A Video Exposure Monitoring (VEM) System for the 21st Century

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Note

Using a video exposure monitoring system as described in this manual, may allow you to visualize worker exposures in a video of them conducting their tasks. See Figure 2, Figure 3, and Figure 4 for examples of what still images of a video may look like.

The guide is intended to give an overview and step-by-step instructions to develop a video exposure monitoring system and produce high quality video footage for training, exposure assessment, and control evaluation purposes. The system described in this document uses software that as of June, 2021 was free for download, though depending on which software package you choose to use, you may need to purchase another software program or upgrades for more functionality, though there are free options. This guide will step you through the use of each of these products on a PC running Windows 10 and discuss pros and cons of their use. The use of these or other products was not investigated for Apple products, though one of the software packages says that their product will run on Mac computers using an app that allows the user to simulate a windows environment.

This guide will not step you through the installation of the software, but will help you use it. For specific errors and problems, each section also contains a link to the manufacture/distributor's manual or help center.

In late August 2021, it was discovered that one software solution with a great deal of potential for video exposure monitoring, DashWare, will no longer be updated and supported by its owner, GoPro. The documentation for this program will still be presented in an Appendix A as a legacy program, but a newer solution, RaceRender, has also been detailed below.

Overview

Video exposure monitoring (VEM) is a method used to animate and overlay real-time worker exposure data onto a video of the worker conducting their job while their exposure was being monitored. This combined video is recorded and can be used to educate workers and management about where and how exposures are occurring, help industrial hygienists better understand how an exposure is occurring, and evaluate controls.

The system described in this document has three basic components, a digital video camera, a real-time air monitoring instrument, and computer software to animate and overlay the data onto the video and to capture the output video. The first two elements can be relatively generic, but within certain bounds. The software is very specific, but three options, EVADE 2.3, RaceRender 3.7.3, and DashWare (legacy software presented in Appendix A), will be discussed.

The anatomy and flow of a basic VEM system can be seen in Figure 1.

