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JSATS Decoder Software Manual

FINAL REPORT

AE Flory
BL LaMarche
MA Weiland

May 2013

Pacific Northwest
NATIONAL LABORATORY

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Richland, Washington 99352

Preface

The Juvenile Salmon Acoustic Telemetry System (JSATS) software user's manual presented here describes the installation and use of the JSATS decoder software. The software was developed for use with the JSATS cabled array system for decoding digitized acoustic signals. A complementary manual describes the use of the detector software used for acquiring the acoustic signals and recording them to file. This software was developed by the Pacific Northwest National Laboratory (PNNL) for the U.S. Army Corps of Engineers, Portland District to assist with estimating dam passage survival and other performance measures stipulated by the 2008 Federal Columbia River Power System Biological Opinion (BiOp) and the 2008 Columbia Basin Fish Accords.

Many others made significant contributions to development and testing of this software including Tom Carlson, Eric Choi, Daniel Deng, Jayson Martinez, Adam Flory, Tylor Abel, Yong Yuan, and Tom Seim. Thank you also to Joanne Duncan, Susan Ennor, George Batten, and Matt Hennen whose edits, comments, and improvements were much appreciated.

Acronyms and Abbreviations

AMT	acoustic micro-transmitter
bwm	binary waveform format
CPU	central processing unit
CRC	cyclic redundancy check
csv	comma separated variable
DSP	digital signal processing
FPGA	field programmable gate array
GPS	global positioning system
GUI	graphical user interface
I/O	input/output
JSATS	Juvenile Salmon Acoustic Telemetry System
ms	millisecond(s)
SNR	signal-to-noise ratio
TOA	time of arrival

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1.0 Introduction

The Juvenile Salmon Acoustic Telemetry (JSATS) system uses acoustic transmitters and receiving systems to track fish in one, two, or three dimensions (McMichael et al. 2010; Deng et al. 2011; Weiland et al. 2011). A modular JSATS array consists of software, a computer, multifunction electronic cards including a global positioning system (GPS) card, and digital signal processing (DSP) cards with field programmable gate array (FPGA) capability, a signal conditioning interface, four hydrophones, and four cables (Weiland et al. 2011). The conditioned signal enters the signal processing environment of the host computer where messages from JSATS transmitters are detected, decoded, and time stamped (Figure 1.1).

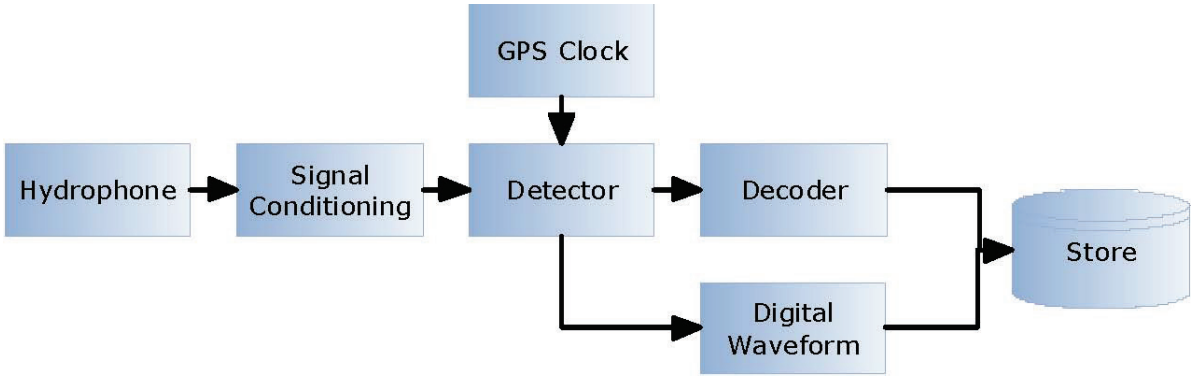


Figure 1.1. Flowchart Depicting the Flow of Data for the JSATS Cabled Receiver

The JSATS cabled array is an integrated system of off-the-shelf and custom components (Figure 1.2) designed for detection and tracking of fish tagged with acoustic micro-transmitters (AMTs) as they pass through the hydrophone array. This system was initially designed for use at hydroelectric facilities to track fish as they approach and pass the dam, but it can be adapted for many types of environments. The signal transmitted by the AMT implanted in a fish is detected by hydrophones deployed in known locations (surveyed positions). This signal is amplified by the hydrophone, or hydrophones, on which the signal is detected and passed through cables to a receiver where the signal is conditioned and further amplified. The signal is then passed to the DSP/FPGA card in the computer for signal verification and acceptance. The signal is paired with the time from the GPS card to provide microsecond accuracy and then the data are written to disk as a .bwm (binary waveform format) file. If the decoder is running in the real-time mode and is able to keep up with the signals coming in, the file is opened, decoded, and the tag code decoded from the acoustic waveform is written to a .csv (comma- separated variable) file for use in future analysis not described in this manual. If the real-time decoder is unable to keep up with the stream of incoming .bwm files or the data are not being decoded in real-time the .bwm files will be decoded later (post-processed) using the Decode Directory function described in Section 5.2.

The JSATS decoder, explained in detail in this manual, is a software application that converts a digitized acoustic signal (a waveform stored in .bwm files) into a list of potential JSATS AMT tag codes along with other descriptive data about the signal, including time of arrival (TOA) and signal-to-noise ratio (SNR). The software is capable of decoding single files, directories, and viewing raw acoustic waveforms. When coupled with the JSATS detector, the decoder is capable of decoding in real time and can also provide statistical information about acoustic beacons placed within the detection range of hydrophones within a JSATS array. This field manual details the features and functionality of the JSATS decoder software.

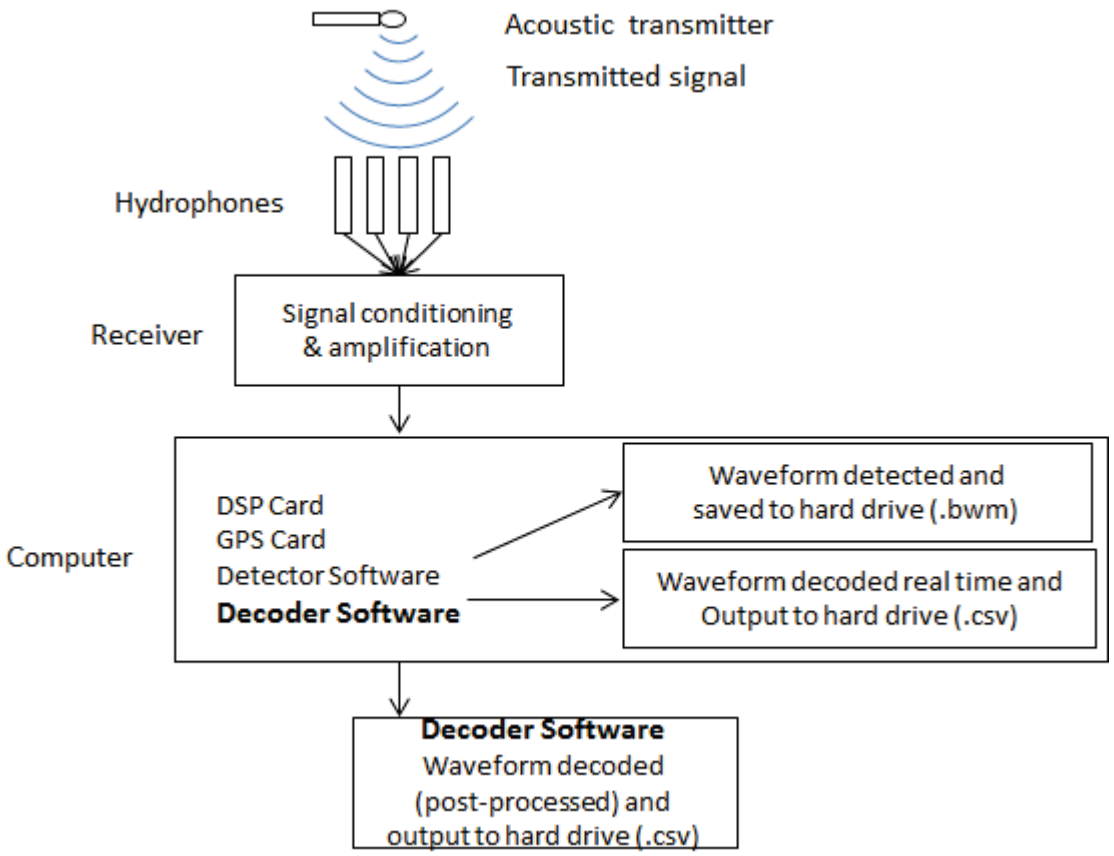


Figure 1.2. Structure of the JSATS Cabled Array System and JSATS Software

System requirements (Section 2.0) are presented first, followed by software installation instructions (Section 3.0), instructions for decoder setup (Section 4.0), decoding process initiation (Section 5.0), and monitoring of beacons using real-time decoding features (Section 6.0). Section 7.0 explains data and file format configurations, and Section 8.0 describes the Command Line decoder, a lightweight version of the JSATS decoder.

2.0 System Requirements

This section provides information about the minimum system requirements for operation of the JSATS decoder.

Hardware Requirements

Decoder only

	Requirement	
System Component	Minimum	Recommended
Processor	1 GHz	2 GHz multicore or greater
RAM	512 MB	4 GB or greater
Disk Space Installation	2.5 GB	2.5 GB

Additional disk space is required for storing decoded waveform data. The amount of hard drive space needed depends on the number of *.bwm* files being decoded and the data stored in the individual *.bwm* files.

Decoder/Detector

	Requirement	
System Component	Minimum	Recommended
Processor	Pentium IV	2 GHz multicore or greater
RAM	1 GB	4 GB or greater
Disk Space Installation	2.5 GB	2.5 GB
PCI-X slots	3	3

Additional disk space is required for acquisition of raw *.bwm* files and storing decoded waveform data. The amount of hard drive space needed depends on the number of *.bwm* files being acquired and decoded and the data stored in the individual *.bwm* files.

Operating System Requirements

- **Windows 7** (32- or 64-bit)
- **Windows XP** (Service Pack 2 or 3)

Required Utility Packages

- **.net Framework 4.0** – (http://www.microsoft.com/download/en/details.aspx?id=17718) – link accessed on December 12, 2012.
- **VC++ Redistributable 8.0** (the appropriate package for your computer's operating system, i.e., x86 for 32-bit operating systems and x64 for 64-bit systems).

- **32-Bit** – (http://www.microsoft.com/downloads/details.aspx?FamilyID=9b2da534-3e03-4391-8a4d-074b9f2bc1bf&displaylang=en) – link accessed on December 12, 2012
- **64-Bit –** (http://www.microsoft.com/downloads/details.aspx?familyid=90548130-4468-4BBC-9673-D6ACABD5D13B&displaylang=en) – link accessed on December 12, 2012

3.0 Installation

This section provides instructions for installation of the JSATS decoder. The software packages listed in Section 2.0 must be installed prior to the installation of the JSATS decoder. Instructions for installation and use of the JSATS detector software are provided in a companion manual, the JSATS Detector Software Manual.

3.1 Decoder Installation

The JSATS decoder installation file "SetupJSATSDecoderOTR.msi" is available from http://jsats.pnnl.gov/Software/.

In Windows Explorer, start the installation by double-clicking the file "SetupJSATSDecoderOTR.msi" (Figure 3.1).

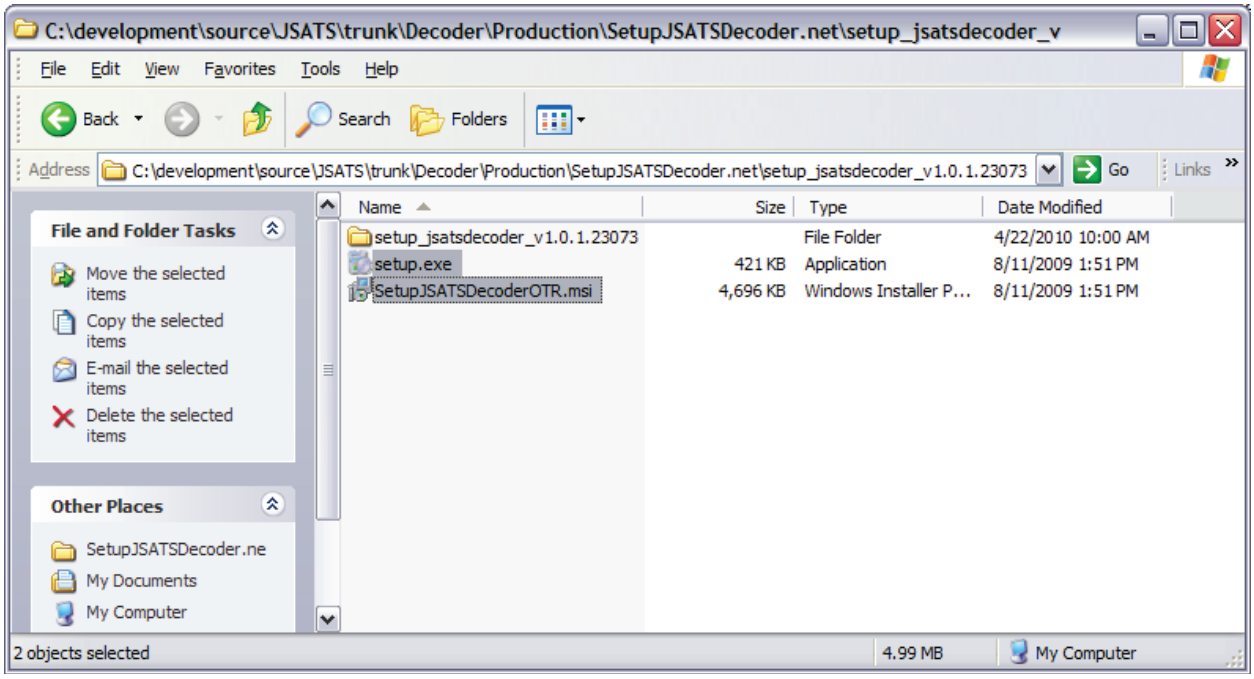


Figure 3.1. Windows Explorer Window Showing the JSATS Decoder Setup File

After the installer loads, you will be guided through a series of steps, beginning with the *Setup Wizard* dialog box (Figure 3.2). Select **Next** to continue installation.

Figure 3.2. JSATS Decoder Setup Wizard Dialog Box

The first step of installation is to identify the folder in which you want to install the decoder. The default location for the installation folder is in the computer *Program Files* Directory, as shown in the *Select Installation Folder* dialog box in Figure 3.3. An alternative installation location may be entered in the **Folder** text box, or **Browse** can be selected to navigate to a designated folder location. Select the option button to choose whether or not the JSATS decoder will be available for others that may use the computer, and select **Next**.

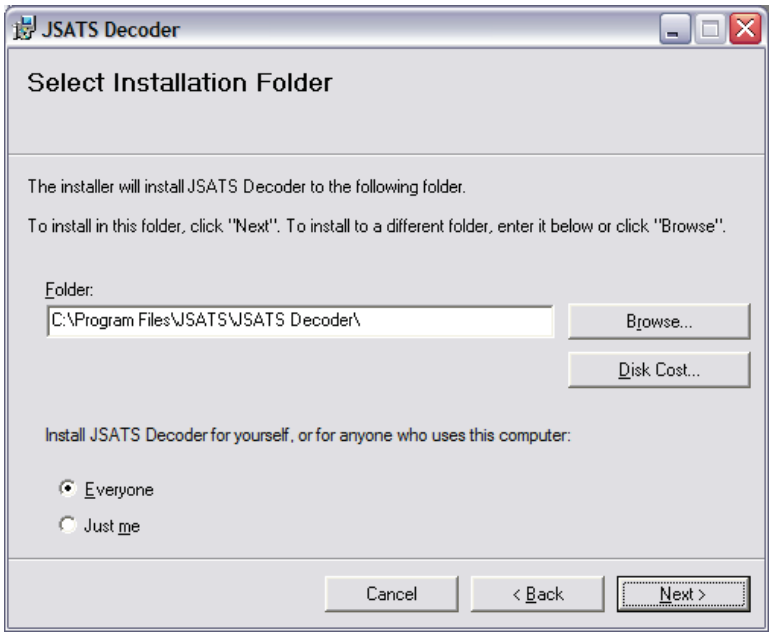


Figure 3.3. Enter or Browse to the Chosen Installation Folder Location within the Installation Folder Dialog Box (first install screen)

The *Select Installation Folder* dialog box will close and the *Confirm Installation* dialog box (Figure 3.4) will open. Select **Next** to confirm that you want to install the decoder and to initiate the software installation.

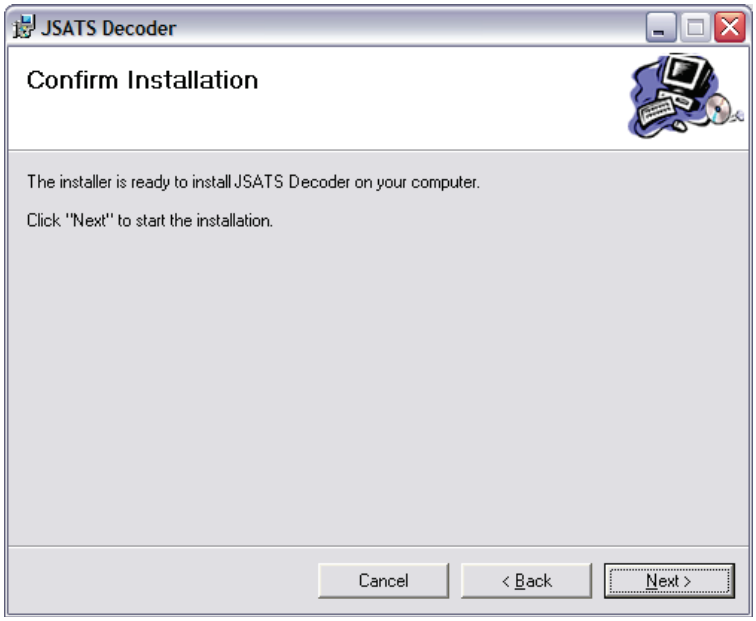


Figure 3.4. Select the Next Button in the Confirm Installation Dialog Box to Initiate the Install Process (second install screen)

The progression of the decoder installation will be indicated by the progress bar shown in the *Installing JSATS Decoder* dialog box (Figure 3.5). When completed, select **Next**.

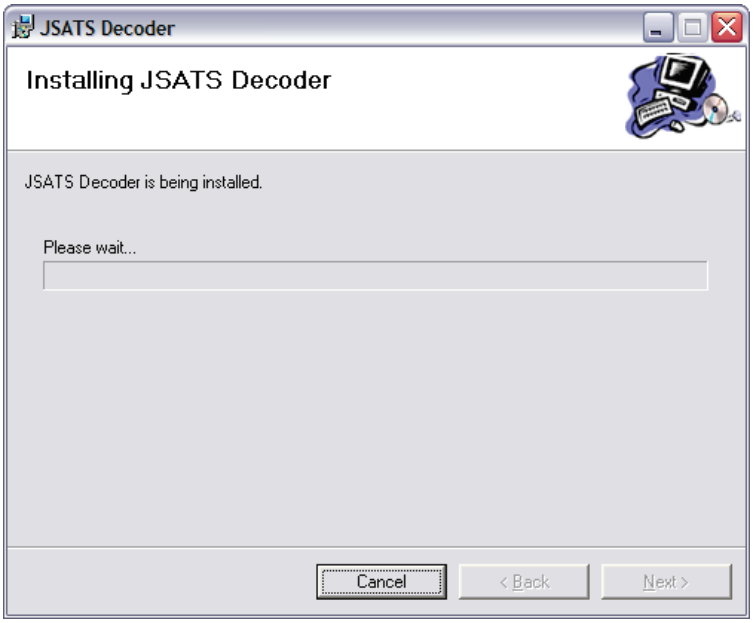


Figure 3.5. Installation Progress Will Be Shown in the Installing JSATS Decoder Dialog Box (third install screen)

A new dialog box will open indicating the successful installation of the JSATS decoder (Figure 3.6); select the **Close** button to complete the installation process.

