usgs.gov/smf/index.php*)

Appendix 1: Input file specifications

Raw ASCII files (WinRiver II® lassic ASCII output)

Data are organized in a space delimited text file. Each ensemble has its own header which follows the format below. Rows 3–9 consist the ensemble header. Rows 10–Nens are the raw data in a rectangular matrix organized by bins.

```
1
2
3      20      25      12      75       1       9      12
4  8 1 12 10 43 13 60  4676       1   -1.120   -2.660   57.500    8.380
5  -15.93   -15.93  -32768  -32768 -32768.00   121.71     0.00    18.06     4.88     4.88     4.88     4.97
6  0.00        0.00        0.00        0.00        0.00
7  38.41461745    -87.74136552   -15.93   -23.09          0.0
8  -0.0         -0.0         -0.0          0.0          12.2          0.0          6.4  0.61   4.21
9  75 cm VTG dB 0.45  0.501
10   0.61     98.88    238.67  -84.5  -51.4   -5.8   -4.7  201.0  205.0  195.0  210.0  100 2147483647
```

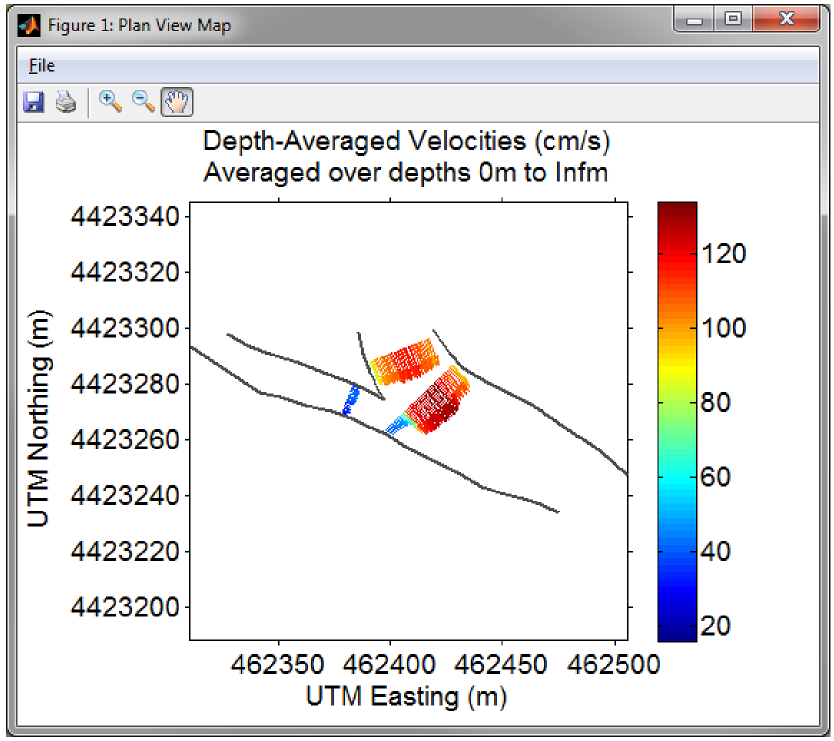
Row 1	Notes (1st header only)
Row 2	Notes (1st header only)
Row 3	WS, WF, Draft, WN, WP, TPE, WM
Row 4	Yy, mm, dd, hh, mm, ssss, en, #en, Pitch, Roll, Heading, TW
Row 5	Ew, ns, ud, BTerr, dpth, Elv, Delv, Hdop/#Sat, D1, D2, D3, D4
Row 6	TEDist, TETime, TDTravelN, TDTravelE, TDMadeGood
Row 7	Latitude, Longitude, NavBTew, NavBTns, TDT_en
Row 8	Qmiddle, Qtop, Qbuttom, QStShore, DistStShore, QEndShore, DistEndShore, EndDTL, StDBL
Row 9	#B, unit, ref, int, scl, absr
Row 10	BDpth, Velmag, Veldir, Velew, Velns, Vud, Verr, [Backscatter 1 2 3 4], %Good , Qm^3

Shoreline file (depreciated)

The Shoreline file is a simple text file with no header. It can be tab, space, or comma delimited. The shoreline coordinates should be supplied in two columns (UTM_East & UTM_North). To create individual (i.e., separate) shorelines, separate coordinate pairs by the value -9999.

Note: This option was added prior to the ability add background files and has found little use since the implementation of that feature. It may be depreciated in future versions.

