



Motion Amplification

User's Manual

Version 2.4

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RDI Technologies

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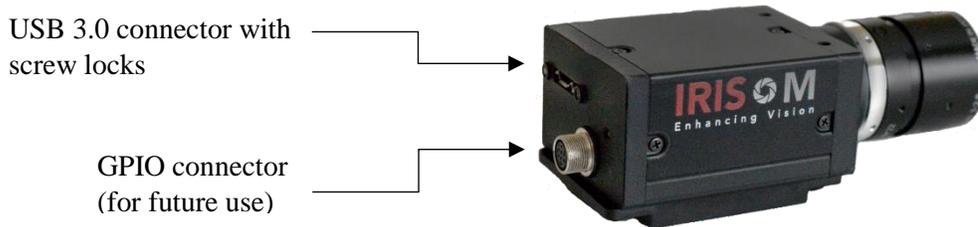
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1 Using the cameras

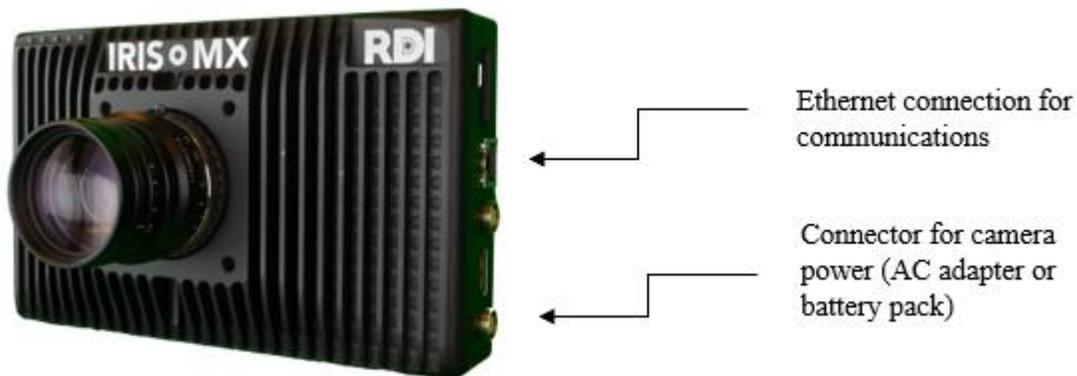
1.1 The Iris M Camera

The Iris M camera supported by the Motion Amplification software uses a USB3 streaming video camera capable of capturing high quality grayscale imagery. The camera is connected to the acquisition computer by a USB3 cable. Power is supplied to the camera by the USB3 cable. The USB3 cable should be connected to the camera at all times by the screw lock connector and the cable should not exceed 3 meters in length (9.84 ft). It is possible the camera works with cables up to 5 meters in length but this is unsupported. The camera can lose data integrity at these lengths. If the camera is disconnected from the computer while the acquisition software is running, the software must be restarted once the camera is reconnected.

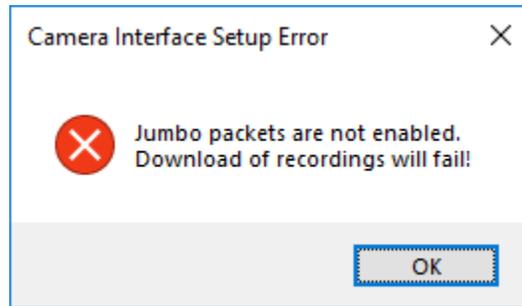


1.2 The Iris MX Camera

The Iris MX camera supported by the Motion Amplification software is a high speed camera capable of capturing high quality grayscale imagery at faster speeds than the Iris M camera and is available as an add-on to the Iris M. This high speed camera can capture up to 1,400 frames per second in HD resolution. The camera is connected to the acquisition computer by an ethernet cable, and a USB to ethernet adapter is typically required to connect the ethernet cable to the USB port on the acquisition computer. Power is supplied to the camera by either an external AC power adapter or a battery pack. If the camera is disconnected from the computer while the acquisition software is running, the software must be restarted once the camera is reconnected.

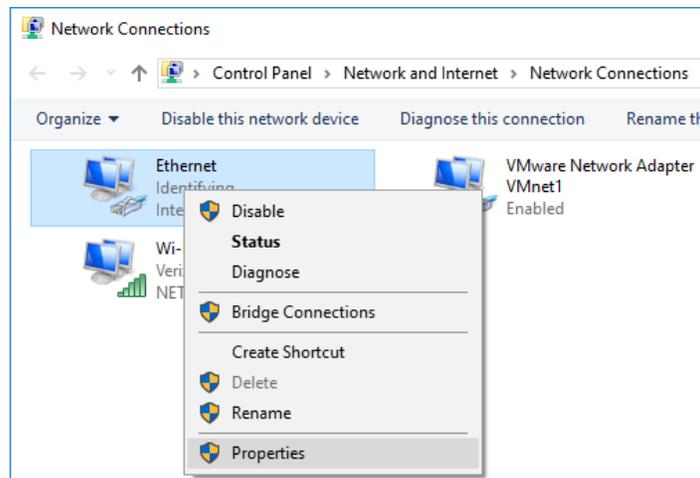


Important: In order to download recordings from the Iris MX camera the network connection used to communicate with the camera must be configured correctly. If the connection is not configured correctly, the message below will be displayed when the acquisition application is launched.

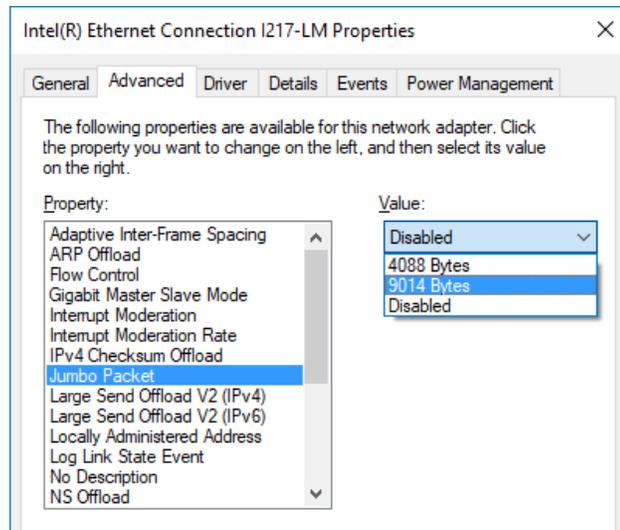


In order to configure the network connection properly, please follow the steps below:

- 1) Open the Windows Network and Sharing Center
- 2) Click “Change Adapter Settings”
- 3) Right click the network connection that will be used to communicate with the Iris MX camera and select “Properties”.

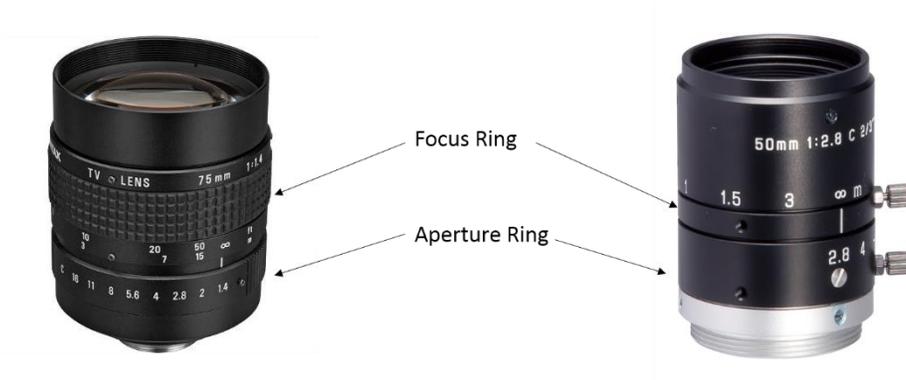


- 4) Under the Networking tab, click the Configure button for the network adapter.
- 5) Select the Advanced tab.
- 6) Select the “Jumbo Packet” item in the list and change it’s value to 9,104 bytes (or 9kB MTU). If the only options for Jumbo Packets is “On” or “Off”, choose “On”.



1.3 Lenses

The types of lenses used with both the Iris M and MX cameras are C-Mount lenses. The lenses mount to the front of the camera via a threaded interface. A standard kit may include several lenses. The focal length of the lens determines the field of view (fov) and magnification. By changing lenses to double the focal length, the magnification will double, while the fov will decrease by one half. By changing lenses to half the focal length, the magnification will decrease by one half and the fov will double.



Aperture Ring – The aperture ring is a collar on the camera that can be rotated to increase or decrease the aperture. The effect is letting more or less light in, respectively.

Focus Ring – The focus ring is a collar on the camera and changes the focus of the image.

2 Software

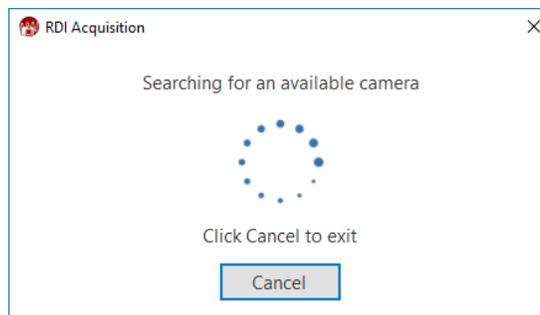
The suite of Motion Amplification software consists of four software applications: Acquisition, Motion Amplification, Motion Explorer, and Motion Studio. These applications are all installed on the acquisition device. An Analysis Only installation may be installed on another PC, and this installation will include Motion Amplification, Motion Explorer, and Motion Studio. The Acquisition software records the data while Motion Amplification software analyzes the data and amplifies the motion. Motion Explorer allows the user to create an organizational hierarchy under which collected recordings can be found. Motion Studio allows the user to create more complex MP4 videos.

2.1 Installation

If after installation and reboot an activation dialog is displayed, see the Managing your License.

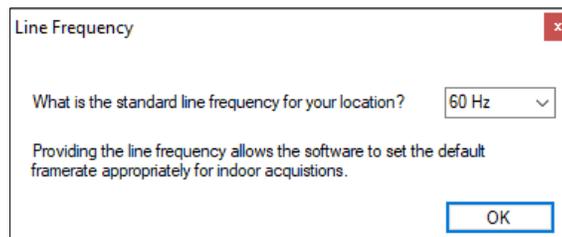
2.2 Acquisition Software

The acquisition application allows the user to record data with either of the two Motion Amplification cameras. The Iris M or the Iris MX camera should be plugged into the computer prior to launching the software. The software will attempt to connect to one of these cameras, and while it is attempting to connect the following message will be displayed.



Selecting “Cancel” will close the Acquisition application.

The first time the software is opened the following dialog appears.



It is important to select the appropriate line frequency for your location when recording indoors. This sets the proper frame rate to ensure your camera is timed to take images at the same frequency as your lights brighten and dim. See the Troubleshooting section on issues with selecting the wrong frame rate with AC lighting.

The default settings for the Iris M camera are as follows. Values are for 60 Hz line frequency unless noted.

Setting	Value
Name	“Current Date”
Distance	50 ft
Focal Length (mm)	50
Time (seconds)	3
Framerate (fps)	120 fps (100 for 50 Hz line frequency)
Brightness (%)	68.2 (57 for 50 Hz line frequency)
Gain (dB)	0.0
Width	1920
Height	1060 (1200 for 50 Hz line frequency)
Left	0
Top	0

The default settings for the Iris MX camera are as follows. Values are for 60 Hz line frequency unless noted.

Setting	Value
Name	“Current Date”
Distance	50 ft
Focal Length (mm)	50
Time (seconds)	3
Framerate (fps)	120 fps (100 for 50 Hz line frequency)
Brightness (%)	68.2 (57 for 50 Hz line frequency)
Gain (dB)	0.0
Width	1920
Height	1060 (1200 for 50 Hz line frequency)
Left	0
Top	0

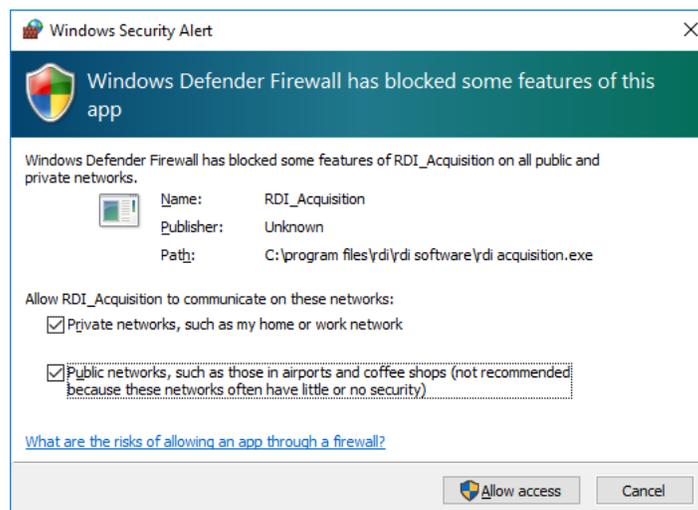
The Motion Amplification Software records video into a “.rdi” format. Each “.rdi” file has a corresponding folder of the same name that also stores data. It is necessary for the “.rdi” file and the corresponding folder to remain in the same directory.



2.2.1 Firewall Access for Iris MX

The first time the RDI Acquisition application is run, the user should see a message from the Windows Defender Firewall (or the currently installed firewall). The message is telling the user that Windows Defender Firewall has blocked some of the features of the RDI Acquisition application.

The RDI Acquisition application talks to the Iris MX camera using an ethernet connection, so the user needs to allow the camera to communicate with the acquisition application through the firewall. Simply check both boxes in the displayed message (shown below) and press the “Allow Access” button. This should allow the camera to properly communicate with the software.



2.2.2 Recording Properties

Name – Sets the filename of the recording. In the event a file with the same name already exists the software will append an auto advance number at the end of the filename. For example, if a recording with the filename “motor.rdi” exists the software will name the next file “motor_01.rdi”.

Distance – Stores the distance from the lens to the object in the recording for retrieval later.

Focal Length (mm) - Stores the focal length of the lens in the recording for retrieval later.

Duration Type – Determines whether the duration of the recording is specified in terms of the number of frames or total time in seconds.

Number of Images – If the duration type is set to “Number of Frames” this option will be visible. The entered value specifies the length of the recording in terms of the number of images to collect. For example, 240 images recorded at 120 fps will give a 2 second recording. Note: The recording time for a given number of frames can be seen in the “Calculated Values” section.

Recording Properties	
Name:	<input type="text" value="motor pump"/>
Distance:	<input type="text" value="50"/> <input type="text" value="ft"/> <input type="button" value="v"/>
Focal Length (mm):	<input type="text" value="50"/>
Duration Type:	<input type="text" value="Number of Frames"/> <input type="button" value="v"/>
Number of Frames:	<input type="text" value="500"/>
<input type="button" value="Add Notes..."/>	

Duration – If the duration type is set to “Time(sec)” this option will be visible. The entered value specifies the length of the recording in terms of the number of seconds to collect data at the specified framerate. The number of frames that will be collected based on the specified time appears in the “Calculated Values” section.

2.2.3 Recording Association

Collection – Specifies the name of the collection the recording will be associated with. A Collection can be chosen, and a new collection can be created with the acquisition software under the Collection Selection Window by pressing the “Change” button. By associating a recording with a collection and asset in the acquisition software, that recording is automatically associated similarly in Motion Explorer on the same computer. See Section 0.

Recording Association	
Collection:	New Job
Asset:	(Unassigned Collection)
<input type="button" value="Change..."/>	

Asset – Determines the asset under which the recording will be associated. Assets cannot be created in the acquisition software. See Section 0 for creating an asset in Motion Explorer.

2.2.4 Iris M Camera Properties

The following camera properties will be displayed if an Iris M camera is connected.

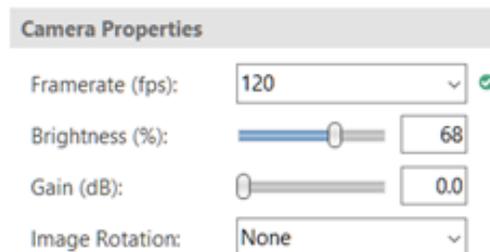
Framerate (fps) – Determines the number of images to be collected in one second. Equivalent to sampling rate.

Frame Rate Quality -  A color indicator is directly to the right of the frame rate setting. This circle informs the user if the software is receiving the requested frame rate. If the camera's framerate drops below the requested value, the circle turns red. This  indicates the camera cannot sustain the requested framerate. It is suggested the user reduce the vertical resolution of the camera to accommodate the requested framerate or drop the frame rate until the circle turns green. The user can hover the mouse over the circle to see what framerate the camera is achieving.

Brightness (%) – Adjusts the brightness of the image by changing the exposure time of the image. The larger the brightness level the longer the exposure time. This value is scaled from 0 to 100 percent.

Gain – Adjusts the sensitivity of the camera's sensor. By increasing the gain, you will brighten your image, but you will introduce more noise and decrease the quality of the measurement. Sometimes this is necessary when the image is too dark.

Image Rotation – Rotates the image in the Image Viewer Window. The image is permanently rotated and appears the same when opened in Motion Amplification. The image can be rotated 90° Clockwise, 180°, and 90° Counter Clockwise.



2.2.5 Iris MX Camera Properties

The following camera properties will be displayed if an Iris MX camera is connected.

Framerate (fps) – Determines the number of images to be collected in one second. Equivalent to sampling rate.

Brightness (%) – Adjusts the brightness of the image by changing the exposure time of the image. The larger the brightness level the longer the exposure time. This value is scaled from 0 to 100 percent.

Gain – Adjusts the sensitivity of the camera's sensor. By increasing the gain, you will brighten your image, but you will introduce more noise and decrease the quality of the measurement. Sometimes this is necessary when the image is too dark. Available setting for gain are None, Low, and High.

Image Rotation – Rotates the image in the Image Viewer Window. The image is permanently rotated and appears the same when opened in Motion Amplification. The image can be rotated 90° Clockwise, 180°, and 90° Counter Clockwise.

Camera Properties	
Framerate (fps):	<input type="range" value="120"/> 120
Brightness (%):	<input type="range" value="100"/> 100
Gain:	None ▾
Image Rotation:	None ▾

2.2.6 Image Properties

Width - Adjusts the width of the image in pixels.

Height - Adjusts the height of the image in pixels.

Left – Offset of the image from the left if the image is less than full width.

Top – Offset of the image from the top if the image is less than full height.

Image Properties	
Width:	<input type="range" value="1920"/> 1920 <input type="button" value="+"/> <input type="button" value="-"/>
Height:	<input type="range" value="1060"/> 1060 <input type="button" value="+"/> <input type="button" value="-"/>
Left:	<input type="range" value="0"/> 0 <input type="button" value="+"/> <input type="button" value="-"/>
Top:	<input type="range" value="0"/> 0 <input type="button" value="+"/> <input type="button" value="-"/>
<input type="button" value="Reset"/>	

The image size and location can also be adjusted by drawing a Region of Interest (ROI) in the image. See Section 2.2.11.

2.2.7 Calculated Values

Fmax(Hz) – The maximum frequency of any spectral plots generated from data collected with the current settings.

Acquisition Time (s) – Total time of the acquisition based on the current frame rate and number of images. Displayed if the Duration Type is set to “Number of Frames”.

Number of Frames –Number of images that will be collected based on the specified duration and frame rate. Displayed if the Duration Type is set to “Time”.

Recording Size (GB) – Total size of the recording based on the number of images.

Available Disk Space (GB) -Available space on the disk drive selected to store recordings.

Calculated Values	
Fmax(Hz)	60
Number of Frames:	360
Recording Size (GB):	2.6
Available Disk Space (GB):	27.0

2.2.8 Recording/Playback Bar

The Recording/Playback bar is located below the Image Viewer Window. It serves to control and inform the user about recording and playback depending on which mode the user is in.

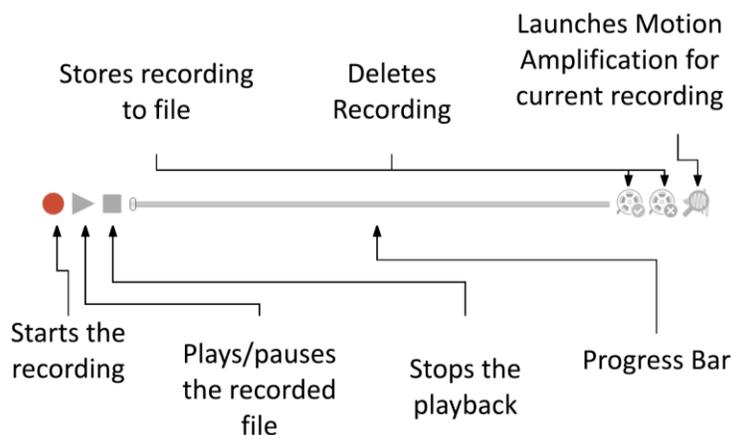
Recording – During live preview the Image Viewer Window will show a live stream of the camera. In the recording/playback bar the only option available will be the record button. Once recording begins the stop button will become active. Recording can be stopped at any time during acquisition without deleting data already collected.

Playback – Once a recording is complete the Recording/Playback bar will enter playback mode. The recording can be played back for viewing. The pause and stop buttons can also be utilized. To advance the playback frame by frame, use the right and left arrows.

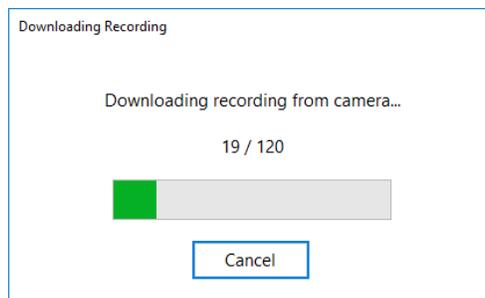
Save Recording  – Pressing this will save the recording after acquisition.

Delete Recording  – Pressing this will delete the recording.

Amplify Recording  – Pressing this will launch Motion Amplification and amplify the current recording.

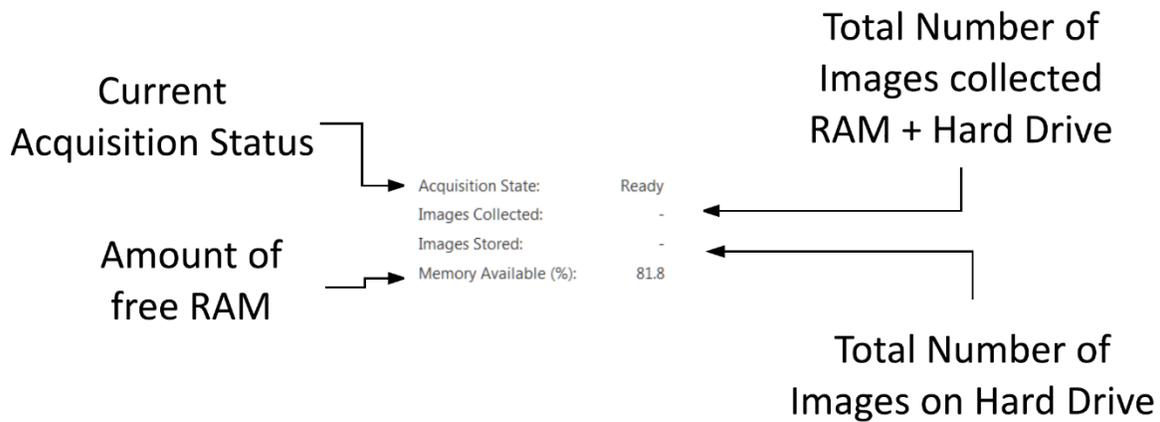


Note: The Iris M camera stores data on the acquisition computer as it is collected. The Iris MX camera initially stores the captured data on the camera, and it is transferred to the acquisition computer when the Save Recording button is pressed. This transfer process may take some time depending on the total size of the recording.



2.2.9 Toolbar for Iris M Recordings

The toolbar gives information about the Iris M acquisition during recording and playback. The software automatically streams the recording to your Solid State Drive (SSD). If the SSD cannot keep up with the recording software, then the application uses RAM as overflow for the images that are not written to the SSD fast enough. Once the recording is done and some images were recorded to RAM the recording will not be accessible to save or playback until the remaining images stored in RAM are transferred to the SSD.



Acquisition State – Displays information about the state of the system. Can be “Ready”, “Recording” or in “Review”.

Images Collected – Displays the total number of images collected. This is the number of images written to SSD and to RAM and accounts for all the images collected at the present time of display.

Images Stored – Displays the total number of images written to the SSD. This does not account for any images that are written to RAM because the SSD could not keep up with saving the files.

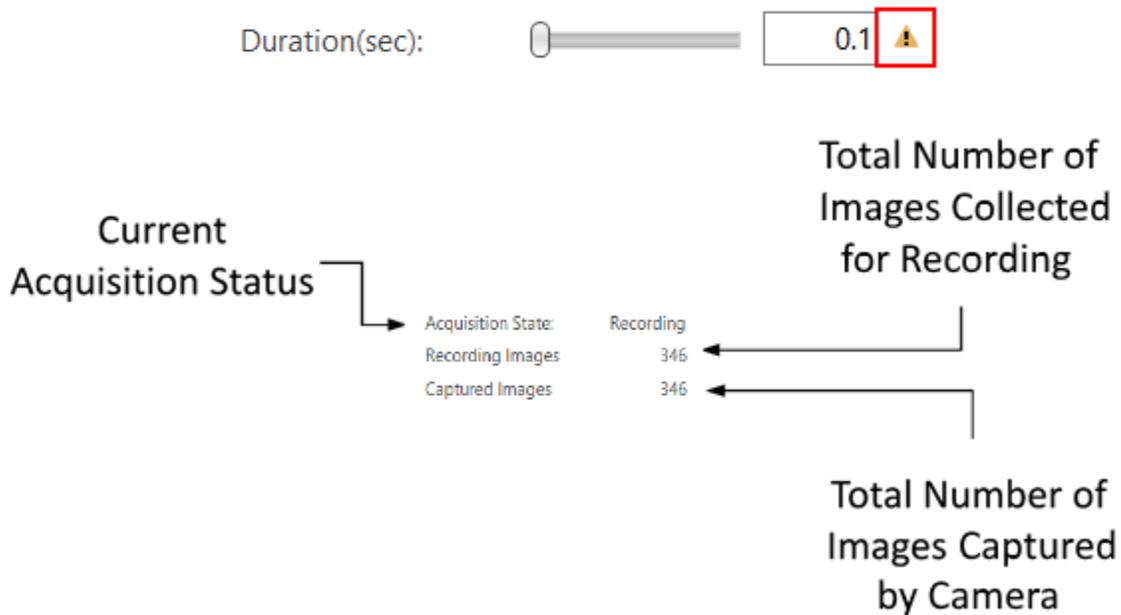
Memory Available (%) – Displays the current percentage of free RAM accessible to the application. If the SSD cannot keep up with storing image during acquisition this percentage will decrease as overflow images are written to RAM. If system RAM reaches a critical state of 5% available, the recording stops.