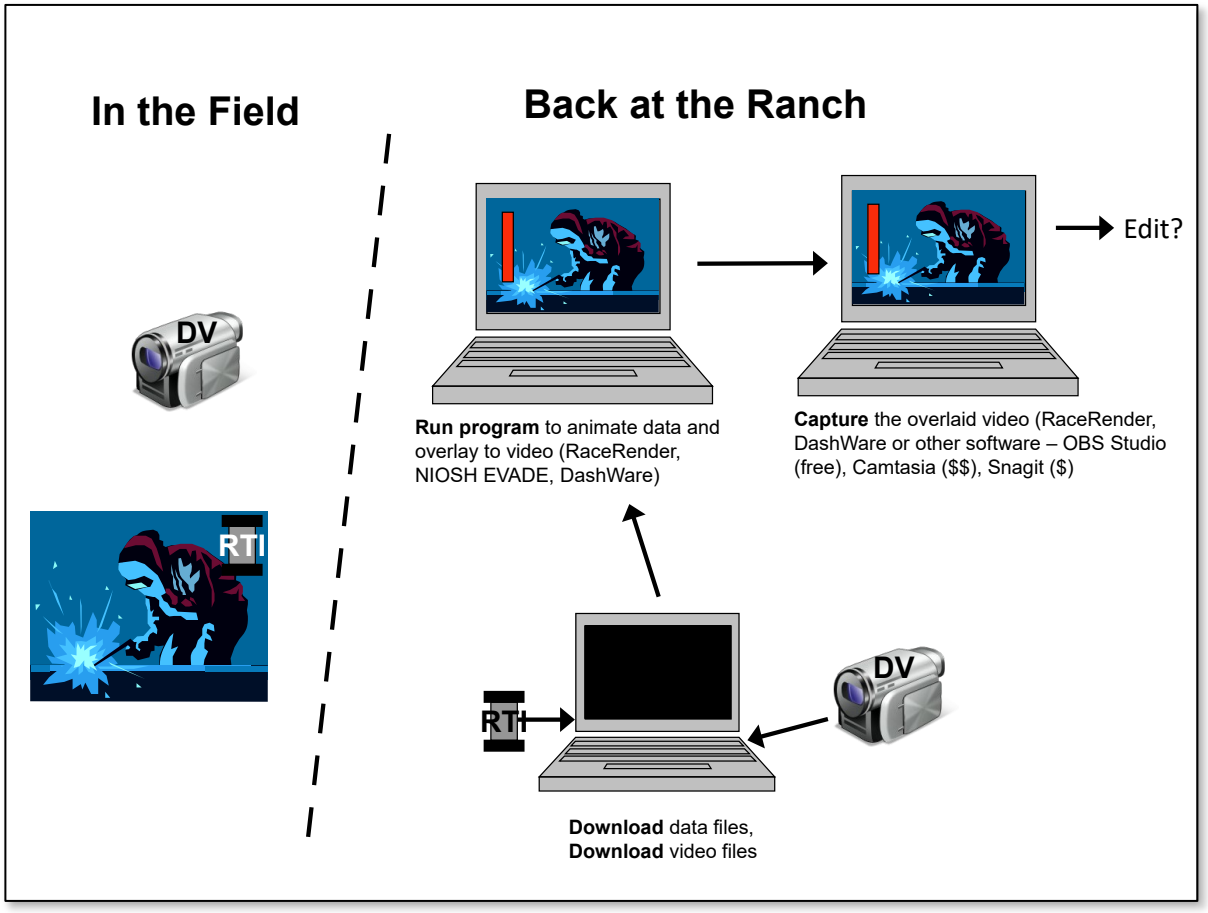

Figure 1 Basic video exposure monitoring system and flow.

Task/scene selection

Before considering the equipment needed for conducting a VEM, the task or scene that is desired for exploring should be considered. There are a number of issues to consider when shooting VEM footage. Some of these issues are listed below:

1. Thoughtfully choose the task to record. Ones that are amenable to video exposure monitoring will have an exposure of interest that varies over time, on a timescale that can be evaluated by the instrument and video, and that timescale is of interest.
    a. If exposures change quickly and are "peaky" (less than 1 second or even every few seconds), your instrument may not be able to measure differences due to its inherent response time and synchronizing the exposure data with video will be very difficult.
    b. If exposures vary on a long time frame (once an hour), be sure to capture both high and low exposure conditions and the transition time. If you are not able to capture the transition, you can edit the video to show both conditions.
    c. Evaluating a job with and without controls can be an effective use of VEM.
2. Choose an effective filming location with respect to the task. Film from a location from which you can see what is causing the worker's exposure to change. Ensure that lighting is adequate and you are not too far from the worker. Some practitioners like to use a body-cam approach, so the you see the work from the workers' perspective.
3. Ensure that you are filming from a safe location as you may not be paying attention to your surroundings.
4. Film the work through a number of cycles of the job. You will be able to capture potential variability in the work. You can always edit the video afterwards, but remember that the duration that someone (your audience) can watch another person doing the same job repeatedly, is limited. Collect more footage than you need because it is easier to edit unwanted scenes than go back and collect more VEM video.
5. Take notes of activities (yours and the worker's) and time. This will allow you to interpret your data and video more accurately. Having a form with time and activity columns works well for this.

    Some observations to be recorded are:
    - "On time" for video and instrument
    - Synchronization time (s)
    - Task activities
    - Activation/deactivation of exposure controls
    - Stop time for video and instruments

Video recording

Important things to remember:

- Ensure that you have adequate battery life to record your video, using extra batteries and/or an AC plug for the camera will help.
- Ensure that you have enough storage on your media to record your video. This will be very dependent on the video camera and the resolution and format that you are recording. It may be helpful to do a test run to see how much storage 10 minutes of video takes up. It is possible to bring extra storage cards.
- Synchronize the clock on the camera and the instrument to the best of your ability.
- Using a tripod will greatly improve your video quality.
- Try not to zoom in or pan too much when recording your video.