The following Example produces the shoreline of the confluence of the Wabash and Vermillion Rivers shown in the figure.




```
462041.6347 4423367.286
462082.952 4423338.511
462128.6963 4423308.999
462165.5868 4423285.389
462201.0017 4423275.798
462248.2215 4423261.779
462293.228 4423251.45
462330.1185 4423238.907
462355.204 4423226.364
462392.0946 4423209.395
462426.7716 4423186.522
462472.5159 4423163.65
462523.4248 4423138.565
462561.7909 4423114.217
462597.2058 4423105.363
462637.7854 4423095.772
462667.2978 4423083.229
462701.9749 4423069.948
-9999 -9999
462822.9758 4423135.614
462799.3658 4423157.748
462772.8047 4423181.358
462735.9141 4423205.706
462699.0236 4423231.529
462654.755 4423261.779
462619.3401 4423280.224
462574.3337 4423301.621
462530.8029 4423326.706
462503.5039 4423356.219
462475.4671 4423396.061
-9999 -9999
462342.6613 4423392.372
462350.7772 4423353.268
462364.0578 4423319.328
462379.5518 4423286.127
462388.4 4423272.1
462371.4359 4423280.962
462334.5454 4423299.407
462285.8499 4423318.591
462234.2032 4423337.774
462183.2942 4423353.268
462147.8794 4423367.286
462105.8242 4423389.42
```

Background image(s)

The background image formats supported by VMT are

- GeoTIFF
- TIFF/JPEG/PNG with a world file (must be in the same folder, and have the same name)

In addition, VMT will recognize geospatial data in these formats (data must be in the UTM projection)

- Shapefile (point, polyline, polygon)
- ARC ASCII GRID
- SDTS raster

User supplied endpoints

The User Supplied Endpoints file is a simple text file with no header. It can be tab, space, or comma delimited. The endpoint coordinates should be supplied in two columns (UTM_East and UTM_North). If supplied, VMT will use the coordinates specified in the file to be the Mean Cross Section (MCS) rather than a linear regression best-fit line through the ensembles in the raw ShipTracks.

Example:

```
435280.84 4252077.57
434968.76 4252231.98
```

Appendix 2: Output file specifications

VMT MAT file

Once raw data are processed, using the Save MAT File option (Ctrl+S) will save a Matlab® native binary format file. If you have Matlab®, you may load this file and view its content. The file consists of two different structured arrays. The first, named (A), contains an organized representation of all of the raw data which was used to produce the Mean Cross Section (MCS), and any stored computations. The second, named (V), contains the resulting MCS, and all its variables. The two tables in this Appendix detail the complete structure of these arrays.

A *size 1 x no. of transects:* is the root structure containing raw and processed ADCP data by transect

Sup

absorbtion_dbpm	Sound adsorption in db/meter (See WinRiver II User Guide, pg. 102)
bins	Maximum number of bins in each ensemble
binSize_cm	Bin size in centimeters
nBins	Maximun number of bins in each ensemble
blank_cm	Surface blanking distance in centimenters
draft_cm	User set transducer draft in centimeters
ensNo	Ensemble or Sample number
nPings	Number of pings per ensemble
noEnsInSeg	Number of enselmbes in each segment
noe	Number of ensembles
note1	User note 1
note2	User note 2
intScaleFact_dbpcnt	Echo Intensity scale factor in db/count (See WinRiver II User Guide, pg. 102)
intUnits	Intensity units (db or counts)
vRef	Watertrack velocity reference
wm	Water mode
units	Measurement units abbreviation
year	Year of each ensemble or sample
month	Month of each ensemble or sample
day	Day of each ensemble or sample
hour	Hour of each ensemble or sample
minute	Minute of each ensemble or sample
second	Second of each ensemble or sample