The Recording /Playback bar displays the position of the recording indicated by where the slider is relative to the bar. Green represents the number of images recorded to SSD and Yellow represents images recorded to RAM. Once acquisition is complete the bar will progressively turn solid green as images are moved from RAM to the SSD. The Save, Delete and Amplify buttons will also become active once recording completes.

2.2.10 Toolbar for Iris MX Recordings

The toolbar gives information about the Iris MX acquisition during recording and playback. The recording is initially stored in the camera. The Iris MX camera captures data in blocks of a certain size. For example, given a certain frame size the camera must capture data in blocks of N frames. So if N+1 frames are requested, then the camera must actually collect 2 * N frames. The unneeded frames will be discarded. When you see the warning sign in the image below displayed next to the duration or time input field, hovering over the warning indicator will explain this behavior.



Acquisition State – Displays information about the state of the system. Can be “Ready”, “Recording”, “Review”, or “Downloading”.

Recording Images – Displays the total number of images collected that will be stored with the current recording.

Captured Images – As mentioned above, the camera may need to capture more images than were requested for the current recording. In this case, captured images will exceed recording images.



The Recording /Playback bar displays the position of the recording indicated by where the slider is relative to the bar. Green represents the number of images collected relative to the number requested for the current recording. Yellow represents any additional images that had to be captured by the camera due to the fact that it acquires data in blocks of a certain size. The Save, Delete and Amplify buttons will also become active once recording completes. Pressing Save or Amplify will initiate the transfer of the recording from the Iris MX camera to the acquisition computer.

2.2.11 Image Viewer Window



Image Viewer Window

Image Information – Image information will be displayed when the mouse is placed on the image. The information is: Percent of Full Brightness, Horizontal Pixel Location, Vertical Pixel Location. Pixel (0,0) is located in the upper left corner.

Image Toolbar – The image toolbar above the Image Viewer Window allows the user to Zoom Out, Zoom In, Reset Zoom to full view and Move the image. The Move Image buttons are only accessible if the image is zoomed in. The Distance Pin icon allows the user to place a distance pin on the image and associate a distance with that location. Multiple pins can be placed on an image. The Grid Lines button will display a grid overlay in the Image Viewer Window.

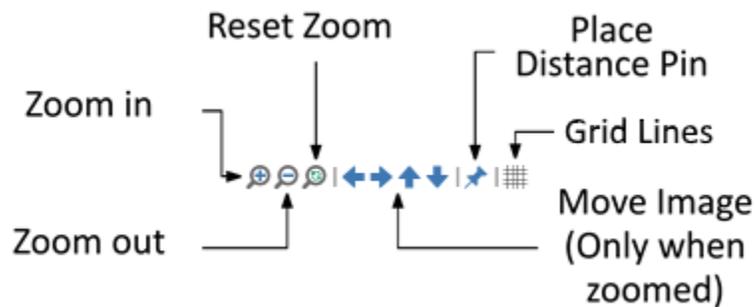


Image Toolbar

The user can draw a Region of Interest (ROI) to change the dimension and location of the image in the field of view. A Left Click + Drag will draw a red box on a portion of the image. When the user releases the mouse the acquisition window will only be the portion of the image containing the ROI.

Note: If the user records at this point only the information in the ROI will be recorded. The user can go back to the full field of view by pressing Reset under Image Properties.

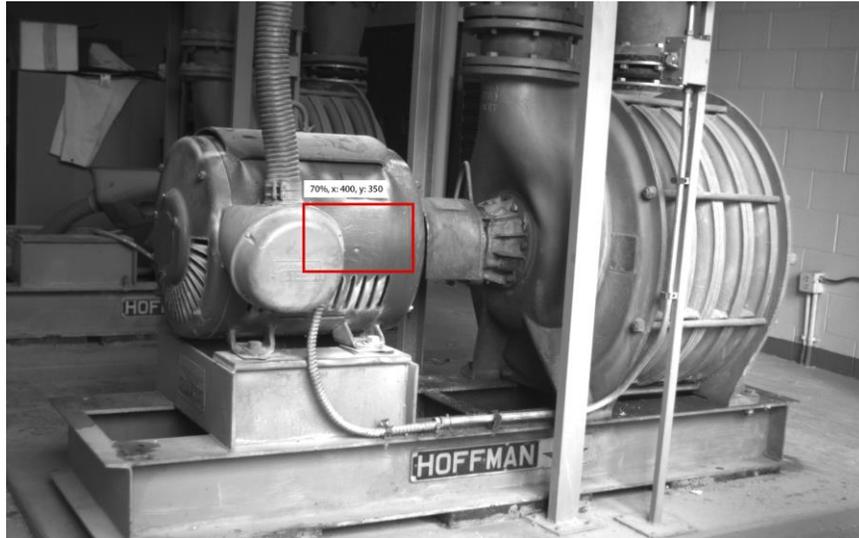
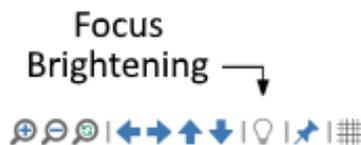


Image Viewer Window with ROI

2.2.10.1 Focus Brightening

When connected to an Iris MX camera, a Focus Brightening item will be present in the toolbar. Selecting this item will put the software into a mode where the exposure is temporarily changed (brightened). The purpose of this mode is to make it easier to focus the camera properly. With very high framerates, it is often difficult to illuminate the subject with enough light. So focus brightening mode temporarily brightens the subject so that it is clearly visible in order to focus the camera lens correctly. When focusing is complete, the user should press the button again to exit focus brightening mode. Note: Focus Brightening only brightens the image prior to recording and not while recording.



2.2.12 Settings

The settings menu can be accessed by pressing the gear icon .

Storage Folder: The storage location of the acquisition application can be changed. This determines the location where recordings are stored.

Default Recording Name: The default file naming convention can be chosen from three different options.

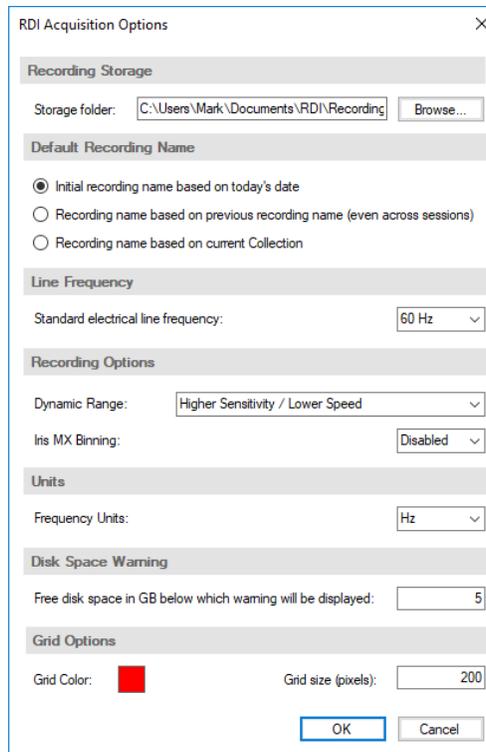
Line Frequency: An option to specify the line frequency is also available. The Line Frequency setting only changes the default frame rate to be 2x line frequency to reduce flicker from indoor lighting.

Dynamic Range: This option determines the dynamic range used by the camera to collect and store a recording. “Higher Sensitivity / Lower Framerate” is one option. This option uses the full dynamic range of the camera, but the available framerate is not as high as if the option “Lower Sensitivity / Higher Framerate” is chosen. This second option allows for higher framerates compared to the first option given the same field of view, but the camera is not quite as sensitive. The default is higher sensitivity, but if there are cases where higher framerate is needed for a given field of view the lower sensitivity option may be used. This option is applicable to both the Iris M and the Iris MX cameras.

Iris MX Binning: The Iris MX camera supports a feature called binning. Binning is another way to achieve higher framerates for a given field of view. Without binning, every pixel on the camera is treated separately. In this case for every pixel of the camera sensor that has data collected, information for that individual pixel is stored. If binning is enabled, 2x2 groups of pixels on the camera’s sensor are aggregated into a single pixel in the stored image. So if the full field of view is used as an example, the full 2560x2048 sensor with binning enabled will result in images that are 1280x1024 without a reduction in the field of view. The images collect without binning and those collected with binning will have the same field of view. This allows the camera to achieve higher framerates for a given field of view. Another way to achieve this effect is to change to a different lens and only collect a portion of that lens’s field of view. An example would be changing from a 50mm lens to a 25mm lens and only collecting a 1280x1024 recording. Higher framerates would be possible with the 1280x1024 recording with the 25mm lens, but the field of view would be the same as that of the 2560x2048 recording with the 50mm lens.

Frequency Units: This option determines whether frequency units are expressed in Hz or CPM. When in displacement mode, F_{\max} is expressed in these terms. The frequency axis of spectrum plots displayed in Motion Amplification is also expressed in these terms.

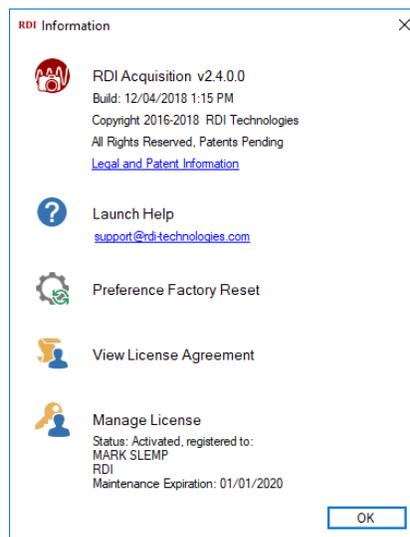
Disk Space Warning: This property can be set to display a warning when disk space falls below a certain amount.



2.2.13 Information

Information about the software can be accessed by pressing the info icon .

The Information dialog provides access to information about the installed RDI Acquisition application. It also provides access to the help system and the email address for RDI support. The Preference Factory Reset option will return the application to the initial default values for all configurable items. The user may also display the License Agreement that was accepted during the installation process. The manage license button provides access to functionality such as activating and deactivating the license for the current installation and informing the user of maintenance expiration dates.

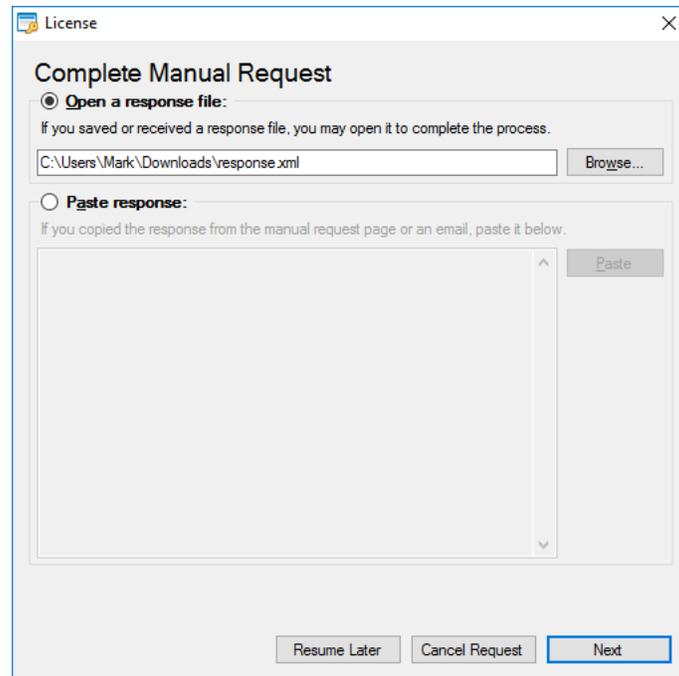
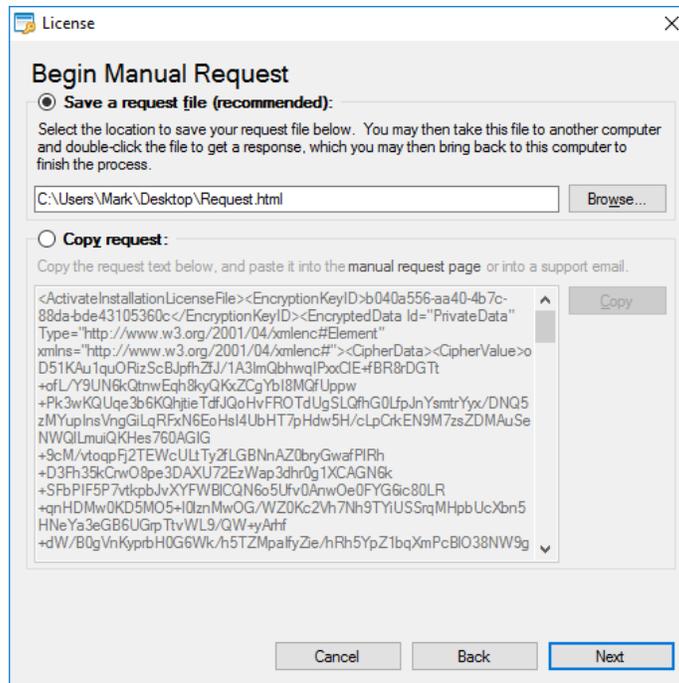


2.3 Managing your License

After installing the software, it can be activated three different ways. The simplest is if the computer is connected to the internet. If that is the case, simply enter the License ID and Password provided with your Motion Amplification purchase, click the “Next” button, and the software will be activated via the internet.

The screenshot shows a dialog box titled "License" with a close button (X) in the top right corner. The main heading is "License Status". Below this is a table with two columns: "Name" and "Status". The first row contains a red 'X' icon, the text "RDI Acquisition and Moti...", and the status "9200: License not found - activation is required." Below the table is an "Actions" section with two sub-sections: "I want to..." and "Using...". Under "I want to...", there are three radio buttons: "Activate a license or renewal." (selected), "Refresh my license.", and "Deactivate this workstation.". Under "Using...", there are two radio buttons: "This computer's Internet connection." (selected) and "Another computer's Internet connection.". Below the actions is a "License Details:" section with four input fields: "License ID:" (with a yellow warning icon), "Password:" (with a yellow warning icon), "Installation ID:", and "Installation Name:" (with "(Optional)" next to it). At the bottom of the dialog are three buttons: "Cancel", "Back", and "Next".

If the computer is not connected to the Internet, you can use another computer’s internet connection. To use another computer’s Internet connection, enter the License ID and Password provided as a part of your purchase, select “Another computer’s internet connection” in the License Status dialog, and press the “Next” button. In the “Begin Manual Request” dialog, you will then be prompted to save an activation request file to your computer. You will then need to manually transfer that file to another computer and double click the file once transferred. This will produce an activation response file using the other computer’s Internet connection. That response file will need to be transferred back to the computer on which the software was installed. When you press “Next” from the “Begin Manual Request” dialog, you will be prompted to select the Activation response file. Selecting the proper response file and pressing the next button will complete the activation sequence.

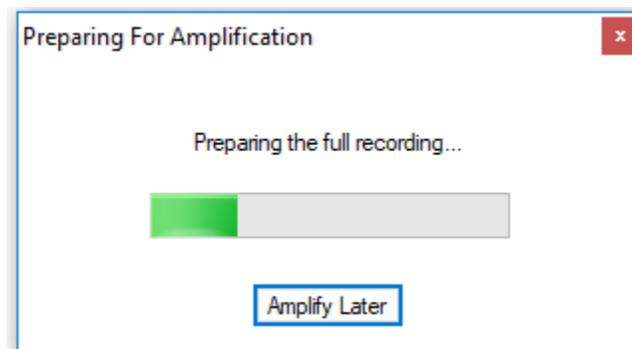


2.4 Motion Amplification Software



2.4.1 Opening a file

Click the “File...” button to select a recording file from the user’s computer for amplification. The software will perform the amplification process once the file is selected. The user may choose the “Amplify Later” option if the entire recording does not need to be amplified. If “Amplify Later” is chosen, the recording will be opened, but amplified playback will not be available until an amplification span is selected and the amplification process is performed.



2.4.2 Toolbar

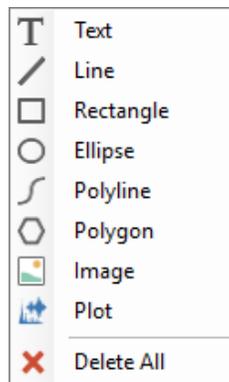


The Zoom In button allows the user to zoom into an area of interest in the amplified recording. Once zoomed, the user can Zoom Out and Reset the Zoom position to full view. When the view has been zoomed, the user can also move the current view in any direction using the Pan buttons.

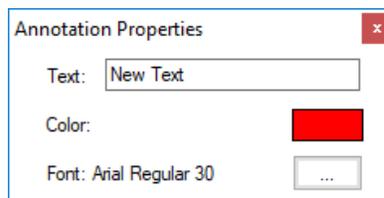
A grid overlay is supported in Motion Amplification. If the Grid button is pressed, a grid will be shown in the Motion Amplification window.

2.4.2.1 Annotations

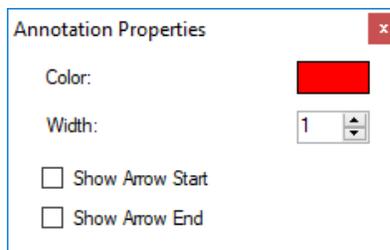
The Add Annotation button allows the user to add Text, Lines, Rectangles, Ellipses, Polylines, Polygons, Image Annotations, and Plot Annotations to the current recording.



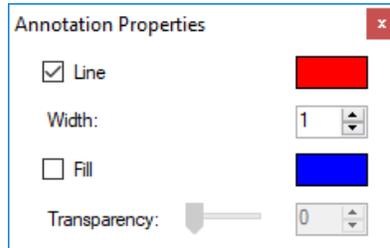
- Text Annotations: Drawn by clicking the left mouse button to define their location. The properties of the text annotation are then displayed, and these can be modified by the user.



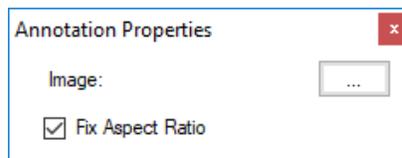
- Line Annotations: Drawn by pressing the left mouse button at the desired start of the line and then dragging the mouse (while still holding down the left mouse button) to release the mouse button at the desired end of the line. The properties of the text annotation are then displayed, and these can be modified by the user.



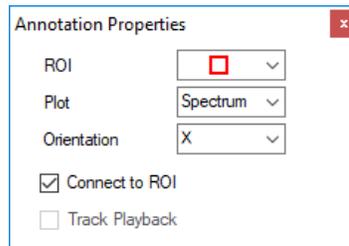
- **Rectangle and Ellipse Annotations:** Drawn by pressing the left mouse button at one corner and then dragging the mouse and releasing the button at the opposite corner. The properties of the text annotation are then displayed, and these can be modified by the user.



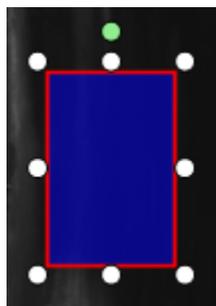
- **Image Annotations:** Drawn by pressing the left mouse button at one corner and then dragging the mouse and releasing the button at the opposite corner. The user then must select an image file that will be used to populate the space defined by the image annotation. BMP, JPEG, GIF, TIFF, and PNG image file types are supported.



- **Plot Annotations:** Drawn by pressing the left mouse button at one corner and then dragging the mouse and releasing the button at the opposite corner. The user then must select an ROI, plot type, and orientation to be used for the plot annotation. Checking the Connect to ROI box will draw a line between the ROI and the plot annotation. For waveform and orbit plot annotations, Track Playback is enabled. This will show a marker on the plot that represents the current playback location.



Annotations may be resized by dragging the white handles. The green handle may be used to rotate the annotation.



The Delete All button will remove all of the currently displayed annotations.

2.4.2.2 Amplification Regions

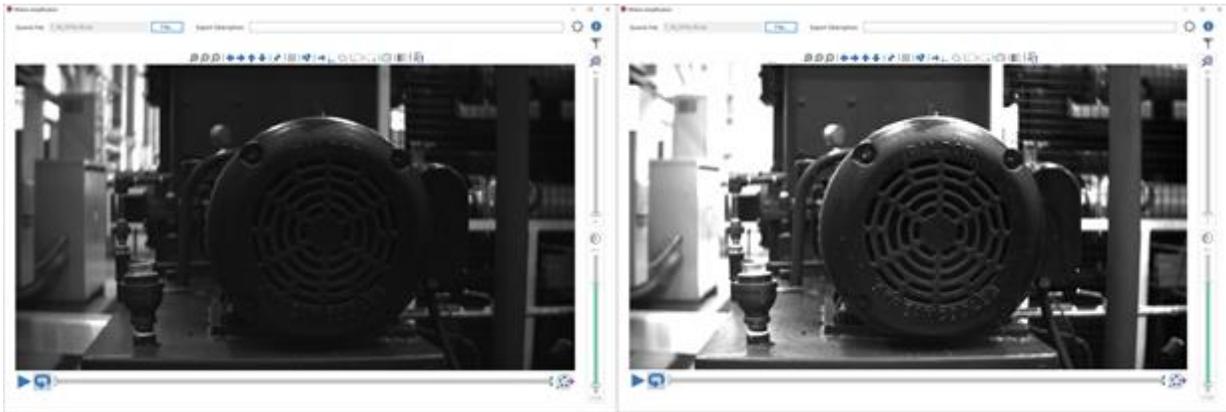
With amplification regions the user can choose to amplify only specific regions of the image. The Amplification Region Editor can be activated by pressing the Regions button on the toolbar. 

The Default Amplification Behavior determines if the entire image is amplified by default or not. If Amplify None is chosen, the shapes act to include amplification in regions they define. If Amplify All is chosen, the shapes act to exclude regions they define. To help with this process, the image is color coded with red being regions where amplification will not occur and green being regions where amplification will occur.

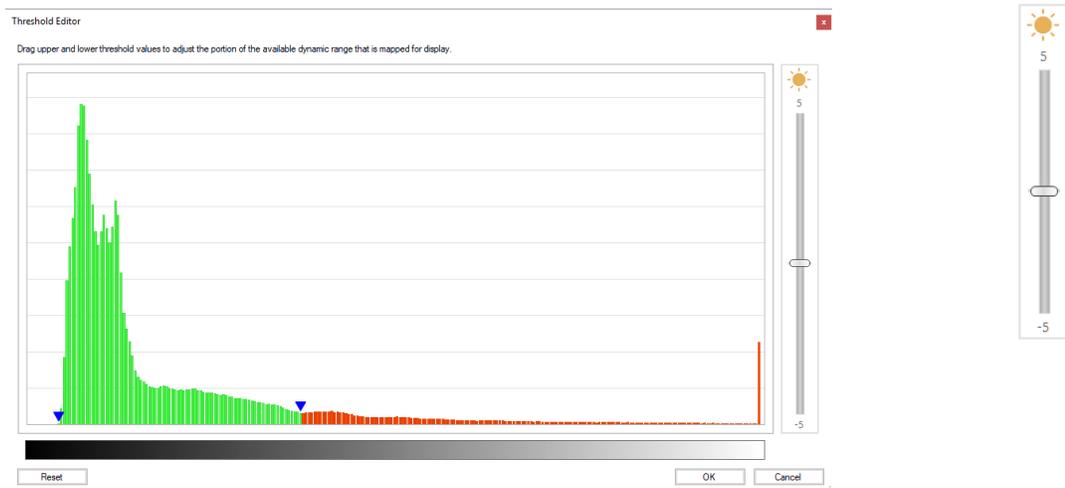
Three shapes can be chosen to define a region: a circle, a square and a polygon. The polygon can be created by using the left mouse button to click and define the points of the polygon. To end the creation of the polygon double click on the location of the last point, right click to define the last point, or press the escape key.



2.4.2.3 Threshold and Brightness



The camera can show more levels of grey than the computer screen is capable of displaying. Applying a Threshold to the image allows the user to choose which parts of the dynamic range of the camera will be shown on the screen. By default, the entire range of values are shown but in less detail. The benefit is making the shadows or highlights show better on the screen. The previous images shows the effect of applying a Threshold. The image to the left is the default image. The image to the right is after applying a threshold to highlight the dark areas of the image. The image below shows the Threshold Editor and the settings that were applied.



The Threshold Editor graph plots the number of pixels vs intensity value. A high peak on the left hand side as seen above indicates a large number of pixels have dark values. The green area indicates the range of intensities that will be shown on the screen. To adjust the range, the blue triangles can be moved to indicate the upper and lower intensity value for the image. In this case the user selected to show darker values to make them appear better on the screen.

The brightness of the recording is typically controlled during acquisition, but it can be fine-tuned during playback with the brightness slider to the right of the threshold window. The default, center position is no adjustment. Moving the slider above the center position will increase the brightness of the amplified playback. Moving the slider below the center position will decrease the brightness of the amplified playback.

2.4.2.4 Save Snapshot to Current Collection

This option saves an image from the current state of the playback window. This image is then attached to the collection with which the current recording is associated. All overlays are saved with the image. 

2.4.3 Playback Bar

The playback bar allows the user to Play and Pause the current recording. The Loop button can be enabled and disabled. If the loop button is enabled, when the recording is played and reaches the end, it will automatically be restarted.



The portion of the recording to be exported is controlled by the green triangles shown on the playback bar. Right click on the playback position indicator to set the current recording position such that it is the Export Start or the Export End (see Section 2.4.7 Exporting a Video).



2.4.4 Adjusting Amplification

The amplification slider located in the upper right of the amplification window controls the amount of amplification that is applied to the current recording as it is played. The lower position of the slider is 0, which corresponds to no amplification being applied. The upper position of the slider is an amplification factor of 50. Increasing the amplification factor will increase the noise that is present in the amplified images.