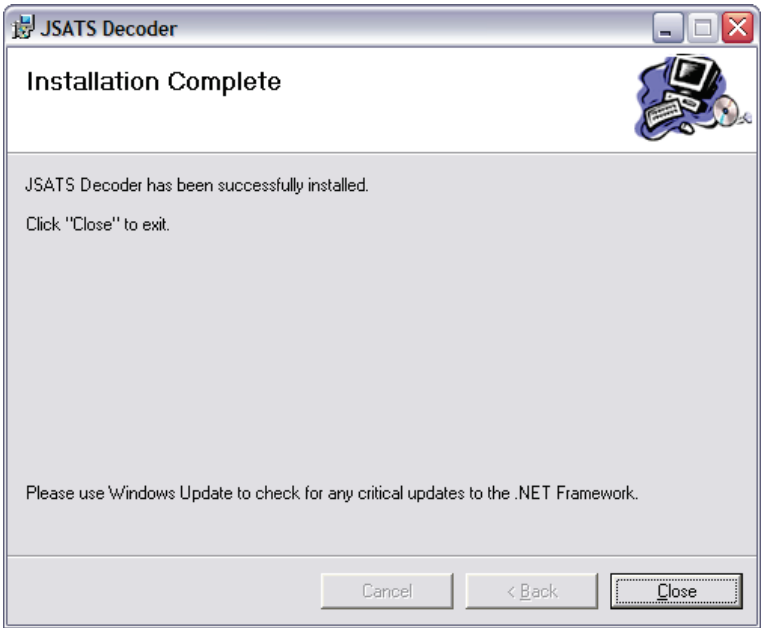


Figure 3.6. The Successful Installation of the JSATS Decoder Will Be Shown in the Installation Complete Dialog Box (final install screen). Select the **Clos**e button to complete the process.

4.0 Software Interface

This section provides a descriptive overview of the layout and the function of the GUI (graphical user interface) and how to navigate the software to set preferences for viewing and decoding data.

4.1 Main Window

Figure 4.1 shows the layout of the main JSATS **Decoder** window. The menu structure is organized into five main categories (bordered in red): the File Menu Bar (Section 4.1.1), Decoder Quick Launch Bar (Section 4.1.2), Decoder Command Bar (Section 5.0), Decoder Options (Section 4.1.3), and Save Commands Bar (Section 4.1.4). Four of these elements are described in the following sections.

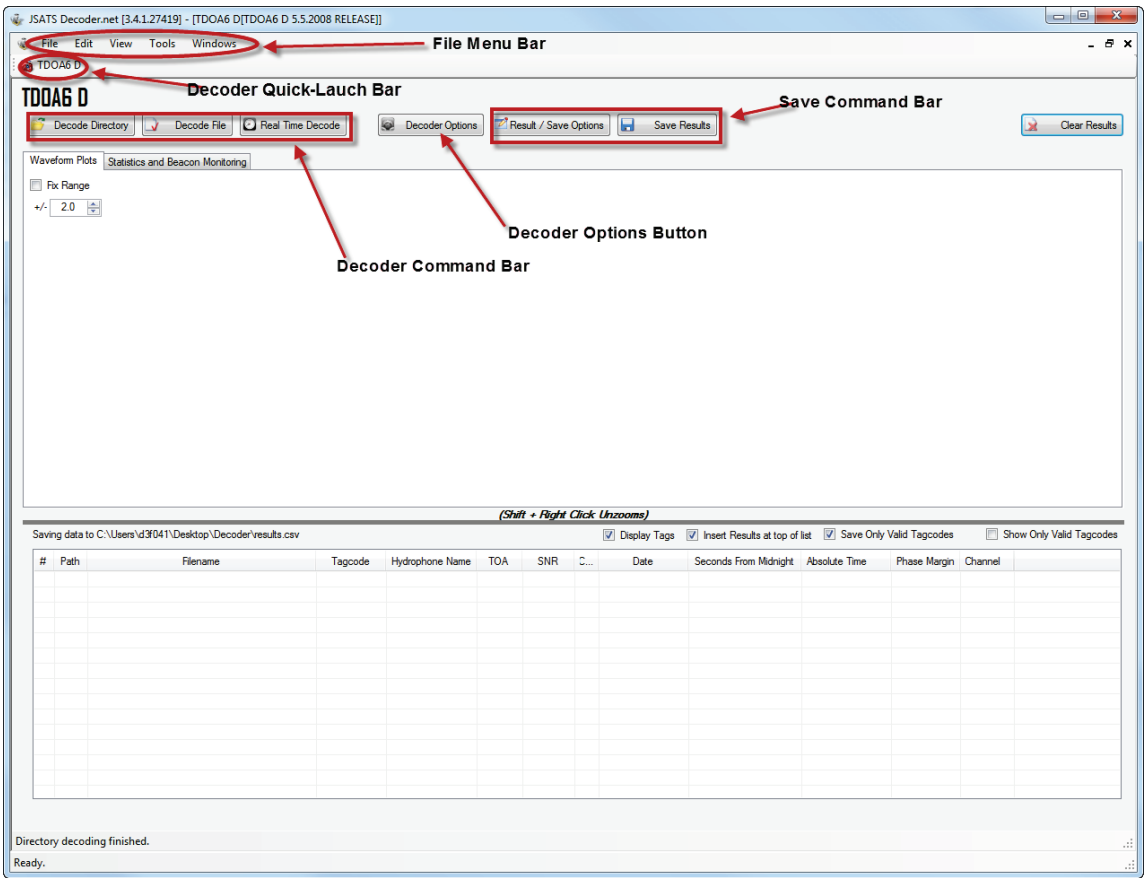


Figure 4.1. JSATS Decoder Main Application Window Showing the Menu Structure

4.1.1 File Menu Bar

The top level File Menu Bar contains several menus and sub-menus.

4.1.1.1 File Menu

The **File** menu allows you to quit the program (**Exit**), save results (**Save**, **Save As**), and decode *.bwm* files (**Decode File**, **Decode Directory**). The **Decode File** and **Decode Directory** options are described in Section 5.0.

4.1.1.2 Edit Menu

The **Edit** menu allows you to change decoder options. The decoder available with this software package, TDOA6D, has options that can be modified to optimize the processing of saved tag waveforms or detector output. The default options described have been tested and optimized for detector algorithm performance. To adjust decoder parameters, select the specific decoder (i.e., TDOA6D) options in the dropdown **Edit** menu, which will open the decoder operation adjustment panel (Figure 4.2). The options and preset parameters, shown as *TDOA6a Options* in Figure 4.2, are identical to TDOA6D options. It is recommended that these options not be adjusted without thoroughly testing the changes. The variables in the Options dropdown menu are not discussed in this manual.

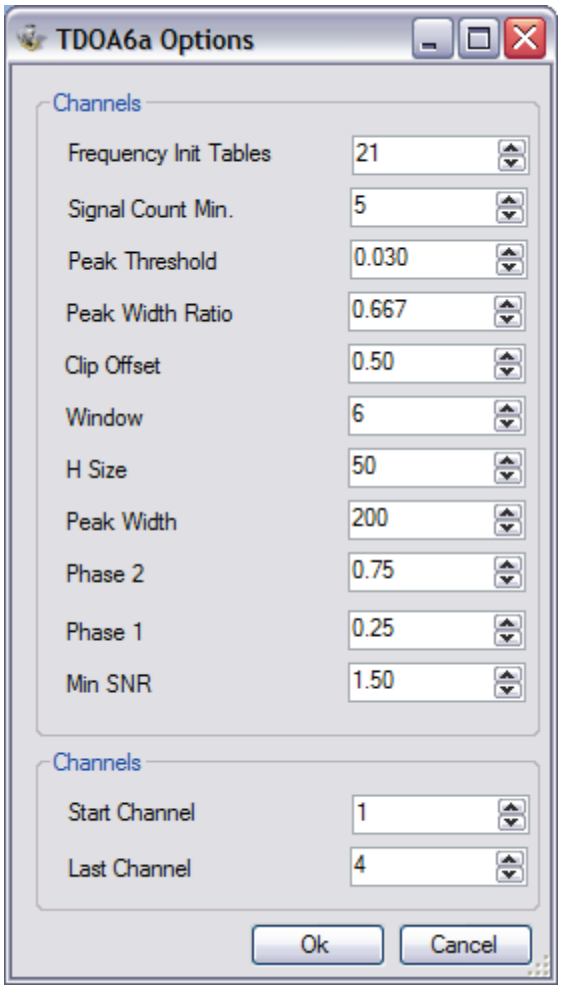


Figure 4.2. TDOA6a Operating Options Adjustment Panel

4.1.1.3 View Menu

The **View** menu allows you to hide the status bar or to display application log or error messages. When application errors occur, they will be displayed in the **Error Log** window (Figure 4.3). Click on the **Clear** button in the lower right corner of the screen to clear the log file or click on **OK** to return to the main application screen.

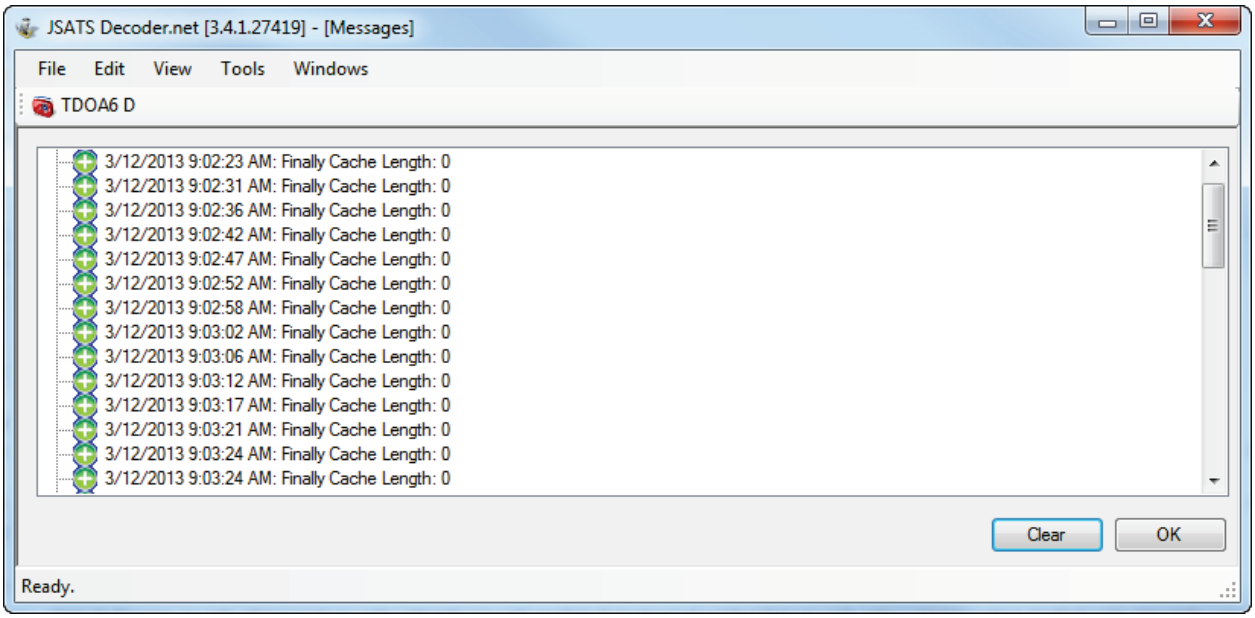


Figure 4.3. Error Log Window

4.1.1.4 Tools Menu

The **Tools** menu allows you to load other decoders not packaged with this software. The JSATS decoder system is plug-in based to permit developers to install and test new decoders without having to construct a user interface or other features. The extension of this decoder through plug-ins is not discussed in this user manual.

4.1.1.5 Windows Menu

The **Windows** menu displays a list of the decoder and log windows currently loaded, allowing the user to toggle through the available views.

4.1.2 Decoder Quick-Launch Bar

The JSATS decoder should automatically load one of the decoder windows upon startup; currently TDOA6D is the only decoder version loaded when the software is installed. If a decoder window is not loaded and opened, you can select the decoder from the decoder quick-launch bar by clicking on the decoder name (Figure 4.1).

When you select the TDOA6D decoder, the window shown in Figure 4.4 will open.

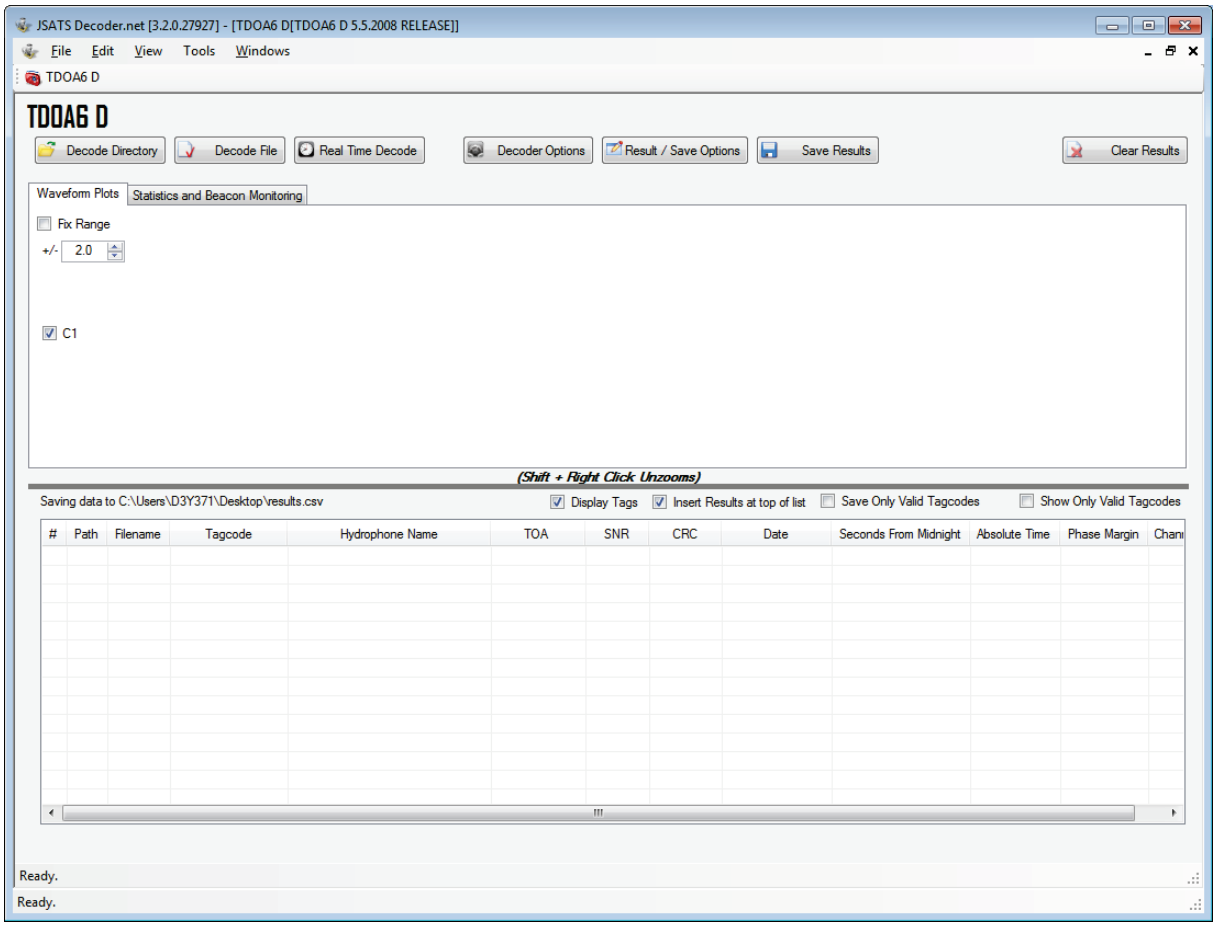


Figure 4.4. TDOA6D Decoder Window

4.1.3 Decoder Options

Each decoder has options that can be adjusted to control its performance. To adjust decoder parameters click the **Decoder Options** button in the main **Decoder** window (Figure 4.1).

Decoder operation options can also be changed by selecting the **Edit** menu, and then selecting the **Decoder Options** item as described in Section 4.1.2.

After changing the decoder operation parameters, select **OK** to accept the changes, or **Cancel** to reject any modifications. The default options have been thoroughly tested and verified in the lab and field. Any changes made to settings should be tested before they are implemented. Improper setting adjustment may result in reduction in decoding efficiency and other undesirable effects on decoder performance.

4.1.4 Save Commands

4.1.4.1 Result/Save Options

The **Result/Save Options** menu allows you to specify where result files will be saved. When the decoder decodes a directory (in real time or during post-processing), the results are saved to a file in a *.csv* format. In the **Result/Save Options** menu you can adjust save parameters and display properties. To set these program parameters, click on the **Result/Save Options** button (Figure 4.5).

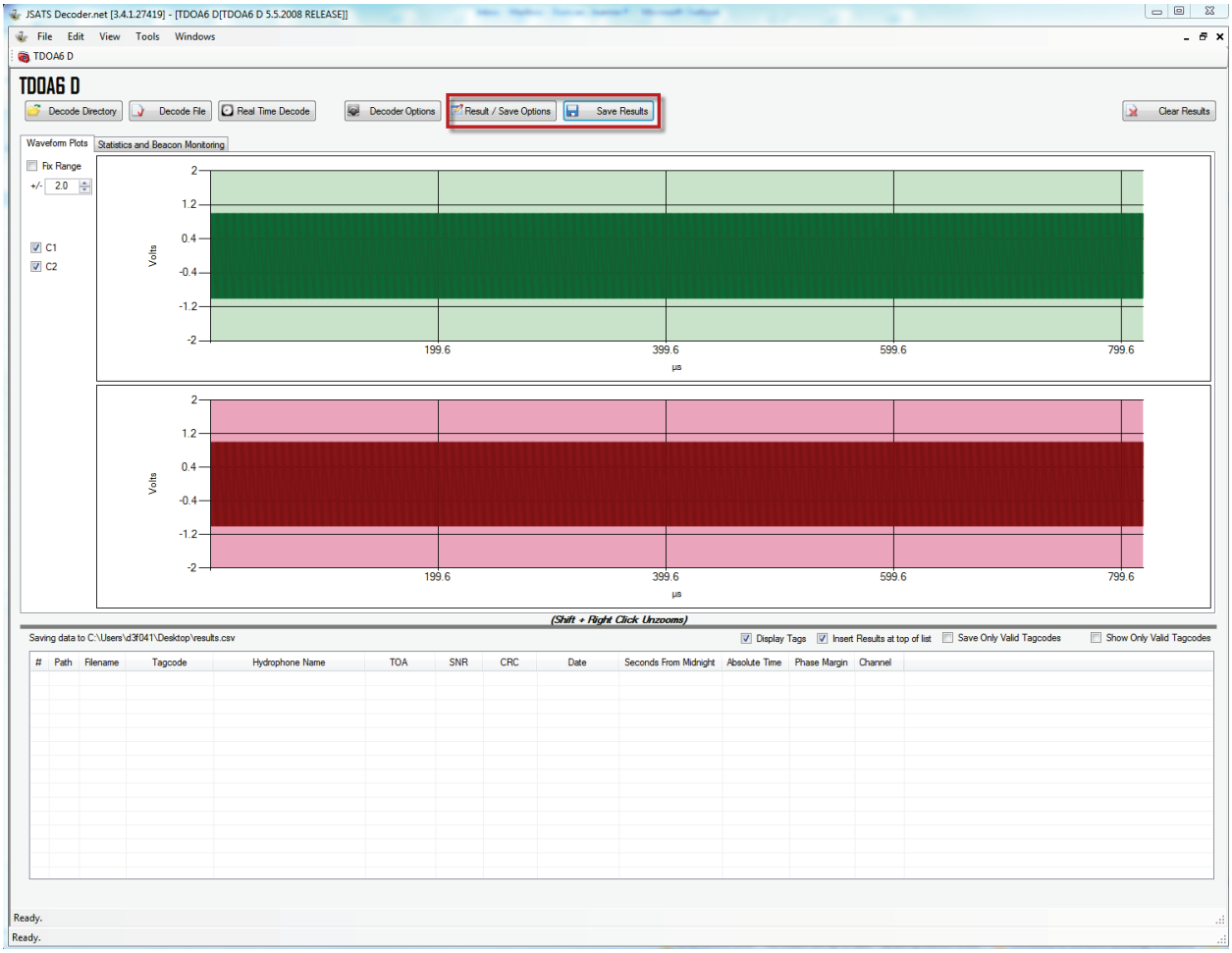


Figure 4.5. TDOA6D Decoder Window (with the Results/Save Options and Save Results buttons outlined in red)

After selecting the **Result/Save Options** menu item, the *Results Properties* dialog box shown in Figure 4.6 will appear.