	sec100	Hundreth of a second of each ensemble or sample
	timeElapsed_sec	Total time elapsed of each ensemble or sample
	timeDelta_sec100	Time between each ensemble or sample in hundredths of a second
Wat		
	binDepth	Depth below the water surface for each bin or cell
	backscatter	Backscatter intensited in decibels for each bin or cell
	beamFreq	Acoustic frequency of each ensemble or sample
	vDir	Geographic angle of the direction of flow in each bin or cell
	vMag	Magnitude of the flow velocity in each bin or cell
	vEast	East velocity component in each bin or cell
	vError	Error velocity component in each bin or cell
	vNorth	North velocity component in each bin or cell
	vVert	Vertical velocity component in each bin or cell
	percentGood	percent good cells per ensemble or sample
Nav		
	bvEast	East component of boat velocity
	bvError	Boat error velocity
	bvNorth	North component of boat velocity
	bvVert	Vertical component of boat velocity
	depth	Depth of each beam, corrected for beam angle
	dsDepth	Depth from depth sounder (must be activated in WinRiver II)
	dmg	Linear distance made good by the ADCP
	length	Total elapsed distance traveled (curvilinear)
	totDistEast	Total distance East traversed by ADCP
	totDistNorth	Total distance North traversed by ADCP
	altitude	Altitude of the GPS antenna
	altitudeChng	Change in altitude reported by GPS
	gpsTotDist	Total distance traveled as reported by GPS
	gpsVariable	GGA HDOP x 10 + # satellites/100
	gpsVeast	GPS track of East velocity component
	gpsVnorth	GPS track of North velocity component
	lat_deg	latitude location in decimal degrees
	long_deg	longitude location in decimal degrees
	nSats	Number of satellites with lock reported by GPS
	hdop	Horizontal dilution of position
Sensor		
	sensor_type	Name of sensor model
	pitch_deg	Pitch of the ADCP in degrees
	roll_deg	Roll of the ADCP in degrees
	heading_deg	Heading of the ADCP in degrees
	temp_degC	External water temperature at the ADCP in degrees Celsius
Q		
	endDepth	End bank depth for edge ensembles
	endDist	User entered edge distance to bank at the end of the transect in meters

	bot	Estimated discharge at the bottom of each ensemble
	end	Estimated discharge for ending bank
	meas	Measured cummulative discharge for each ensemble
	start	Estimated discharge for starting bank
	top	Estimated discharge at the top of each ensemble
	unit	Unit discharge (per bin, per ensemble)
	startDepth	Start bank depth for edge ensembles
	startDist	User entered edge distance to bank at the start of the transect in meters
Clean		
	backstandf	Standard deviation of screened backscatter
	bsf	Censored backscatter data having stdev > 10
	bs	Filtered and cleaned backscatter
	vMag	Filtered and cleaned velocity magnitudes
	vEast	Filtered and cleaned East velocity component
	vNorth	Filtered and cleaned North velocity component
	vVert	Filtered and cleaned Vertical velocity component
	vDir	Filtered and cleaned Velocity direction (geographic angles)
Comp		
	xUTMRaw	Raw x UTM coordinates
	yUTMRaw	Raw y UTM coordinates
	utmzone	UTM zone in which the data resides
	gps_reject_locations	Logical array of any GPS data which are to be rejected
	gps_fly_aways	GPS flyaways as determined using a velocity filtering technique
	gps_dropped_ensembles	Dropped ensembles with no GPS data
	gps_repeat_locations	Repeat GPS locations
	xUTMf	Temporary array for bracketing bottom track locations in GPS replacement algorithm
	xUTMb	Temporary array for bracketing bottom track locations in GPS replacement algorithm
	yUTMf	Temporary array for bracketing bottom track locations in GPS replacement algorithm
	yUTMb	Temporary array for bracketing bottom track locations in GPS replacement algorithm
	xUTM	Temporary array for bracketing bottom track locations in GPS replacement algorithm
	yUTM	Temporary array for bracketing bottom track locations in GPS replacement algorithm
	xm	X coordinate of Centroid of locational data
	ym	Y coordinate of Centroid of locational data
	dx	Change in X from start point of each observation
	dy	Change in Y from start point of each observation
	dl	Distance from left bank of the MCS for an individual transect
	dlsort	Sorted distance from left bank of the MCS for an individual transect