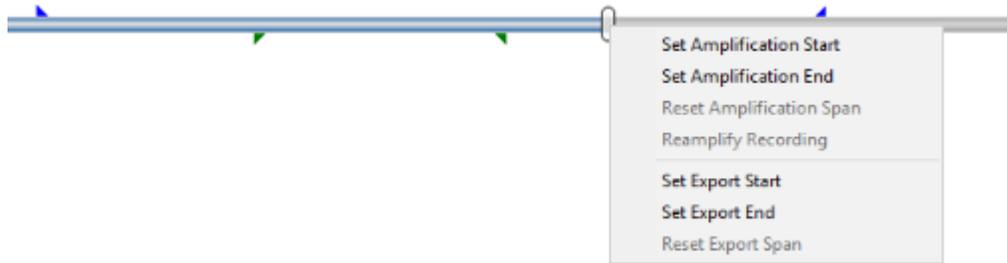
2.4.5 Determining Amplification Period

Often motion is present in the video that the user may not want to amplify or the motion is so large that amplification has undesirable effect. For example, the motion of a press during impact may be interesting but the motion of the press lowering may not. To account for this the period of amplification can be changed. This will allow the user to set a start and end for amplification to occur. The software then only looks at this time period to determine motions and amplify those motions. This is beneficial when a motion that occurred at the beginning of the acquisition is large and may be adversely affecting a motion in the scene that occurs later and is subtler.

To adjust the period over which the amplification occurs place the playback indicator at the starting position you would like amplification to occur and then right click the playback position indicator. From the drop down menu select Set Amplification Start. This will move a blue triangle above the bar to the current position indicating it is the start of amplification. Now move the playback position indicator to the point where you would like amplification to end. Right click and choose Set Amplification End. A second blue

triangle will appear above the bar at the current position indicating the ending point of the amplification period.

Important: To apply amplification for this period of time right click and select Reamplify Recording.



Note: When a period less than the total length of the recording is set as the Amplification region, only the portion of the recording that is amplified will appear amplified on playback. The remaining period outside of the amplification window will appear as normal video.

2.4.6 Playback Speed

The Playback Speed button has multiple positions. The slowest position is at the bottom, and the fastest position is at the top. The fastest position will result in playback being four times the speed as the data was collected. The slowest position will result in playback speed equal to 1/N of the acquired speed where N is the framerate. For example, for a recording acquired at 120 fps playback at the slowest playback speed would be shown at 1/120 fps. The default position is 10% of the original recording speed.



2.4.7 Exporting a Video

The Export button  is to the lower right of the Motion Amplification window. It will pause any playback in progress and initiate an export of the current recording. The exported recording will include any overlays (grid and/or annotations) that are currently displayed.

It should also be noted that only the currently displayed portion of the full frame will be exported, so if the user has zoomed into a certain portion of the window only that portion will be exported.

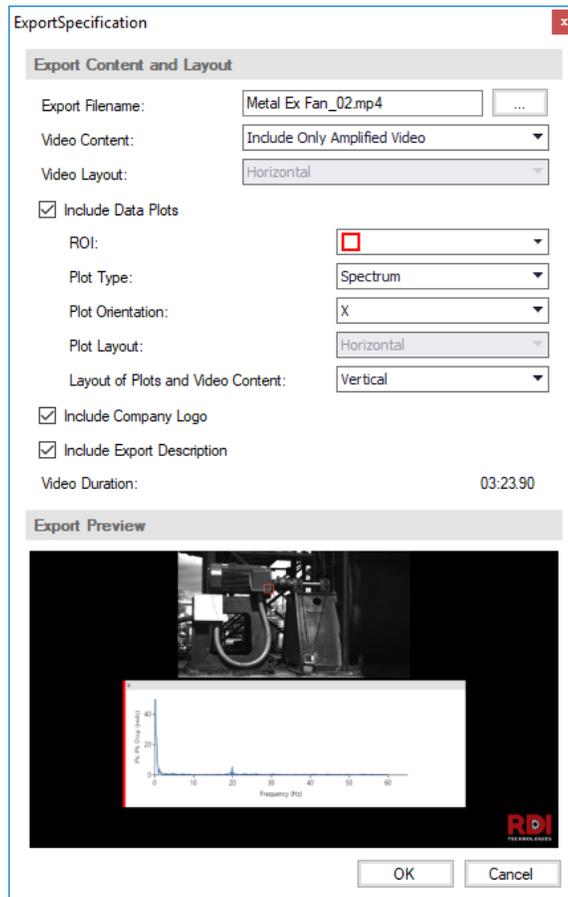
As discussed in 2.4.3, if the user doesn't want to export the entire duration of a recording, a portion of the recording can be identified for export by setting the Export Start and Export End.

Once the Export button has been pressed, the user is presented with a dialog containing several options (see image below):

- Specify the filename of the mp4 that is to be created.
- Specify to include only amplified content or include both the original video and the amplified video.
- If both original and amplified video are selected, the orientation between this content may be specified.
- The user may choose to include data plots. If no ROI is present, this option will not be enabled.
 - The ROI for the data plots to be included in the exported video must be specified.
 - The type of plot to be included must be specified. Available options include Spectrum, Waveform, Spectrum & Waveform, and Orbit.

- The next available option is Plot Orientation. If Spectrum or Waveform were previously selected, the options available include X, Y, and X & Y. If Spectrum & Waveform was previously selected, the only two choices available are X and Y. If Orbit was selected previously, this option is not enabled.
- Plot Layout is the next option available. If the previous selection result in more than one plot being included in the export, then this option determines the layout of those plots relative to each other.
- Layout of Plots and Video Content determines the layout between the video content and the plot content.
- Include Company Logo will result in the logo specified in the user preferences dialog being included in the generated plots.
- Include Export Description will include the description available on the main Motion Amplification window in the exported video.

At the bottom of this dialog is a preview window. All of the options above will be reflected in the preview window as they are changed. Pressing the OK button will produce the requested MP4 video.



2.4.8 Settings

The settings button in Motion Amplification provides access to options related to the grid and producing an exported MP4 video.

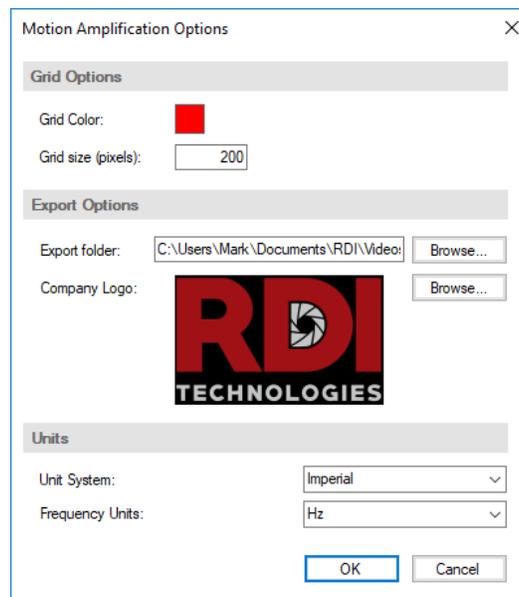
The Grid Options section includes items that control the color for the grid lines and the grid size in pixels.

The Export Options section includes an option to specify the location for exported files to be written to the user's computer. An option to include a company logo is available. If selected the company logo will be displayed in the lower right of every frame in the video. The last option is a browse button to select the user's own logo. The logo file needs to be either png, jpg, or bmp format. When displayed, the logo file will be resized proportionally such that it is 100 pixels high. For better appearances use a logo that has transparency set or a black background since the logo will be applied to the black bar region below the video.

The Measurements Units section allows you to change units between Metric and Imperial with the respective units being:

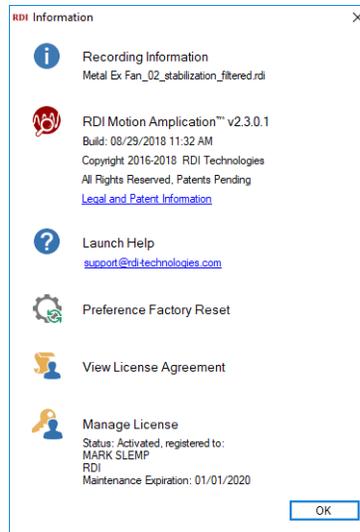
Metric: Microns (μm) and Millimeters per Second (mm/sec)

Imperial: Thousands of an Inch (mils) and Inches per Second (in/sec)



2.4.9 Information

The information dialog provides access to further information about the current recording and the installed Motion Amplification application. It also provides access to the help system and the email address for RDI support. The user may also display the License Agreement that was accepted during the installation process. The manage license button provides access to functionality such as activating and deactivating the license for the current installation.

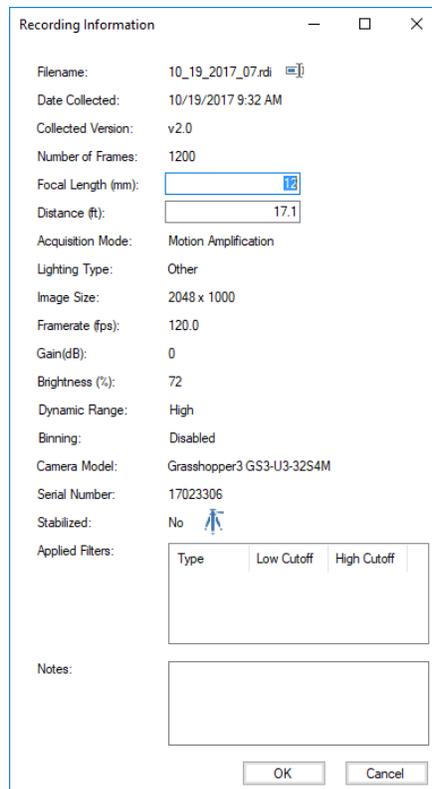


2.4.10 Recording Information

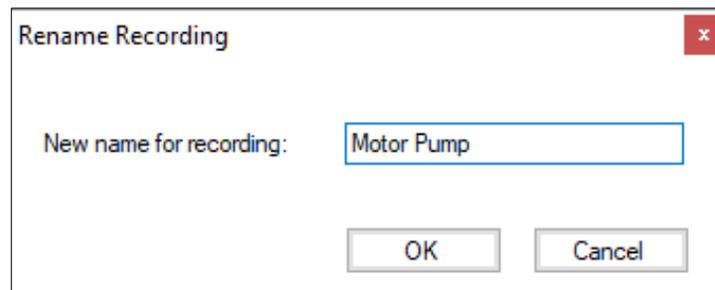
Pressing the recording information button will display information about the current recording. This includes information entered by the user at the time of collection and information about the hardware used to collect the data.

Two fields are editable, Focal Length and Distance. This allows the user to change these values if they were entered incorrectly at recording or not entered at all.

This dialog also provides access to the stabilization functionality that is discussed in [Chapter 4](#).



Users can choose to rename recordings from the recording information window. To rename a recording click the cursor text button in the upper right-hand corner of the window in the Filename field as seen below. This will open a “Rename Recording” window, also shown below. Enter the new file name in the field and select OK to accept. The “.rdi” file and all files associated with it will be renamed.



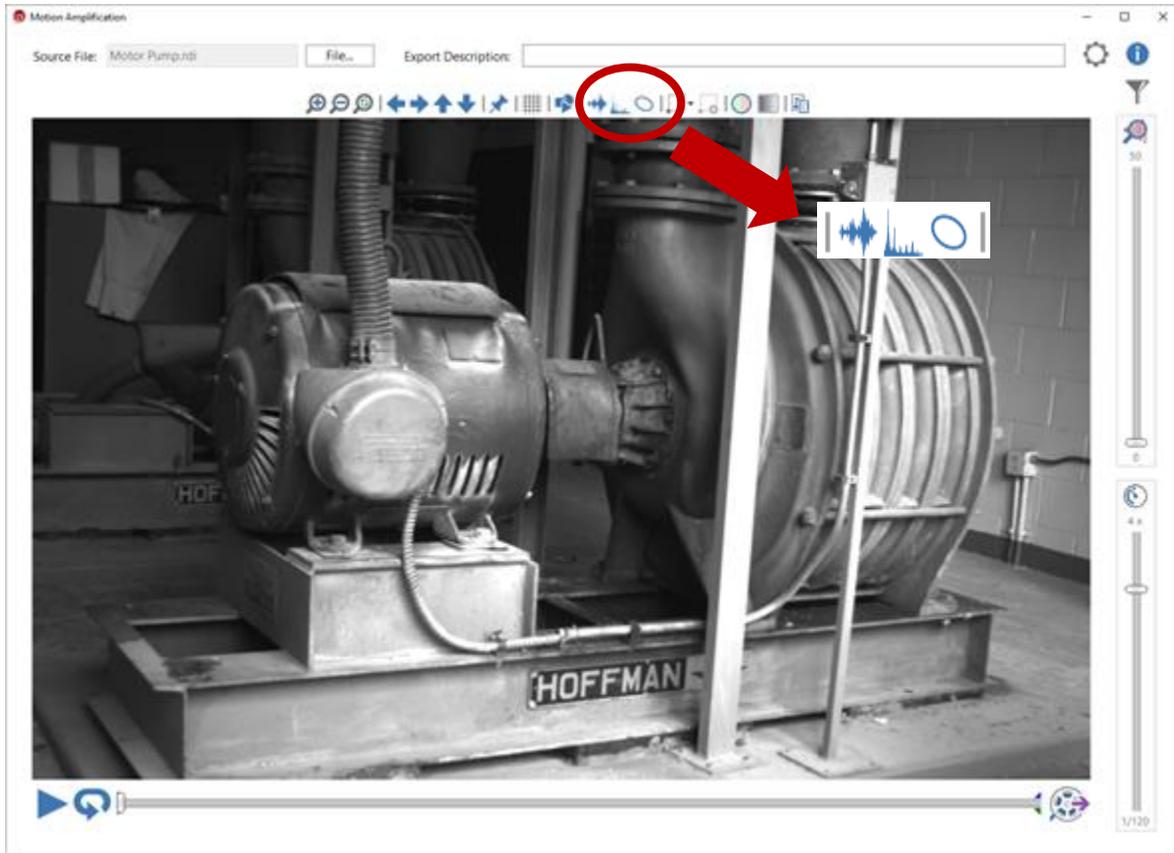
2.5 Displacement and Frequency

2.5.1 Drawing a Region of Interest for measurement

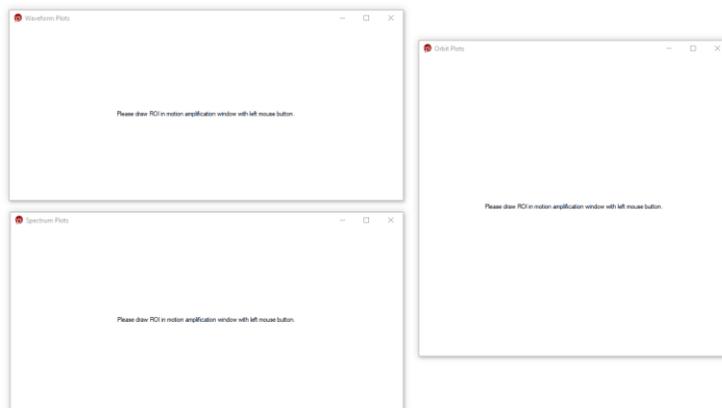
Displacement measurements can be made directly from the recording in the Motion Amplification Software. To do this a Region of Interest or ROI must be drawn on the image at the location where the measurement is desired. The following image shows the location of the Time Waveform, Spectrum, and Orbit buttons. Once activated these buttons will launch separate windows for the different types of plots.

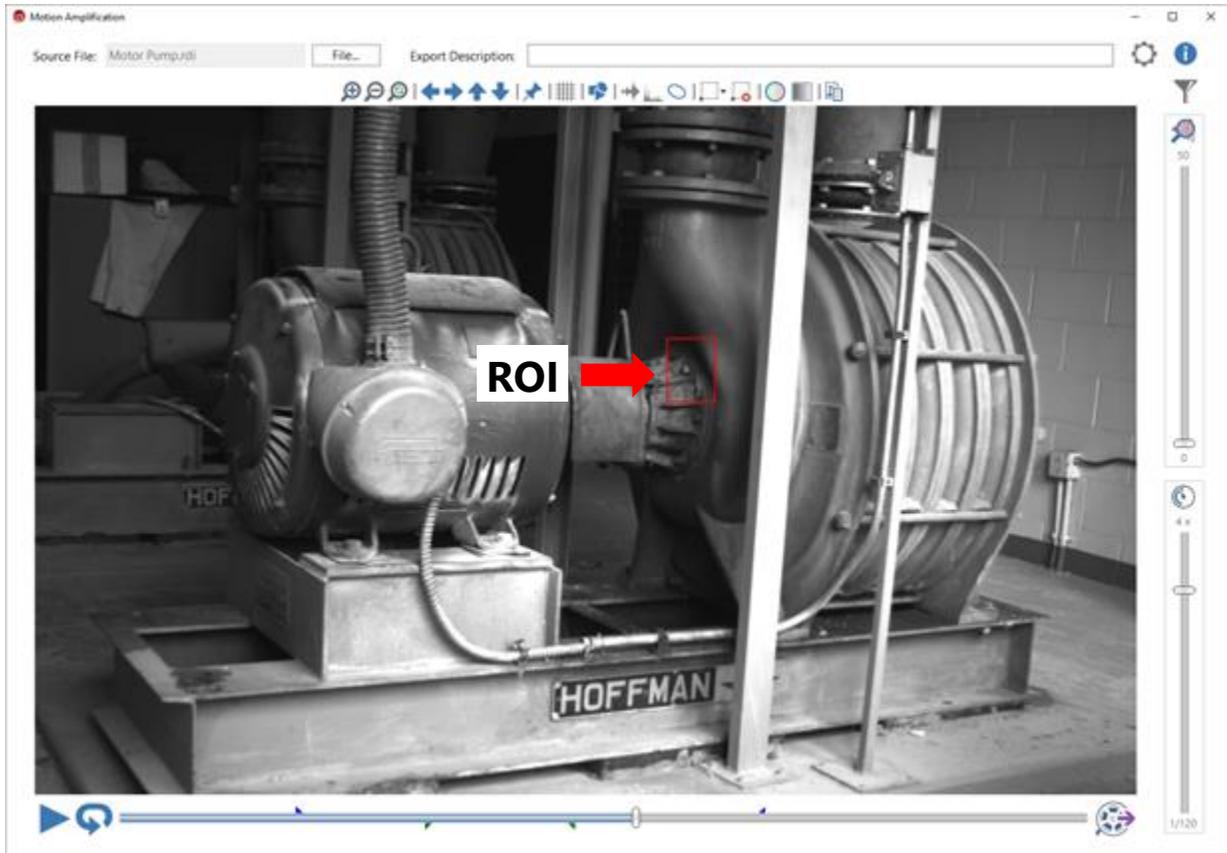
To draw an ROI for which displacement measurements are to be made, the user will Left Click and hold the left mouse button. Then drag the mouse over the region to measure. Once the ROI is in the suitable place, the user then releases the left mouse button. At this point the software determines the displacement measurement within the ROI.

Note: The software can look at any location within the ROI to measure displacement. This is done to ensure the software is given adequate signal to make a quality measurement. It is important to only draw an ROI over an area in which you are OK with a measurement being made anywhere within the ROI.

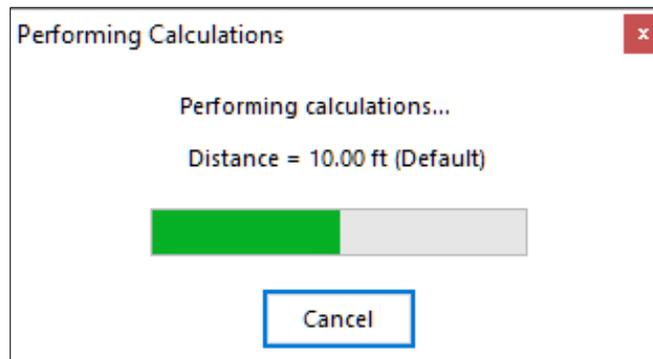


Below are the Time Waveform and Spectrum Windows when they are launched by clicking the respective button. They remain blank until an ROI is drawn. The Orbit Window behaves in the same manner.





Once an ROI is drawn as shown above, a progress window will pop up as seen below. The software will then calculate the displacement in the ROI. Once complete, the Time Waveform, Spectrum, and Orbit windows will populate with the displacement data calculated from the ROI.

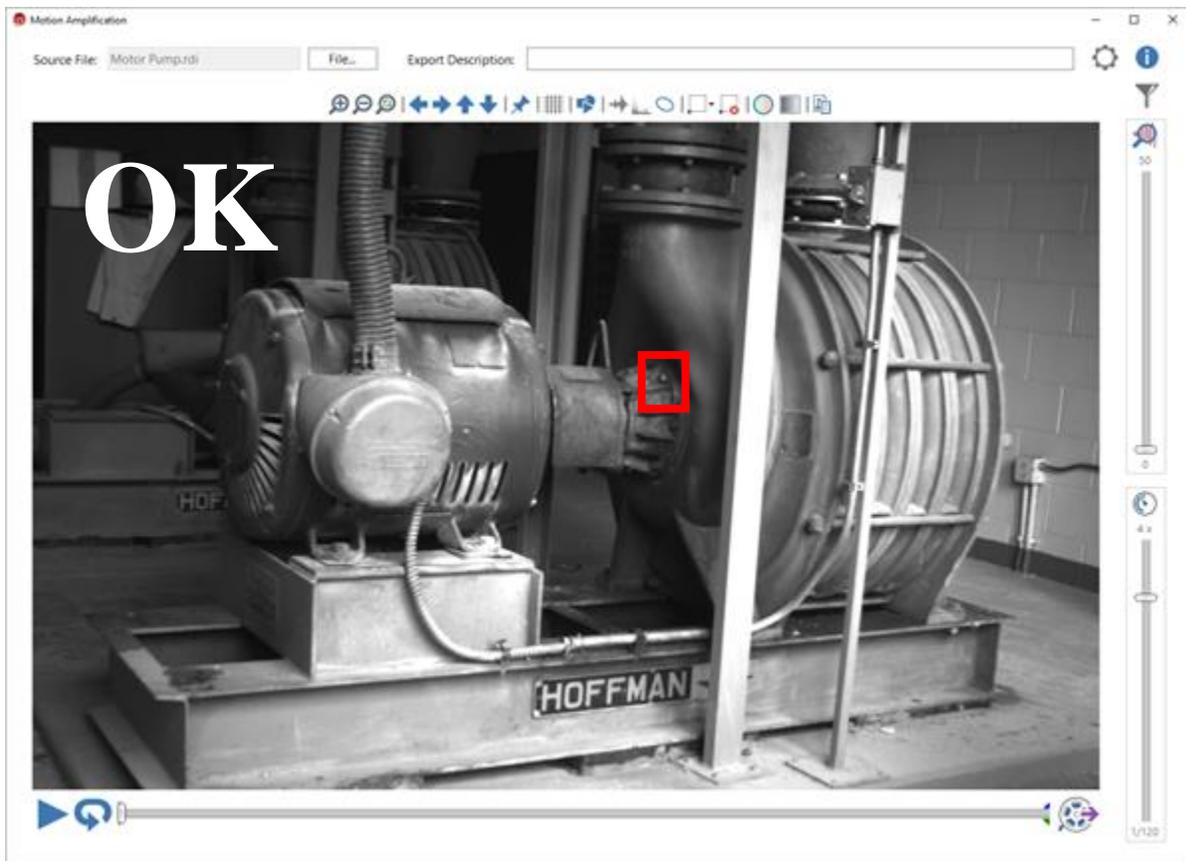


IMPORTANT

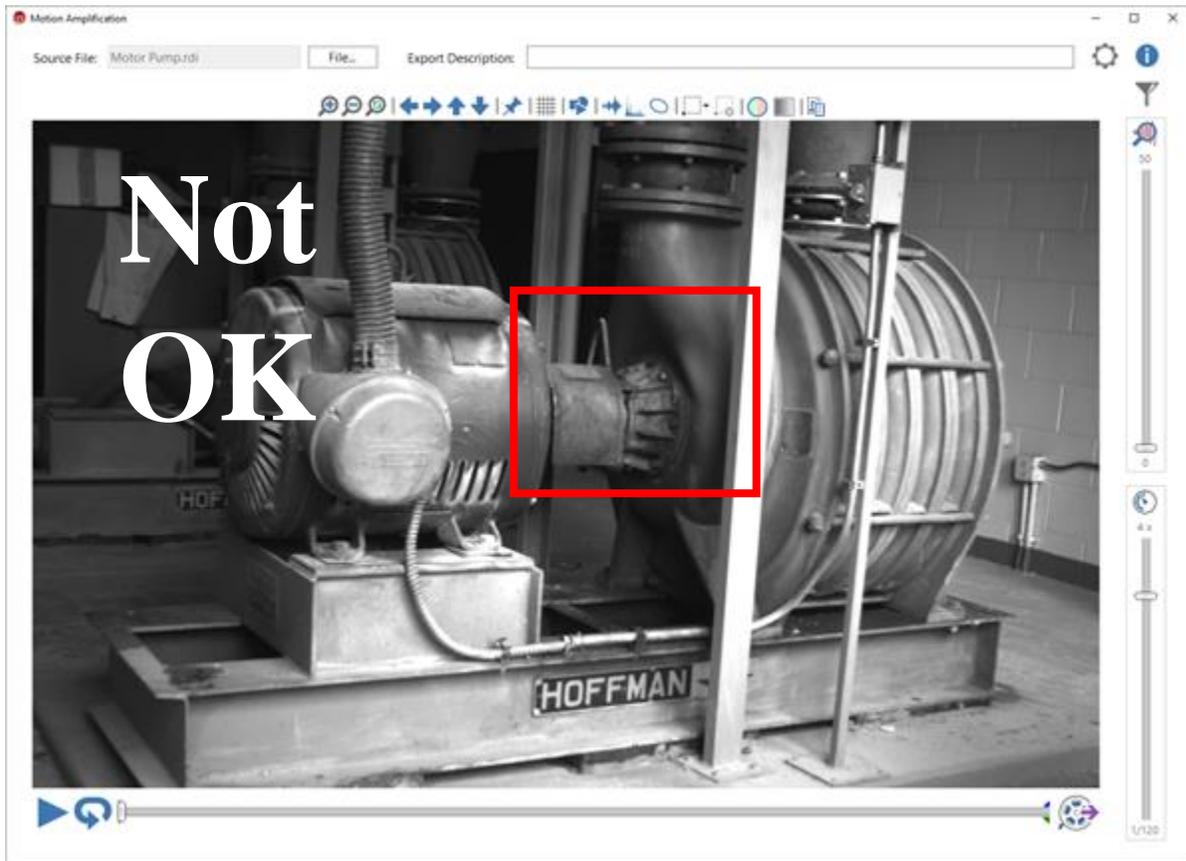
It is important to understand the basics of drawing an ROI to return an accurate time waveform. The ROI should only be drawn over a region for which you are interested in measuring. If the ROI shares an area with two different objects that are moving differently there is no guarantee which object the time waveform represents. Therefore, care must be taken in drawing the ROI. The time waveform measurement cannot be made over a uniform surface, some level of contrast must be present for the software to “see”. This means some level of contrast must be present in the ROI for proper measurements and alternatively this makes it possible to draw an ROI over an edge of an object that has a uniform background.

