Velocity Mapping Toolbox (VMT)

An Overview/Update for the HAWG
About VMT

Matlab-based code for post-processing and visualization of ADCP data

- For moving-boat measurements with GPS
- Averages multiple transects at a single cross section to obtain a single representative velocity distribution for the cross section
- Reads TRDI ASCII output files
- Computes Primary and secondary velocity components using a variety of accepted methods
- Visualizes data in cross-sectional views as well as in planform
- Allows depth and layer-averaging over user-specified intervals
- Allows reachwise visualization of velocity data in planform
- Includes utilities for bathymetry export and data export to Google Earth, Tecplot, GIS, and iRIC.
Graphical User Interface (GUI)

Velocity Mapping Toolbox (VMT)
v. 2.3 beta

Data Import
- ASCII Output (.txt)
- Matlab Files (.mat)
- Tecplot (*.dat) file
- Output KMZ File (Google Earth)

Graphic Export
- Figure 1 (Shiptracks)
- Figure 2 (Plan View)
- Figure 3 (Cross Section)

Processing
- Secondary Flow Definitions
  1) Zero Net Cross-Stream Discharge Definition (zsdx)
  2) Rozovskii Definition (Roz)
- Manually Set Cross-Section Endpoints (User Input File Required)

Bathymetry
- Output Multibeam Bathymetry
- Beam Angle (deg)
- Mag Var
- VSE (m)

Plotting
- Map Depth-Averaged Velocities
- Plot Secondary Flow Vectors
- Plot Shoreline
- Vector Scale
- Vertical Offset (m)
- Vector Spacing
- Smoothing Window Size

Cross Sections
- Contour Variable: Streamwise Velocity (u)
- Secondary (zdz)
- Secondary (Roz)
- Secondary (Roz, Cross-Stream C)
- Primary (Roz, Cross-Stream Comp)

HydroAcoustics
USGS
Basic Data Processing

**Velocity Mapping Toolbox (VMT) v. 2.3 beta**

**Data Import**
- Save Data [Net RRA]
- Output ASCII (text file)
- Output Text File (txt file)
- Output KMZ file (Google Earth)

**Graphical Export**
- Figure 1 (View window)
- Figure 2 (Graph window)
- Figure 3 (Cross section)

**Processing**
- Secondary Flow Definitions
  1. Zero Net Cross-Stream Discharge Definition [264]
  2. Pressure (Pressure [123])
  3. Manually Set Cross-Section Endpoints (User Input File Required)

**Bathymetric**
- Output Null Surface (Grid)
- Output Auxiliary Data

**Plotting**
- Plan View
  - Plot Depth-Averaged Velocities
  - Depth Range (m)
  - Vector Scale
  - Vector Spacing
  - Horizontal Vector Spacing
  - Vertical Vector Spacing

**Cross Sections**
- Contour Plot
  - Cross Section Contour Plot
  - Vertical exaggeration
  - Vector Scale
  - Vector Spacing
  - Horizontal Vector Spacing
  - Vertical Vector Spacing

**Step 1. Define the average cross section orientation and grid**

Options:
1. Least-squares fit of data cloud
2. User-defined end points

**Step 2. Project transect data to the cross section plane using an orthogonal translation**

**Step 3. Interpolate projected data to the cross section grid for each transect (no interpolation in vertical is required when using a vertical grid defined by the bin size)**

**Step 4. Compute arithmetic average of all transects at each grid node for basic variables (e.g., velocity components)**

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**One-Dimensional Moving Average (planform)**

n = 2

**Two-Dimensional Moving Average (cross section)**

nh = 2
nv = 1

- Grid Node
- Grid node used in average
- Grid node replaced by average
Streamwise and Transverse

- **Streamwise** defined perpendicular to mean cross section
- **Transverse** is parallel to mean cross section

\[ u = \text{Streamwise} \]
\[ v = \text{Transverse} \]

See Lane et al. 2001
Primary and Secondary (ZSD)

- Zero Net Cross Stream Discharge Definition (ZSD)
- No net secondary discharge for entire cross section
- Finds components of velocity perpendicular (Vp) and parallel (Vs) to rotated cross section
- Better for bends (in general)

Vs = Secondary Vel.
Vp = Primary Vel.

See Lane et al. 2001
Primary and Secondary (ROZ)

- Rozovskii Definition (ROZ)
- No net secondary discharge for each profile (ensemble)
- Vs and Vp differ for each ensemble
- Recompute X and Y components of Vp and Vs
- Better for confluences and bifurcations

Vs = Secondary Vel.
Vp = Primary Vel.