vecmap	Temporary array formapping vectors to the proper stationaing in the MCS
sd	Array of any remaining repeated locations in the MCS
dlsortgpsfix	Linearly interpolated positions of missing data not replaced by the VMT_RepBadGPS function
itDist	Stationing of each ensemble on the MCS
itDepth	Depth of each ensemble on the MCS
mcsBack	Interpolated indvidual transect Backscatter onto MCS regular grid
mcsEast	Interpolated indvidual transect East Velocities onto MCS regular grid
mcsNorth	Interpolated indvidual transect North Velocities onto MCS regular grid
mcsVert	Interpolated indvidual transect Vertical Velocities onto MCS regular grid
mcsError	Interpolated indvidual transect Error Velocities onto MCS regular grid
mcsTime	Average time based on the nearest ensembles (from the ADCP) mapped to each grid node
mcsMag	Interpolated indvidual transect Velocities onto MCS regular grid
mcsDir	Interpolated indvidual transect Velocity Directions (geographic angles) onto MCS regular grid
mcsBed	Interpolated indvidual transect beam-averaged depths onto MCS regular grid
u	Streamwise velocities of the individual transect
v	Cross stream velocities of the individual transect
w	Vertical velocities of the individual transect
psi	Angle of deviation of the flow from the MCS
u1	Temporary array of velocities
v1	Temporary array of velocities
w1	Temporary array of velocities
qyi	Y component unit discharge for each bin
qxi	X component unit discharge for each bin
qpi	Primary component unit discharge for each bin
qsi	Secondary component unit discharge for each bin
Qp	Total primary component discharge for the transect
Qs	Total secondary component discharge for the transect
vp	Decomposed primary velocities
vs	Decomposed secondary velocities
mcsDirDevp	Computed velocity deviations from the primary direction

hgns	Horizontal grid node spacing
vgns	Vertical grid node spacing
wse	Water surface elevation

V *size 1:* is the root structure containing processed VMT data from the Mean Cross Section

mfd	Mean flow direction of the MCS (geographic angle)
b	Intercept of the line of the MCS
theta	Angle of the MCS (arithmetic angle)
phi	Angle of the perpendicular to the MCS
N	Normal unit vector to the MCS
M	Average streamwise direction unit vector
meddens	Median ensemble spacing
stddens	Standard deviation of the ensemble spacing
xe	East-most X coordinate bounding MCS
ys	South-most Y coordinate bounding MCS
xw	West-most X coordinate bounding MCS
yn	North-most X coordinate bounding MCS
dx	Total distance spanned in X of the MCS
dy	Total distance spanned in Y of the MCS
dl	Total segment distance of the MCS
startBank	Label indicating start bank method
xLeftBank	X coordinate of the Left Bank
yLeftBank	Y coordinate of the Left Bank
xRightBank	X coordinate of the Right Bank
yRightBank	Y coordinate of the Right Bank
probeType	ADCP probe type
eta	Computed datum reference
mcsDist	Grid of MCS Distances from Left Bank
mcsDepth	Grid of MCS depths
mcsX	Grid of X coordinates of the MCS
mcsY	Grid of Y coordinates of the MCS
countBack	
mcsBack	Grid of backscatter intensity data for the MCS
countMag	
countVert	
countBed	
mcsEast	Grid of East velocities for the MCS
mcsNorth	Grid of North velocities for the MCS
mcsVert	Grid of Vertical velocities for the MCS
mcsError	Grid of Error velocities for the MCS
mcsTime	Grid of Matlab Serial times for the MCS
mcsMag	Grid of velocity magnitudes for the MCS
mcsDir	Grid of velocity directions for the MCS
mcsBed	Depth to the bed for each vertical in the MCS
mcsBedElev	Depths corrected by the user supplied Water Surface Elevation
psi	Deviation angle of velocity from perpendicular for each sample in the MCS
u	Streamwise velocities for the MCS
v	Cross stream velocities for the MCS
w	Vertical velocities for the MCS