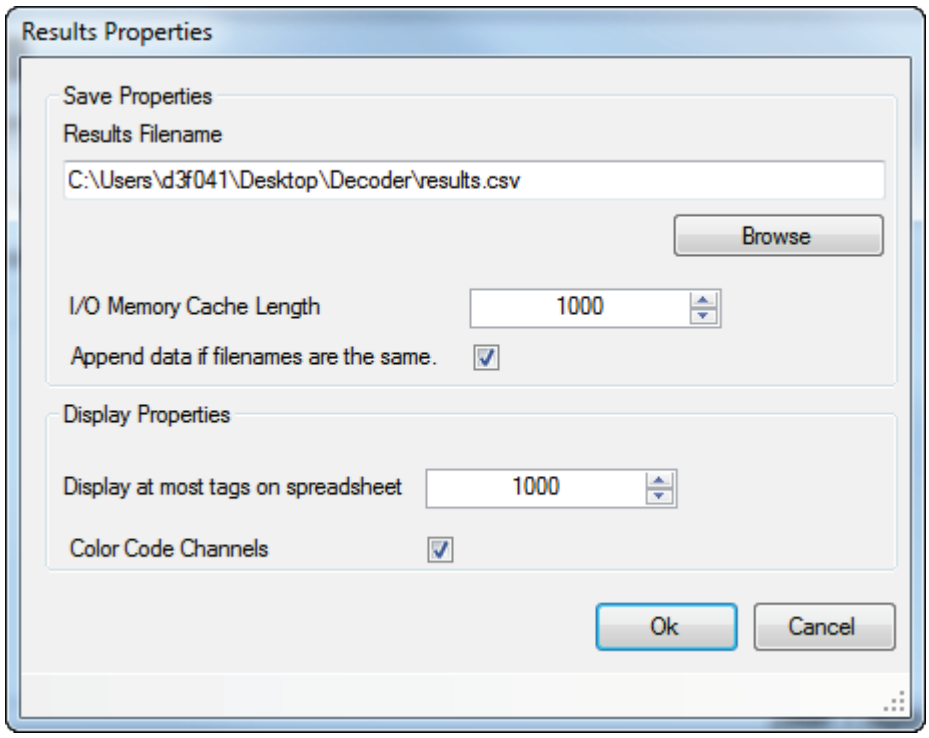


Figure 4.6. Results Properties Dialog Box

Enter preferred values in the *Results Properties* dialog box, which are described in the next subsections, and select **OK** to accept or **Cancel** to reject changes.

Results Filename

The **Results Filename** text box in the *Results Properties* dialog box specifies two things: the directory where the file will be saved and the base file name. For example, Figure 4.6 shows that the file results.csv will be saved to the *C:\Users\d3f041\Desktop\Decoder* directory.

The name of each results file created by the decoder program is unique in the sense that all data will not be saved into a single file with the name "results.csv"; instead, the decoder will create a unique file name by appending the date the data were processed and the directory where the decoded file was located to the output file name. This feature assists with data management. For example, if files located in directory "*c:\temp\jsatsStudy*" were decoded on April 22, 2010, the output file name assigned by the decoder would be

Results_20100422_1_jsatsStudy.csv.

To have the decoder append a number to the Results Filename when data are reanalyzed, check the **Append data if file names are the same** box (Figure 4.6). The decoder will append the new data to those already in the file instead of creating a new file for the reanalysis, keeping the file name the same as the original, as shown below:

Results_20100422_1_jsatsStudy.csv.

The directory location can be edited by entering a new directory path and file name into the **Filename** text box or by clicking the **Browse** button, which will bring up the file *Save As* dialog box (Figure 4.7).

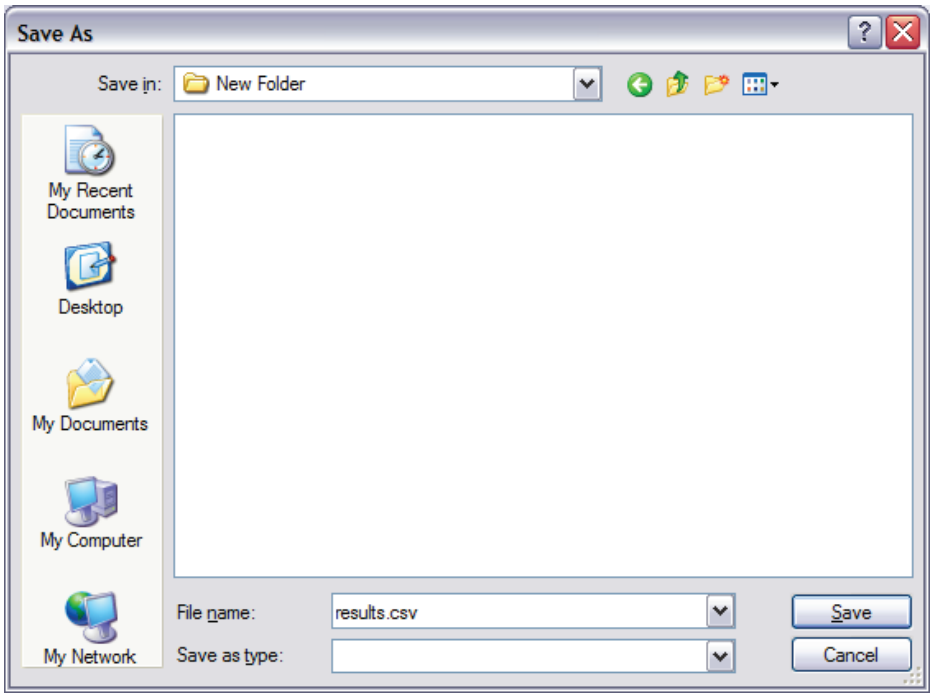


Figure 4.7. Results File Save As Dialog Box

Navigate to the directory to which you wish to save your results files, then enter the file name to be saved as described above and click **Save**.

Input/Output Memory Cache Length

As the decoder runs it handles several files (post-processing, real-time) and performs many file saving and file management operations. These input/output (I/O) operations can significantly slow processing because of computer disk performance inefficiency during access. The I/O Memory Cache Length parameter (Figure 4.6) allows the decoder to retain tag code results in a memory buffer until the buffer is filled to its specified capacity. Then the program performs a single block operation to write results to the disk. This reduces the number of disk access operations during processing and improves performance. By default, the decoder buffer is set to hold 1000 tag codes before writing the data to file.

Display at Most Tags on Spreadsheet

The **Display at Most Tags on Spreadsheet** feature, which is accessible through the *Results Properties* dialog box (Figure 4.6), permits the modification of the maximum number of tag codes displayed in the results spreadsheet list. By default, this number is 1000. The tag codes displayed will be those most recently obtained by the program. Increasing this number will greatly reduce decoder performance by consuming computer resources.

Color Code Channels

The **Color Code Channels** checkbox option allows data channels to be displayed in color (green, red, yellow, blue) or grayscale format. This feature confirms that acoustic data are being received on individual hydrophones during program setup (Figure 4.6).

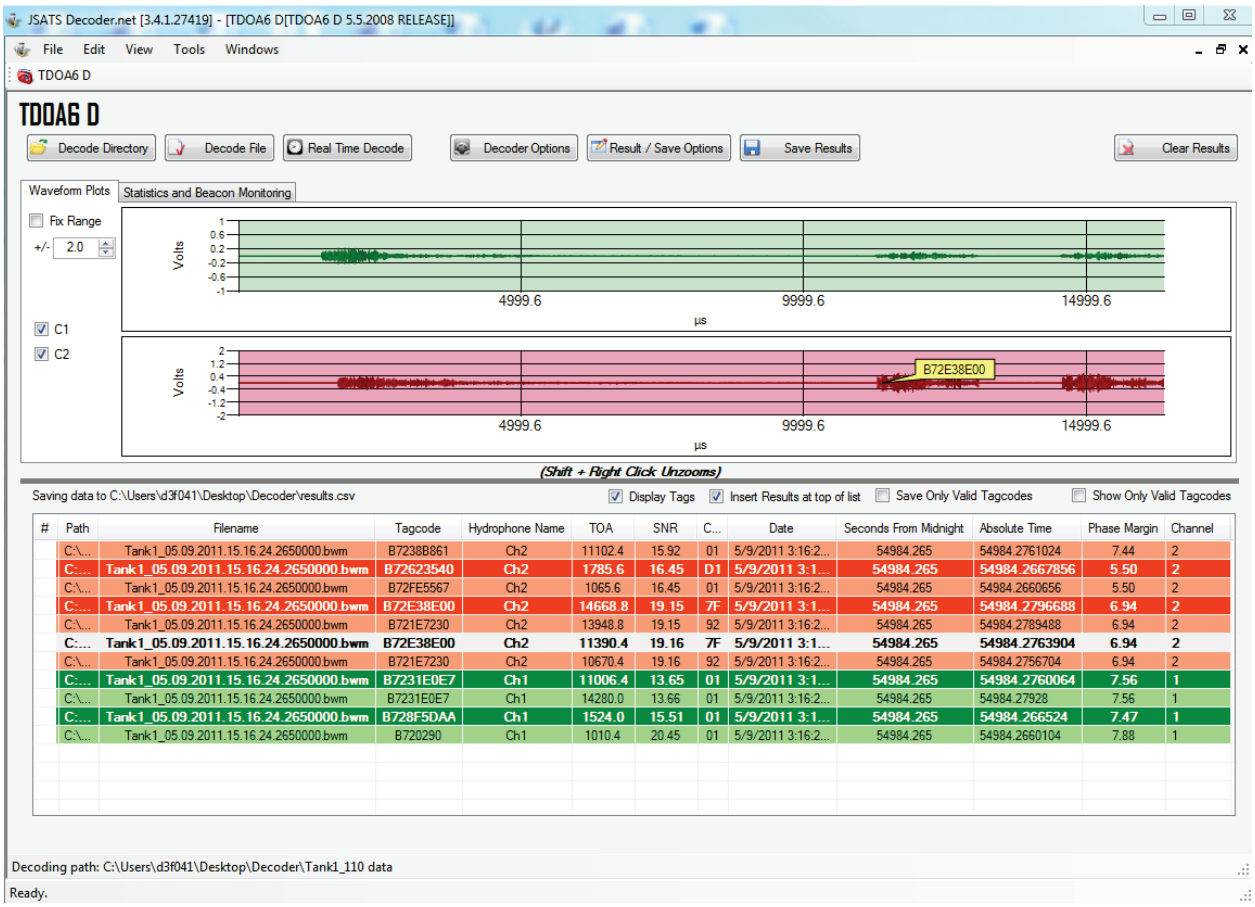
4.1.4.2 Save Results

The decoder automatically saves the results as it processes acoustic signals.

4.2 Results Frame

The Results frame, shown in the lower half of the JSATS **Decoder** window, displays a spreadsheet listing tag codes and other relative data, obtained when *.bwm* files are decoded (Figure 4.8). Information displayed in this spreadsheet includes the following:

- # (a decode index value)
- **Path** (the directory for the processed file)
- **Filename** (name of the *.bwm* file)
- **Tagcode** (prefixed with G for good, B for bad based on checksum values)
- **Hydrophone Name** (the name for the hydrophone set in the detector software and contained in the processed file)
- **TOA** (time of arrival)
- **SNR** (signal-to-noise ratio)
- **CRC** (cyclic redundancy check). Checksum computed over the 16-bit binary representation of the tag code
- **Date** (date acquired)
- **Seconds from Midnight** (when the file was created)
- **Absolute Time** (seconds from midnight plus the TOA)
- **Phase Margin** (a confidence metric for binary phase-shift keying phase transitions)
- **Channel**.



#	Path	Filename	Tagcode	Hydrophone Name	TOA	SNR	C...	Date	Seconds From Midnight	Absolute Time	Phase Margin	Channel
	C:\...	Tank1_05.09.2011.15.16.24.2650000.bwm	B7238B861	Ch2	11102.4	15.92	01	5/9/2011 3:16:2...	54984.265	54984.2761024	7.44	2
	C:...	Tank1_05.09.2011.15.16.24.2650000.bwm	B72623540	Ch2	1785.6	16.45	D1	5/9/2011 3:1...	54984.265	54984.2667856	5.50	2
	C:\...	Tank1_05.09.2011.15.16.24.2650000.bwm	B72FE5567	Ch2	1065.6	16.45	01	5/9/2011 3:16:2...	54984.265	54984.2660656	5.50	2
	C:...	Tank1_05.09.2011.15.16.24.2650000.bwm	B72E38E00	Ch2	14668.8	19.15	7F	5/9/2011 3:1...	54984.265	54984.2796688	6.94	2
	C:\...	Tank1_05.09.2011.15.16.24.2650000.bwm	B721E7230	Ch2	13948.8	19.15	92	5/9/2011 3:16:2...	54984.265	54984.2789488	6.94	2
	C:...	Tank1_05.09.2011.15.16.24.2650000.bwm	B72E38E00	Ch2	11390.4	19.16	7F	5/9/2011 3:1...	54984.265	54984.2763904	6.94	2
	C:\...	Tank1_05.09.2011.15.16.24.2650000.bwm	B721E7230	Ch2	10670.4	19.16	92	5/9/2011 3:16:2...	54984.265	54984.2756704	6.94	2
	C:...	Tank1_05.09.2011.15.16.24.2650000.bwm	B7231E0E7	Ch1	11006.4	13.65	01	5/9/2011 3:1...	54984.265	54984.2760064	7.56	1
	C:\...	Tank1_05.09.2011.15.16.24.2650000.bwm	B7231E0E7	Ch1	14280.0	13.66	01	5/9/2011 3:16:2...	54984.265	54984.27928	7.56	1
	C:...	Tank1_05.09.2011.15.16.24.2650000.bwm	B728F5DAA	Ch1	1524.0	15.51	01	5/9/2011 3:1...	54984.265	54984.266524	7.47	1
	C:\...	Tank1_05.09.2011.15.16.24.2650000.bwm	B720290	Ch1	1010.4	20.45	01	5/9/2011 3:16:2...	54984.265	54984.2660104	7.88	1

Figure 4.8. TDOA6D Results Are Shown in Spreadsheet Format in the Lower Frame of the Decoder Window

4.2.1 Tag Code Row

Selecting one of the rows in the Results spreadsheet will open the acoustic waveform plot in the visualization window above the spreadsheet (Figure 4.8). The decoded tag's relative position in the waveform plot and decoded code will be indicated.

4.2.2 File Length

The decoder will calculate several potential tag codes per file. The results derived from the decoding are best estimates of the potential tag codes present in the file waveform. As a result, there may be multiple tag code lines in the output spreadsheet with the same file name and possibly the same tag code, distinguished from one another by different TOA values. Multiple tag code lines will increase the *.csv* file length.

4.2.3 Context Menu

Right-clicking within the Results spreadsheet opens a **Context** menu (Figure 4.9). From the **Context** menu one or more tag codes can be selected and added to the beacon monitoring list by selecting the

Monitor Tagcode option (explained further in Section 6.0); the **Results Properties** can be edited (Section 4.1.4.1); or the waveform plot for a specific tag code can be displayed.

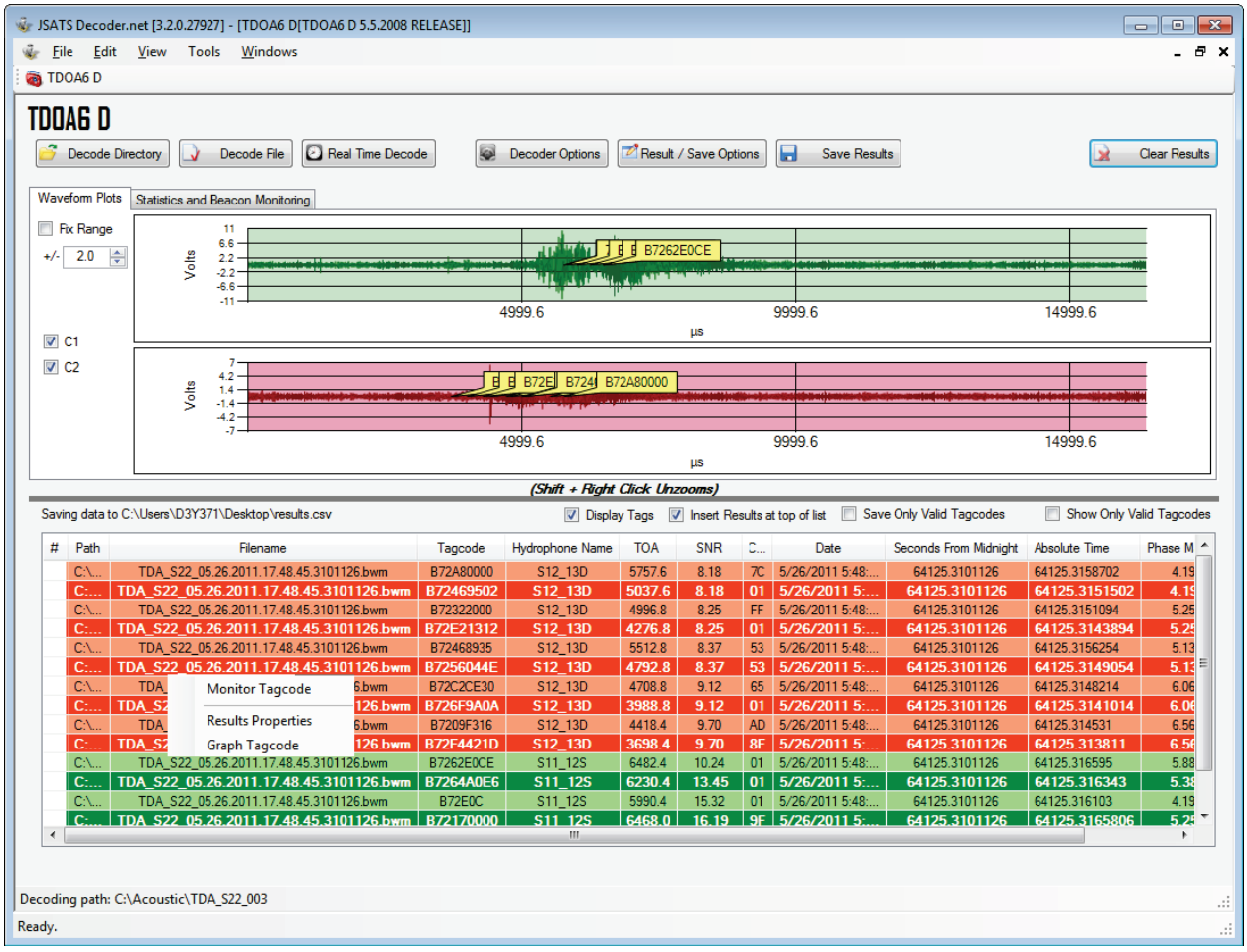


Figure 4.9. The Context Menu Is Revealed by Right-Clicking on the Results Spreadsheet

4.2.4 Viewing Tag Code Data Waveforms

If waveforms are not visible within the Results frame, the window can be expanded or reduced by clicking and dragging the thick gray scroll bar (highlighted in red in Figure 4.10 and Figure 4.11) to provide more or less space to display tag code data.