Examples

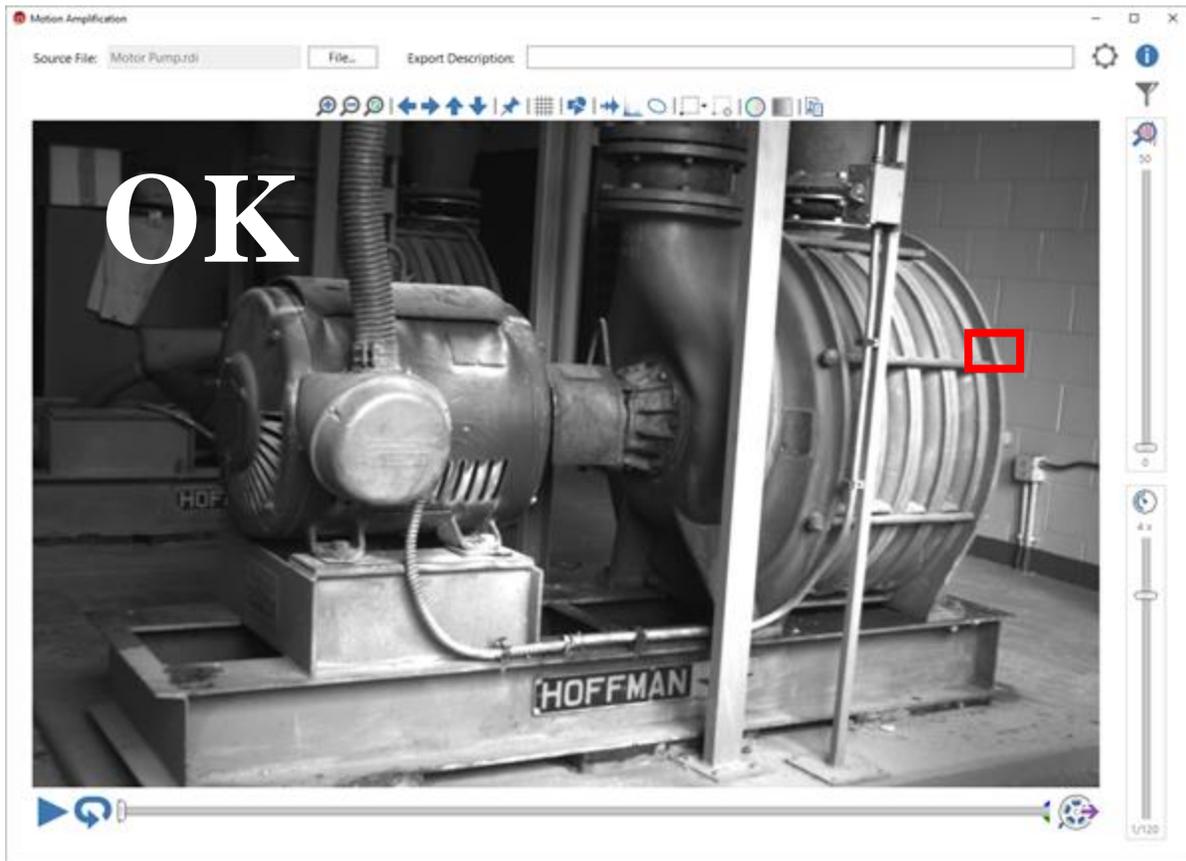
In the following image the ROI is drawn on a very small piece of machinery. It is suitable for the software to select any location in the box to measure from.



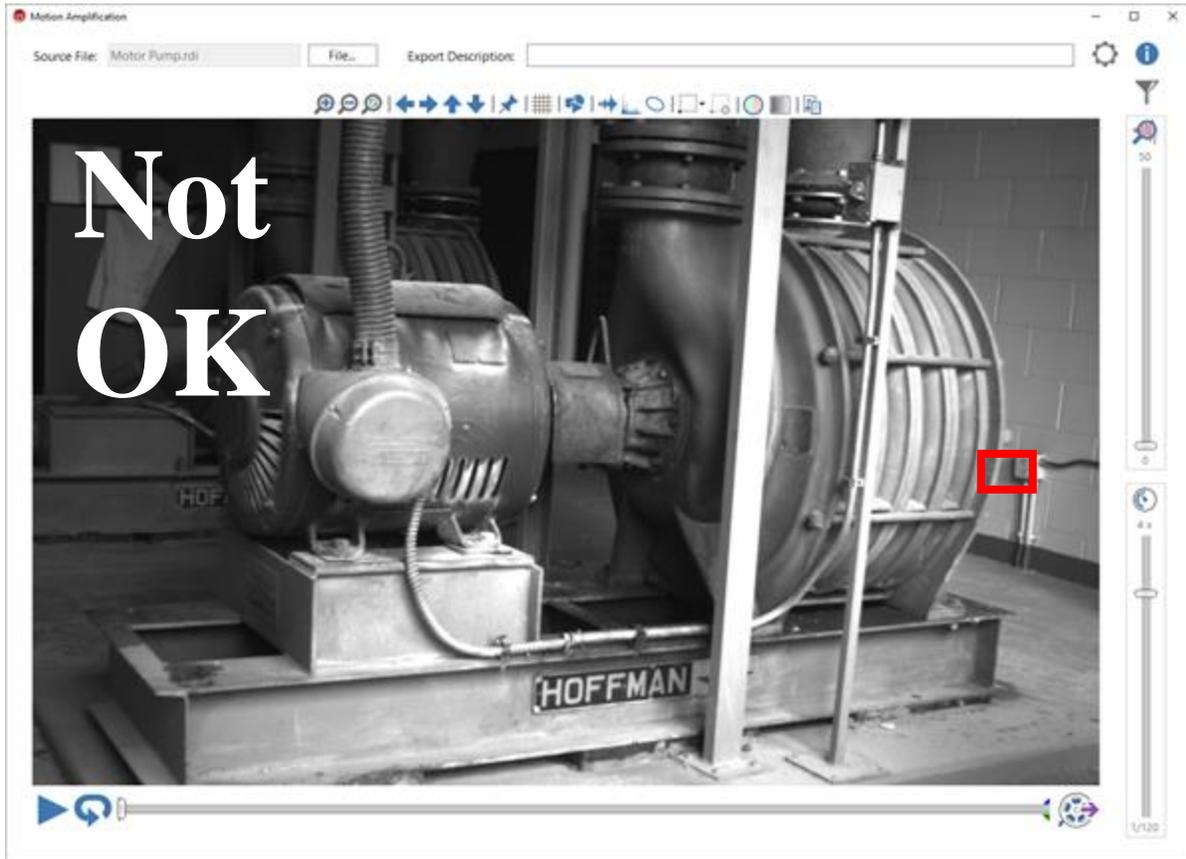
In the following image the ROI is much bigger. This is undesirable because the software may choose any location within the ROI from which to measure. There is uncertainty as to where the time waveform originates.



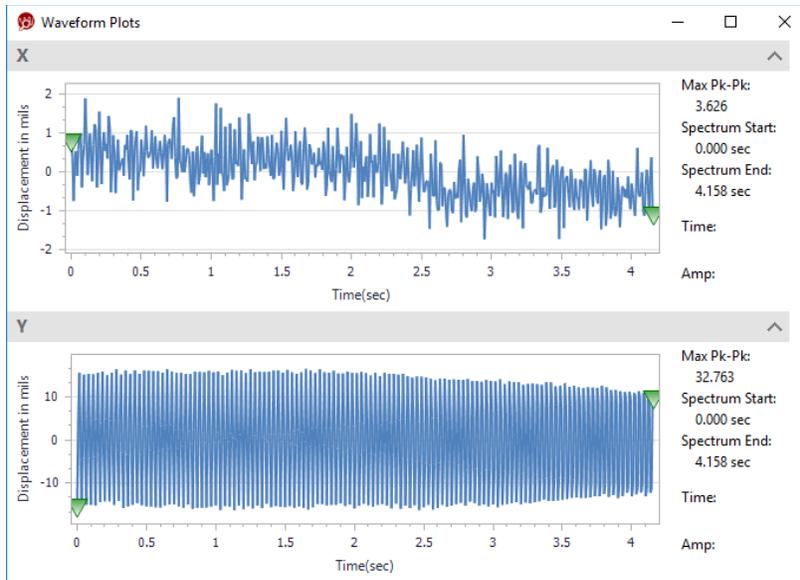
In the following image the ROI is drawn on the edge of the machine, however the background is uniform while the machine has contrast. The user can be confident the software will measure on the machine.



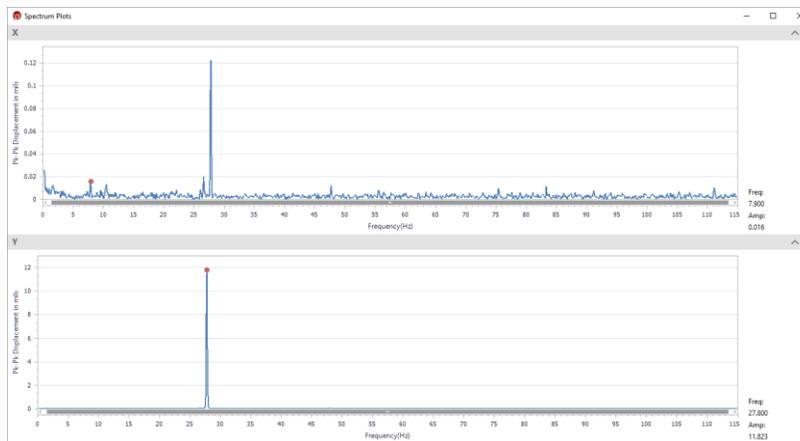
In the following image the ROI is drawn on the edge of the machine but in this case there is contrast in the background. This is undesirable as the software may measure the machine or background.



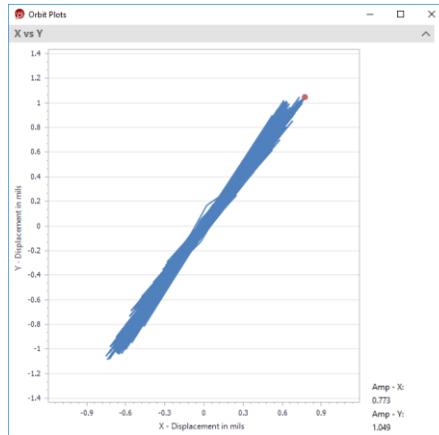
Below are examples of the Time Waveform, Spectrum, and Orbit plots. The software measures both the X and Y direction as seen from the camera. For the Time Waveform and Spectrum plots, the X direction is shown in the top plot of each image while the Y direction is shown in the bottom plot of each image. The Orbit plot includes measurements from both the X and Y directions.



Time Waveform Plots



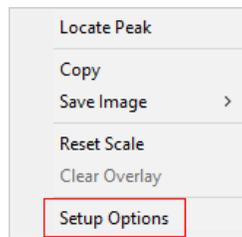
Frequency Spectrum Plots



Orbit Plot

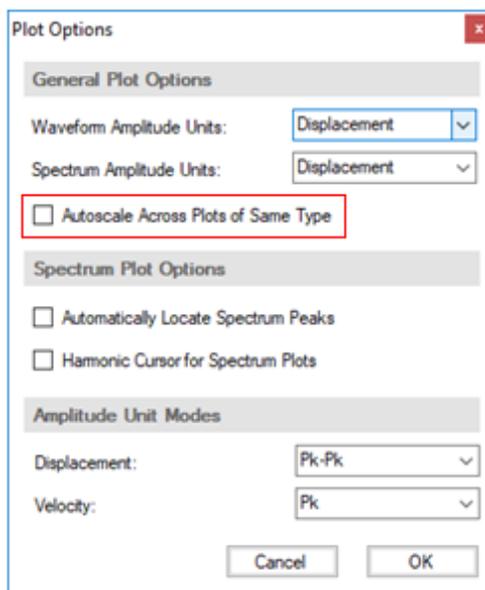
2.5.2 General Plot Options

The waveform, spectrum, and orbit plots all provide access to plot-related preferences via the “Setup Options” context menu item.



2.5.2.1 Autoscale Across Plots of Same Type

The default amplitude scaling behavior is for the amplitude axis for all plots to be scaled independently. This option allows the user to change that behavior such that all plots of the same type are scaled to the same maximum amplitude value.

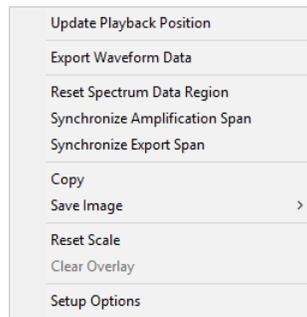


2.5.3 Time Waveform Plots

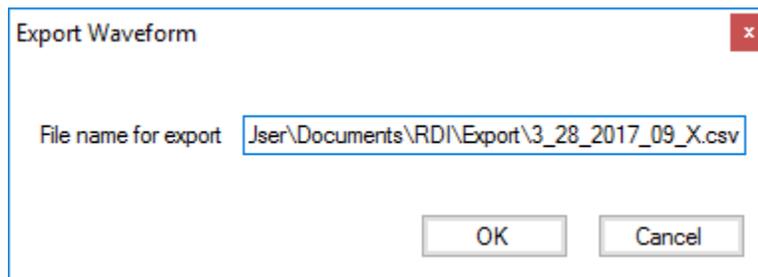
The Time Waveform plots the displacement (Y-axis) as a function of time (X-axis) over the time period the measurement was made. The available amplitude units are thousandths of an inch (mils) or microns (μm) for displacement.

The Time Waveform Plot displays the maximum peak-to-peak values on each waveform on the upper right corner of the plot. The lower right corner displays the information at the cursor position. The cursors may be moved by moving the mouse over the waveform and left clicking. The values of time and amplitude for that location are then updated in the lower right corner of the plot. The cursor location can be fine adjusted by using the right and left arrows keys to move the cursor one increment at a time.

Clicking the right mouse button in the context of a time waveform plot exposes additional functionality.



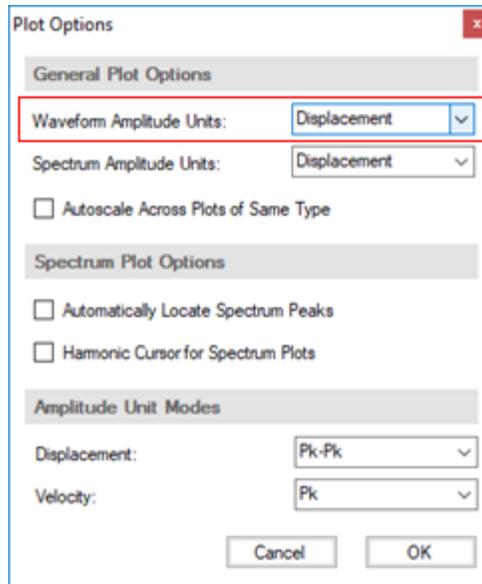
The Export option will send the data samples of the selected waveform to a “.csv” file. This file format can be easily imported to Microsoft Excel or other software applications for further data manipulation. Once this option is selected, a dialog is displayed that allows the user to specify the file name for the exported data.



An option to Copy the current plot to the clipboard is also available in the plot’s context menu. When this option is selected, a bitmap representing the current plot is placed in the Windows clipboard. Once the plot is in the clipboard, the image can be pasted into many other applications such as Microsoft Paint or Microsoft Word.

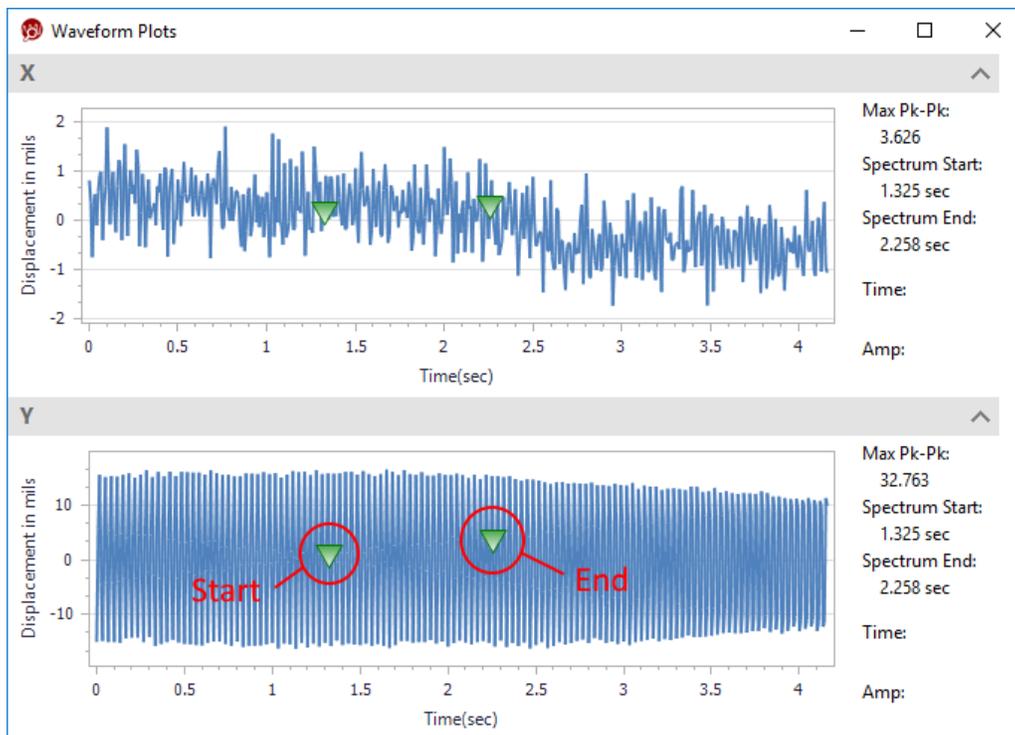
2.5.3.1 Waveform Amplitude Units

The Time Waveform plot can be shown in units of velocity by right clicking the graph. From the menu select “Setup Options”. A configuration screen will display, shown below, that allows a choice between displacement or velocity on both the Time Waveform and Spectrum. If velocity is selected the Time Waveform is differentiated to determine velocity. Available units are inches per second (in/s) or millimeters per second (mm/s). Imperial or metric units can be changed under the Settings menu in the upper right corner of the Motion Amplification Software.



2.5.3.2 Time Span for Spectrum Plots

The waveform plots allow the user to specify the start and end position of the time span that is to be used to construct the spectral plots. The start and end indicators are represented by the inverted green triangles shown in the image below. These indicators can be dragged with the left mouse button to change the span from which spectral data is calculated. The spectrum plots will be updated dynamically as the span is changed. The start and end times are displayed in the upper right corner of each waveform plot.

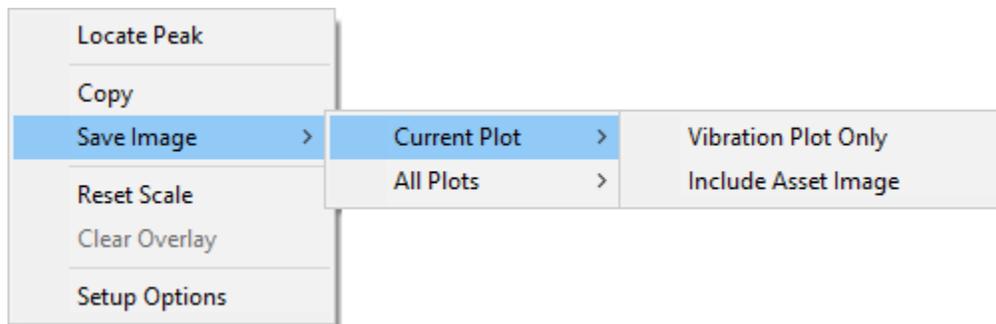


2.5.3.3 Update Playback Position

The video playback can be adjusted so the video shows the exact moment that corresponds to a specific sample in the time waveform. The user can right click at a point in the time waveform and click Update Playback Position. The video will then adjust to that specific time as well. This is helpful to easily observe what is happening in the video for a specific event in the time waveform.

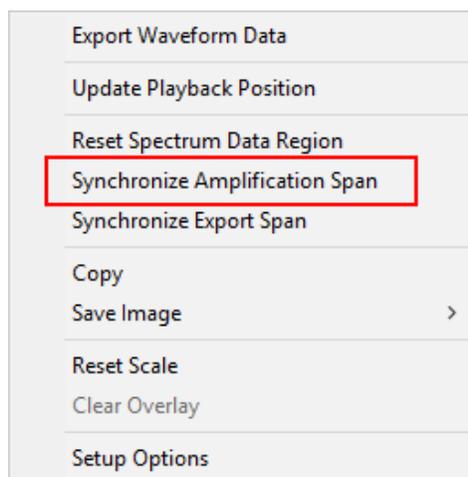
2.5.3.4 Save Image

The user can save an image from the video along with the corresponding plots. The user can right click on a plot and choose Save Image. From there the user has the option for either Current Plot or All Plots. For both of these selections the user can choose whether the resulting image should only include the vibration plot(s) or if the asset image (with the measurement locations indicated) should also be included. If one of the two options under Current Plot are chosen, only the selected plot is displayed. If the user selects one of the options under All Plots, all displayed plots are saved in the resulting image. All data is saved as an image file and automatically imported into Motion Explorer if the recording is associated with a Collection and Asset. See Section 0.



2.5.3.5 Synchronize Amplification Span

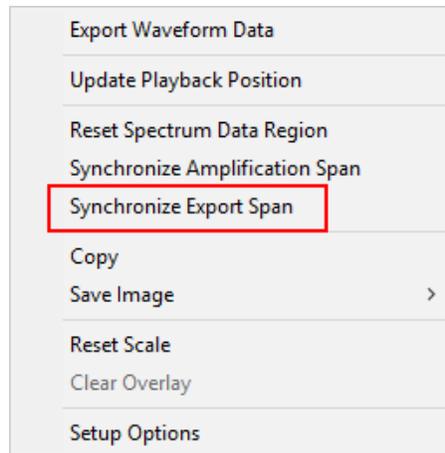
There is an option in the waveform context menu to “Synchronize Amplification Span”. This will take the span defined by the green start/end indicators on the waveform (also used to determine the span used for calculating spectral data) and set the span that is to be used for amplification in the main Motion Amplification playback window to this same time frame. The consequence of this is that the amplification span can be set graphically using the content in the waveform plot.





2.5.3.6 Synchronize Export Span

There is an option in the waveform context menu to “Synchronize Export Span”. This will take the span defined by the green start/end indicators on the waveform (also used to determine the span used for calculating spectral data) and set the span that is to be exported in the main Motion Amplification playback window to this same time frame. The consequence of this is that the export span can be set graphically using the content in the waveform plot.

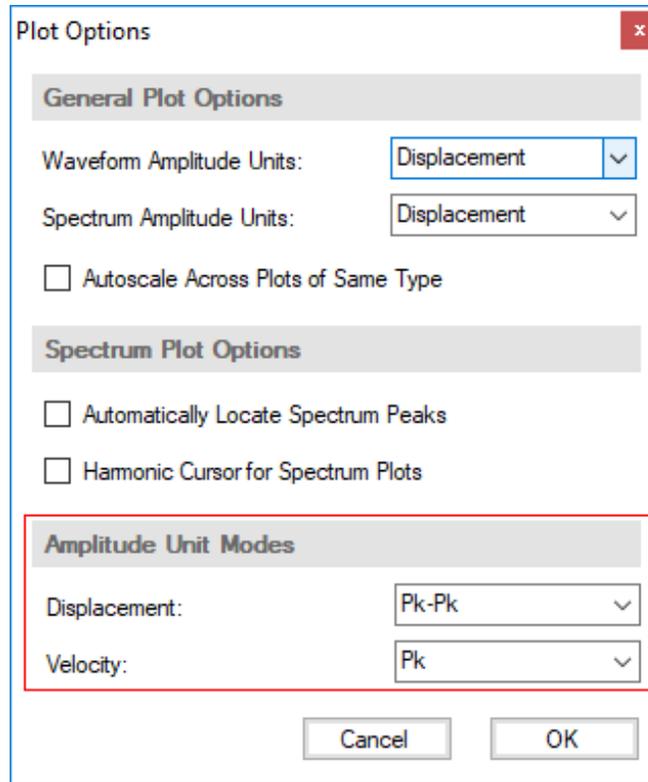




2.5.4 Frequency Spectrum Plots

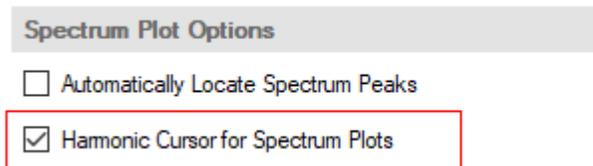
The frequency spectrum is determined from the time waveform by process of the Fast Fourier Transform (FFT). All spectra have a Hanning Window applied to them by default. This window gives a good representation of both amplitude and frequency. The lower right hand corner displays the information at the cursor position. The cursors may be moved by moving the mouse over the spectrum and left clicking. The lower right hand values of frequency and amplitude for that location are then updated. The cursor location can be fine adjusted by using the right and left arrows keys to move the cursor one increment at a time. A peak locate feature is available to determine peak locations and amplitudes more accurately. This feature can be enabled to automatically locate peaks by left clicking the spectrum and selecting "Setup Options", then check the box to automatically locate peaks. The software will automatically locate a peak if it is near a peak. The information indicated in the lower right hand corner of the spectrum window will be updated with the located peak information. When a peak has been located, a triangle will be shown in the spectrum at the extrapolated peak location, indicating peak locate is active. Alternatively, the user can choose to manually locate peaks without it being automatically activated by selecting a location close to a peak and right clicking and selecting "Locate Peak". Again, a triangle will be shown when peak locate is active.

From the Plot Options screen, the user can specify the amplitude unit mode for the displayed spectral data. The available options are RMS, Pk, and Pk-Pk, and the unit mode can be set independently for displacement and velocity.



2.5.4.1 Harmonic Cursor

The default cursor for spectrum plots is a single cursor. The “Harmonic Cursor” option allows the user to change the cursor type to a harmonic cursor. This cursor type shows additional cursors at integer multiples of the primary cursor’s frequency.