	Qy	Total discharge in the Y direction for the MCS
	Qx	Total discharge in the X direction for the MCS
	phisp	
	Qp	Total discharge in the primary flow direction for the MCS
	Qs	Total discharge in the secondary flow direction for the MCS
	vp	Primary velocities (zero secondary flow definition) for each sample in the MCS
	vs	Secondary velocities (zero secondary flow definition) for each sample in the MCS
	mcsDirDevp	Computed velocity deviations from the primary direction for each sample in the MCS
	uSmooth	Smoothed streamwise velocities for each sample in the MCS
	vSmooth	Smoothed cross stream velocities for each sample in the MCS
	mcsEastSmooth	Grid of Smoothed East velocities for the MCS
	mcsNorthSmooth	Grid of Smoothed North velocities for the MCS
	mcsMagSmooth	Grid of Smoothed Velocitity magnitudes for the MCS
	vpSmooth	Smoothed streamwise velocities (zero secondary flow definition) for each sample in the MCS
	vsSmooth	Smoothed cross stream velocities (zero secondary flow definition) for each sample in the MCS
	mcsDirSmooth	Grid of smoothed velocity directions for the MCS
	wSmooth	Smoothed vertical velocities for each sample in the MCS
	mcsErrorSmooth	Grid of smoothed Error velocities for the MCS
	vorticity_vw	Vorticity (curl) of the transverse and vertical velocity components
	vorticity_zsd	Vorticity (curl) of the secondary and vertical velocity components (zero secondary discharge definition)
	vorticity_roz	Vorticity (curl) of the secondary and vertical velocity components (Rozovskii definition)
	version	Version of VMT used in processing current file
	release	Release date of VMT used in processing current file
plotSettings		
	shiptracks	Stucture containing the data and handles used in creation of the shiptracks plot
	planview	Stucture containing the data and handles used in creation of the planview plot
	mcs	Stucture containing the data and handles used in creation of the Mean Cross Section plot
Roz		
	U	Layer-averaged mean streamwise velocities for each vertical in the MCS
	V	Layer-averaged mean cross-stream velocities for each vertical in the MCS
	U_mag	Layer-averaged mean velocity magnitudes for each vertical in the MCS

phi	Deviation angle of velocity from perpendicular for each vertical in the MCS
phi_deg	Deviation angle in degrees
u	
v	
u_mag	
depth	
theta	
theta_deg	
up	Primary velocities (Rozovskii definition) for each sample in the MCS
us	Secondary velocities (Rozovskii flow definition) for each sample in the MCS
upy	Y component of primary velocities (Rozovskii)
usy	Y component of secondary velocities (Rozovskii)
upx	X component of primary velocities (Rozovskii)
usx	X component of secondary velocities (Rozovskii)
ux	X component of Rozovskii velocities rotated to global coordinate system
uy	Y component of Rozovskii velocities rotated to global coordinate system
uz	Z component of Rozovskii velocities rotated to global coordinate system
alpha	
upSmooth	Smoothed Primary velocities (Rozovskii definition) for each sample in the MCS
usSmooth	Smoothed Seoncdary velocities (Rozovskii definition) for each sample in the MCS
upySmooth	Smoothed Y component of primary velocities (Rozovskii)
usySmooth	Smoothed Y component of secondary velocities (Rozovskii)
upxSmooth	Smoothed X component of primary velocities (Rozovskii)
upySmooth	Smoothed X component of secondary velocities (Rozovskii)

iRic© ANV file

The iRic© river modeling interface allows input of vector velocity data for model calibration and validation (2-D) in the form of ANV files. VMT will export ANV files from the GISEXPORTTOOL utility (depth-averaged velocity along the curvilinear boat path) and ANV files containing the depth- or layer-averaged velocity as displayed in the plan view plot with vector spacing and smoothing applied. The format of these data files is as follows:

The vector files contain x, y, z, vx, and vy values in each line and separated by spaces. Units are MKS. x: x position (UTM Easting in m) y: y position (UTM Northing in m) z: z position - Presently the z- value is unused and can be set to zero. vx: the x or easting component of velocity vy: the y or northing component of velocity. There is no header with the number of points in the file. The extension for vector files is .anv

Example:

```
324149.52 855806.24 0 -0.157983784 0.003032246
324149.36 855806.27 0 -0.223229456 0.039234629
324149.26 855806.32 0 -0.124340297 0.073863539
324149.02 855806.33 0 -0.205609318 0.079592921
324148.7 855806.35 0 -0.056268607 0.036997848
324148.36 855806.36 0 -0.326218383 0.032733164
324148.09 855806.39 0 -0.352748183 0.081762639
324147.78 855806.5 0 -0.605494602 0.625695435
```

Multibeam bathymetry file

These files contain the bathymetry data from the four individual beams of the ADCP, corrected for heading, pitch, and roll using an algorithm provided by TRDI and in use in Dave Mueller's ADMAP. The data is formatted as a simple CSV (comma-separated value) file that is easily imported into ArcGIS® using the XY data import tool. The user has the option to add ancillary data to the data file. A description of the data files with and without the ancillary data is as follows:

Without Ancillary Data

NAME	DESCRIPTION
EnsNo	Ensemble Number
Easting	Easting (UTM, WGS84)
Northing	Northing (UTM, WGS84)
Elev_m	Elevation in meters

With Ancillary Data

NAME	DESCRIPTION
EnsNo	Ensemble Number
Easting	Easting (UTM, WGS84)
Northing	Northing (UTM, WGS84)
Elev_m	Elevation in meters
Year	Year of sample
Month	Month of sample
Day	Day of sample
Hour	Hour of sample
Minute	Minute of sample
Second	Second of sample
Heading_deg	Heading reading at time of sample in degrees from true north
Pitch_deg	Pitch reading at time of sample in degrees
Roll_deg	Roll reading at time of sample in degrees

Note: UTM coordinates referenced to the WGS84 reference frame if that was set in the GPS unit used during data collection (typical).