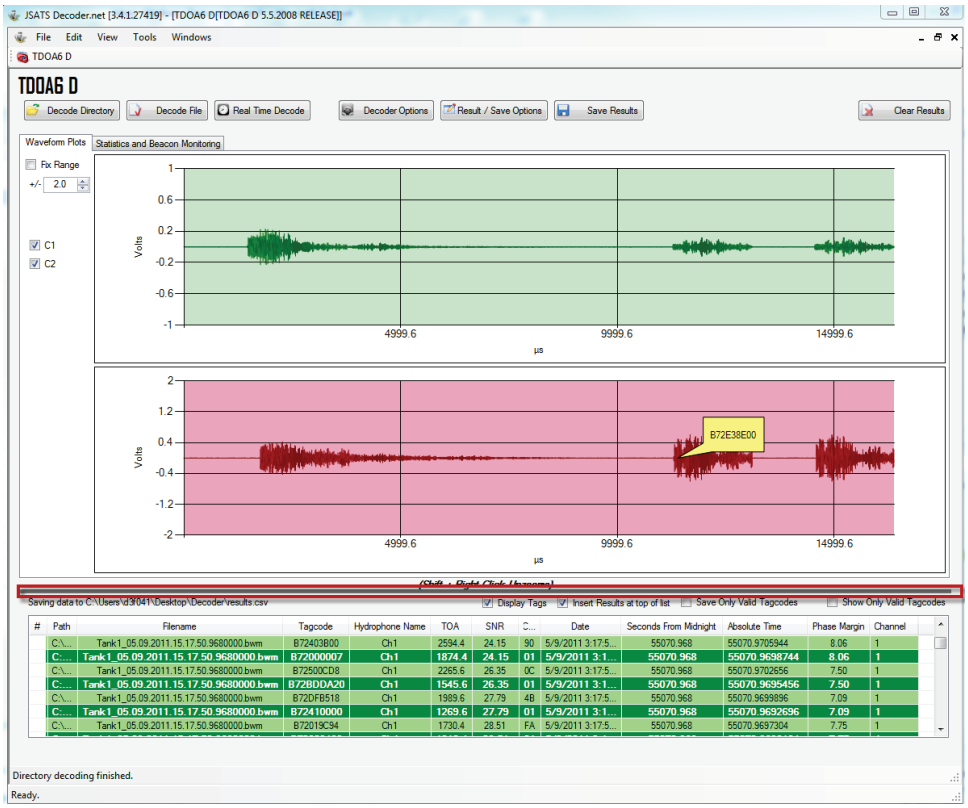


Figure 4.10. Resize the Results Spreadsheet by Repositioning the Scroll Bar (highlighted in red)

Figure 4.11. Resized Results Space after Repositioning the Scroll Bar

4.3 Save and Display Options

Several options available within the decoder program for saving and visualizing data (Figure 4.12) are discussed in the following sections.

4.3.1 Save Only Valid Tagcodes Option

If the **Save Only Valid Tagcodes** box is checked (Figure 4.12), the decoder will only save tag codes that have a G prefix. The G indicates that a tag code has passed the checksum test.

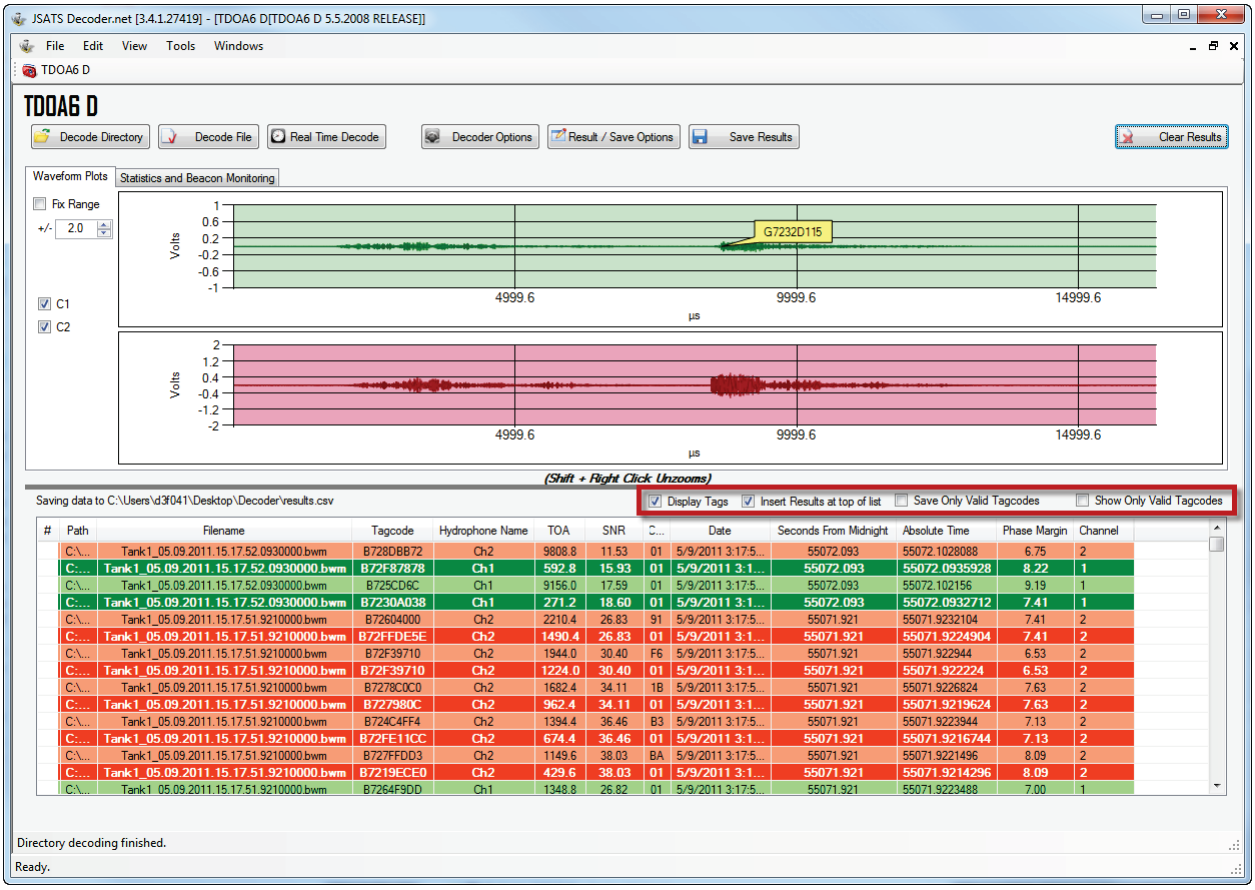


Figure 4.12. Save and Display Options (highlighted in red)

4.3.2 Show Only Valid Tagcodes Option

Checking the **Show Only Valid Tagcodes** box (highlighted in Figure 4.13) instructs the decoder to only display tag codes in the result window spreadsheet that have a G prefix. The G indicates the code passed the checksum test. If this box is checked, and the **Save Only Valid Tagcodes** box is not checked (Section 3.7.1), all tag codes will be saved even though only valid tag codes are displayed. This program feature reduces the number of potentially invalid codes that are displayed and is very useful for monitoring the system in the field.

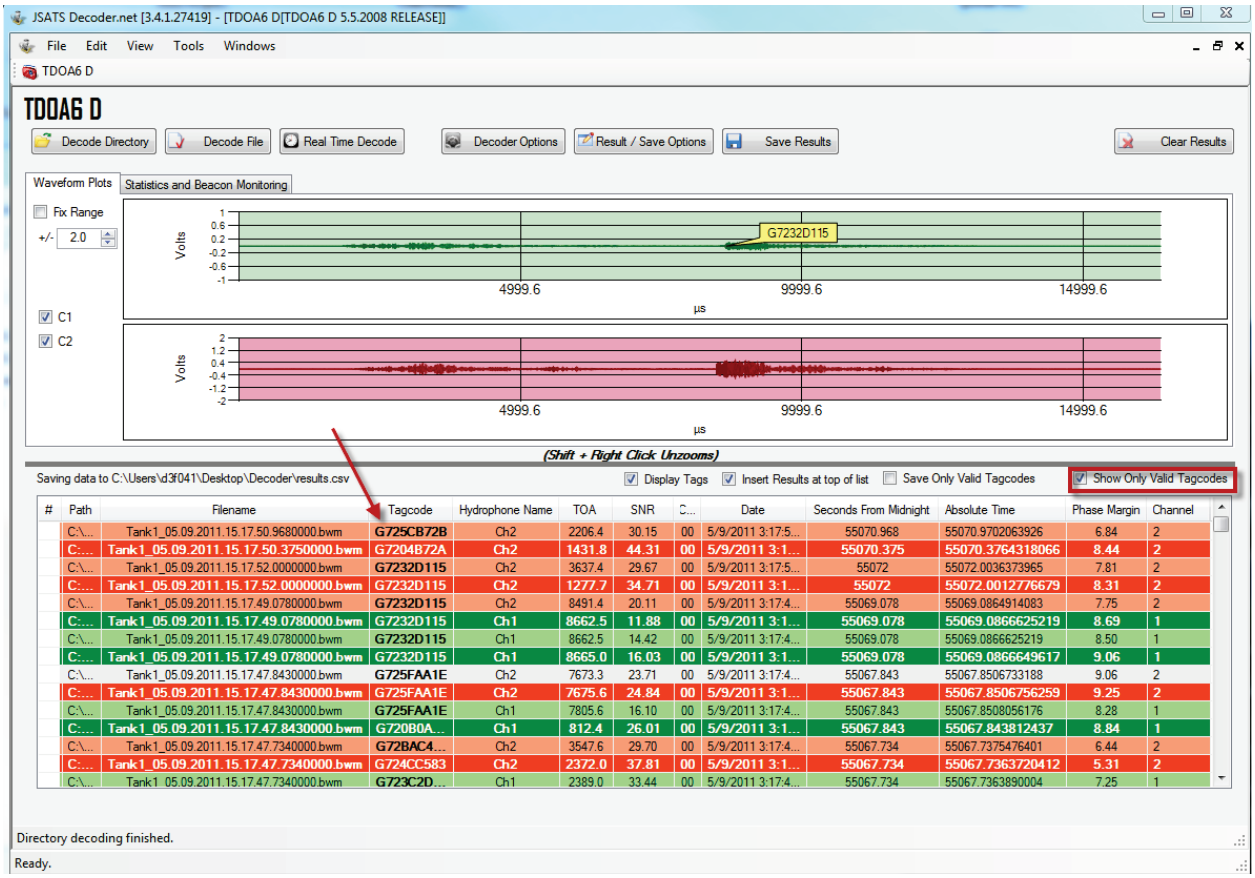


Figure 4.13. Tag Code Values with a G Prefix (identified by the red arrow) Are Displayed when the Show Only Valid Tagcodes Option is Selected (highlighted in red)

4.3.3 Insert Results at Top of List Option

When the **Insert Results at Top of List** box (Figure 4.12) is checked, the list of tag codes is increased by addition of new codes at the top of the spreadsheet. When this box is not checked, new tag codes are appended at the bottom of the spreadsheet.

4.3.4 Display Tags Option

The decoder program consumes memory and central processing unit (CPU) cycles to display tag codes. If tag codes are not displayed, decoding can be completed approximately 20 ms more quickly per file. While not a significant time cost for a single code, the time required to display thousands of tag codes contained in the data directory can be substantial. Consequently, it is best practice not to check the **Display Tags** box (Figure 4.12) when performing real-time decoding in potentially noisy environments.

4.4 Clear Results

The **Clear Results** button (highlighted in Figure 4.14), when clicked, will remove data from the results window.

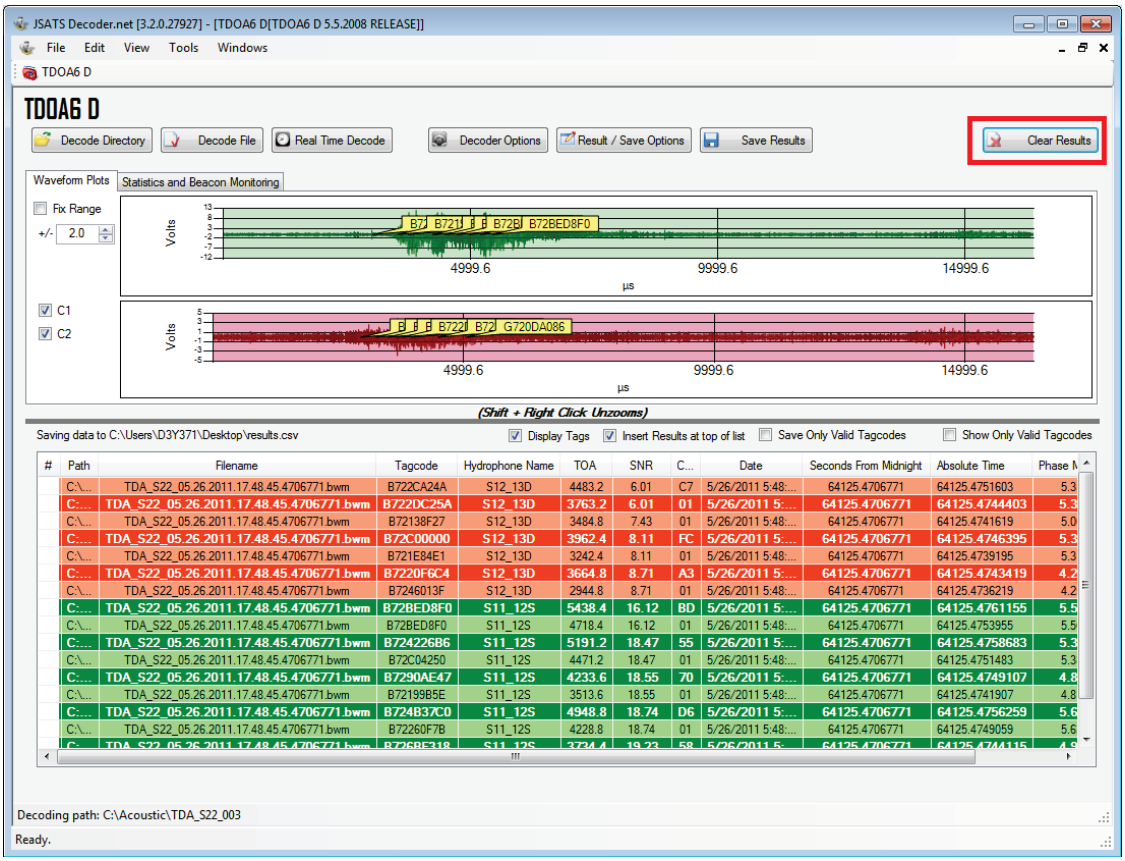


Figure 4.14. Clear Results Option (highlighted in red)

If the decoder is decoding files and the **Clear Results** button is pressed a *Confirm Data Clear* alert box will appear (Figure 4.15).

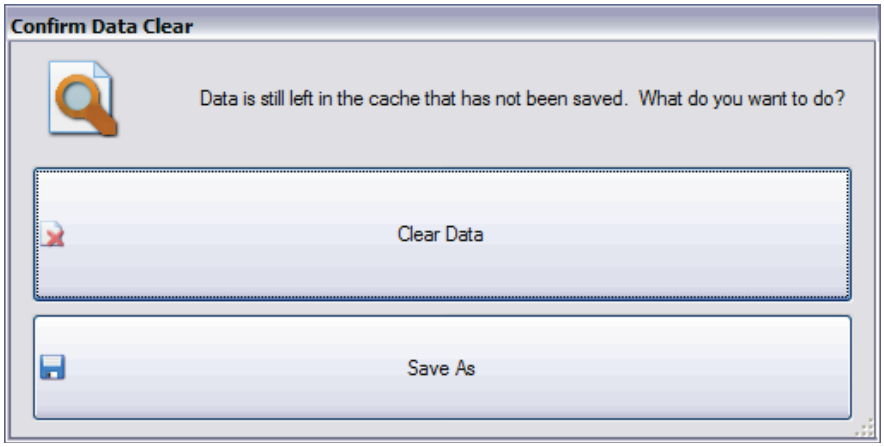


Figure 4.15. Confirm Data Clear Alert Box

5.0 Decoding

Several methods for decoding waveform files are included with this software: decoding a single file, decoding directories, and real-time decoding. Each is described below.

5.1 Decoding a Single File

To decode a single file, press the **Decode File** button in the Decoder Command Bar (Figure 5.1).

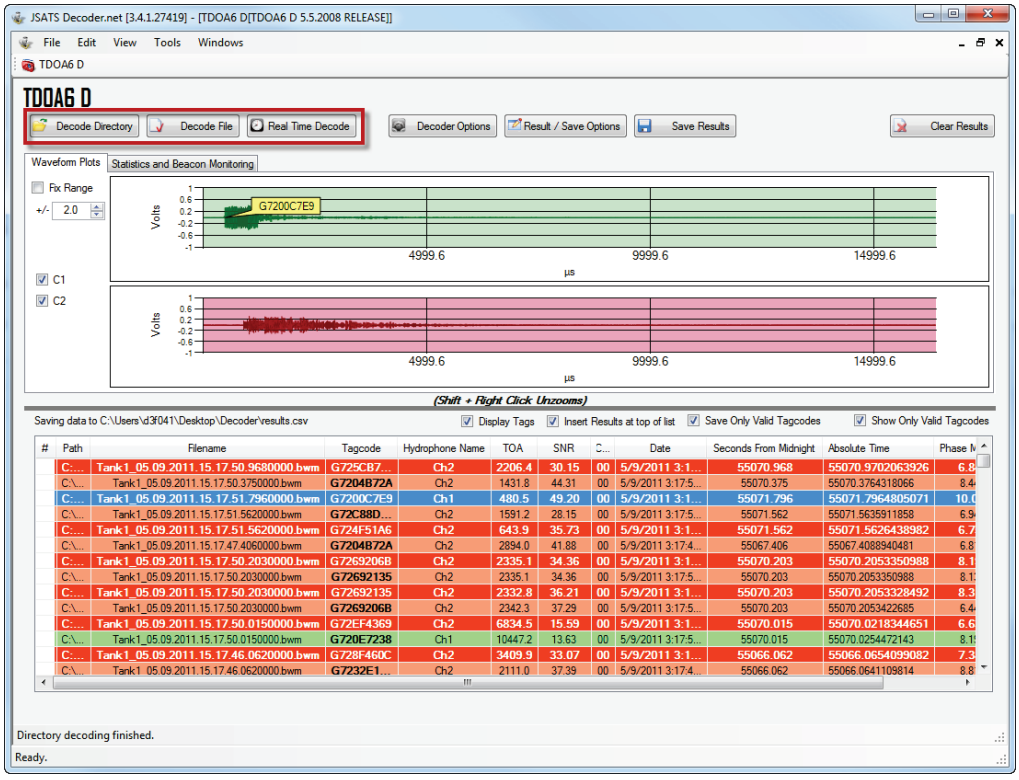


Figure 5.1. Decoder Command Bar Options (highlighted in red)

When this button is selected, a file dialog menu (Figure 5.2) will appear.

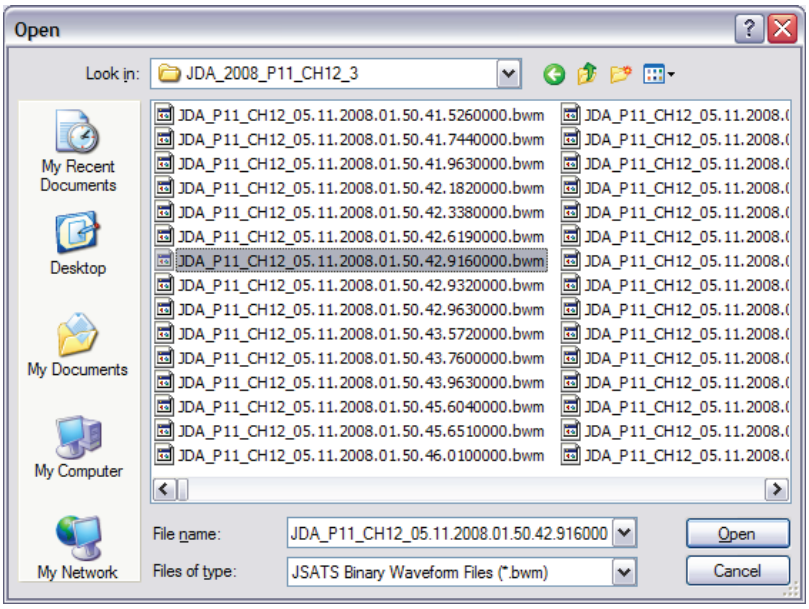


Figure 5.2. Decode File Open File Dialog Box

Select the file to be decoded or type the file name in the **File name** text box. Select **Open** to start the decode process or **Cancel** to terminate the Decode File operation.