See Lane et al. 2001
Example Output – Planform

Wabash-Embarras Confluence

Upper St. Clair River

Without Spatial Averaging

With Spatial Averaging
Clinton Lake (IL)

With temperature data extracted from the ADCP

Above Thermocline Velocities

Below Thermocline Velocities
Example Output – Cross Sections

Wabash-Embarras Confluence (XS4)

- No Rotation Scheme
- Zero Net Secondary Discharge Definition
- Rozovskii Method

Upper St. Clair River (XS9)

- Single Transect
- Two-Transect Average
- Four-Transect Average
- Six-Transect Average
- Eight-Transect Average
VMT Standalone Utilities

**ASCII2KML**
- Shiptrack to Google Earth KML file
- Note: Mean XS from VMT can also be output to GE

**ASCII2GIS**
- ADCP data to text file formatted for GIS import
- Layer-Averaged (DFS or HAB)
- Temporal Averaging
- Plotting
ASCII2GIS Example

Depth-Average Velocity

MBES bathymetry
Status of VMT

- Taught VMT training class in Tampa (2011)
- Limited distribution to < 20 beta testers (inside and outside of USGS, but no industry) in late July 2011
- OSW website and forum established July 2011 (user guide, training material, video tutorials)
  - Username: VMTuser, Password: VMTrules
- Journal article submitted to ESPL in July 2011
- Paper reviews received and revisions made (resubmit any day now)
- Package nearly complete for Bureau approval
- Some feedback received from beta testers (but not as much as expected)
- VMT training class scheduled for HMEM 2012 (August, Snowbird, UT)
Feedback on VMT

- Can be slow for large data sets
- Considerable interest in extending code to accept SonTek and RiverRay data
- Additional manual control of plots needed
  - Manual setting of color scales and reference vectors
- Output shows excellent agreement with similar plots produced outside VMT
- Add more QA/QC and clean-up minor bugs
- Four minor bug reports (fixed)
## Prioritized List of VMT Improvements

<table>
<thead>
<tr>
<th>Number</th>
<th>Task</th>
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<tbody>
<tr>
<td>1</td>
<td>Add generic input capabilities</td>
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<td>2</td>
<td>Add dynamic cell/bin size data handling</td>
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<td>3</td>
<td>Add temporal averaging to ASCII2GIS utility</td>
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<td>4</td>
<td>Update multibeam bathy comp to include M9, SS, and RiverRay data</td>
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<td>5</td>
<td>Look into issue with TecPlot primary velocity (sign convention)</td>
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<td>6</td>
<td>Improve 2-D interpolation of data on mean cross section (normalize, triangulate and then interpolate to regular 2-D grid)</td>
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<td>7</td>
<td>Determine how to handle multiple frequencies and backscatter</td>
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<td>8</td>
<td>Improve efficiency</td>
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<td>9</td>
<td>Improve memory usage</td>
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<td>10</td>
<td>Determine how to better integrate extensions</td>
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<td>11</td>
<td>Add iRIC bathy export compatibility</td>
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<td>12</td>
<td>Add iRIC ANV file export for plan view data</td>
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<td>13</td>
<td>Improve error handling to provide feedback for EXE users</td>
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<td>14</td>
<td>Improve GPS filter</td>
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<td>15</td>
<td>Start using version control software</td>
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<td>16</td>
<td>Develop better autoscaling routines to give better visualizations on first run (users and tune-in best results from there)</td>
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<td>17</td>
<td>Improve the figure export capabilities (add EPS option, format for USGS pubs, Remove titlebar, add axis to colorbar, etc.)</td>
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<td>18</td>
<td>Allow variable WSE file for bathy</td>
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<td>19</td>
<td>Investigate vertical velocity negative bias</td>
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<td>20</td>
<td>Update GPS script to pull nav file rather than rely on ASCII positions</td>
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<td>21</td>
<td>Build -in threshold/filter for data to remove data far away from the mean cross section</td>
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<td>22</td>
<td>Add QA/QC routines</td>
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<td>23</td>
<td>Add vorticity computation</td>
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<td>24</td>
<td>Improve batch processing capabilities (allow input of a processing file that has all transect groupings and settings)</td>
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<td>25</td>
<td>Allow fixed color scales and vector scales</td>
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<td>26</td>
<td>Integrate stationary extension</td>
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<td>27</td>
<td>Improve routines for estimating shear velocity and bed shear stress from moving boat data (and stationary data)</td>
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<td>28</td>
<td>Add option to interpolate missing data</td>
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<td>29</td>
<td>Improve handling of edge data (missing data at edges and top and bottom can cause loss of additional data during averaging)</td>
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<td>30</td>
<td>Add capabilities to develop/input calibrations for suspended sediment</td>
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<td>Add corrections for backscatter (sediment and water adsorption, etc.)</td>
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<td>32</td>
<td>Improve reachwise plotting capabilities including 3-D display of multiple cross sections</td>
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<td>33</td>
<td>Improve GIS export capabilities (output shapefiles of bathy points, velocity vectors)</td>
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<td>34</td>
<td>Improve Google Earth Export (export velocity vectors--both plan view and cross section-- to GE)</td>
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<td>35</td>
<td>Add data editor tool to allow removal of outliers</td>
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<td>36</td>
<td>Add bed velocity computation following Rennie</td>
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<td>37</td>
<td>Add uncertainty computation for bathy data (for obliques)</td>
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<td>38</td>
<td>Improve routines for estimating longitudinal dispersion coefficient</td>
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<td>39</td>
<td>Add TIN and contour generation for bathymetry and allow use as a background for velocity data (currently requires users to TIN and contour outside of VMT and import as background)</td>
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<td>40</td>
<td>Develop handling of longitudinal data</td>
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<td>41</td>
<td>Add water quality import capability (YSI or other import with GeoRef from ADCP GPS using timestamp)</td>
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<td>42</td>
<td>Allow multiple plots to be generated simultaneously (by selecting more than one parameter and using subplot)</td>
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<td>Add capability to process data without GPS</td>
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