KML and KMZ files

These files are generated to allow the user to display the transect shiptracks (*.kml) and mean cross sections (*.kmz) in Google Earth®. The KML files are generated using the VMT utility ASCII2KML and the KML files must be loaded into Google Earth® for display. The KMZ files are generated at the request of the user in the VMT interface and will open automatically in Google Earth® through a request in the VMT code. The KMZ files are best viewed as 3-D cross sections so the user should adjust the view in Google Earth®® to get the best display of the cross section. In order to display each KMZ file as a 3-D cross section, the user must enter an offset in the VMT interface that is greater than or equal to the max depth in the reach. This will ensure the cross section is fully displayed above the image plane in Google Earth®. Failure to enter an offset will place the cross section below the plane of the background image in Google Earth®, thus blocking the view of the data.

Tecplot® files

Files contain processed and averaged ADCP data formatted for direct import into Tecplot®. Choosing the Tecplot® export option will export the average cross-section data only with no smoothing or data reduction (vector spacing) applied. Data files contain a header with all necessary information. One data file (*_TECOUT.dat) contains the velocity and backscatter data array for the cross section while the other data file (*_TECOUT_XSBathy.dat) contains the georeferenced bed depth and bed elevation data. The data files contain the following variables:

TECOUT.dat

NAME	DESCRIPTION
X	UTM Easting (m)
Y	UTM Northing (m)
Depth	depth (m)
Dist	dist across XS, oriented looking u/s (m)
u	stream-wise velocity magnitude per bin (cm/s)
v	cross-stream velocity magnitude per bin (cm/s)
w	vertical velocity magnitude per bin (cm/s)
vp	primary vel. component-0 discharge meth. (cm/s)
vs	secondary vel. comp.-0 discharge meth. (cm/s)
U (Rotated)	depth-avg. stream-wise magnitude (cm/s)
V (Rotated)	depth-avg. cross-stream magnitude (cm/s)
ux (Rotated)	component of vel. in X dir., rotated (cm/s)
uy (Rotated)	component of vel. in Y dir., rotated (cm/s)
uz (Rotated)	component of vel. in Z dir., rotated (cm/s)
Mag	vel magnitude (need better desc.) (cm/s)
Bscat	backscatter (dB)
Dir	direction deviation (degrees)
vp (Roz)	primary vel. per bin using Rozovskii (cm/s)
vs (Roz)	secondary vel. per bin using Rozovskii (cm/s)
vpy (Roz)	cross-stream comp. of primary vel. (cm/s)
vsy(Roz)	cross-stream comp. of secondary vel. (cm/s)
phi_deg (Roz)	depth-avg. vel. vector angle (degrees)
theta_deg (Roz)	individual bin vel. vector angle (degrees)

TECOUT_XSBathy.dat

NAME	DESCRIPTION
X	UTM Easting (m)
Y	UTM Northing (m)
BedDepth	Bed depth (m)
Dist	Dist across XS, oriented looking u/s (m)
BedElev	Bed Elevation (m) (Only accurate if user entered value in VMT GUI)

Excel® file

VMT will produce an Excel® (*.xlsx) file of the processed results when prompted. There are two version of the file: Typical, single cross-section output; and, multiple transects loaded (i.e., plan view) output.

VMT writes 5 worksheets in the Excel® File:

VMTSummary: this contains an overview of the data processed, including several parameters related to the MCS, and the raw ASCII Files associated with the processed data.

Planview: this contains the UTM coordinates, elevation, and depth- or layer- averaged velocities of the MCS. Data are organized in rows (one vertical per row). If you have selected a particular depth range, in the Plan View Plot Panel, VMT will output the resulting velocities for that layer only. The depth range used in the computation is appended to the name of the velocity fields for reference.