5.2 Decoding a Directory

Post-processing of an existing file, directory, or series of directories, is initiated by selecting the **Decode Directory** button on the Decoder Command Bar (Figure 5.1).

When **Decode Directory** is selected, the *Directory Options* dialog box shown in Figure 5.3 will open, allowing data processing options to be selected. Select options and click **Ok** to initiate decoding of the data in a directory, or **Cancel** to exit the decoding process.

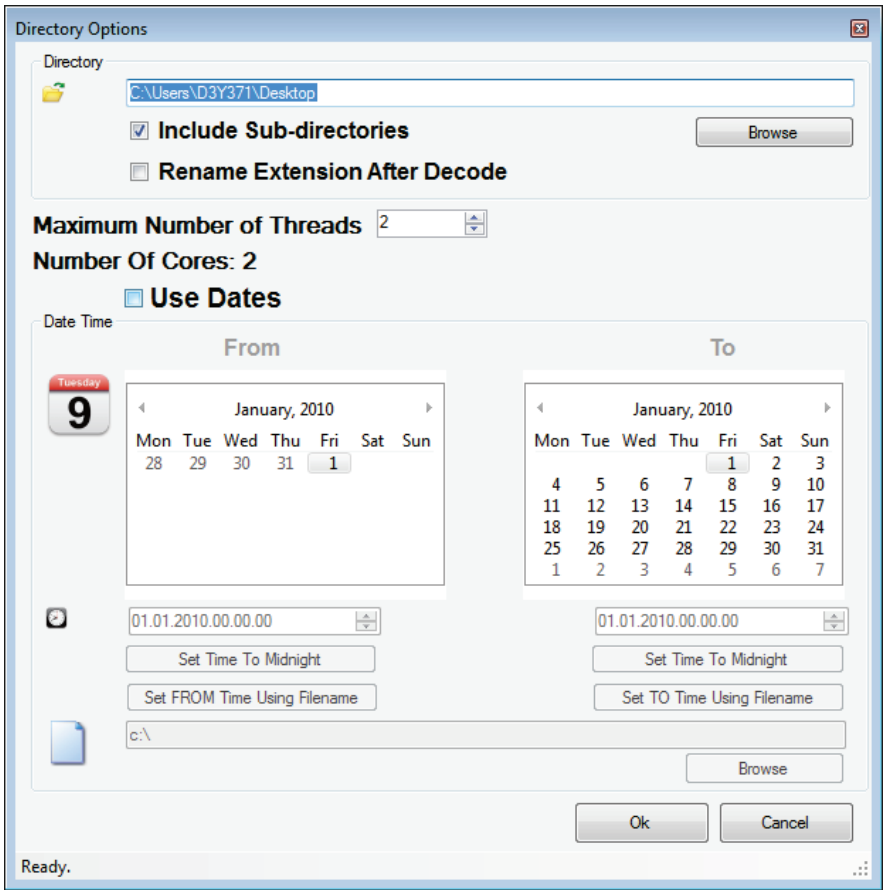


Figure 5.3. Decoder Directory Options Dialog Box

5.2.1 Selecting the Decoding Directory

The directory containing the data to be decoded is selected by entering the preferred name in the **Directory** text box (Figure 5.3) or by pressing the **Browse** button to locate the required folder. Selecting the **Browse** button opens the *Browse for Folder* dialog box (Figure 5.4). Navigate to the directory to be decoded, select the directory, and then click **OK**. Selecting **Cancel** will close the dialog box and no changes will appear in the *Decode Directory Options* dialog box.

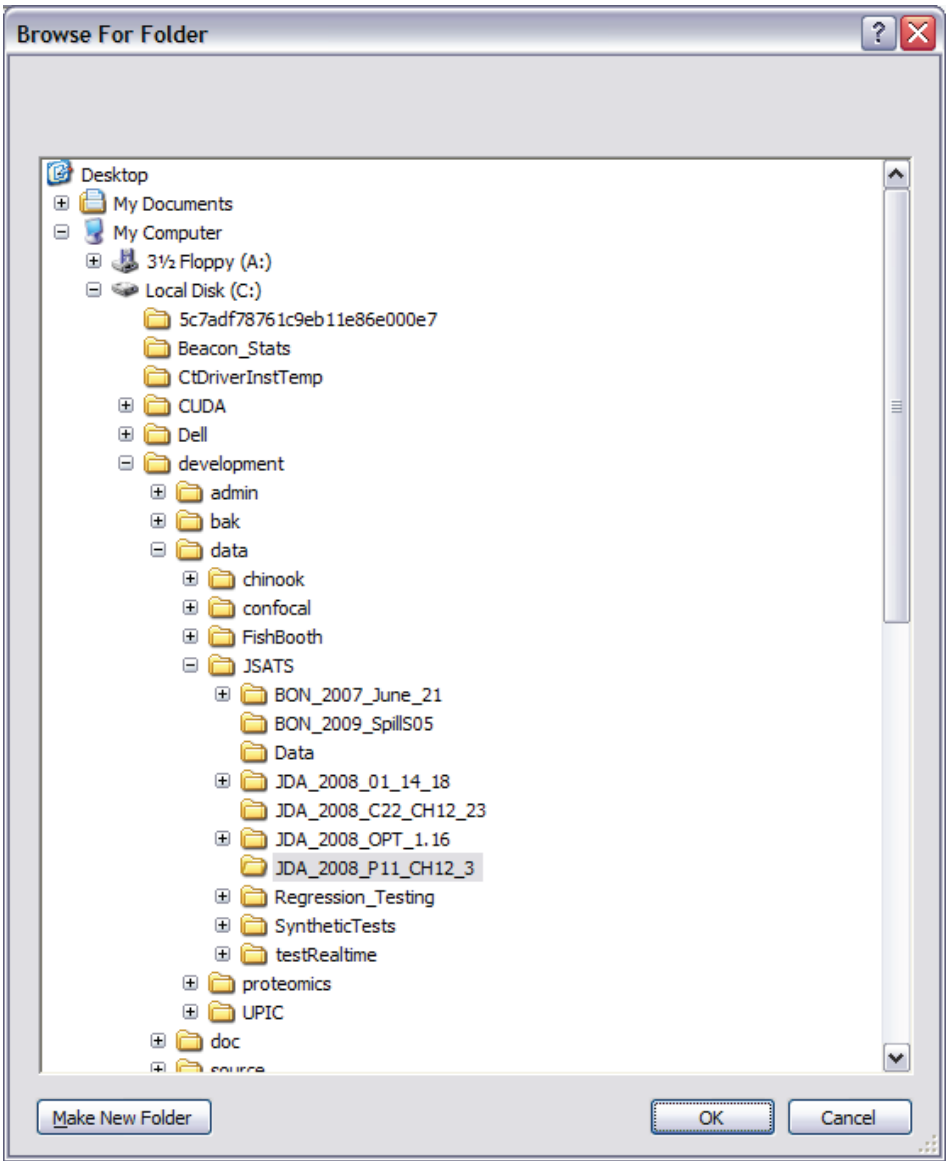


Figure 5.4. Decode Directory Browse for Folder Dialog Box

5.2.2 Include Sub-Directories Option

To exclude the decoding of sub-directories, i.e., only decode the top-level of a directory containing sub-folders, uncheck the **Include Sub-directories** box (Figure 5.3). Otherwise, the decoder will process files found in the directory specified as well as all sub-directories within the directory.

5.2.3 Rename Extension After Decode Option

Checking the **Rename Extension After Decode** box (Figure 5.3) will instruct the decoder to rename the extension of decoded files after decoding is complete. This is useful for verifying whether data have been processed.

5.2.4 Use Dates Option

The **Use Dates** command (Figure 5.3) allows the file dates to be chosen for files to be decoded. This is useful when reprocessing data or subsampling the data for a given time period, because the directories are chosen by date and don't have to be identified by name. To use this option complete the following steps:

1. Check the **Use Dates** box.
2. Select the start date in the calendar displayed in the **From** dialog box.
3. Select the end date in the calendar displayed in the **To** dialog box.

Respective From and To dates can also be entered in the numeric spin boxes below the calendars. Times are set in the following format: Month.Day.Year.Hour.Minute.Second. Values can be reset within the day selected in the calendar by pressing the **Set Time To Midnight** button.

Because the detector saves files with the date in the name during data acquisition, you can select the **Set FROM Time Using Filename** or **Set TO Time Using Filename** buttons as shown in Figure 5.5.

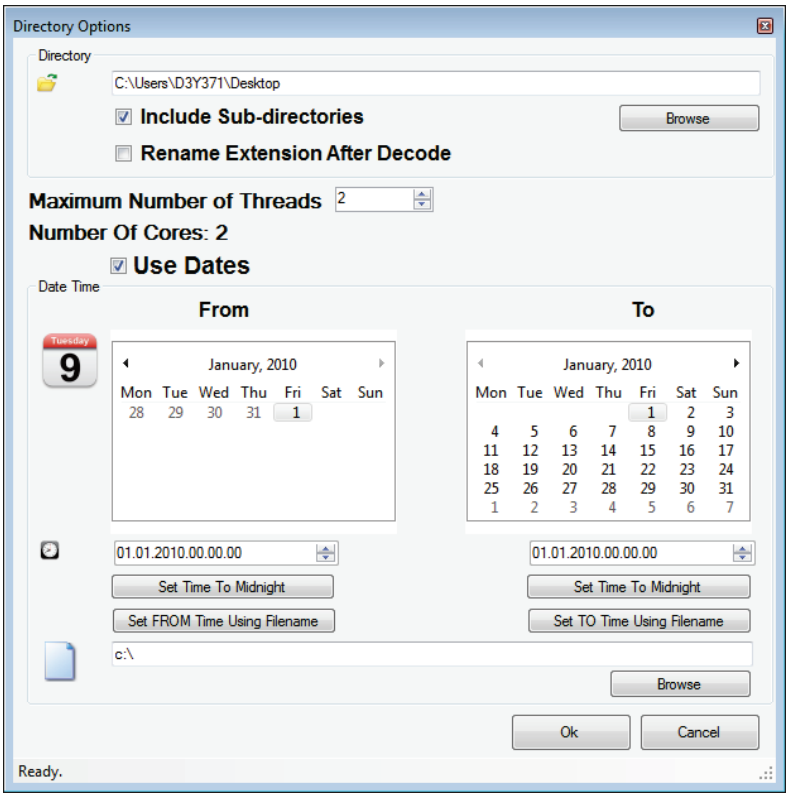


Figure 5.5. Decoder Directory Selection Options

The name of the file was entered in the spin box for the example shown in Figure 5.5. When selecting the **Browse** option to choose a file, the *Open* file dialog box (Figure 5.6) will appear, allowing navigation to the required file.

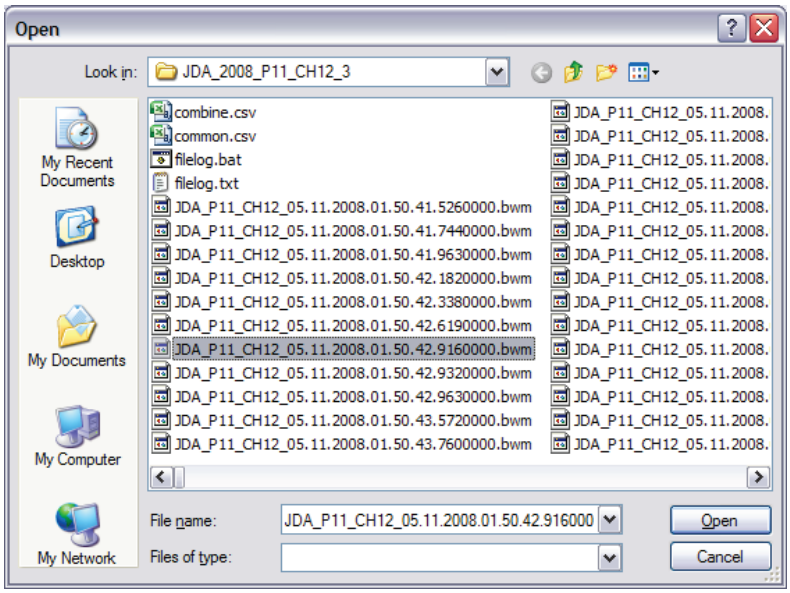


Figure 5.6. Selecting the Decode Start Date and Time from a *.bwm* File

When the file with the desired start date and time is located, highlight it, select **Open**, and press the **Set FROM Time Using Filename** button (Figure 5.7) to complete selection of a start date and time. When **Set FROM Time Using Filename** is selected, the date in the **From** calendar will change to the selected file name. This process can be repeated to select a file to identify the **TO** date to complete identification of the time period over which processing will occur.

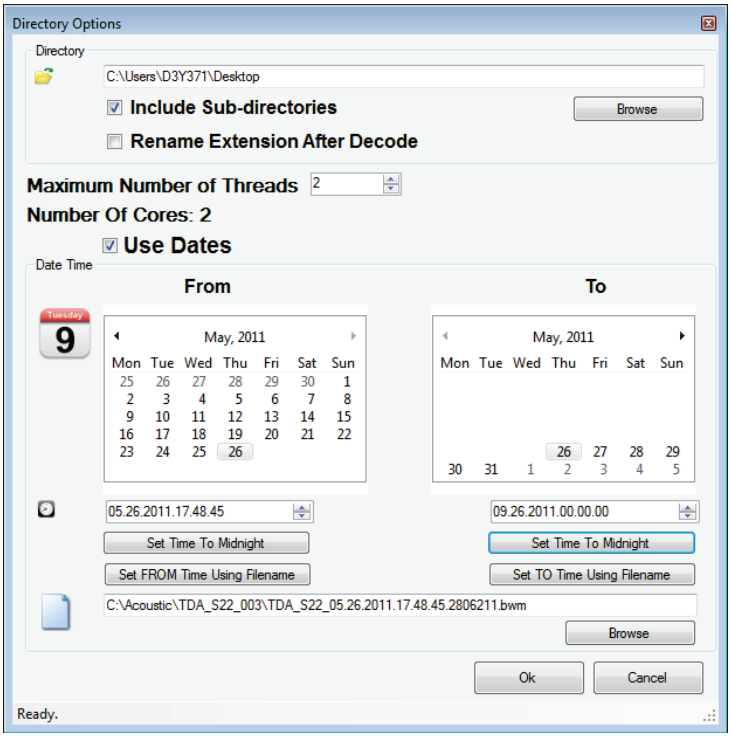


Figure 5.7. Updating the Calendar Using Set From and Set To Times

5.2.5 Maximum Number of Threads

The **Maximum Number of Threads** field (Figure 5.7) can be adjusted to increase or decrease the number of instances of the decoder running at any one time. If the number of threads is the same as the number of cores on the decoding computers' CPU, the application decodes that number of files simultaneously, allowing the application to decode files more quickly. If the number of threads exceeds the number of cores, the application will attempt to decode as many files simultaneously as possible.

As a rule of thumb, set the maximum number of threads to twice the number of cores available in the processing computer if there is no other application that needs to run. If another application will be running at the same time as the JSATS decoder and needs to execute as quickly as possible, such as the JSATS detector during real-time decoding (explained in Section 5.3), reduce the maximum number of threads to less than the number of cores.

5.2.6 How Do I Know It Is Decoding?

When the decoder directory options are configured in the *Directory Options* dialog box, press the **Ok** button (Figure 5.8).

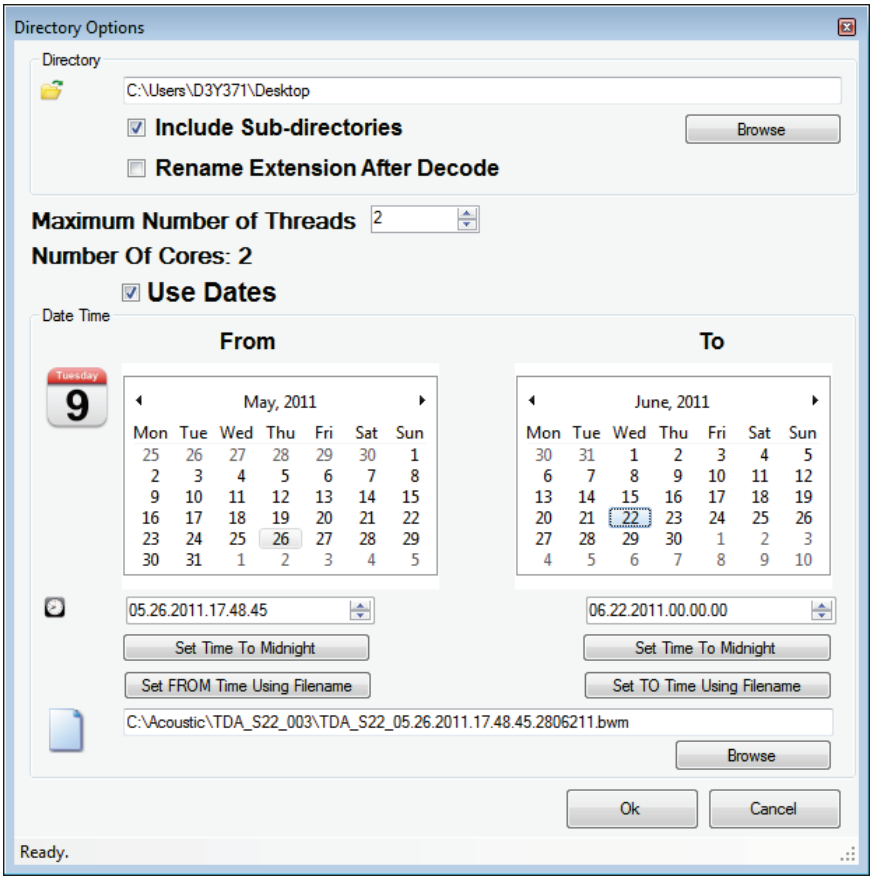


Figure 5.8. Select Ok to Start the Decoding Process

The decoder *Directory Options* dialog box will disappear and the main window shown in Figure 5.9 will start displaying decoded data in the spreadsheet in the bottom frame of the window, indicating the decoding progression. The Decoder Command Bar (Decode Directory, Decode File, Real Time Decode), Decoder Options, and Save Command Bar (Result/Save Options and Save Results) buttons at the top of the **Decoder** window will be grayed out and will be inaccessible. A green progress bar at the bottom of the window will indicate the percentage of files processed. The list of processed files will be continuously appended as the decoding progresses.