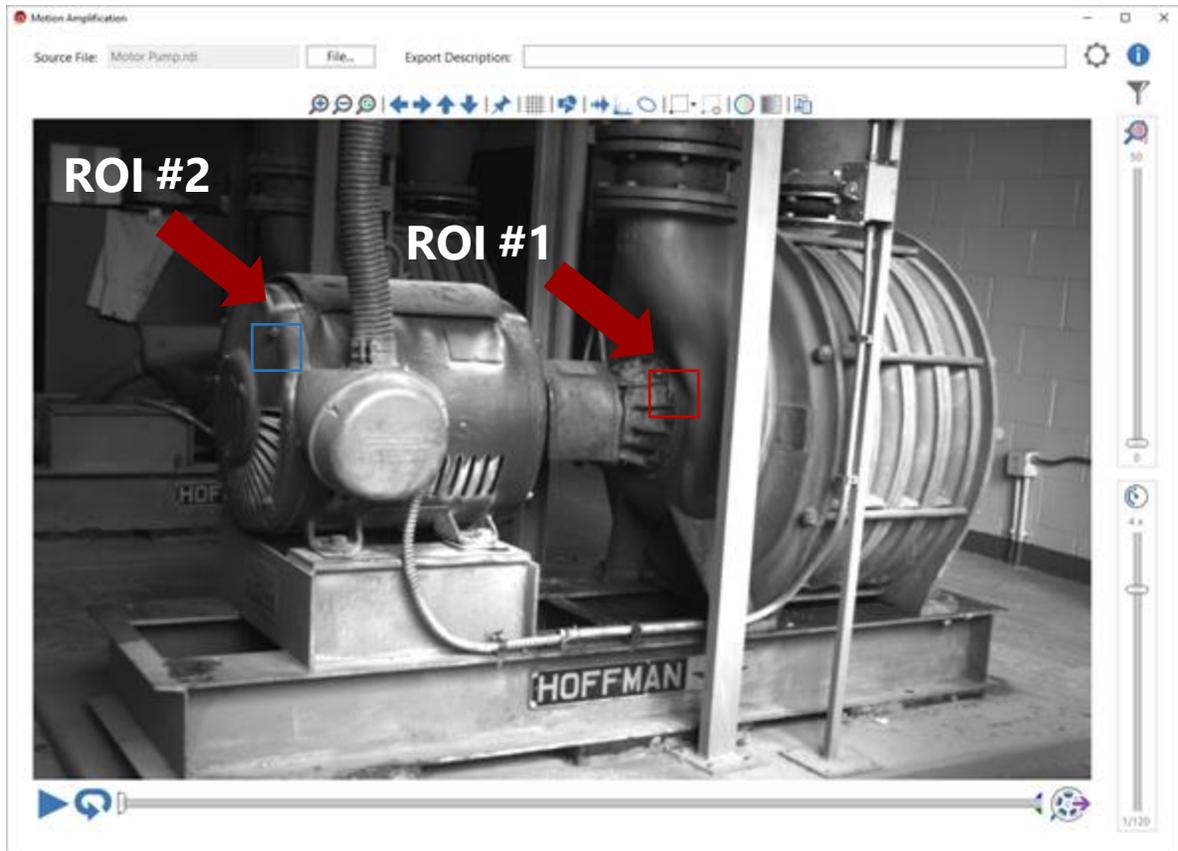


2.5.5 Orbit Plots

An orbit plot combines the vibration in both the X and Y directions into a single plot. The X and Y waveforms consist of a sequence of data samples, and for each data sample the X and Y measurements are collected at the same time. The orbit plot takes each of these data samples and plots the value from the X waveform on the X axis and the value from the Y waveform on the Y axis. So the resulting data trace follows the X-Y motion over time. The available units are thousandths of an inch (mils) or microns (μm) for displacement.

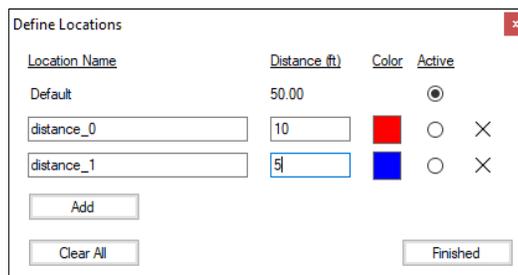
2.5.6 Measuring Multiple Locations Simultaneously

Multiple locations can be measured for displacements within the video. To do this, simply draw a second ROI. This process can be continued for multiple ROI’s. The image below shows the interface when two ROI’s are drawn.



2.5.6.1 Using Multiple Distance for Multiple Measurements

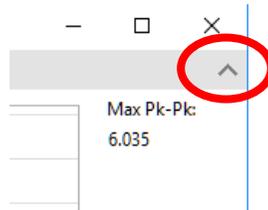
At times the user may want to make displacement readings for locations in the image that are at different distances from the camera. It is important to know the distance from the camera to the object being measured to ensure an accurate displacement. The user can load different distance measurements for different locations in the image. To do so the user can click the Distance Pin  in Motion Amplification. This will launch a Define Locations Window as shown below that will allow the user to select different active distances. Once a distance is selected all measurements will be made with that distance until it is changed. All previous measurements are unaffected if a new distance is selected. This allows multiple displacements measurements to be made at different distances. Distance can also be added in Motion Amplification.



2.5.7 Advanced Plot Features

2.5.7.1 Collapsing Plots

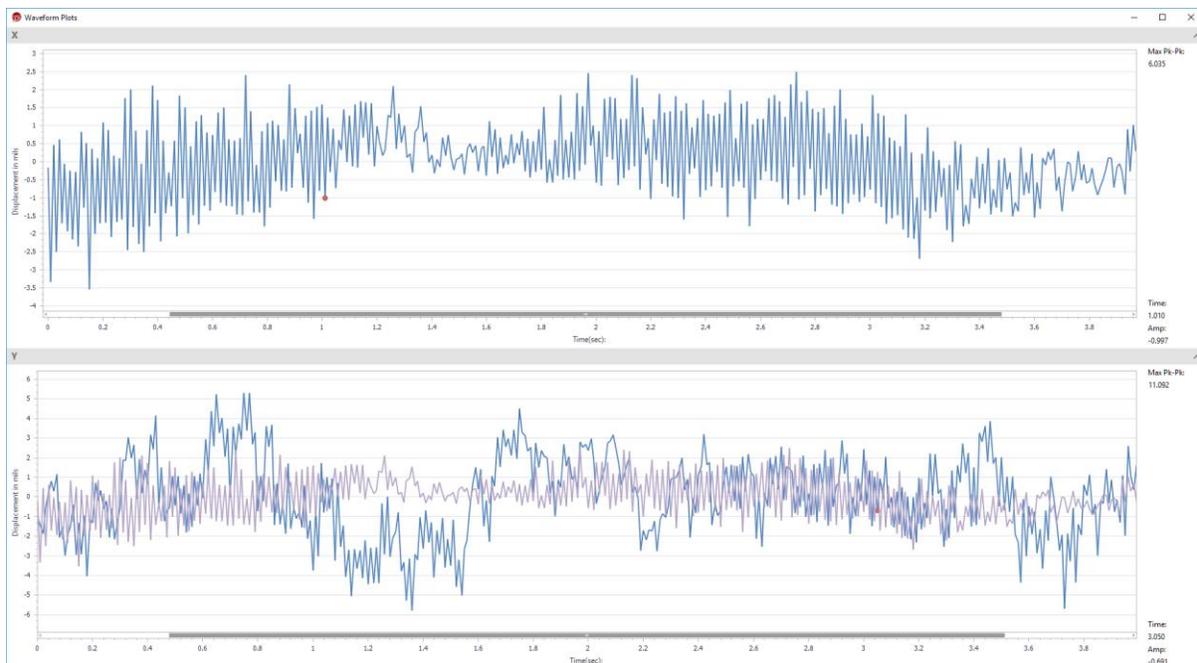
When multiple ROIs are drawn, each ROI has both an X and Y component. This can quickly fill the screen with Time Waveform and Spectrum plots. Each plot is collapsible making it easy to keep plots from taking up space on the screen. To collapse a plot simply click on the caret symbol “^” in upper right hand corner of the plot.



To un-collapse the plot click the carrot symbol a second time.

2.5.7.2 Plot Overlays

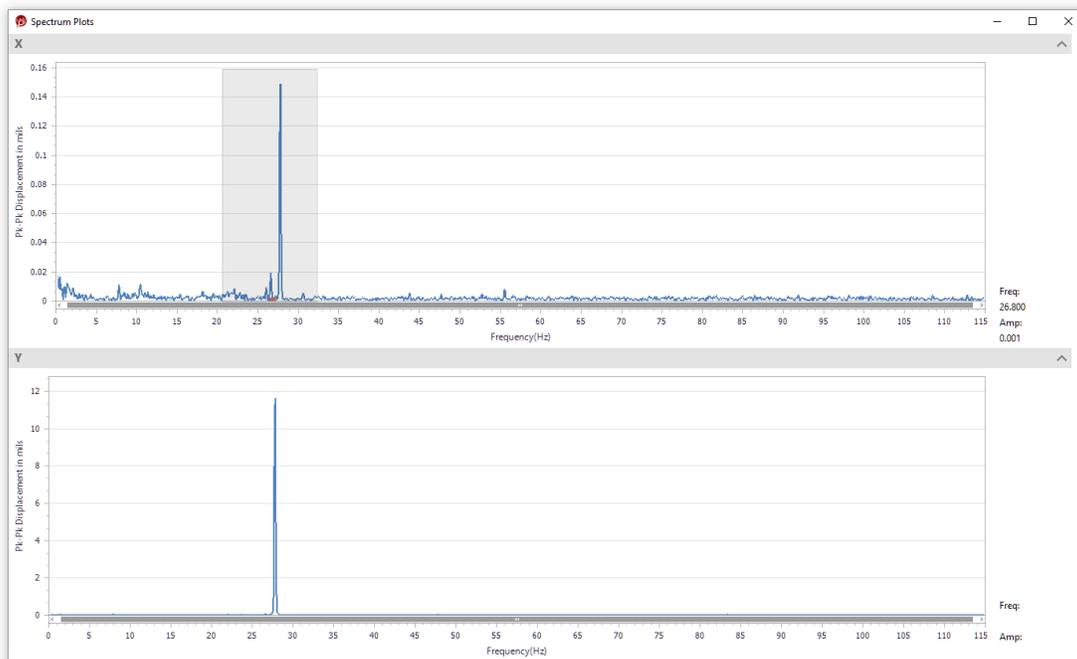
Plots can be overlaid onto one another for comparison. This is done by right clicking and holding on a plot. Then dragging the mouse until you are on the plot you would like to overlay onto. Then the user releases the mouse and the initial plot you clicked on is now overlaid onto the plot you dragged it to. To remove the plot simply right click and click “*Clear Overlay*” from the menu. Below are examples of the Time waveform and Spectrum showing overlaid plots. This feature is available for Time Waveform, Spectrum, and Orbit plots.



2.5.7.3 Plot Zooming

Zooming in and out of a plot can be achieved by scrolling forward and backward respectively with the center mouse wheel to zoom in and out. The plot scaling can be reset at any time by right clicking and choosing “Reset Scale” from the menu.

Sections of the plot can be zoomed to fill the entire plot region. This is accomplished by holding the shift key while the mouse is on a plot. Then with the shift key held, the user left clicks and drags the mouse over the region to zoom and fill the plot. The user then releases the mouse button and the plot zooms. The image below shows the plot appearance as the user drags over a region to zoom. The shaded area shows the area in which the plot will be zoomed.



2.5.8 Oversampling Aliasing Reduction

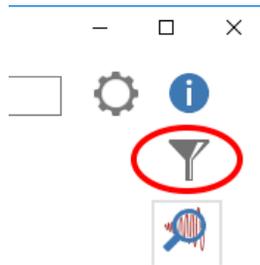
To eliminate aliasing of high frequency content into the lower frequency range, the acquisition software employs the method of oversampling. This method of antialiasing filter works by sampling at a much higher frequency range than that of interest. The frequency content above the frequency of interest or F_{max} that is resolved in the FFT is rejected reducing the chance that a higher frequency component will alias into the lower frequency spectra displayed.

3 Filtering

The Filtering functionality in the Motion Amplification software allows users to amplify certain frequencies that are present in the vibration data extracted from a recording. If filtering is not applied to a recording during the amplification process, all of the motion that is present is amplified. So assuming multiple frequency components are present, the user may choose to amplify the motion of any specific frequency that is present or the motion associated with multiple frequencies may be amplified. When filtering is applied to a recording, the original recording is not altered. Instead a new recording is created.

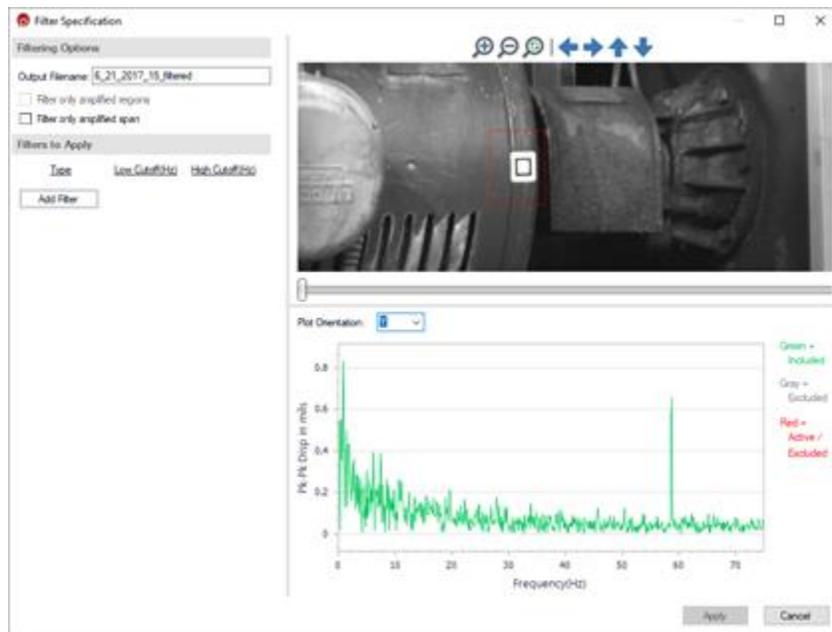
3.1 How to Apply Filtering

Filtering functionality can be accessed from the Motion Amplification main window via the filtering button shown below.



3.2 Filtering Interface

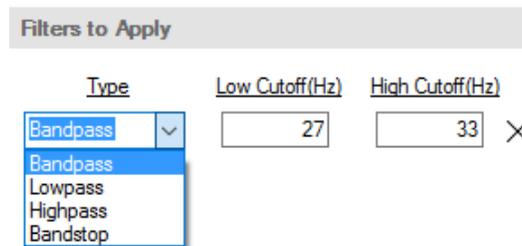
Once this button is pressed, a filtering-specific dialog is displayed. It includes the name for the filtered recording that will be created when the Apply button is pressed. A section of the dialog is present for the filters that will be applied to the recording. In the upper right corner, an image viewer window is also included. It shows an image from the original recording and allows the user to step through the recording. The user can draw an ROI on the image to calculate displacement for that region. In the lower right corner, a spectrum plot will display the frequency data from the displacement calculations.



3.2.1 Filters to Apply

Once the Add Filter button is pressed, a filter will be displayed. It will default to a bandpass filter, and it will have a default low and high cutoff. The options for filter type include Bandpass, Lowpass, Highpass, and Bandstop. A bandpass filter will only allow frequency content between the low and the high cutoff to be amplified. All other frequency content will be excluded from amplification. A lowpass filter will only allow frequency content below the high cutoff to be amplified. A highpass filter will only allow frequency content above the low cutoff to be amplified. A bandstop filter will exclude frequency content between the low and the high cutoff limits, and all other frequency content will be amplified. Multiple filters may be added to ensure that only the desired frequency content is amplified.

Note: In order for a frequency to be amplified, it must be allowed by ALL of the defined filters. If any of the defined filters exclude a frequency, it will not be amplified. This is the reason that the user interface only allows one bandpass filter, one lowpass filter, and one highpass filter.



Type	Low Cutoff(Hz)	High Cutoff(Hz)
Bandpass	27	33 X

3.2.2 Image Viewer Window

The image viewer window in the filter specification interface allows the user to draw an ROI for which displacement calculations are performed. Once an ROI is drawn and the calculations are complete, the spectrum plot is populated. Different ROI's can be drawn to understand the different frequencies that are present at different locations in the image. The slider below the image viewer represents the entire duration of the recording, and moving the slider's position will update the image appropriately.

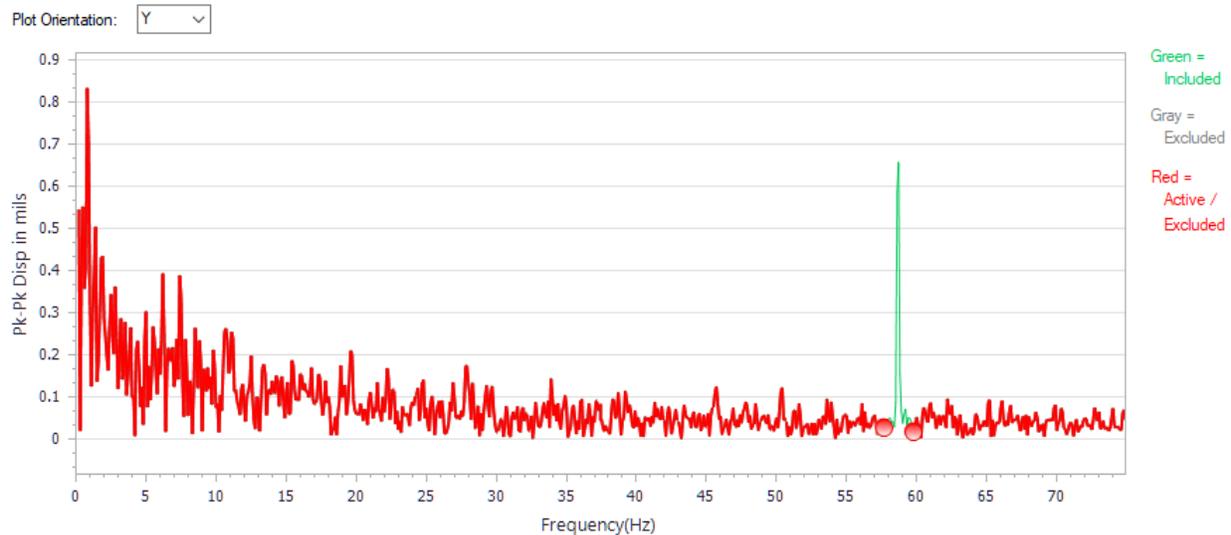


3.2.3 Spectrum Plot

Once an ROI is drawn in the image viewer window, the spectrum plot will be populated. In the upper left corner of the spectrum plot, the user can choose whether to display the spectrum from the X direction or

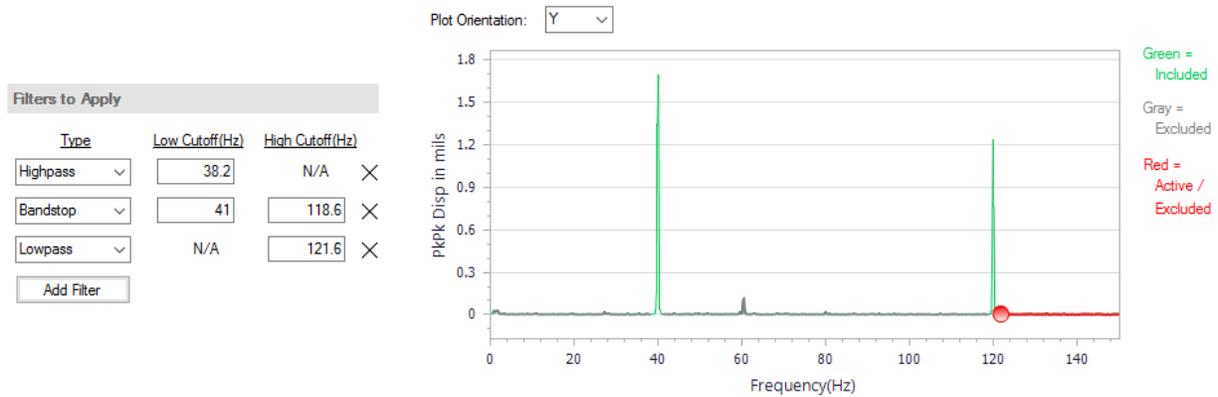
the Y direction for the current ROI. The spectrum plot provides a graphical means to specify filters appropriately relative to the frequency content that is present and what is desired to be included in amplification. The frequency content associated with the green portion of the spectrum will be included in amplification. The red portion of the spectrum indicates that it is associated with the current or active filter and will be excluded from amplification. To change the active filter, select a different filter in the list of filters to apply. Gray portions of the spectrum are also excluded, but they are excluded because of a filter other than the one currently active. Please see the next section for an example.

Cutoff frequencies for the active filter can be adjusted graphically by using a left mouse click and dragging the cutoff frequency handle (shown circled in blue below) to the left or right. The cutoff frequency value in the table of filters to apply will be updated when frequencies are adjusted graphically. To change the active filter, select a different filter in the list of filters to apply.



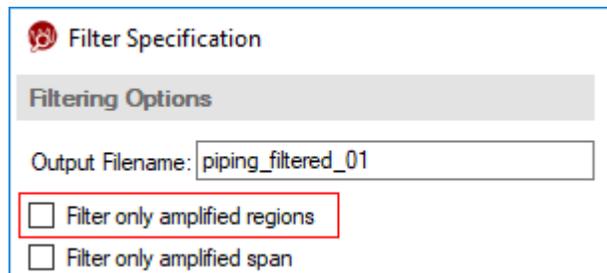
3.2.4 Example with Multiple Filters

Below is an example where the intention is to include the 40 Hz and the 120 Hz frequency content in the amplification process. Three filters are required. First, a highpass with a cutoff just below the lower frequency of interest. Second, a bandstop between the two frequencies of interest. Finally, a lowpass with a cutoff just above the higher frequency of interest. The green portions of the spectrum are the only frequencies that will be included in the amplification process.



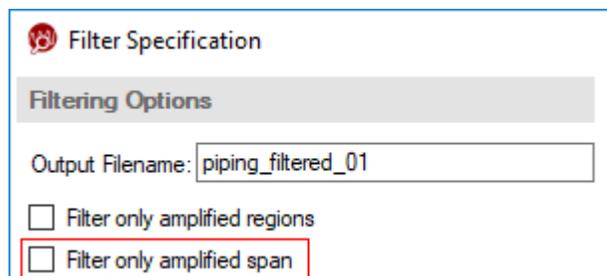
3.2.5 Filter Only Amplified Regions

An option is available to “Filter only amplified regions”. It is only available when amplification regions have been defined. If this option is NOT selected, filtering will be applied to the entire field of view, not just the pixels “included” by the amplification regions. If this option is selected, only pixels “included” by the amplification regions will have filtering applied. Only filtering included pixels can increase the processing time required for filtering. It can also prevent filtering effects (such as “smearing”) from showing up in regions that are not intended to be the focus of the video.



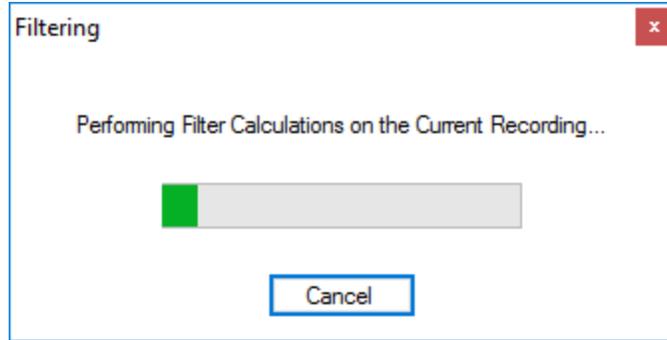
3.2.6 Filter Only Amplified Span

An option is available to only perform filtering on time frame identified by the amplification span. One effect of choosing this option is that the duration of the filtered recording will be trimmed such that it starts at the time specified by the amplification span start and ends at the time specified by the amplification end.

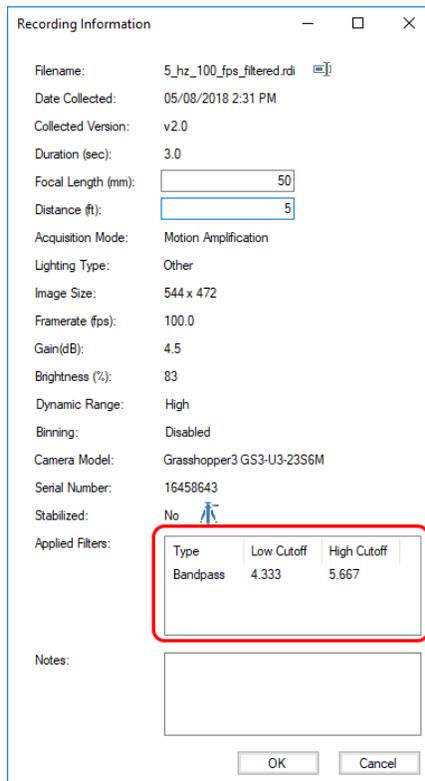


3.3 Applying Specified Filters to a Recording

Once the filters have been defined, press the Apply button. This will initiate the filtering process which results in a new recording. During the filtering process, the dialog below will be displayed.



Once the filtering process is complete, the new recording will be loaded. If the user looks at the recording information, the filters that have been applied are listed. See the image below for an example.



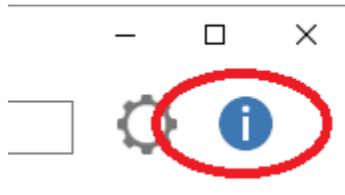
4 Stabilization

Stabilization offers the ability to digitally stabilize rdi recordings if camera vibration has been introduced into the video. Sometimes vibration makes it to the camera despite best attempts to eliminate it at the source.

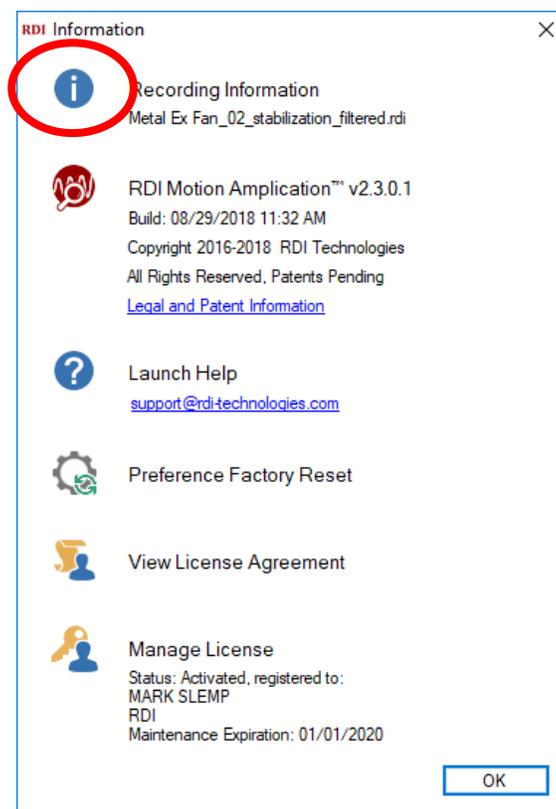
Note: Passive methods of stabilization are preferred. Always use the vibration pads and avoid vibrating surfaces as the first method of eliminating camera vibration. Digital stabilization is designed to be used only in cases where other vibration methods are not possible.