MeanCrossSection: this contains the UTM coordinate, distance along transect (i.e., stationing), elevations, bed elevations, and a suite of various velocity variable for every grid node of the MCS. Data are organized in block format, with rows representing vertical locations. Missing/non-data locations are denoted by a value of -9999.

Smoothed_Planview: this contains the UTM coordinates, distance (station), and depth- or layer- averaged velocities of the MCS using the same spacing and smoothing as is employed in the Plan View Map figure (i.e., the data are the same as the vecotrs in the figure). Data are organized in rows (one vertical per row). If you have selected a particular depth range, in the Plan View Plot Panel, VMT will output the resulting velocities for that layer only. The depth range used in the computation is appended to the name of the velocity fields for reference.

Smoothed_MeanCrossSection: this contains the distance along transect (stationing), depth from surface, and the currently plotted countour and vector components in the Mean Cross Section Contour Plot. Data are organized in block format, with rows representing vertical locations. Missing/non-data locations are denoted by a value of -9999.

Note: If multiple MAT files are loaded, the worksheet MeanCrossSection will not be written, and the worksheet Planview will contain all transect data.

GIS compatible ASCII file (GISEXPORTTOOL)

These files contain georeferenced depth- or layer-averaged data for every ensemble along the curvilinear shiptrack. The file also includes ancillary data. Data is formatted in a CSV file with a header that allows direct import in to ArcGIS® using the XY data import tool. A description of the data contained in the file is as follows: GIS.csv files

NAME	DESCRIPTION
EnsNo	Ensemble Number
Year	Year of sample
Month	Month of sample
Day	Day of sample
Hour	Hour of sample
Min	Minute of sample
Sec	Second of sample
Lat_WGS84	Latitude in WGS84
Lon_WGS84	Longitude in WGS84
Heading_deg	Heading reading at time of sample in degrees from true north
Pitch_deg	Pitch reading at time of sample in degrees
Roll_deg	Roll reading at time of sample in degrees
Temp_C	Temperature at time of sample in deg. C
Depth_m	Mean bed depth at time of sample in meters
B1Depth_m	Beam 1 bed depth at time of sample in meters
B2Depth_m	Beam 2 bed depth at time of sample in meters
B3Depth_m	Beam 3 bed depth at time of sample in meters
B4Depth_m	Beam 4 bed depth at time of sample in meters
B5Depth_m	[optional]Vertical Beam bed depth at time of sample in meters
Backscatter_db	Acoustic backscatter in dB
DAVeast_cmps	Depth- or Layer-averaged velocity (east component) in cm/s
DAVnorth_cmps	Depth- or Layer-averaged velocity (north component) in cm/s
DAVmag_cmps	Depth- or Layer-averaged velocity magnitude in cm/s
DAVdir_deg	Depth- or Layer-averaged velocity direction in degrees from true north
DAVvert_cmps	Depth- or Layer-averaged velocity (vertical) in cm/s (+ is up)
U_Star_mps	Shear velocity estimate in m/s
Z0_m	Roughness length estimate
COD	Coefficient of determination

Appendix 3: Keyboard accelerators and hotkeys

Acellerator	*Function*
F1	Opens this user guide in a web browser
Ctrl+O	Open WinRiver II® classic ASCII output file(s)
Ctrl+M	Open processed VMT mat-file(s)
Ctrl+S	Save processed VMT mat-file
Ctrl+F	Export current figure(s) as graphics
Ctrl+I	Export iRic© ANV text file
Ctrl+B	Export multibeam bathymetry (RioGrande and StreamPro only)
Ctrl+Z	Export 3-D Google Earth® KMZ file of MCS
Ctrl+T	Export Tecplot DAT txt file of processed MCS and bathymetry
Ctrl+E	Export Excel® file of processed MCS, or multiple processed files if loaded
Ctrl+1	Change graphics rendering endine to OpenGL (default)
Ctrl+2	Change graphics rendering endine to Painters (Adobe Illustrator)
Ctrl+3	Change graphics rendering endine to Z-buffer
Ctrl+G	Start the GIS Export tool
Ctrl+L	Start the ASCII to KML tool
Ctrl+C	Start the Batch Processing tool
Ctrl+Shift+S	Hidden functionality to process SonTek RiverSurveyorLive data (no guarantees)
Ctrl+Shift+L	Export SonTek ADCP shiptracks to KML tool
Ctrl+Alt+E	Open the custom flat-file export utility