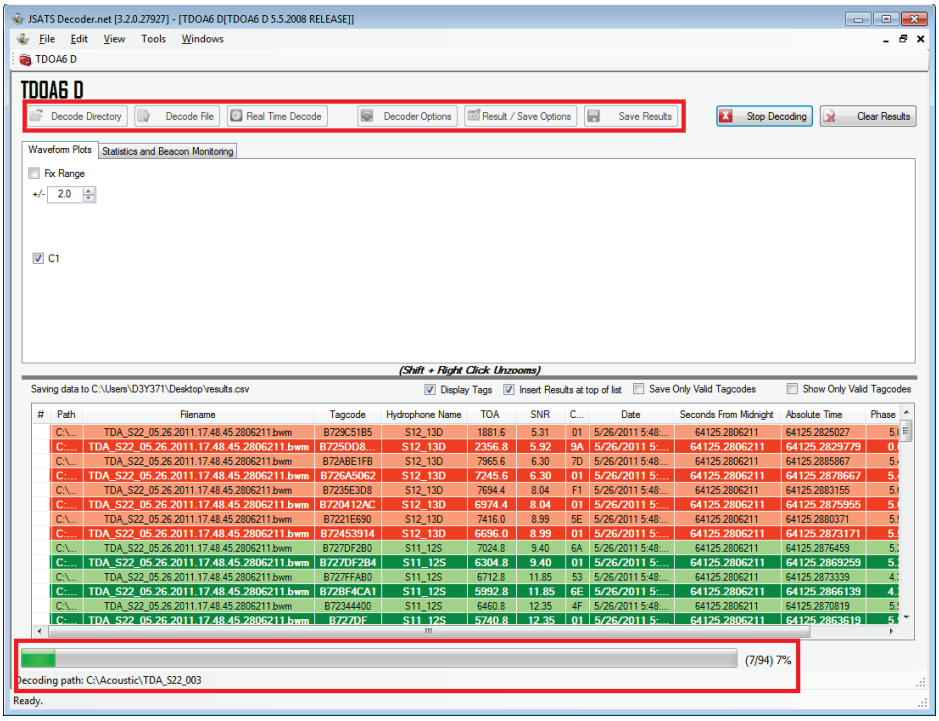


Figure 5.9. Options at the Top of the Decoder Window (highlighted in red) Are Disabled during the Directory Decoding Process. The progress bar at the bottom of the window (also highlighted in red) indicates processing advancement.

5.2.7 Stopping the Directory Decoding Process

To stop data decoding within a directory after it has begun select the **Stop Decoding** button (highlighted in Figure 5.10). The results from files that have been processed will be saved automatically to the Results file.

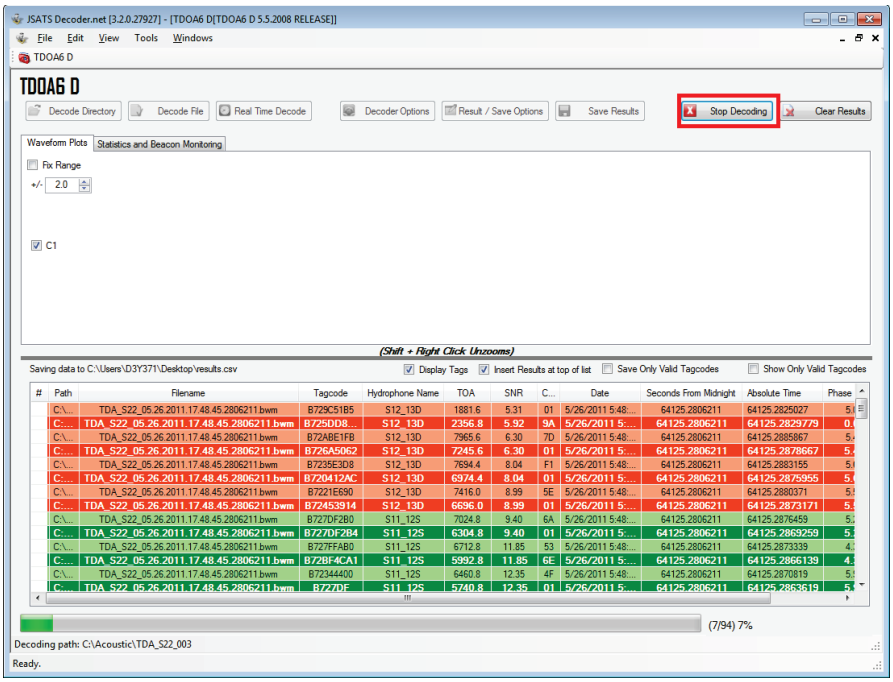


Figure 5.10. Select the Stop Decoding Button to Terminate a Directory Decode

5.3 Real-Time Decoding

Real-time decoding is accomplished when the JSATS detector and decoder are running simultaneously. When the JSATS detector is running and collecting files, the decoder can automatically access and decode the new waveform files created by the detector. This assists in managing the number of waveform files saved because post-processing will not be required and waveform files can be decoded as they are acquired, then discarded. However, if retaining waveform files after decoding is required for future investigation, the decoder can rename the waveform file names extension and save the processed files.

5.3.1 Real-Time Decoding

Real-time decoding is customized and launched by selecting the **Real Time Decode** button (highlighted in Figure 5.11).

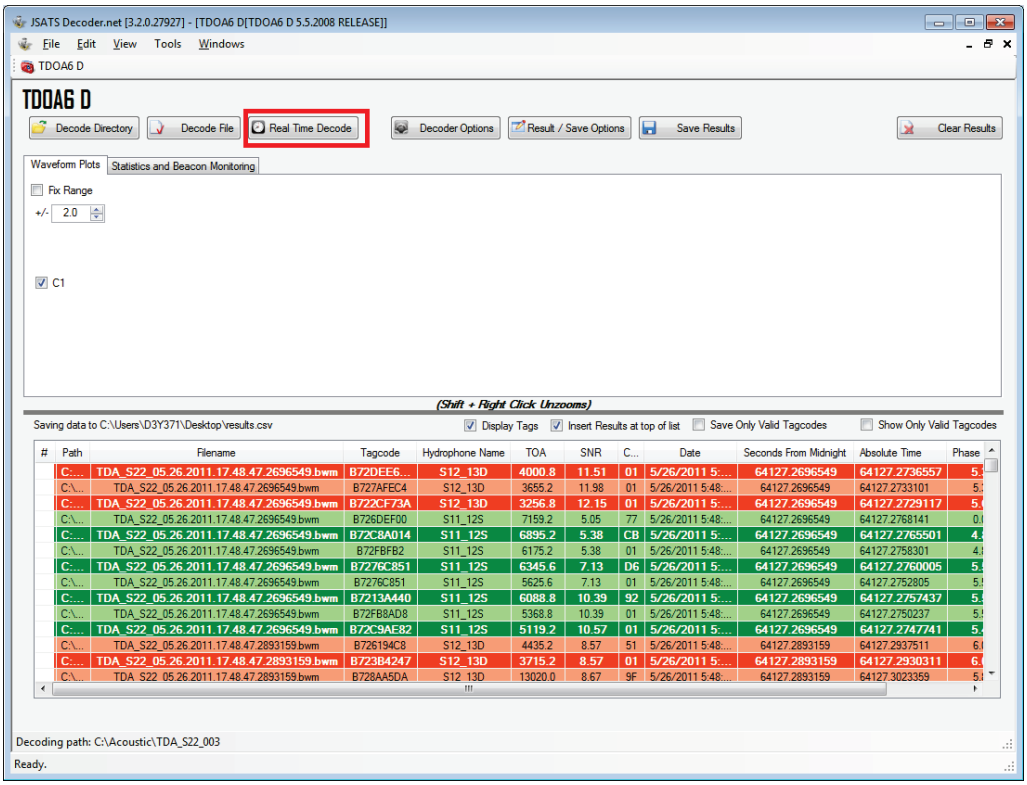


Figure 5.11. Real-Time Decoding Option (highlighted in red)

When the **Real Time Decode** button is selected, the *Real-Time Decoder Options* dialog box shown in Figure 5.12 opens.

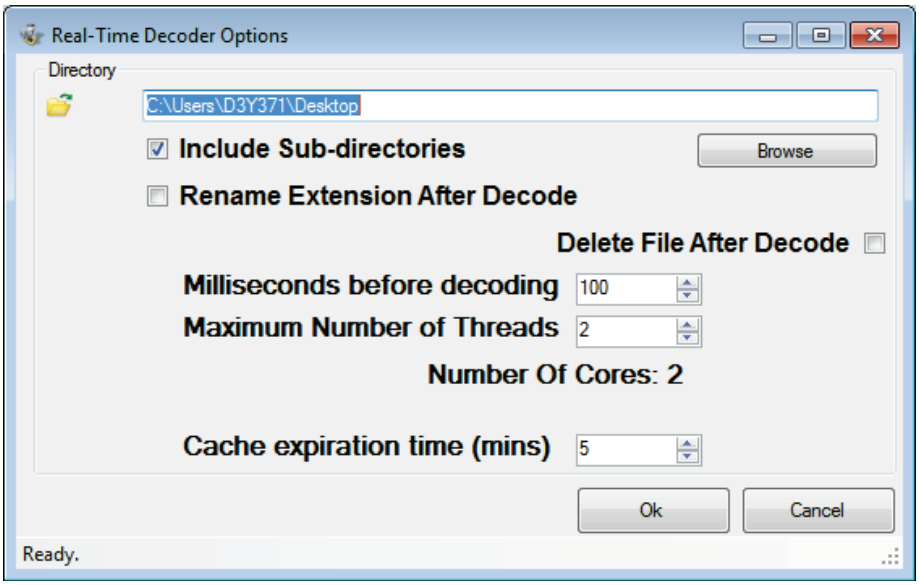


Figure 5.12. Real-Time Decoder Options Dialog Box

Enter the name of the directory where the JSATS detector has been directed to save data into the **Directory** text box (Figure 5.13). Confirm that you are decoding candidate tag waveforms from only one receiver board with the JSATS decoder. Multiple copies of the JSATS decoder can be run to real-time process waveform files from multiple receiver boards simultaneously if enough cores are available on the CPU to handle the additional processing. A multi-core CPU or computer with multiple CPUs is necessary to operate real-time decoding during data acquisition.

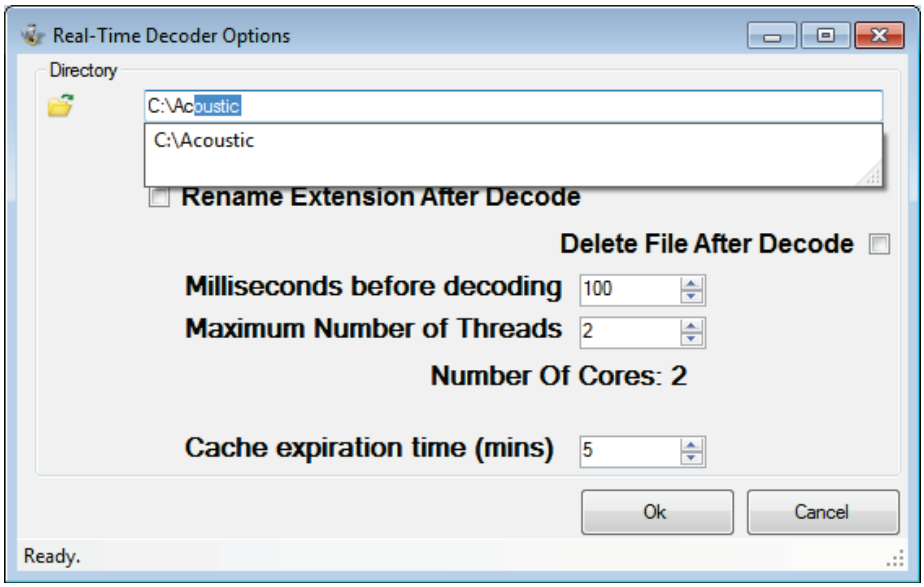


Figure 5.13. Real-Time Decoder Directory Selection

As a directory name is entered, the text box will suggest directory names that are available on the computer. The directory may also be located by pressing the **Browse** button and navigating to the directory in the *Browse For Folder* dialog box (Figure 5.14).

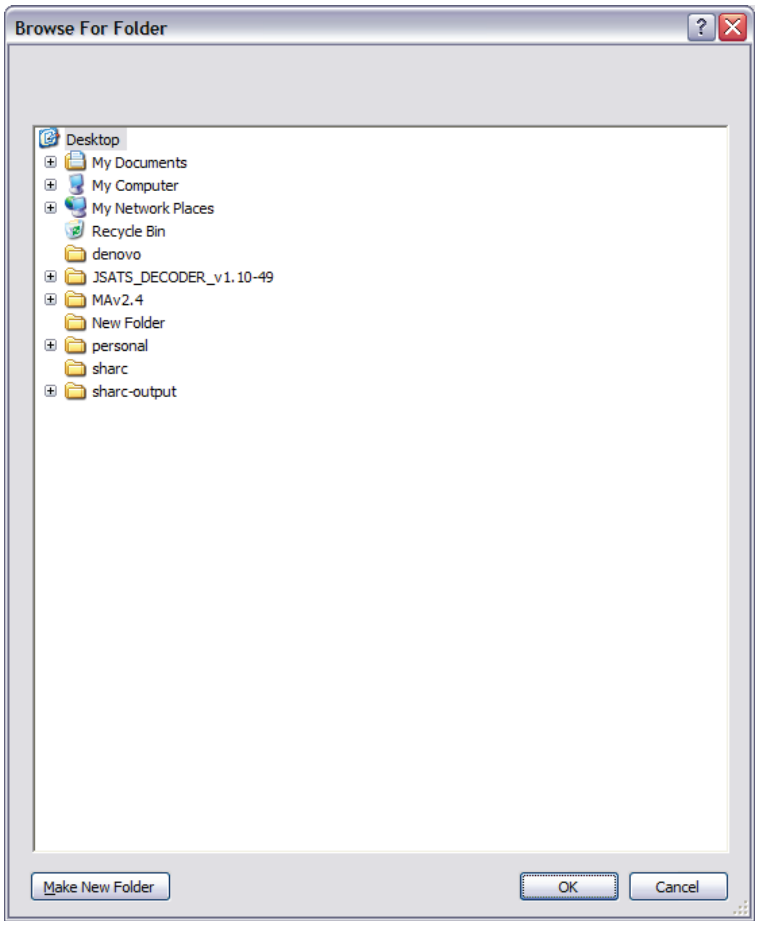


Figure 5.14. Real-Time Decode Directory Browse for Folder Option Dialog Box

5.3.2 Include Sub-Directories

Real-time decoding can be achieved with a single directory or, if the **Include Sub-directories** option is selected, a directory and its sub-directories (Figure 5.12). It is recommended that the **Include Sub-directories** option always be selected.

5.3.3 Rename Extension After Decode

The **Rename Extension After Decode** option (Figure 5.15) will rename decoded files with a *.com* extension, by default. When this option is selected, the renamed files will be saved and the **Delete File After Decode** box will be inaccessible (Section 5.3.4). The **Rename Extension After Decode** feature is very useful if all waveforms are being saved, including those that have been decoded, and the decoder cannot keep up with the number of incoming waveform files. If the number of candidate tag waveforms to be processed by the decoder overwhelms the real-time feature of the decoder, the user can post-process the remaining files later using the **Decode Directory** option (see Section 5.2). The decoder will only decode files that have the *.bwm* extension; it will ignore files that have other extension designations.

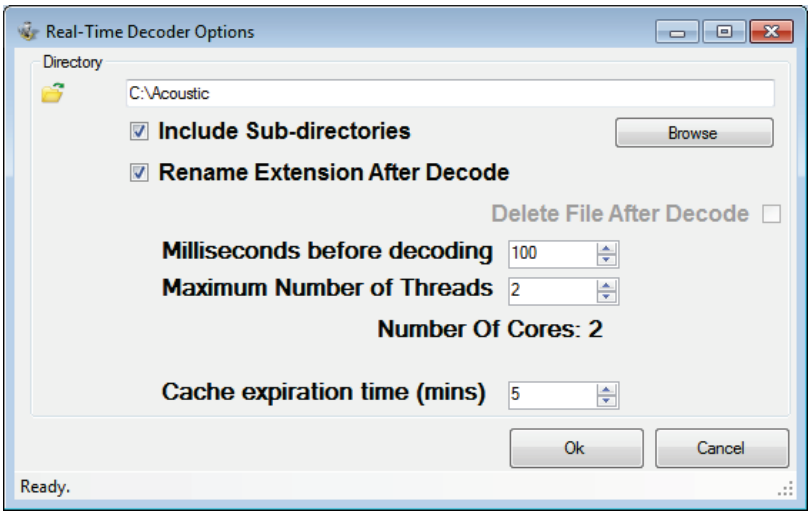


Figure 5.15. Real-Time Decoder Options Dialog Box

The extension of the renamed file can be changed from *.com* to any extension if the file "JSATSDecoder.net.exe.config" file is modified with a text editor (e.g., Notepad or WordPad). This configuration file can be found in the directory in which the JSATS decoder program was installed on the computer, usually the *JSATS Decoder Program Files* directory (Figure 5.16). Near the bottom of the file, there is a **RenameExtension** setting. Within the two <value></value> tags, the extension can be changed from *.com* to the desired extension, such as *.cmp* (Figure 5.17).

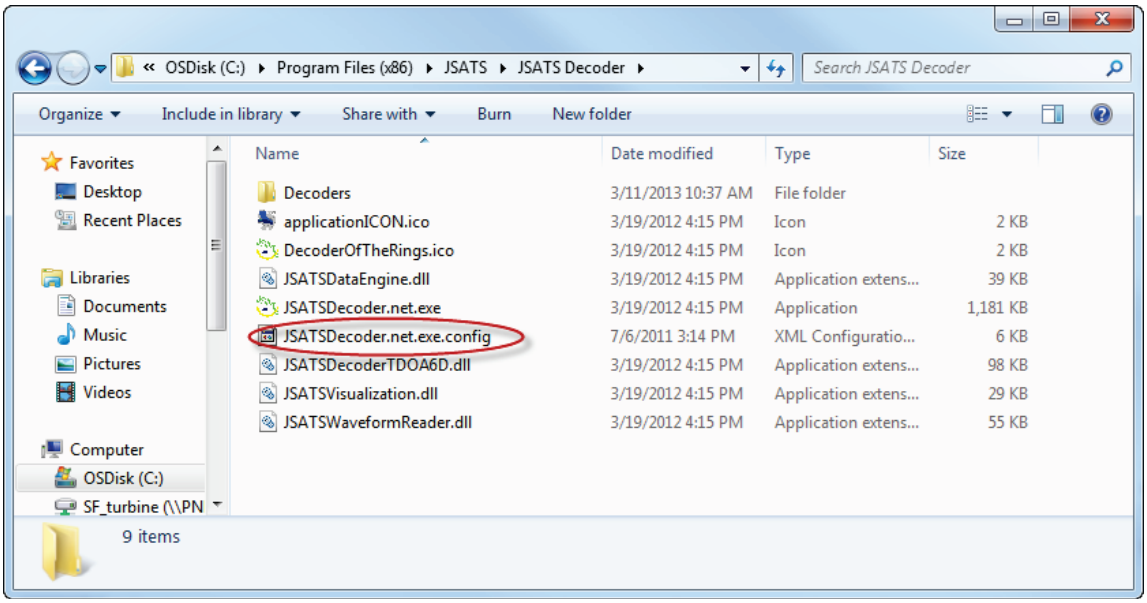


Figure 5.16. The JSATS Decoder Configuration File Is Commonly Located in the Program Files Directory

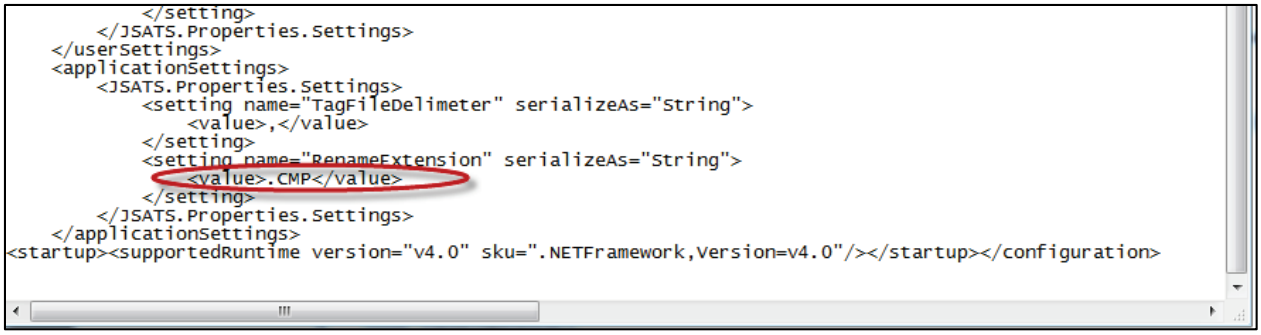


Figure 5.17. The File Extension for Renamed Files Can Be Changed by Modifying the Configuration File

5.3.4 Delete File After Decode

Selecting the **Delete File After Decode** checkbox (Figure 5.15) will result in waveform files to be deleted after they have been decoded. As a precautionary measure, this option is not set by default to avoid deleting files until all aspects of data flow through the JSATS receiving system have been verified to be functioning as intended.