4.1 How to Stabilize

To stabilize a file press the info button at the top right of the Motion Amplification Analysis window.



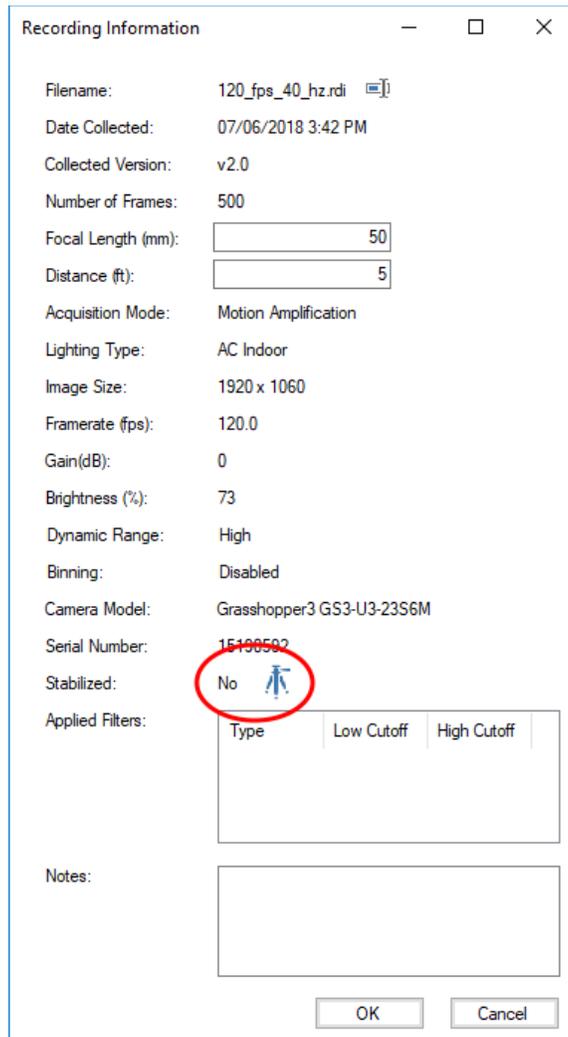
This will bring up the “RDI Information” window. Next press the recording information  button .



This will bring up the “Recording Information” window giving details about the file. One of the properties is “Stabilized”. This line indicates whether the recording has been stabilized.

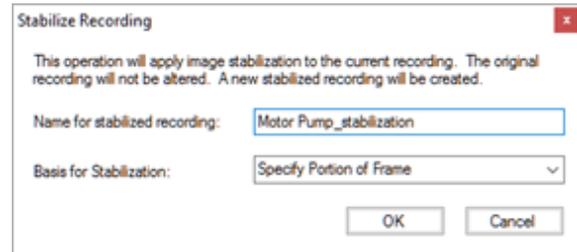
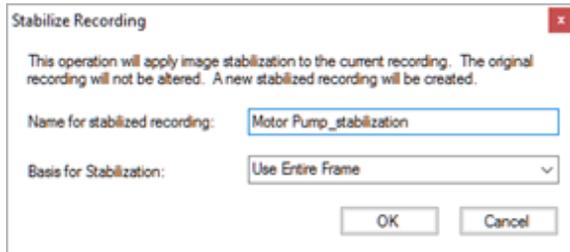
Note: A recording can only be stabilized once.

If the recording has not been stabilized this line will read “No” and the tripod icon will be blue, indicating the button is clickable. To stabilize the recording press the tripod icon.



After clicking the tripod icon, the “Stabilize Recording” window will be displayed.

When a file is stabilized, it creates a new stabilized .rdi file. The original file is not altered. The first entry box is where the new filename is entered. The second dialog box allows a choice of stabilization types. The user can choose between stabilizing the file based on the entire frame (default) or selecting a portion of the frame for stabilization



If “Use Entire Frame” is selected the file will proceed to be stabilized. Now see Section 4.3 Completed Stabilization.

If “Specify Portion of Frame” is selected see Section 4.2 Stabilize Based on a Portion of the Frame.

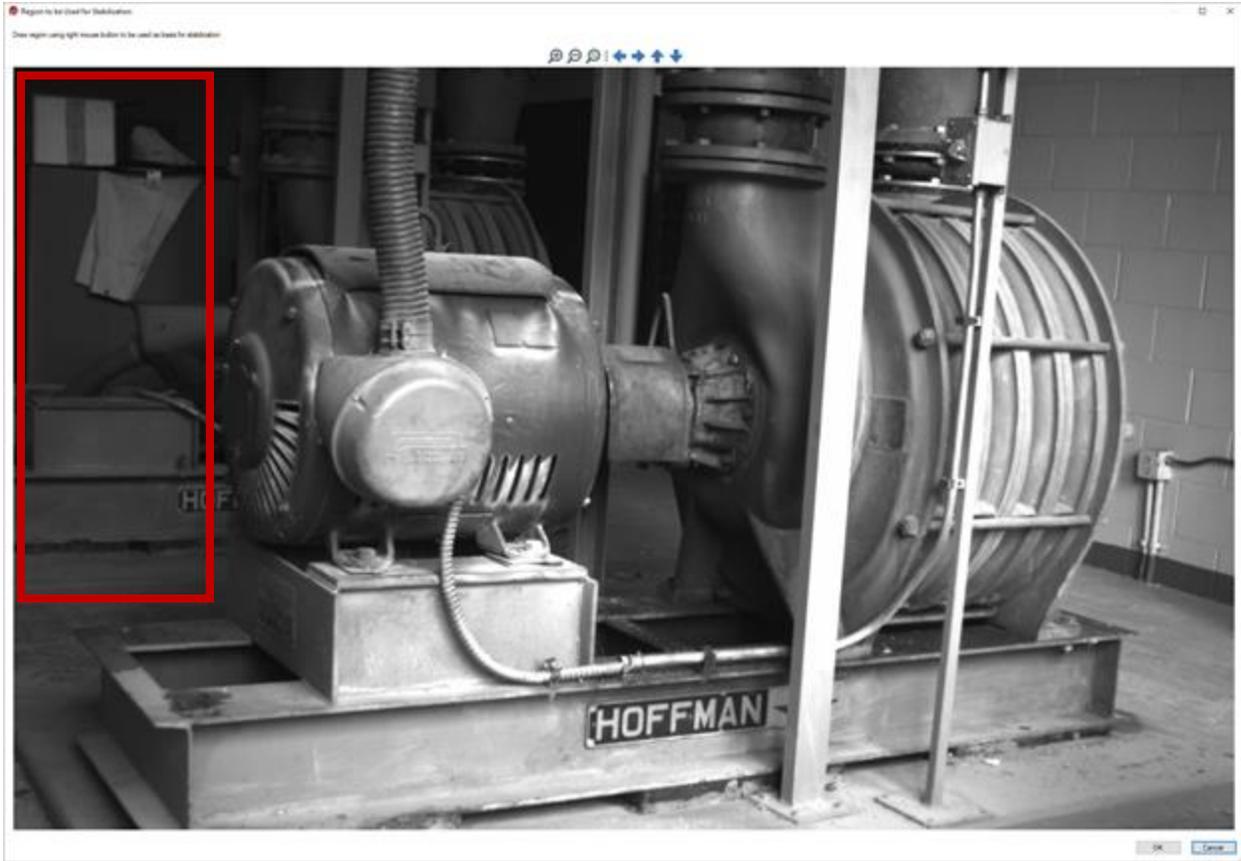
4.2 Stabilize Based on a Portion of the Frame

In some instances, the motion of the object of interest may dominate the frame and make it difficult to decide what is of interest and should be moving, and what is the background and should not be moving. In these instances, it may be useful to manually select an ROI in the frame in a region that should not be moving. The stabilization software can then better determine how to stabilize the motion of the camera.

Note: Do not select regions containing objects that are moving.

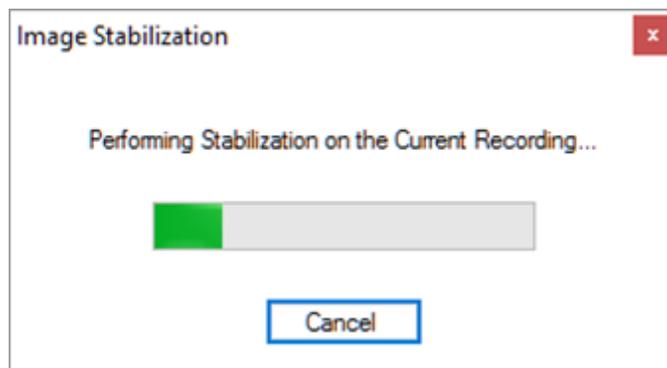
To do this, select “Specify Portion of Frame” from the “Stabilize Recording” window and select “OK”. A new window showing an image of the recording will be displayed. Now an ROI can be drawn on the image by right clicking and dragging the mouse. Once the appropriate ROI is drawn release the mouse button. If satisfied with the ROI click “OK”. If not redraw the ROI.

Once the OK button is pressed the software will now stabilize based on the ROI drawn. With this method, select regions of the image that are known to be stationary.

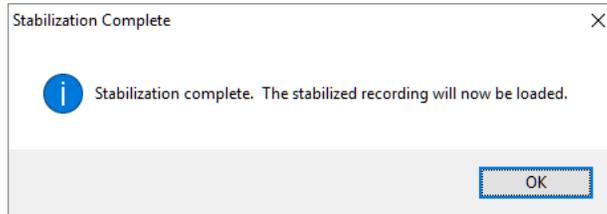


4.3 Completed Stabilization

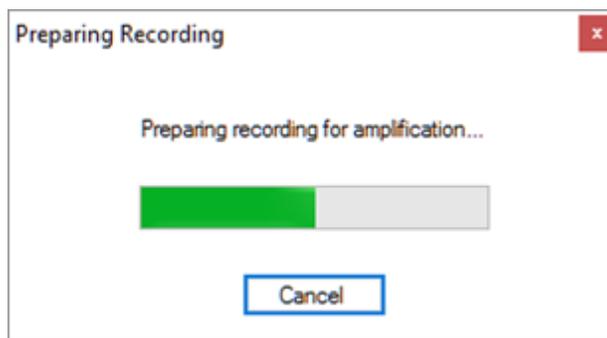
After either stabilizing from the entire frame or a portion of the frame, a progress window will appear indicating stabilization is occurring.



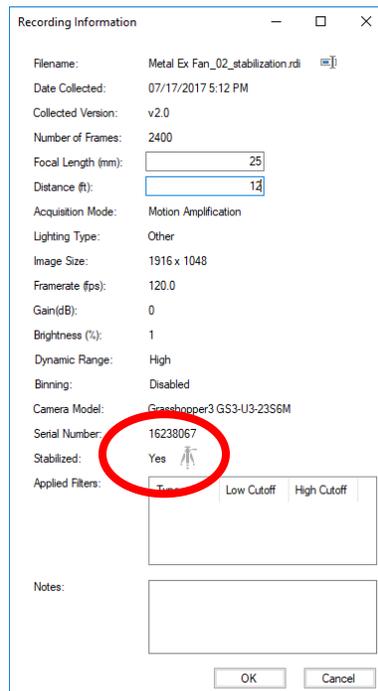
Once stabilization is complete a window will appear informing the user that stabilization is complete and the new stabilized recording will be loaded in the software. The original un-stabilized recording will be closed.



After closing the "Stabilization Complete" window the new stabilized file will be amplified.



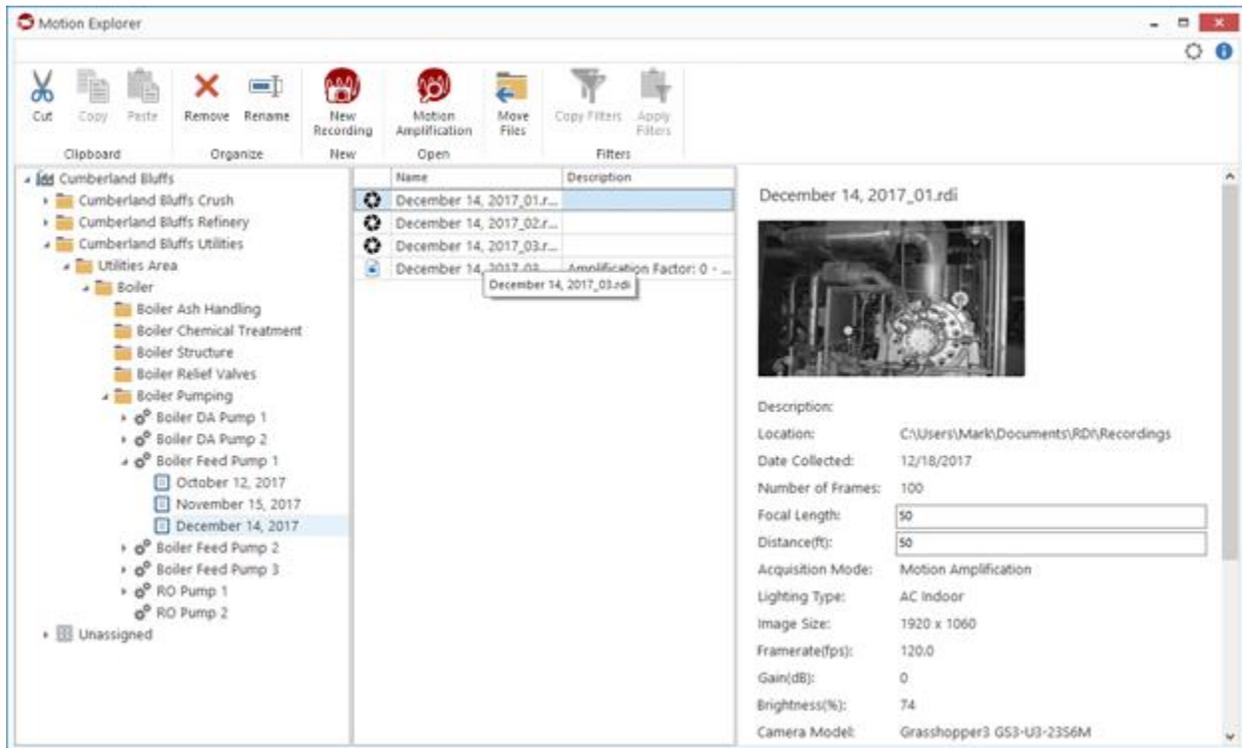
Once the stabilized recording is amplified, it is now ready to be viewed. The "Recording Information" window will still be open and must now be closed. Note: The Stabilized entry now reads "Yes" and the stabilization tripod icon now appears grayed and inactive, indicating the file can no longer be stabilized.



5 Motion Explorer

Motion Explorer allows you to create a hierarchy of folders and assets and organize your recordings, exported MP4 videos, and other files under the appropriate asset. Assets have one or more collections associated, and these collections are where recordings and exported MP4 videos reside.

When the RDI Acquisition application collects a recording, it will automatically be associated with the selected collection from the asset hierarchy. When Motion Amplification creates recordings as a result of filtering or stabilization, these recordings will automatically be associated with the same collection as the original recording. MP4 videos exported from Motion Amplification will also be associated with the same collection as the source recording.



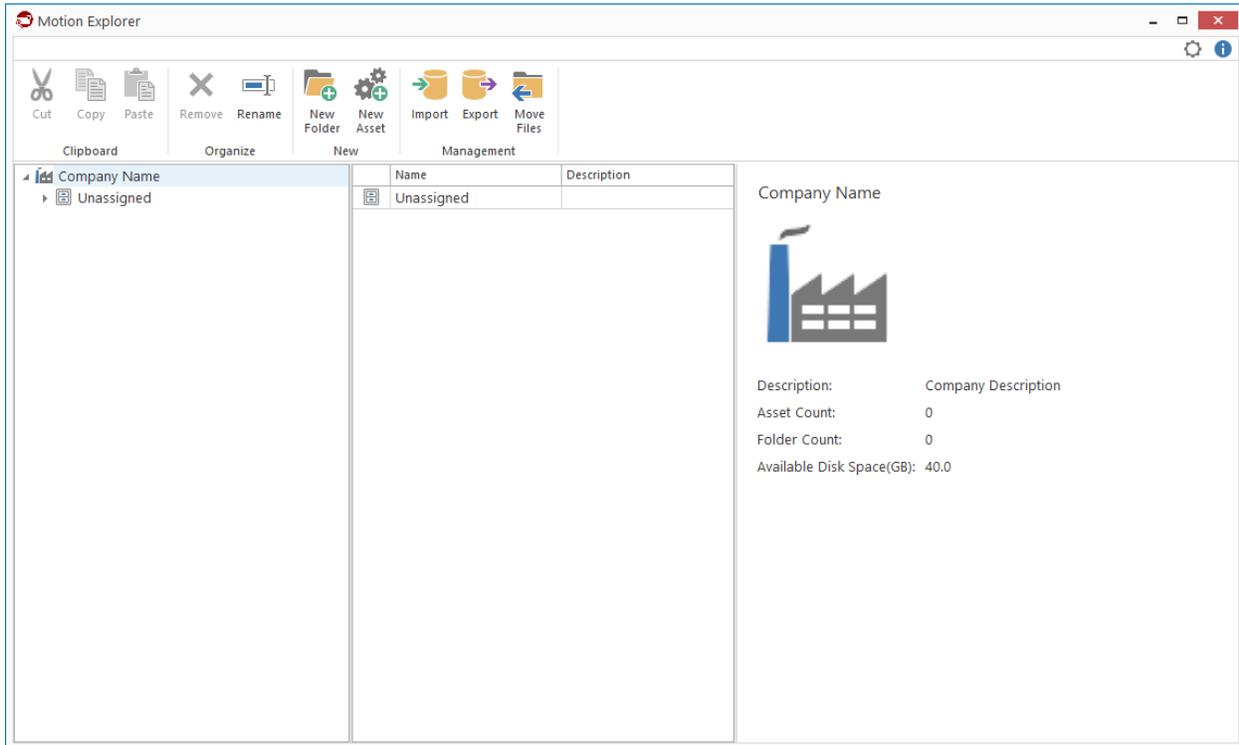
5.1 Levels in the Hierarchy

The highest level of the hierarchy is the company. You can rename this item to something appropriate for your organization. Under this highest item in the hierarchy, folders and assets can be added. Folders can contain other child folders or assets. Assets can only contain Collections. Collections contain recordings, exported MP4 videos, and other files. So one approach is to use collections to organize the data associated with a given survey of an asset. The collection name can be anything, and naming them with the data of the survey is one approach. So a given asset can have a collection for each survey that you perform.

There is also an Unassigned folder in the hierarchy. This may be used to hold collections that are not associated with a particular asset. Until a collection under an asset is selected in RDI Acquisition, all collected recordings will be associated with the default collection in the Unassigned folder.

5.1.1 Getting Started

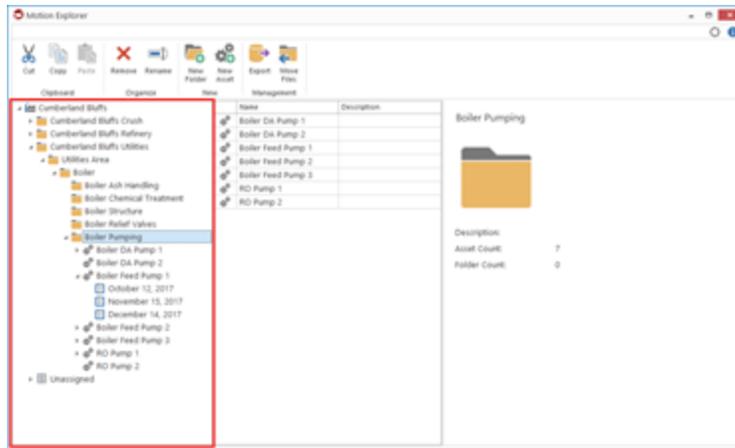
When you first install the RDI Software, you will have a hierarchy that only contains an item representing your company and an Unassigned folder. You can rename the company item to something appropriate for your organization. You can also add Folders and Assets to represent the logical organization of your facility or facilities. The recordings you collect and the MP4 videos that you export will be associated with the assets that you define. Please keep reading this manual to learn the details of building an asset hierarchy.



5.2 Parts of the Application

5.2.1 Left Pane

The left pane of Motion Explorer represents the asset hierarchy by using a tree control. You can expand any given item to see its child items. Individual recordings, exported MP4's, and other files are not shown in the left pane. The item in the tree shows the item's name. When an item in the left pane is selected, the applicable options for the selected item are shown in the ribbon control.



5.2.1.1 Drag/Drop to Reorganize Hierarchy

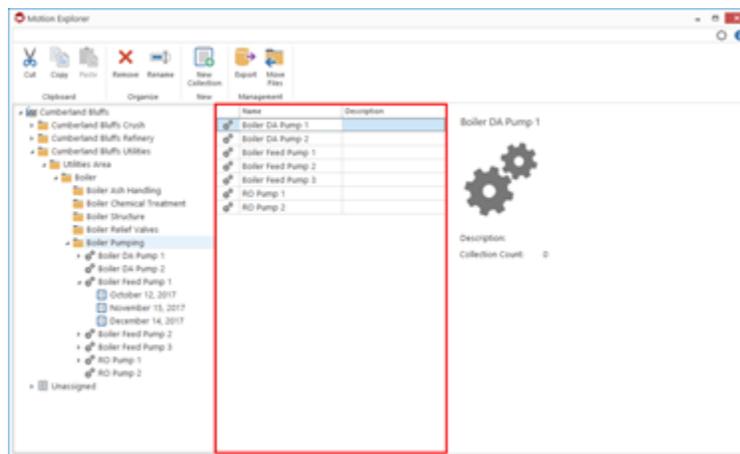
You can reorganize the items in the left pane by using the drag/drop mechanism also found in Windows File Explorer.

5.2.2 Middle Pane

The middle pane displays a list of items associated with the item selected in the tree. When an item is selected, the applicable options for the selected item are shown in the ribbon control.

Multi-select is supported in the middle pane. For example, you can select several items and choose to delete them all at once. Items can be dragged from the middle pane and dropped onto the left pane in order to move the items from one location to another.

To rename an item in the middle pane, once the item of interest is selected just click on the Name or Description that you would like to change. An edit cursor will be displayed in the text field and you are then free to change the text. Pressing the enter button or clicking anywhere other than the field being edited commits the changes. Pressing the Escape key will cancel the changes.

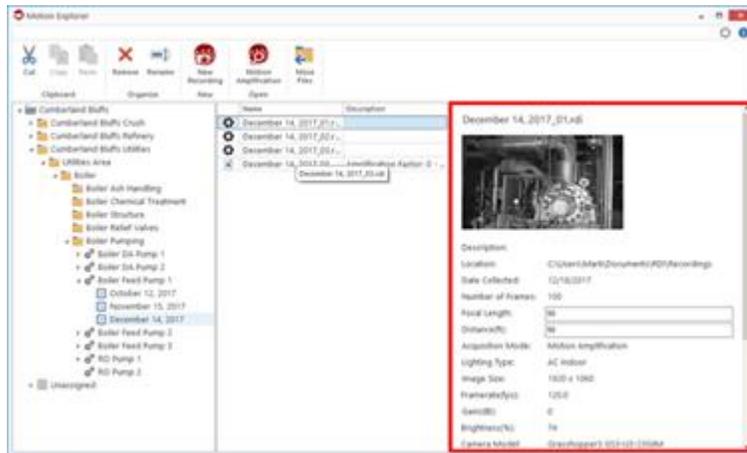


5.2.3 Right Pane

The right pane shows additional information about the selected item. The right pane is customized for the different types of hierarchy items.

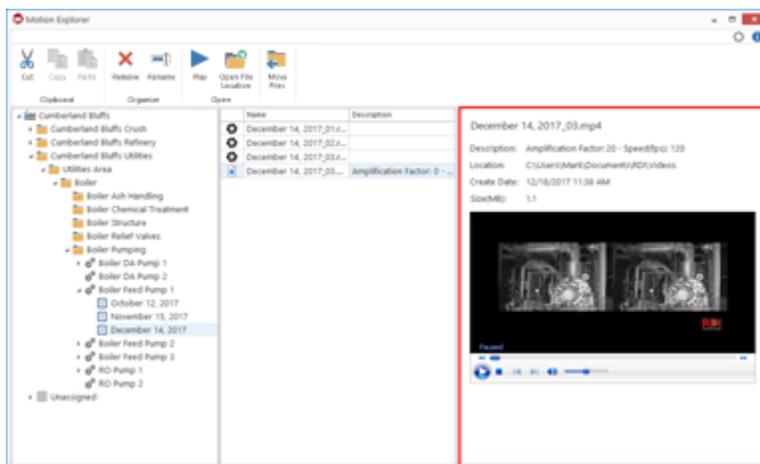
5.2.3.1 Recording Preview

When a recording is selected, a preview of the recording content is shown. The properties associated with the recording are also displayed. The focal length, distance, and notes may be edited in the right pane.



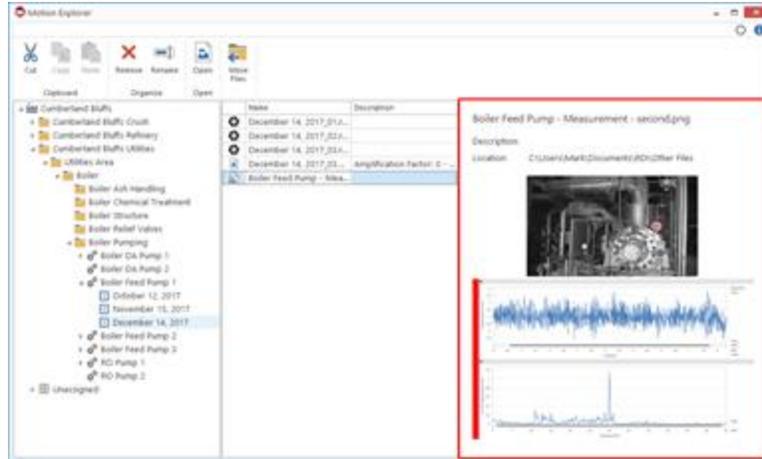
5.2.3.2 Exported MP4 Preview

When an exported MP4 is selected, the content of the MP4 is shown. It can also be played by pressing the play button.



5.2.3.3 Other Content

The content of PDF's and images is also displayed in the right pane of Motion Explorer.

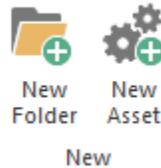


5.2.4 Ribbon Bar

The Ribbon Bar is context sensitive so it shows only the functions that can be performed on the currently selected item.

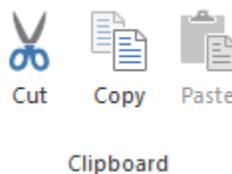
5.2.4.1 Add Items to the Hierarchy

When the Company item is selected, Folders and Assets can be added as children. When a Folder is selected, Folders and Assets can be added as children. When an Asset is selected, Collections may be added as children.



5.2.4.2 Cut/Copy/Paste

Items can be Cut and then Pasted to perform a move operation. Items can also be Copied and then Pasted to perform a copy operation. Recordings, exported MP4's, and other file type items cannot be copied from within Motion Explorer.

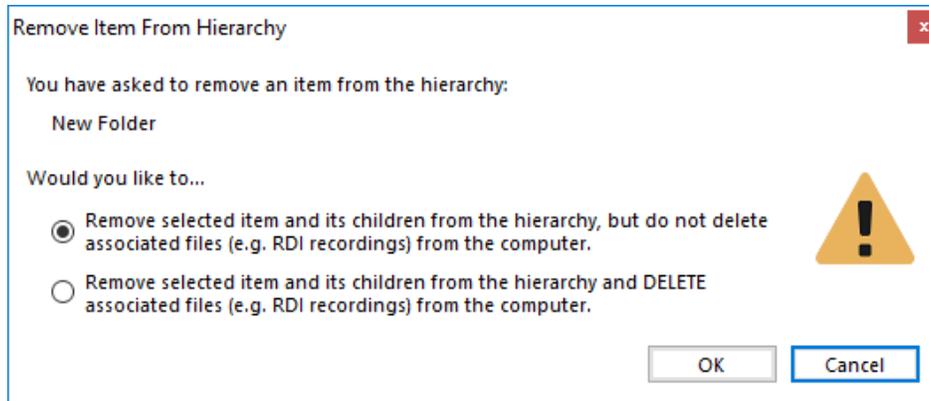
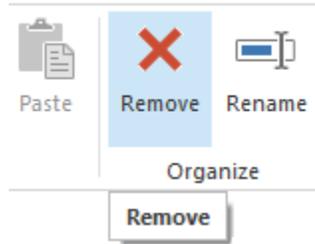


5.2.4.3 Remove

Any item except the Company can be removed from the hierarchy.

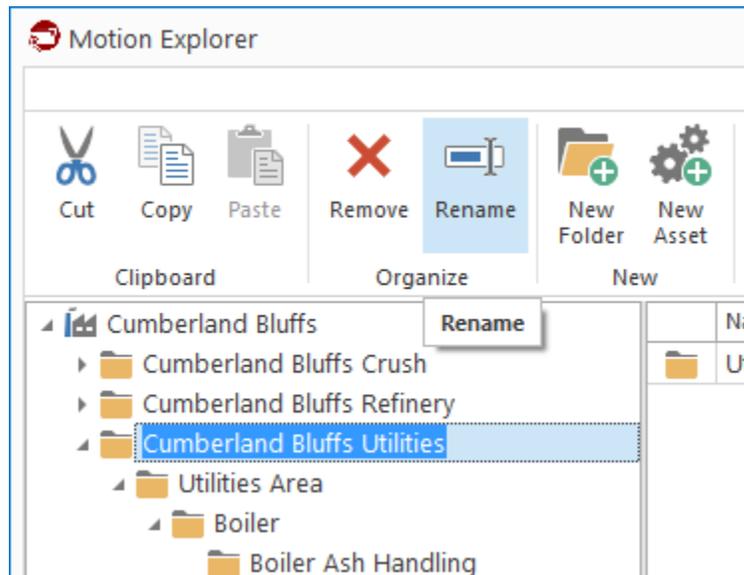
Important: When an item is selected to be removed, a dialog will be displayed asking a question about whether to A) remove the item and its children from the hierarchy OR b) remove the item and its children from the hierarchy and DELETE any associated files. The recordings, exported MP4's, and other files associated with a collection are not actually stored in the RDI Hierarchy Database. They are stored separately in the Windows File System and a link to their storage location is stored in the RDI Hierarchy

Database. So you may choose to remove just the link to the file OR remove the link and delete the associated files. If the files are deleted, they cannot be recovered.



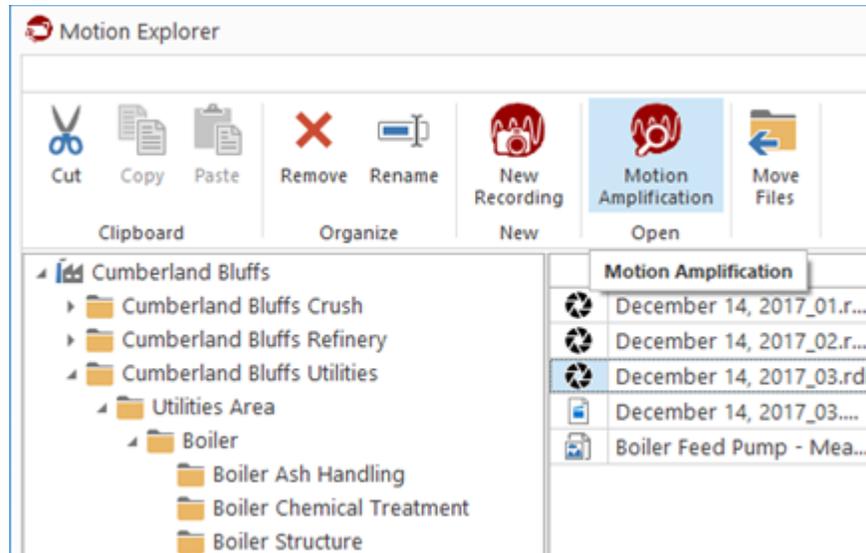
5.2.4.4 Rename

Any item can be renamed with the Rename function available in the ribbon. When this option is selected, the selected item in the left or middle pane will be shown in edit mode as seen in the following image. Use the keyboard to rename the current item. Pressing the enter key or selecting another items commits the change. Pressing the Escape key will cancel the change.



5.2.4.5 Launch Motion Amplification in Context

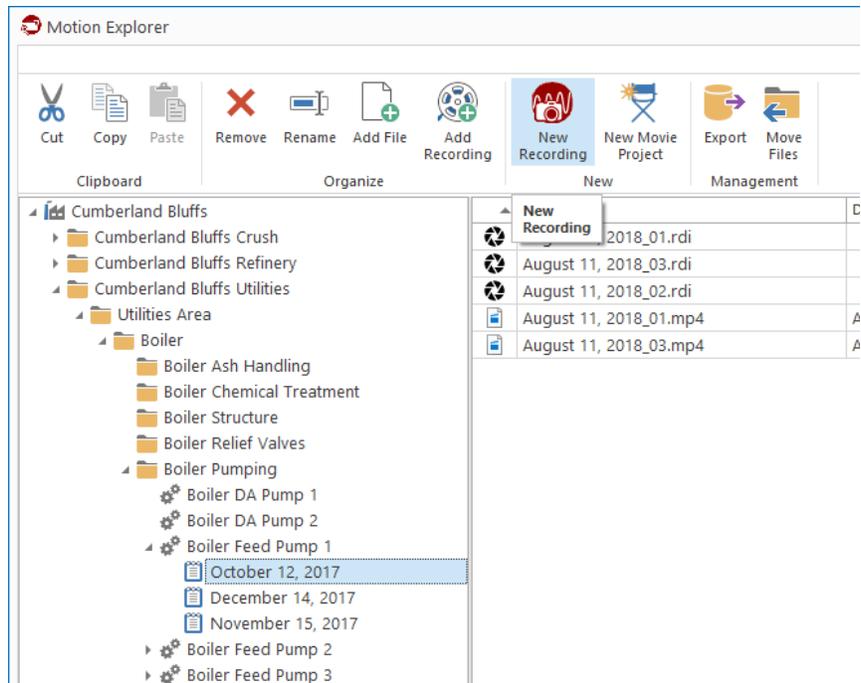
When a recording is selected in the middle pane, a Motion Amplification option will be available in the Ribbon Bar. When this button is pressed, the selected recording will be opened in Motion Amplification. If Motion Amplification isn't currently running, the program will be started.



5.2.4.6 Launch RDI Acquisition in Context

When a collection item is selected in the left pane or middle pane, a RDI Acquisition option will be available in the Ribbon Bar. When this button is pressed, RDI Acquisition will be launched in the context of the selected collection. This means that any recordings collected will be stored as a member of that collection. However, you can always change the active collection from the Acquisition application.

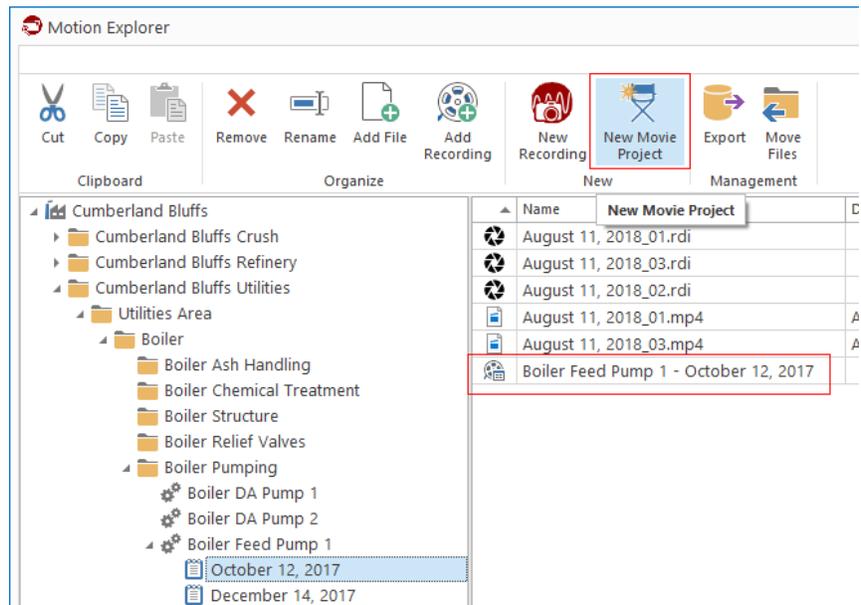
Another way to launch RDI Acquisition in context is to select a recording and press the New Recording button available in the ribbon bar. This will launch RDI Acquisition and set the current recording properties such that they match those of the selected recording. So the purpose of this functionality is to quickly collect another recording whose properties match those of an existing recording.



5.2.4.7 Launch Motion Studio In Context

When a collection item is selected in the left pane or middle pane, a Motion Studio option will be available in the Ribbon Bar. When this button is pressed, Motion Studio will be launched in the context of the selected collection.

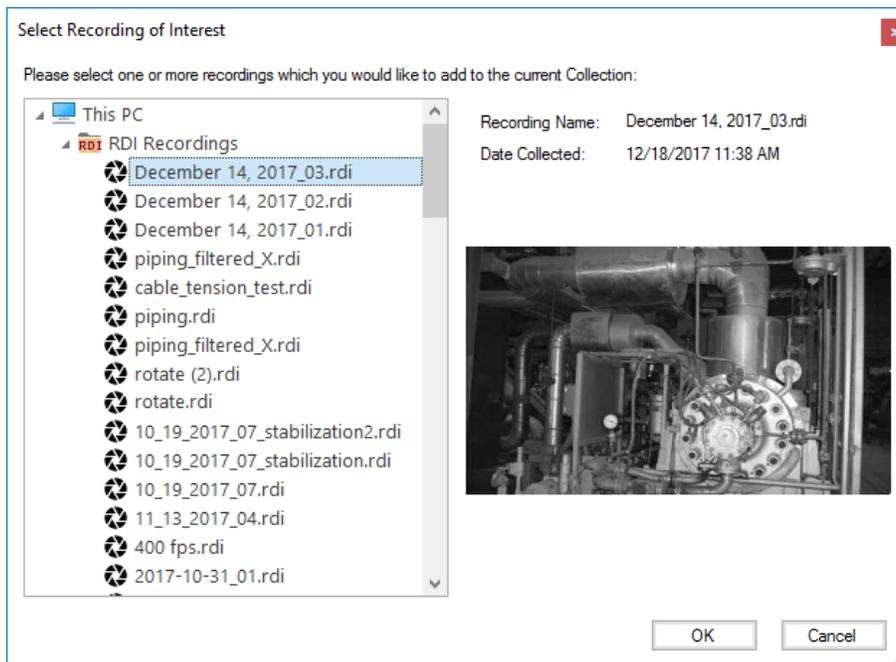
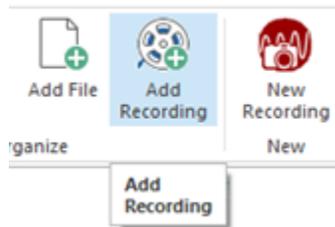
Motion Studio can also be launched in context by double clicking a movie project in the middle pane or selecting a movie project and then selecting the Open option in the ribbon bar.



5.2.4.8 Add Existing Recordings to a Collection

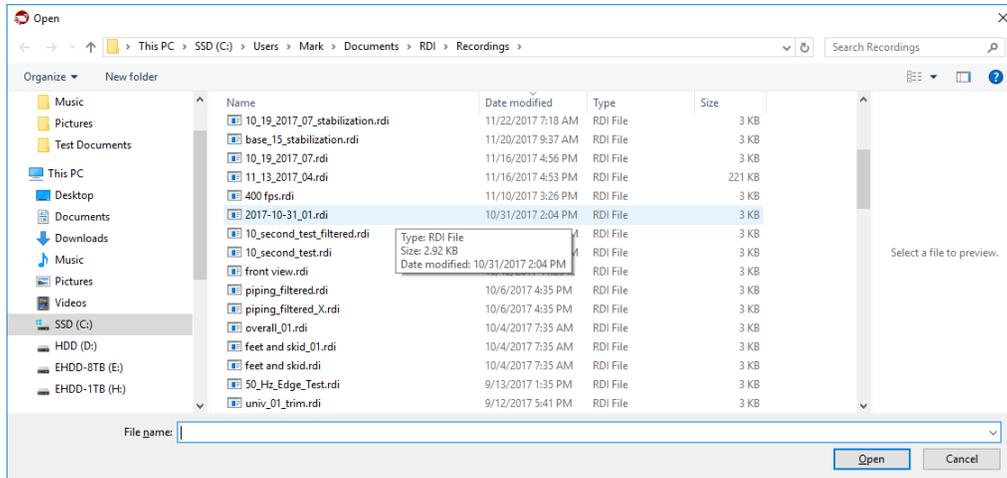
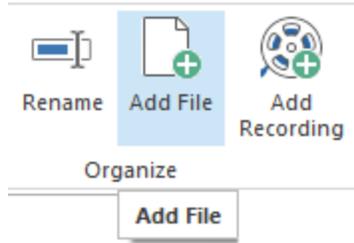
If you would like to add previously collected recordings to a collection, select a collection in either the left pane or center pane and choose the Add Recording option in the ribbon bar. This will display a dialog that lets you browse the recordings on your computer. A preview of the recording is shown when one is selected. This dialog supports multiple selection, so if you would like to add more than one recording use the standard Windows functionality: control+click / click or shift+click. A given recording may only be added to the hierarchy once. Attempting to add a recording already present in a collection will result in an error.

When a recording is added to a recording, only a link is added to the RDI Hierarchy Database. The file itself remains in its original location. So if the file is moved, the link from the RDI Hierarchy Database to the recording will be broken.



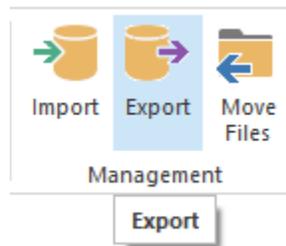
5.2.4.9 Add Existing Files to a Collection

If you would like to add previously exported MP4 video or another previously saved file to a collection, select a collection in either the left pane or center pane and choose the Add File option in the ribbon bar. This will display a dialog that lets you browse the files on your computer. The displayed dialog is a standard Windows File Open Dialog and it supports multiple selection. So if you would like to add more than one file, use the standard Windows functionality: click, control+click or click, shift+click. A given file may only be added to the hierarchy once. Attempting to add a file already present in a collection will result in an error.



5.2.4.10 Export

The purpose for the Export functionality available within Motion Explorer is to allow you to move a group of recordings (and their parent collections, assets, and folders) from one computer to another. For example, every Iris M system comes with an Acquisition System license and an Analysis Only license. Export provides an easy way to get a group of recordings from the Acquisition system computer to the Analysis Only computer.



You need to answer four questions before an export operation can begin:

- 1) What would you like to export?

There are several options that attempt to help you export only the items that need to be moved (since moving recordings is typically not an overly quick operation). The first option allows you to export any collection that has not been previously exported. A collection is considered to have been exported if all of its contents are exported. If an item is added to a collection, it is marked as not having been exported. The second option allows you to specify a date range such that only recordings created within that date range are exported. The third option simply allows you to manually specify what you want exported.

2) Types of Collection files to include?

You can also choose to export the following types of files: Recordings, Exported MP4's, other files associated with collections.

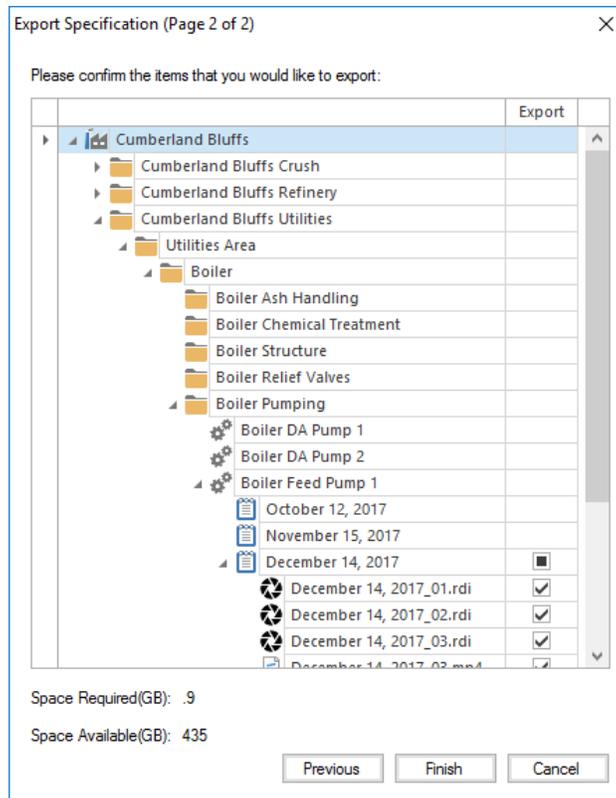
2) Target location for export operation?

You also need to specify a name for the export and select a directory where to store it. This is typically going to be an external drive that can be moved or a network drive that can be accessed by the destination computer where the files will be imported.

3) After exporting collection files, what would you like to do with the files on the current computer?

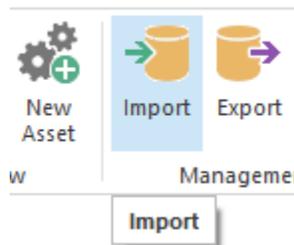
The last choice that needs to be made is to delete the files that are exported or leave them on the current computer. Deleting when exported will create free space on the computer.

Once you make selections for these four options a confirmation screen will be displayed. This allows you to change the items that are marked as to be exported. Once you click finish on this screen, the export operation will begin and a progress bar will be displayed. Once the export has completed a file will be created with the specified name and the extension “.exp”. There will also be a folder with the same name as the export. This file and folder comprise the export package. Both must be available to perform an import operation of the contents.



5.2.4.11 Import

Importing is the process of moving previously exported collections and files onto a different computer from which they were exported. Importing involves selecting the “.exp” file created during the export process. Once you select this file, a confirmation message will be displayed telling you how many assets, recordings, and collection are contained in the export file. If you choose to continue the import, a progress bar will be displayed.



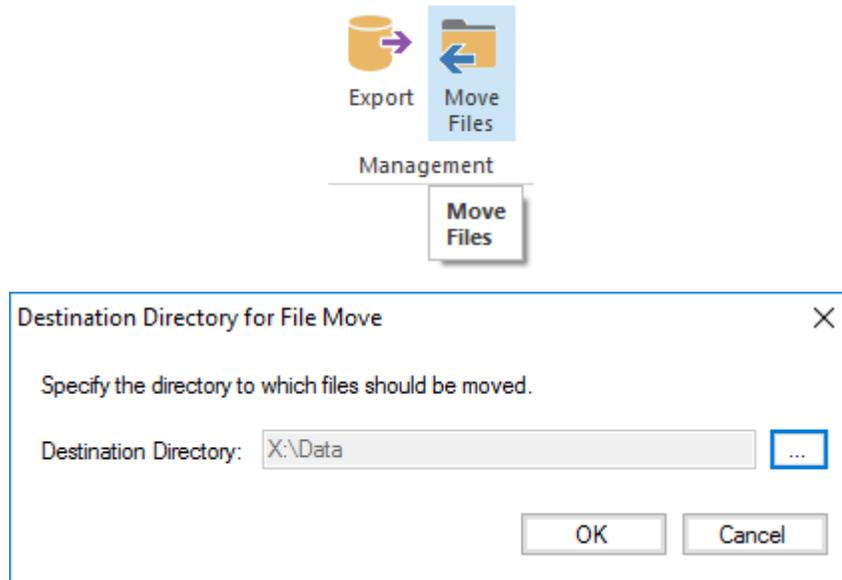
Part of this process is to create the necessary folders and assets with which the collections and recordings in the export file are associated. If a recording is imported that appears to be a duplicate, it is still imported but with a new, incremented name. For example, if “recording.rdi” was imported but already exists, it would still be imported but with the name “recording (2).rdi”.

5.2.4.12 Move Files

The move file function is intended to move one or more files from one storage location to another. For example, from the Acquisition computer’s internal SSD to an external SSD. An important difference

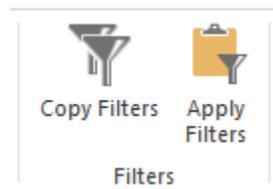
between move and export is that moved files will still be shown under their parent collection in Motion Explorer. Their place in the hierarchy is not altered. They are just moved from one storage location to another, most likely to increase available disk space.

This operation can be initiated from any level of the hierarchy. If it is initiated at a level in the hierarchy above an individual file, all of the files below the selected item will be moved. Once a destination directory is specified and you press “OK” a progress bar will be displayed.

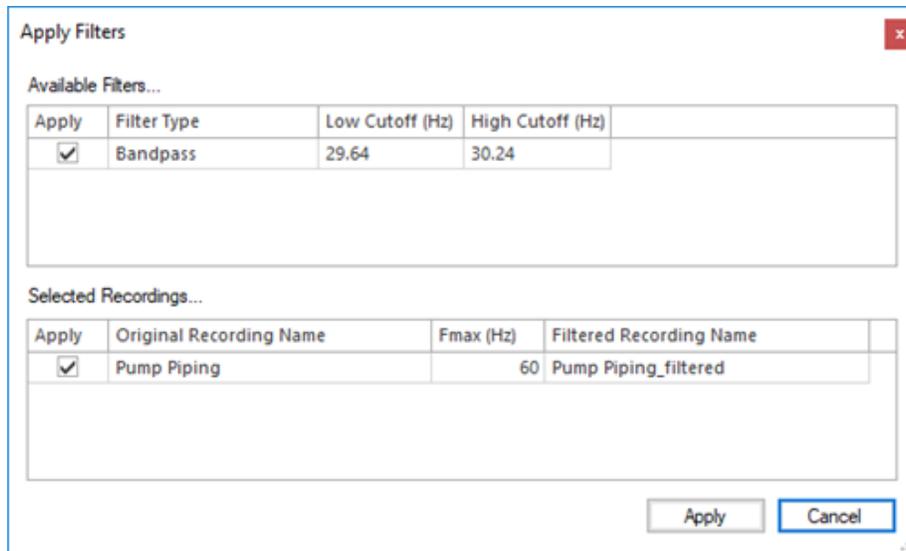


5.2.4.13 Bulk Filtering

Motion Explorer allows the user to copy the filters that have been applied to one recording and apply those filters to one or more different recordings. This functionality would be useful in the case where the user collects multiple recordings on a given asset, but they would like to apply the same filters to all of the recordings. Thus, the user only has to set up the desired filters once. This functionality is accessed in the “Filters” section of the ribbon. The “Copy Filters” option will be enabled if a recording with one or more filters having been applied is selected. Once filters are copied, the user needs to select one or more different recordings, and then the “Apply Filters” button will be enabled.



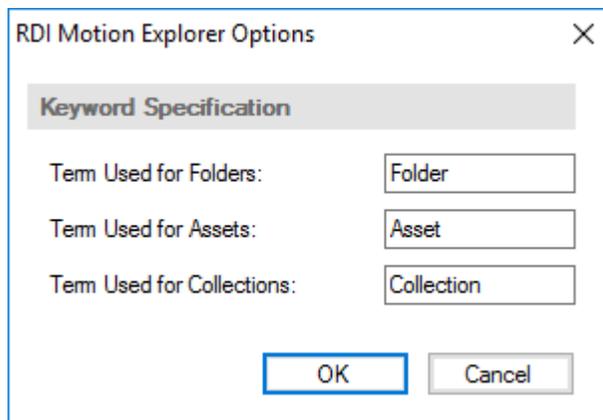
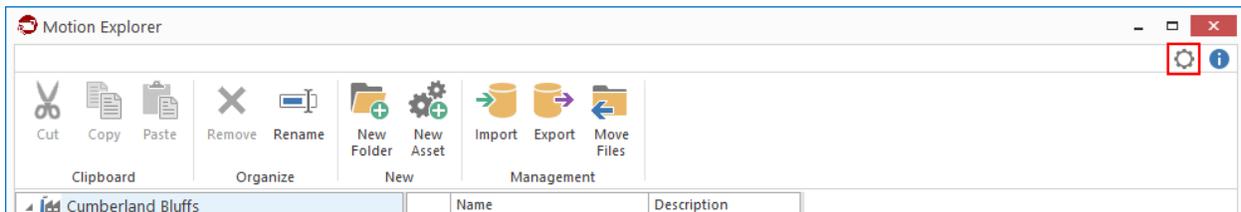
When the Apply Filters options is selected, a confirmation dialog is shown (image included below). This presents the filters that will be applied, and also the recordings to which they will be applied. The filters to be applied may be disabled as well as the recordings to which they will be applied. At least one filter and one recording must be enabled in order to perform the filtering operation.