5.3.5 Milliseconds Before Decoding

The decoder will pause for a few milliseconds prior to decoding a newly saved file, allowing the detector to finish writing the file to disk. The recommended wait time is 100 ms—the default value in the **Milliseconds before decoding** spin box found in the *Real-Time Decoder Options* dialog box (Figure 5.15). If the wait time is too short, the decoder will attempt to read the waveform before the detector has completed writing the file to disk and the system will crash.

5.3.6 Maximum Number of Threads

Selection of the **Maximum Number of Threads** in the *Real-Time Decoder Options* dialog box (Figure 5.15) has the same effect as the selection of the maximum number of threads in the *Decode Directory* dialog box (Section 5.2.5).

The **Maximum Number of Threads** option allows the user to increase or decrease the number of instances of the decoder running at any one time. If the number of threads is the same as the number of cores, the application will decode that number of files simultaneously, allowing the application to decode files more quickly. If the number of threads exceeds the number of cores, the application will attempt to decode as many files simultaneously as possible.

When using real-time decoding, it is best practice to increase this field to as high as possible without affecting other applications. The maximum value of the field is twice the number of CPU cores. When at the maximum, the JSATS application will consume 100% of the CPU cycles available if files are being detected at a high rate.

5.3.7 Cache Expiration Time (mins)

The **Cache expiration time (mins)** option (Figure 5.15), found in the *Real-Time Decoder Options* dialog box, is the maximum amount of time the application will store tag codes in the buffer memory before writing them to file. For example, if the cache limit is 1000, and the expiration time is 30 minutes; when the decoder collects 200 tag codes in 30 minutes, it will write all 200 to the results *.csv* file. If it collects 1000 tag codes in 15 minutes, with the same expiration time, all 1000 will be written to the results *.csv* file after 15 minutes. This feature is useful in quiet environments or other circumstances when the number of candidate waveforms per unit time is low.

6.0 Beacon Monitoring

This section describes an advanced decoder feature—beacon monitoring. This option monitors the codes transmitted by beacons deployed in the study area. Receiving and monitoring beacon transmissions assists in verifying the operation of hydrophones in a JSATS receiving array and are used to estimate detection range and detection efficiency.

6.1 Statistics and Beacon Monitoring Window

Select the *Statistics and Beacon Monitoring* tab in the **Decoder** window to open the beacon monitoring options and related controls (Figure 6.1). Selections include **Load Beacon File**, **Save Beacon List**, **Add**, **Delete, Edit Selected Beacon**, **Stats Options**, **Delete Beacons**, and **Clear Statistics**.

A list in the upper frame of the **Decoder** window displays beacons that were entered manually (see Section 6.2), beacons added using the context menu option (Section 4.2.3), or beacons added by file selection (see Section 6.6). Figure 6.1 shows three beacons in the beacon list.

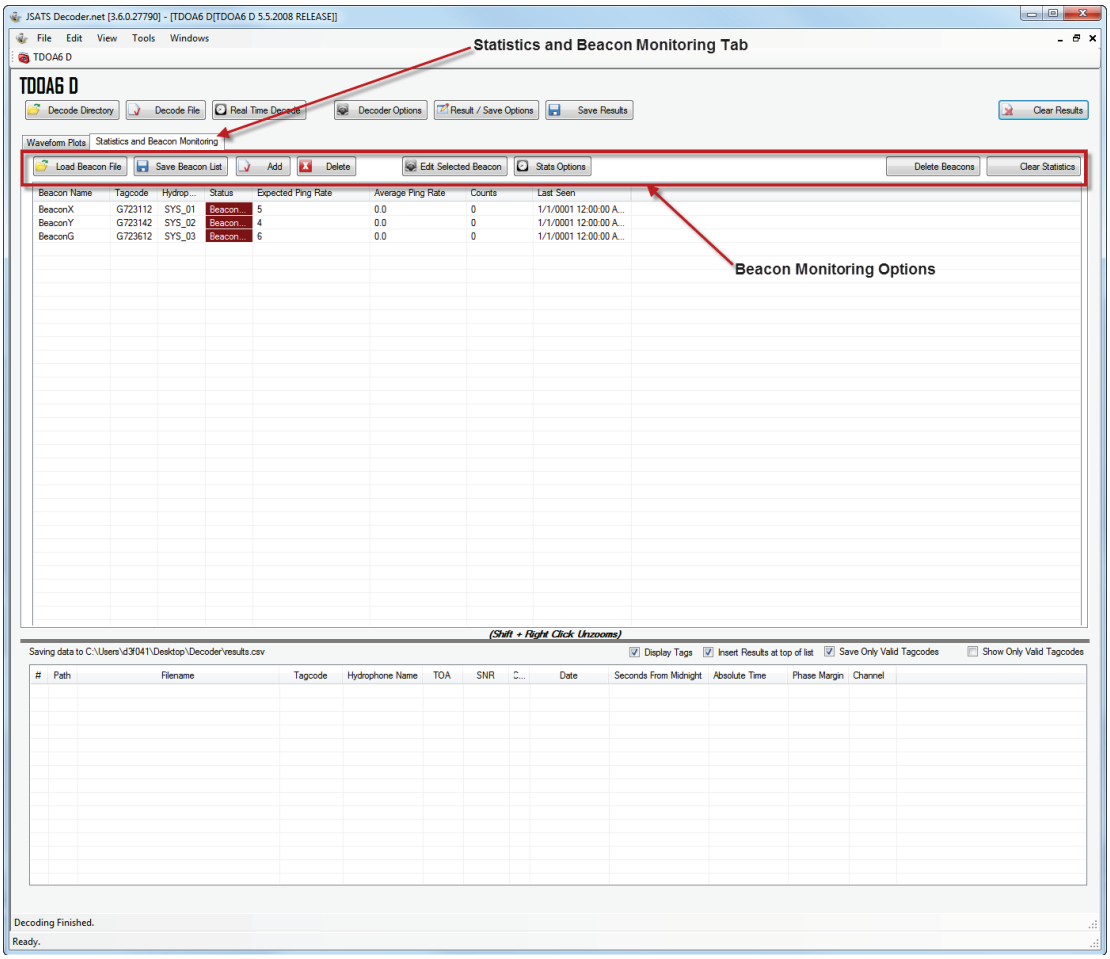


Figure 6.1. Statistics and Beacon Monitoring Options

The beacon information contained in the spreadsheet includes the following:

- Beacon Name – an alias assigned to the beacon by the program user
- Tagcode – the code transmitted by the beacon, the code must include a G at the beginning of the tag code
- Hydrophone Name – the alias for the hydrophone receiving the beacon code (assigned in the Detector software)
- Status – decoder assessment of the operating status of the beacon
- Expected Ping Rate – the number of transmissions per unit time by the beacon
- Average Ping Rate – the number of transmissions per unit time observed for the beacon
- Counts – the number of times the beacon has been detected within a period of time
- Last Seen – the last time the beacon was detected.

6.2 Adding a Beacon to the Statistics and Beacon Monitoring List

To manually add a beacon, press the **Add** button in the **Statistics and Beacon Monitoring** window (Figure 6.1), which will open the *Edit Beacon* dialog box. Enter the beacon information in the *Edit Beacon* dialog box and press **OK** to accept the changes or the **Cancel** button to reject the changes (Figure 6.2). Tag codes can also be added to the beacon list by selecting a row(s) in the Results file, right-clicking to open the **Context** menu, and selecting **Monitor Tagcode** from the options (Section 4.2.3).

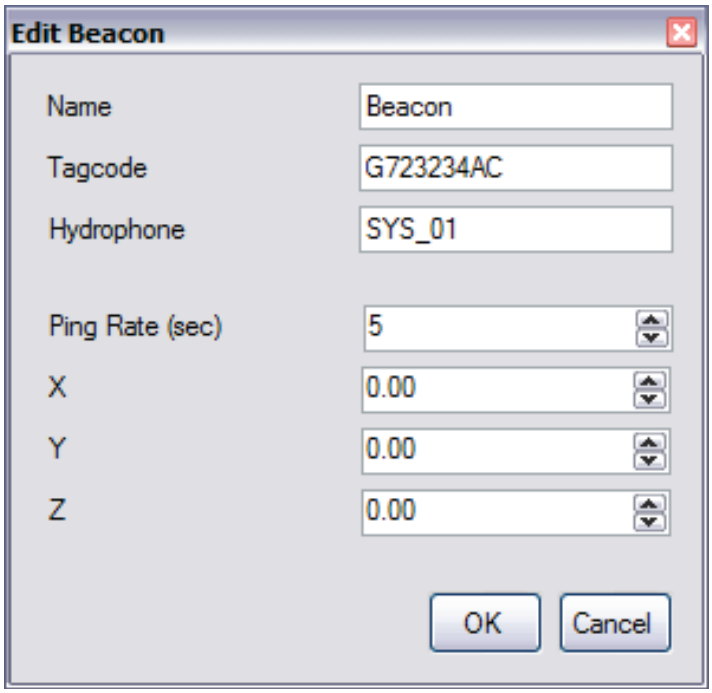


Figure 6.2. Edit Beacon Dialog Box

6.3 Deleting a Single Beacon

To delete a beacon, select the beacon from the list by clicking on the row, which will highlight the row in light gray (Figure 6.3). When the **Delete** button is selected, the beacon will be removed from the list.

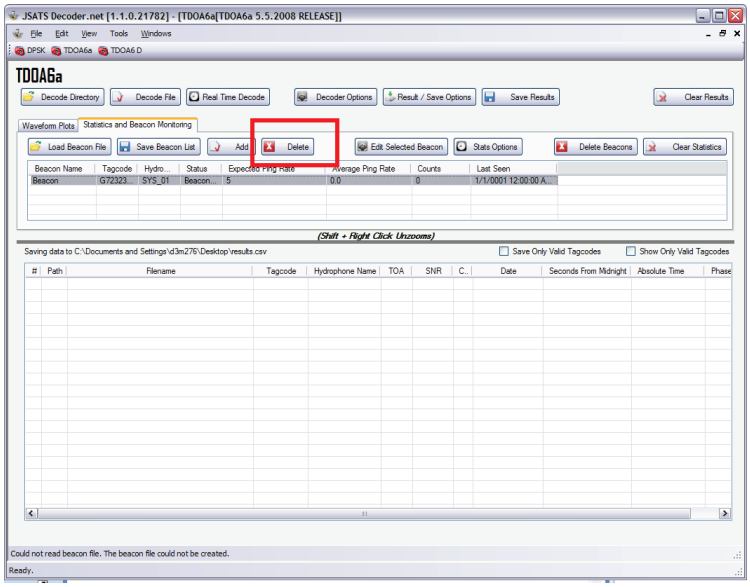


Figure 6.3. To Delete a Beacon, Highlight the Row and Select Delete

6.4 Deleting All Beacons from the List

To delete all beacons from the Beacon List, press the **Delete Beacons** button (Figure 6.1).

When the **Delete Beacons** button is pressed, an alert dialog box will open (Figure 6.4) requesting confirmation of the command to clear the beacon list. Select **Yes** to clear all beacons from the list or **No** to cancel the **Delete Beacons** command.

Figure 6.4. The Confirmation Dialog Box to Delete All Beacons on the List

6.5 Editing a Beacon

To edit the information for a beacon, select the beacon from the list and press the **Edit Selected Beacon** button (Figure 6.1). The *Edit Beacon* dialog box will open (Figure 6.2). Edit the beacon information as needed, then press **OK** to accept changes or **Cancel** to reject the changes.

6.6 Loading a Beacon File

Beacon information can also be entered into the beacon list using an ASCII text file. Each line of the file contains the information for one beacon in the correct file format, as described in Section 6.1. An example text file displaying three beacons as viewed with Notepad is shown in Figure 6.5.

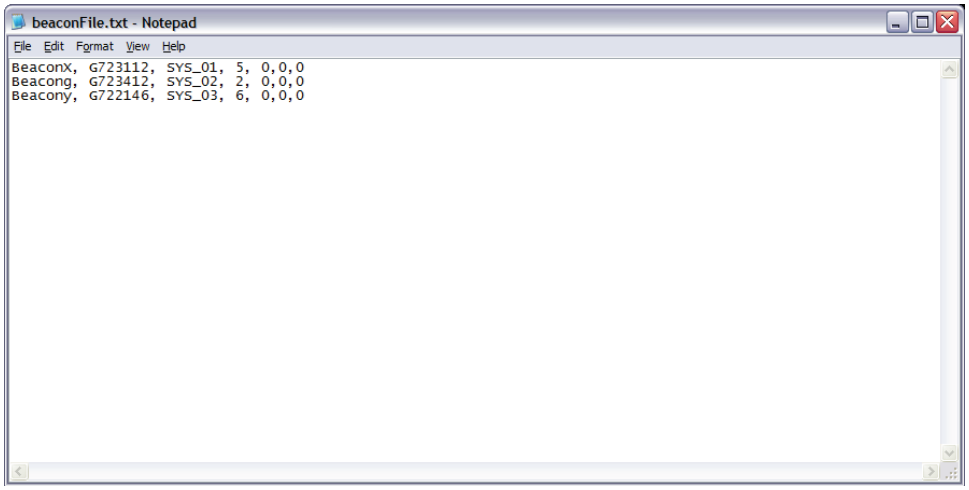


Figure 6.5. Beacon List File Example Using Notepad

The sequence of operations to load a beacon text file is initiated by pressing the **Load Beacon File** button (Figure 6.1).

Navigate to the beacon text file in the *Open* file dialog box and initiate it by clicking the **Open** button (Figure 6.6). The file loads to the spreadsheet as shown in Figure 6.7.

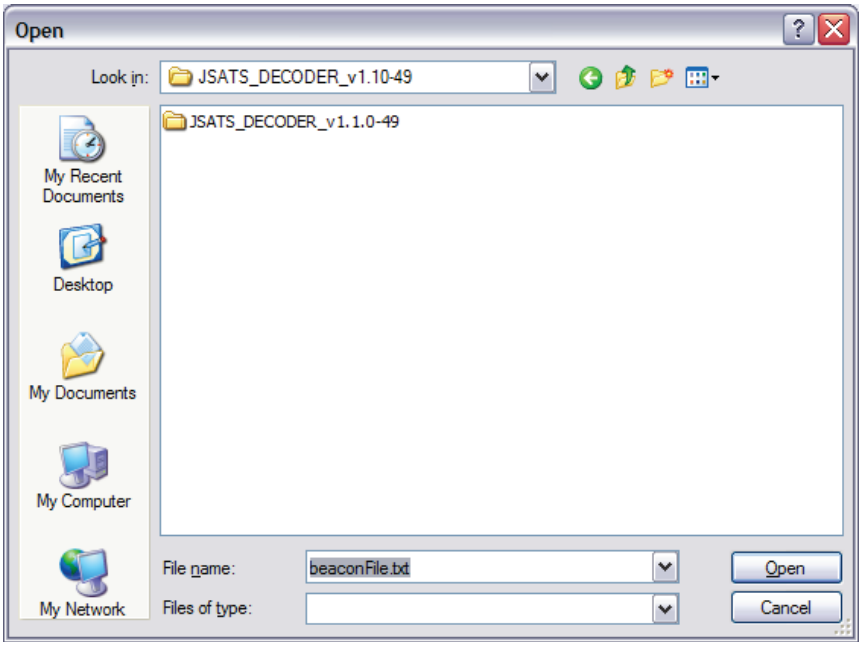


Figure 6.6. The Text File Containing Beacon Information Is Selected from the Open File Dialog Box

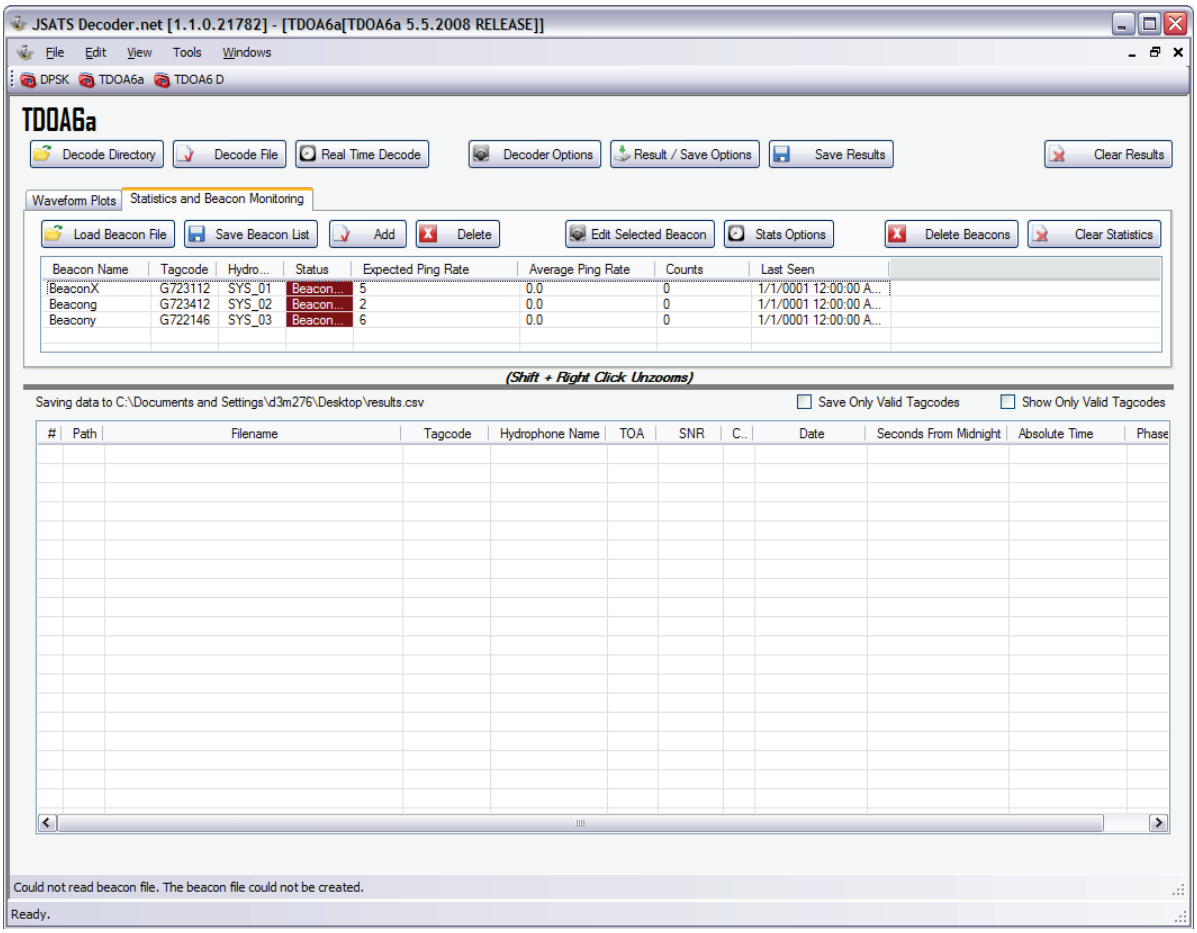


Figure 6.7. Beacon List Loaded from an ASCII Text File

6.7 Saving a Beacon File

When a beacon list is complete, it is saved by pressing the **Save Beacon List** button (Figure 6.1).

When the **Save Beacon List** button is selected the *Save As* file dialog box opens (Figure 6.8). Create or navigate to the directory to which to save the beacon list and type the name of the new beacon list file. Select the **Save** button to save the file or **Cancel** to reject the process.