5.2.5 Settings

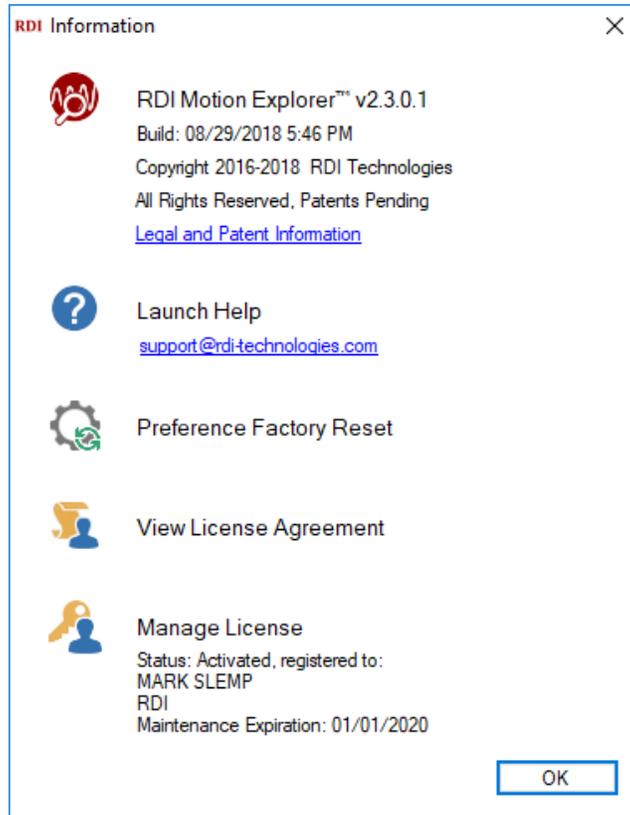
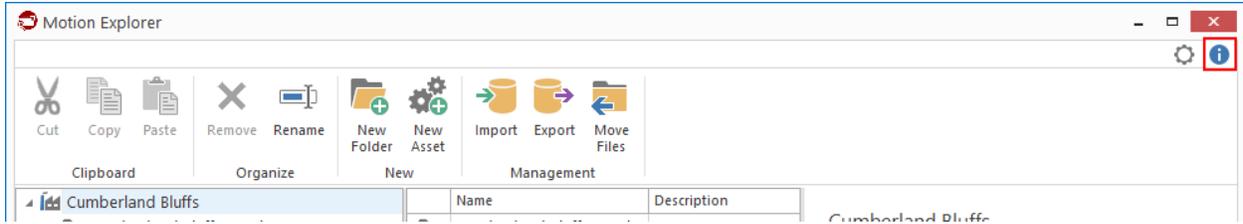
The Settings button is found in the upper right corner of the Motion Explorer application. It provides access to several settings that are configurable.

The default terms that are used in the asset hierarchy are Folder, Asset, and Collection. You may specify different terms for these items in the hierarchy.



5.2.6 Information

In the upper right corner of the Motion Explorer application is an Information button. Press this button to access information about the application, help, view the license agreement, and access license information.



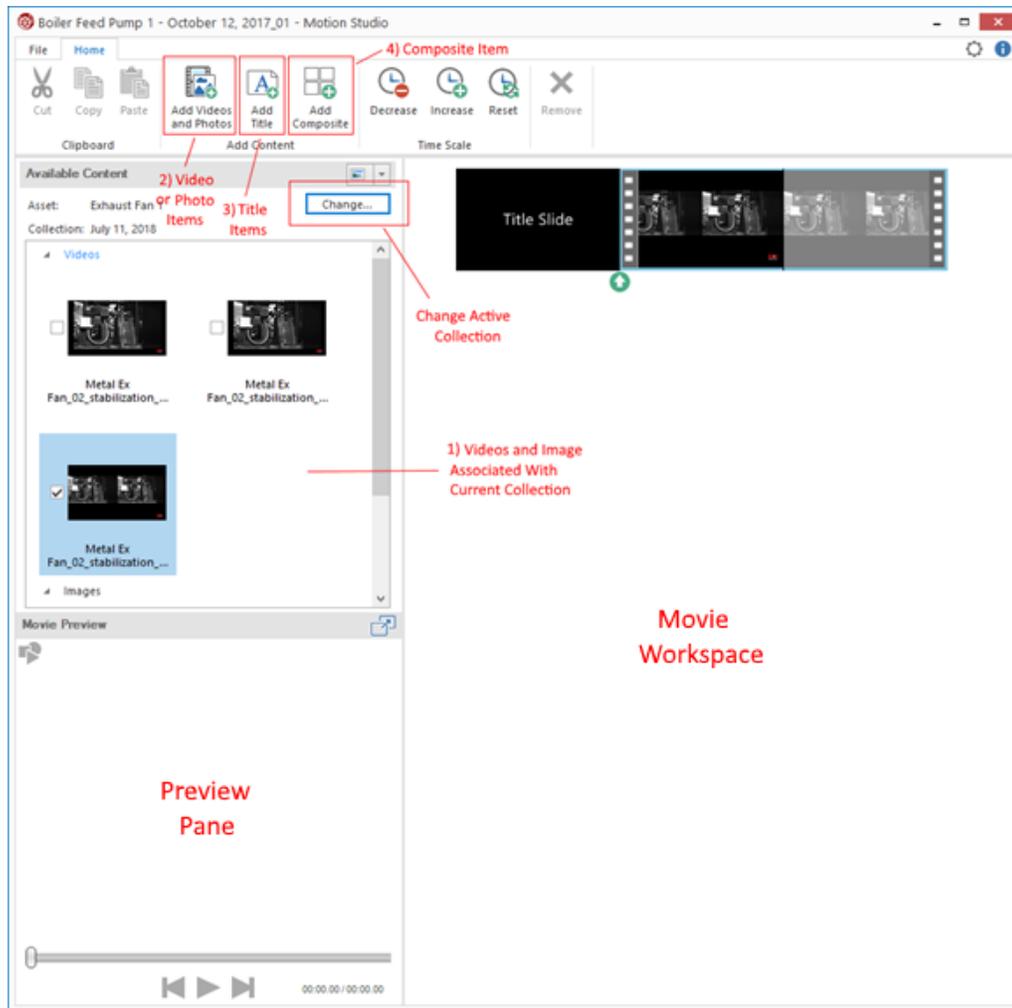
6 Motion Studio

Motion Studio brings video editing capability into the RDI suite of software. It supports the building of a movie project, where the movie project is composed of one or more various items. Title slides are one of item types that can be added to a movie, and they can contain text, images, and other various annotations. Previously created videos and images can also be added to a movie project. Annotations can be added to any file type. Motion Studio supports trimming and fade effects. Once the movie project has been completed, the user simply saves the movie and an MP4 is created that contains all the items contained within the movie project.

6.1 Adding Content to a Movie Project

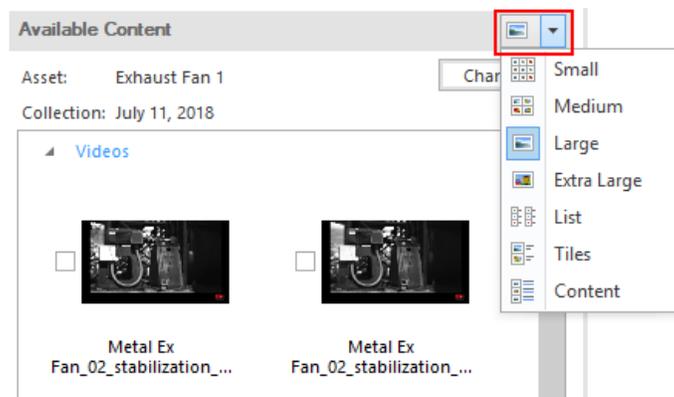
The first step in building a movie using Motion Studio is to add content to the movie project. This may be done one of several ways:

- 1) Check the boxes next to the items in the Available Content window in the upper left of the main workspace. When you check an item in the content pane it will be included in the project workspace. The Change button will allow the user to select a different Collection whose Video and Photo content is to be displayed in the upper left window.
- 2) Click the Add Videos and Photos button in the Ribbon Bar. Selecting this button will allow the user to browse the RDI hierarchy and the files on the computer's file system. Selecting an MP4 or photo/image will add that item to the movie project.
- 3) The Add Title button in the Ribbon Bar will add a title slide to the movie project. The default text of a title slide can be changed.
- 4) Composite Items can also be added to a movie project. This tile type allows the user to combine multiple videos, photos, and other images into a single item in the movie. Composite items will be covered more thoroughly in the following sections.



6.1.1 Adjusting View in the Available Content Pane

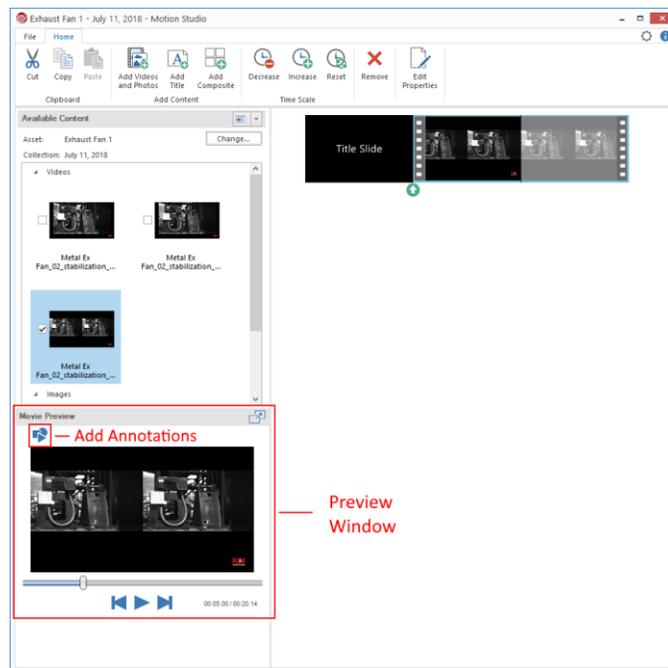
There are six different views available for the Available Content Pane. They range from Small to Extra Large with the addition of Tiles and Content options. The user can change this to see more or less information about the items, and this selection also affects the size of the thumbnail displayed for each item.



6.2 Previewing the Movie

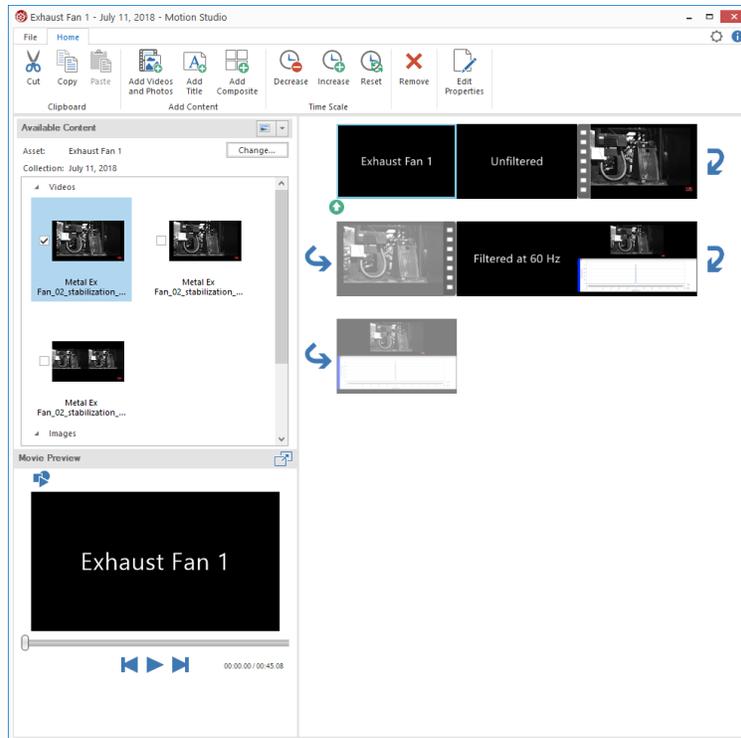
The Preview Window will show the current playback position of the movie. At the bottom of the window are Play, Pause, Previous Frame, and Next Frame buttons. In the upper right corner of the Preview Pane is a Maximize button. Pressing this button will maximize the preview window so that it fills the entire application main window.

Important: The Preview Pane is also where you change the text of Title Items and add annotations to all the different item types. To edit an existing annotation (including text), click on the annotation of interest and the properties of that annotation will be displayed in a dialog box. The mechanism for editing annotations is identical to that used in Motion Amplification (See [Editing Annotations](#)).



6.3 Movie Workspace

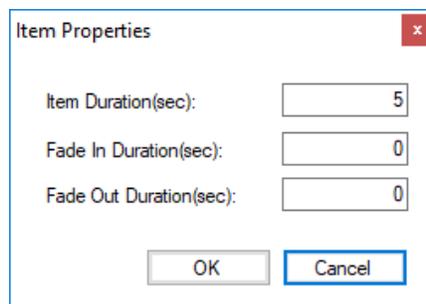
The right side of the application displays the contents of the current movie project. The movie will begin with the item in the upper left and play from right to left. When the end of a row is reached, the movie will wrap to the left side of the next row. The blue arrows indicate this order. The number of blocks representing an item is proportional to the item's duration. The default time scale is that 1 block represents 10 seconds. Anything items less than 10 seconds will appear as 1 block. Hovering over each item with the mouse will display a tooltip with the duration of the item.



6.3.1 Title Items

Title Items contain mainly text, but any annotation (including additional text) can be added to a Title Item. Additional annotations are added via the Add Annotation button available in the preview window.

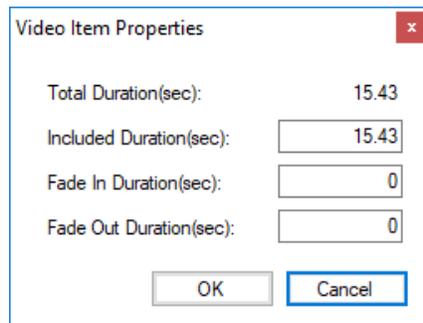
With a Title Item selected in the Movie Workspace, selecting the Edit Properties button in the ribbon will display its properties in a dialog. The available properties include the duration that the item should be displayed in the movie and the fade in and fade out durations.



6.3.2 Video Items

Video Items contain previously created MP4 videos. Annotations can be added to Video Items. Annotations are added via the Add Annotation button available in the preview window.

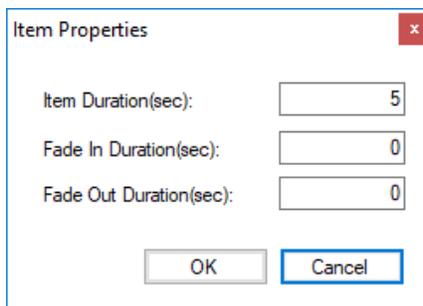
With a Video Item selected in the Movie Workspace, selecting the Edit Properties button in the ribbon will display its properties in a dialog. The available properties include the original duration of the MP4. The Included Duration property is the amount of the original video that is to be included in the movie. Fade in and fade out durations are also available.



6.3.3 Image Items

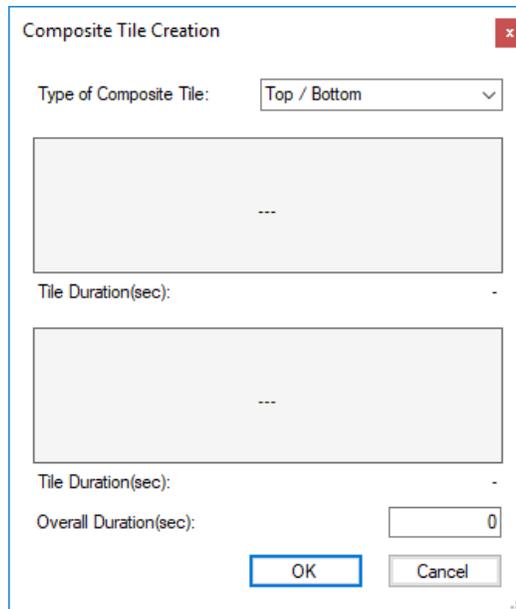
Image Items contain previously created photos and images. Annotations can be added to Image Items. Annotations are added via the Add Annotation button available in the preview window.

With an Image Item selected in the Movie Workspace, selecting the Edit Properties button in the ribbon will display its properties in a dialog. The available properties include the duration that the item should be displayed in the movie and the fade in and fade out durations.



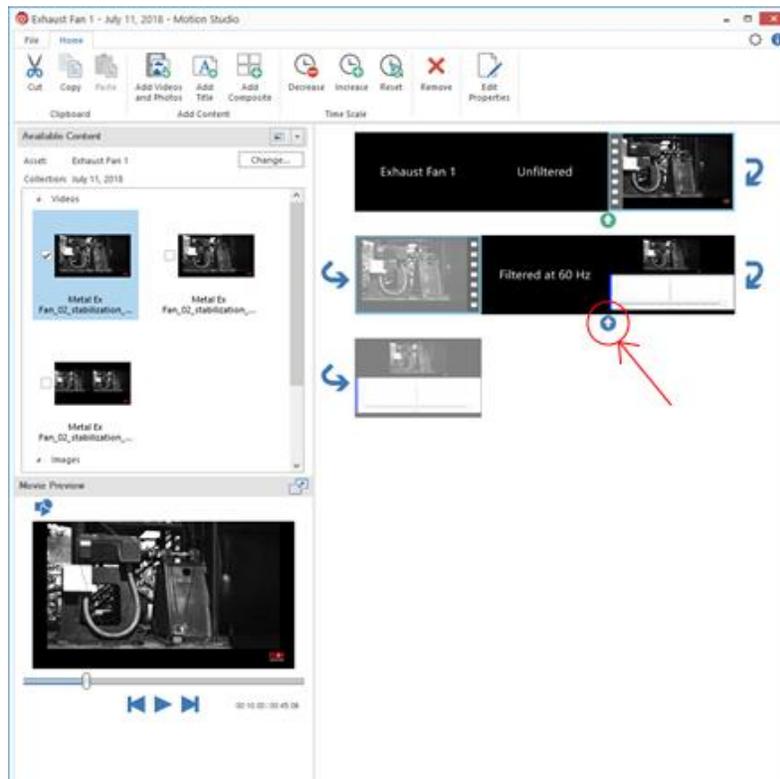
6.3.4 Composite Items

Composite Items can contain MP4 videos, photos, and other images. The Composite item can be either left-right, top-bottom, or window pane. Left/right and top/bottom allow the user to choose two different items to be displayed simultaneously. Window pane allows the user to choose up to four items to display. To add content to a Composite Item, click on the “...” shown in the dialog. This will bring up another dialog to let the user browse the RDI asset hierarchy or the computer’s file system. The overall duration may be specified, and this can be used to trim the duration of any MP4 videos included in the Composite Item.



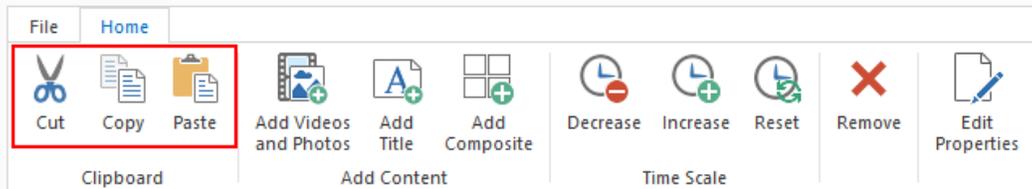
6.3.5 Reordering Items

To reorder an item, click the item in the Movie Workspace with the left mouse button. Hold the mouse button down and drag it to the desired location. The blue drop indicator with the white arrow is indicated in the image below, and it indicates where in the sequence the item will be placed.



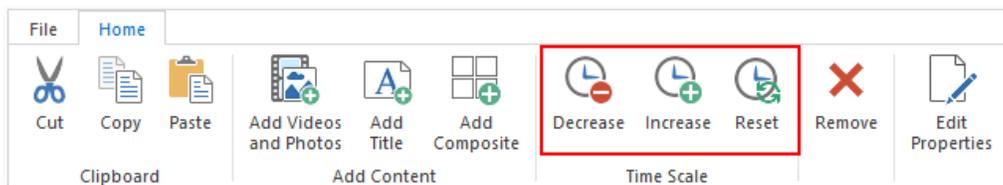
6.3.6 Cut/Copy/Paste

The Cut, Copy, and Paste items in the Ribbon Bar may be used to copy any item in the Movie Project. Pasted items will be placed before the item currently selected when the Paste button is pressed.



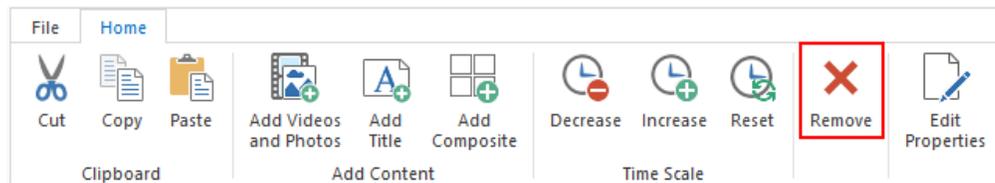
6.3.7 Alter Time Scale Representation of Movie Project Items

The time scale items in the Ribbon Bar may be used to alter the amount of time represented by each block shown in the Movie Workspace. As mentioned previously, each block represents 10 seconds by default. Pressing the Decrease button will reduce the current amount of time represented by each block by one half. Pressing the Increase button will double the amount of time represented by each block.



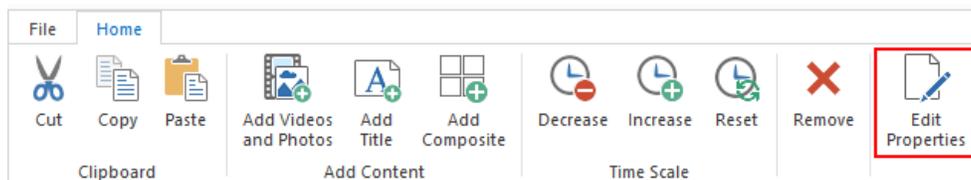
6.3.8 Removing Project Items

Pressing the Remove button in the ribbon bar will remove the item currently selected in the Movie Workspace.



6.3.9 Editing Project Items

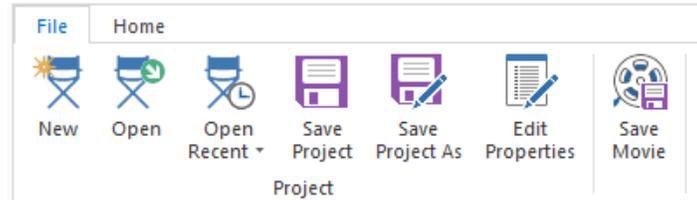
Pressing the Edit Properties button in the Ribbon Bar will display the properties dialog for the currently selected item.



6.4 File Menu

The File Menu in Motion Explorer is used to perform project-level operations. These include the following:

- Creating a New Project
- Open an Existing Project
- Open Recent Project
- Save Project
- Save Project As
- Edit Properties (of the Movie Project)



Save
Movie

Important: Pressing the Save Movie button will construct an MP4 movie based on the current content of the Movie Project. This operation may take several minutes, and a progress bar will be displayed to help estimate the amount of time remaining. Once the movie creation is complete, the user is presented with a choice to play the movie, open Windows File Explorer to the location where it was stored, or continue working in Motion Studio. Once the movie is saved, it can also be found in Motion Explorer under the Collection with which the Movie Project is associated.

7 Specification

Specification	
Motion Amplification™	
Available Lens	6mm, 12mm, 25mm, 50mm, 100mm
Acquisition System	i7 processor, 16GB RAM, 500GB SSD, dual batteries, lightweight, MIL-STD-810G standard drop protection, 3 yr accidental damage protection
Iris M Sample Rate	120/100 fps default, up to 1,300 fps at reduced resolution
Iris M Frequency Range	US: Up to 3,600 cpm @ 120 fps default Int: Up to 3,000 cpm @ 100 fps default Maximum: 39,000 cpm @ 1,300 fps with reduced resolution
Iris MX Sample Rate	1,400 fps default, up to 29,000 fps at reduced resolution
Iris MX Frequency Range	Up to 42,000 cpm @ 1,400 fps default Maximum: 870,000 cpm @ 29,000 fps with reduced resolution
Minimum Displacement	0.1 mil (2.5 µm) at 3.3 ft (1m) with 50mm lens at max brightness
Motion Amplification Factor	1-50x
Vibration Pads	95% impulse absorption
Tripod	Professional Grade with pistol grip
Case	Watertight, dustproof, crushproof
USB3 Cable Length	16.4 ft. (3 m)
Features	
Motion Amplification™	
Export Format	HD MP4 at 1920x1080 resolution
Video Annotations	Text, shape and annotations overlays with export to video
Playback/ Export Video Speeds	4x speed to 1/framerate
Grid Overlay	Configurable grid overlay (size, color)
Export Options	Side-by-side playback of original and amplified video or amplified video Only
Logo Export	Ability to overlay custom logo onto exported videos
Image Zoom	Exported video shows only zoomed region

8 Troubleshooting

Lighting brightens and dims during playback/Motion Amplification.

For indoor recording, check the framerate (fps) during acquisition. If the frame rate is set at a frequency other than 2x the line frequency a beating (beat frequency) between the frame rate and lighting may occur.

Motion Appears across the entire image.

It is possible the camera was shaking during acquisition. Ensure vibration reduction pads were used during acquisition.

Motions seem too slow or stops when I adjust playback speed of the amplified video.

It is possible to select a playback speed that affects the way the motion appears in the video. This is the classic “Wagon Wheel Effect”. For example, if a motion is at 30 Hz and you select a 30fps playback it may appear stopped or without motion. To accommodate this, it is recommended to try multiple playback speeds to see what works best for the specific motion you are trying to illustrate.

For more troubleshooting and general support see the RDI Technology Support page.

<http://www.rdi-technologies.com/support>

9 Revision History

Revision	Date	Notes
1.0	September 03, 2016	Initial Release
1.1	December 31, 2016	Displacement and Frequency Added
1.2	January 23, 2017	Displacement and Frequency Updates
1.3	February 27, 2017	Stabilization Added
1.4	April 18, 2017	Orbits Added
1.5	June 9, 2017	Filtering Added
2.1	December 20, 2017	Motion Explorer Added
2.2	April 9, 2018	v2.2 Updates
2.3	August 31, 2018	v2.3 Updates, Motion Studio Added
2.4	December 8, 2018	v2.4 Updates, Iris MX Added

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