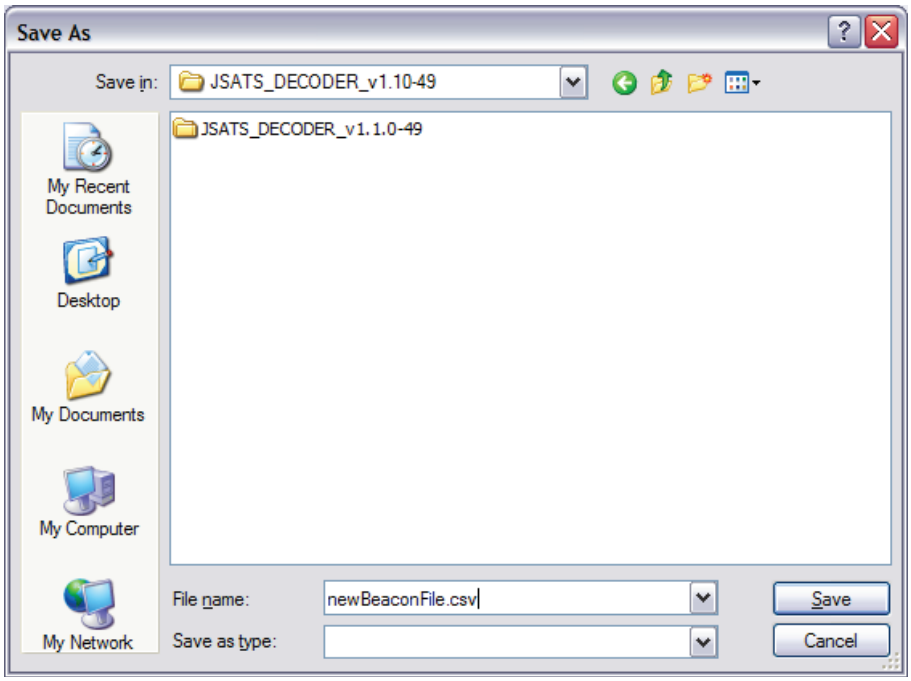


Figure 6.8. When Saving a Beacon List the Save As Dialog Box Opens, Prompting Insertion of a File Name

The decoder keeps a local list of all manually added beacons or those loaded using ASCII text files. The Save Beacon List function saves a beacon list as a file that can be loaded into the decoder program running on other computer systems.

6.8 Setting Statistics Options and Saving Stats Options

The details for the computation of beacon statistics can be changed by pressing the **Stats Options** button (Figure 6.1).

Pressing the **Stats Options** button opens the *Statistics Options* dialog box shown in Figure 6.9.

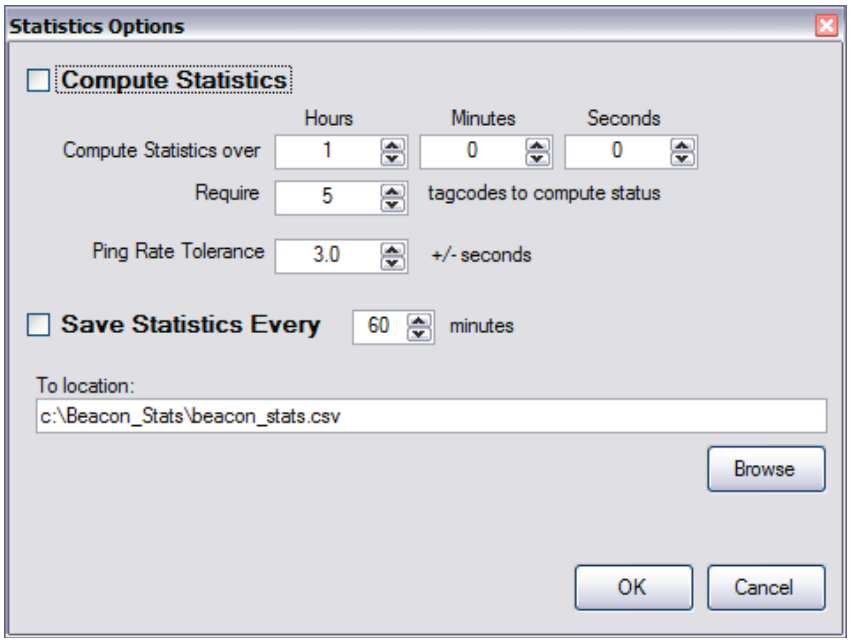


Figure 6.9. Statistics Options Dialog Box

6.8.1 Compute Statistics

In the *Statistics Options* dialog box, the **Compute Statistics** box must be checked for statistics to be computed for tag codes or beacons (Figure 6.9).

6.8.2 Time Period for Computing Statistics

The **Compute Statistics Over** option identifies the time period in hours, minutes, and seconds within which the decoder will compute statistics. Statistics are calculated over a moving window of the duration specified. By default the duration is an hour, as shown in Figure 6.9.

6.8.3 Tag Codes Required to Compute Statistics

The **Require [—] Tagcodes to Compute Status** option designates the number of observations the decoder will make before computing the statistics needed to report beacon status (Figure 6.9).

6.8.4 Ping Rate Tolerance

The average ping rate value will seldom exactly match the expected ping rate value. The **Ping Rate Tolerance** option allows the user to set a specific range within which the average ping rate can vary and still be considered to be working correctly. The example in Figure 6.9 shows a ping rate tolerance range of +/- 3 seconds.

6.8.5 Saving Statistics

The **Save Statistics Every [—] Minutes** checkbox and spin box instruct the decoder how frequently to save statistics to the statistics file described in Section 6.8.6. The **Save Statistics Every [—] Minutes** box must be checked to enable the save function (Figure 6.9).

6.8.6 Saving Beacon Statistics

The **To Location** text box identifies the location where the statistics file will be saved. During each save, the new statistics will be appended to the statistics file. Enter the directory and name of the file in the text box or press the **Browse** button, navigate to the preferred directory, and enter a file name (Figure 6.10). Select **Open** to save or **Cancel** to reject the process.

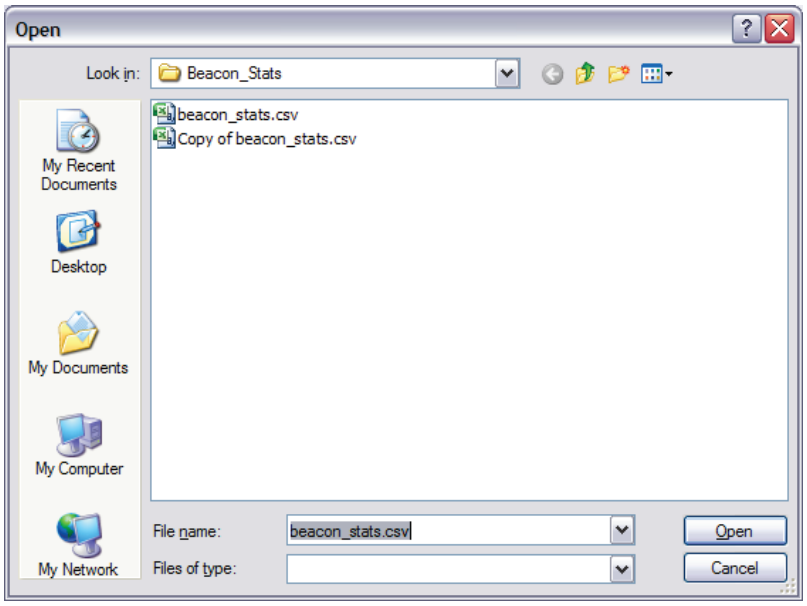


Figure 6.10. The Open Dialog Box where Beacon Statistics Will Be Saved

6.9 Clearing Statistics

The beacon statistics being displayed in the **Decoder** window can be cleared by pressing the **Clear Statistics** button (Figure 6.1). The results will be deleted and will not be saved unless saved previously.

7.0 Data and File Formats

File formats for beacons, beacon statistics, and decoder results are described in this section.

7.1 Beacon File Format

The beacon file configuration is a comma separated file format as shown in Figure 7.1. The columns within a row for a single beacon are as follows:

- Beacon Name
- Beacon Tagcode
- Hydrophone Name
- Expected Ping Rate
- X Position
- Y Position
- Z Position.

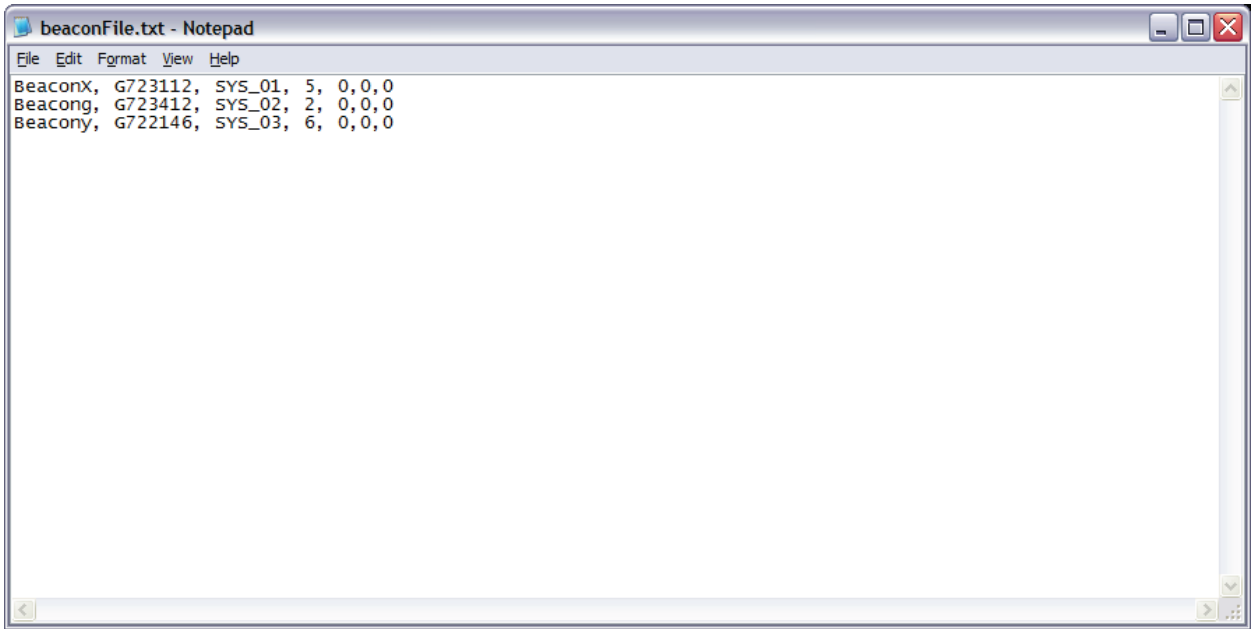


Figure 7.1. Beacon File Format Example

The X, Y, and Z position columns are not used by the decoder and are only placeholders to indicate the location of the beacon if needed for reference purposes.

7.2 Beacon Statistics File Format

The beacon statistics file (Figure 7.2), which is appended after every Save Beacon Statistics procedure, has the following format:

- Statistics Heading – Time and Date of save
- Column Headings:
  - Beacon Name
  - Beacon Tagcode
  - Hydrophone Name
  - Expected Ping Rate
  - Average (or observed) Ping Rate
  - Position X
  - Position Y
  - Position Z.

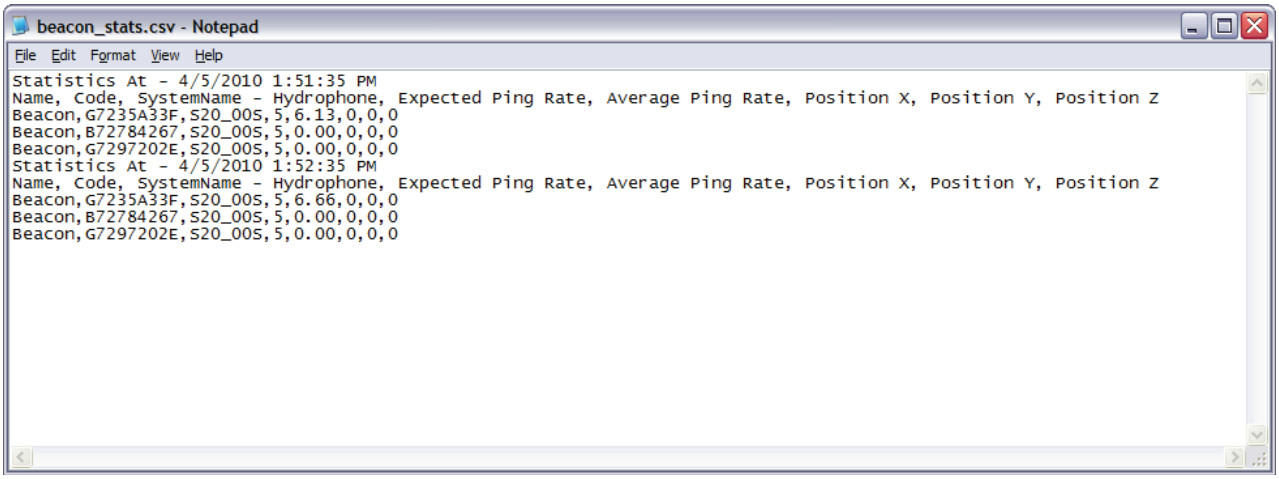


Figure 7.2. Beacon Statistics File Format

Specific time and date statistics and column headings are repeated each time the file is appended.

7.3 Decoder Results File Format

The Results file is formatted as shown in the Excel spreadsheet in Figure 7.3. Data rows are configured as follows:

- The first line is blank.
- The second line describes the decoder's assembly file, useful developer information for troubleshooting.

- The third line describes the decoder type (name), version, and options.
- The fourth line contains the column headings.
- The next lines are the data. Each line represents a single tag code, possibly from the same hydrophone, possibly from the same file.

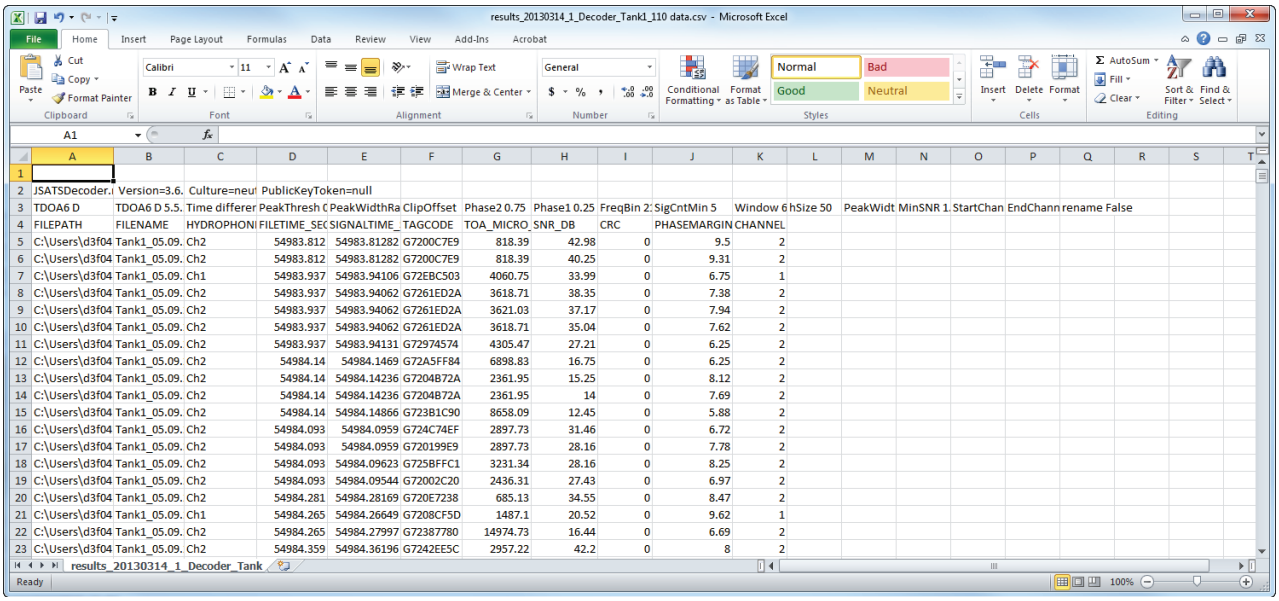


Figure 7.3. Results File Format

The data columns contain the following information:

- FILEPATH – directory name of the decoded waveform file
- FILENAME – file name
- HYDROPHONENAME – name of hydrophone where the tag waveform was detected
- FILETIME_SEC_FROMMIDNIGHT – seconds from midnight (fractional) when the file was created using GPS clock
- SIGNALTIME_SEC_FROMMIDNIGHT – seconds from midnight (fractional) when the tag signal was detected using the JSATS receiver GPS clock
- TAGCODE – tag code decoded from the detected waveform
- TOA_MICRO_SEC – time of arrival relative to the start of the file in microseconds signal when the waveform was decoded
- SNR_DB – Signal-to-noise ratio in decibels – SNR for the waveform relative to the background noise of the environment
- CRC – cyclic redundancy check computed over the 16-bit binary representation of the tag code
- PHASEMARGIN – confidence metric for binary phase-shift keying phase transitions
- CHANNEL – data channel.

8.0 Command Line Decoder

The Command Line decoder is a lightweight version of the JSATS decoder. This version is intended for post-processing of *.bwm* files and is not designed for real-time decoding. All major post-processing functionality in the graphical user interface (GUI) version of the JSATS decoder is available in the Command Line decoder.

The argument format for the Command Line decoder is as follows:

> JSATSDecoderCommandline.exe <directory containing *.bwm* files> [-r to check sub-directories] [- o *.csv* file name] [-p to use parallel processing].

The path to decode is required; the options (parallel, out file, and parallel) are not. By default, only top-level directories are searched, waveform files are decoded serially, and output is written to results*.csv* files and will be in the same directory as the program.

For example, to decode all waveform files in the directory *C:\.bwm* Files, the following command is entered:

>JSATSDecoderCommandLine.exe "C:\.bwm Files"

Decoding speed can be increased using parallel decoding. To enable parallel decoding, the following command is entered:

>JSATSDecoderCommandLine.exe "C:\.bwm Files"-p

If the results are to be saved to *C:\myResults.csv* and decoded in parallel, the following command is entered:

>JSATSDecoderCommandLine.exe "C:\.bwm Files" -p -o C:\myResults.csv

To check all the files in the *C:\.bwm* Files sub-directories, the –r option is used:

>JSATSDecoderCommandLine.exe "C:\.bwm Files" –r

For example, two hard drives labeled E: and F:, respectively, contain tag waveforms to be decoded. Decoding needs to be completed as quickly as possible, so the decoders will be run on the processing computer and results will be saved on the computer desktop.

Two instances of the Command Line decoder prompts are needed to decode the waveform files on the hard drives. The first prompt is

>JSATSDecoderCommandLine.exe "E:\" –p –r –o "C:\Users\User\Desktop\e drive.csv"

After entering the first prompt, press **Enter** and select the second prompt. The second prompt will be:

>JSATSDecoderCommandLine.exe "F:\" –p –r –o "C:\Users\User\Desktop\f drive.csv"

After the prompt has been completed, press **Enter** to begin processing the waveform files. The format of the results files from the Command Line decoder will be of the same format as the GUI version of the JSATS decoder (see Figure 7.3).

9.0 References

Deng Z, MA Weiland, T Fu, TA Seim, BL Lamarche, EY Choi, TJ Carlson, and MB Eppard. 2011. "A Cabled Acoustic Telemetry System for Detecting and Tracking Juvenile Salmon: Part 2. Three-Dimensional Tracking and Passage Outcomes." *Sensors* 11(6):5661−5676.

McMichael GA, MB Eppard, TJ Carlson, JA Carter, BD Ebberts, RS Brown, MA Weiland, GR Ploskey, RA Harnish, and Z Deng. 2010. "The Juvenile Salmon Acoustic Telemetry System; A New Tool." *Fisheries* 35(1):9−22.

Weiland MA, Z Deng, TA Seim, BL Lamarche, EY Choi, T Fu, TJ Carlson, AI Thronas, and MB Eppard. 2011. "A cabled acoustic telemetry system for detecting and tracking juvenile salmon: Part 1. Engineering design and instrumentation." *Sensors* 11(6):5645−5660.

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