Choice of video camera
Most digital video cameras can be used to collect the video for a VEM, but it should be able to record video at the appropriate aspect ratio for a computer screen (cell phone isn't great), high resolution, and a frame rate of at least 24 or 30 frames/sec.

Note: RaceRender also has the ability to use 360° video from a camera such as the GoPro Max.

Set up and use of video camera
The video camera should be set up to record to a file of the appropriate format (see Downloading of video) to be used for your VEM project. If the camera you use records to a format that is not supported by your software, there are a number of programs that can convert one format to another.

- Set the clock of you video camera as best you can.
- Remember that if you record footage with the date and time stamp and/or time increment, that will appear in your video and be distracting and may be difficult to remove.
- Ensure that you have adequate storage media for the length of footage that you will be collecting.
- Ensure that you have adequate power (extra batteries or AC power supply) to collect your desired length of video.
- Ensue that there is adequate lighting to collect the video. You may be able to either adjust the lighting or adjust the camera for the conditions. Beware that operations such as hot work and the handling of molten materials may overwhelm the video camera's optical sensors.
- Ensure that the white balance is appropriate for the lighting.
- Use a tripod whenever possible. If the worker moves between multiple stations, you can move the tripod with them and edit out the transition periods.
- Zoom in or out prior to filming to capture the elements that you want to highlight. Be aware that zooming out too much may prevent people from seeing details and zooming in too much will prevent people from seeing the surrounding situation. If you film too widely, it is possible to correct that during the editing. If you zoom in too much, you can't correct that.
- Be careful of dust and moisture getting on your camera and lens. Moisture may not always be benign water. Dust can scratch lenses, so blow and wipe off carefully. An enclosure can be used, but if it covers the lens, it may impact the image quality. An enclosure may also alter the audio quality.
- When capturing video, be aware that unless you have an external microphone, the camera you are using will be picking up the audio and it is most likely that the videographer is closer to the microphone than the worker, so what gets said behind the camera is picked up better than what the noise worker is making. Many video cameras can be used with either wired and/or wireless microphones that the worker can wear.
- It is recommended that test footage and audio be collected to ensure that all settings will make for a good video. It is possible to adjust video and audio settings in the editing process, but some things cannot be adjusted very well.
- The video should be started prior to starting the data collection instrument.

Downloading of video
If the video is too long, your camera may partition the video into multiple files.

Try not to reduce the resolution or file size of your videos until you have a final VEM product. Video file formats that are acceptable to the different software solutions are discussed in the respective sections of the manual.

Because video files are typically very large, you may need to use an external hard drive to store your video. It may be possible to store the video on a cloud-based service, but be aware that some services reduce the file size, which may impact video resolution. Store your raw videos in one location because you may have edited or smaller versions and you want to keep the originals if anything happens to the edited versions.

Data collection

Important things to remember:

- Ensure that you have adequate battery life on your instrument to collect the desired data.
- Ensure that you have enough storage on your instrument to record your data at a high time resolution, typically 1 s. This will be very dependent on the instrument and how you have set it up.
- Set the clock on the instrument to the best of your ability. Try to synchronize the clocks of you video camera and instrument. This is very helpful but not critical. There will be other ways to synchronize the data and the video.

The choice and use of an appropriate instrument to collect the data for your VEM project is critical to the success of your project.

Instrument choice

Choose an instrument that will be able to measure your contaminant of concern, or a surrogate of that contaminant. We have used total particle monitors as a surrogate to measure airborne lead, welding fume, and hexavalent chromium and a photoionization detector (PID) that measures total volatile organic compounds (TVOCs) has been used as a surrogate for various specific solvents. It is also possible to show noise exposures with VEM using a noise dosimeter with this method. In choosing an instrument, the following attributes are important to consider:

- A short data logging time, 1 data point per second is adequate.
- A short response time. This is important and may impact your ability to synchronize the data and the video. If the response time is very consistent, it may be possible to offset your video to take this into account during the synchronization.
- Passive samplers, especially with long response times, will tend to make it difficult to see what is causing the exposure of concern.
- Long sampling lines with relatively low flow rates may also slow down the response and should be avoided.
- The instrument should have adequate storage capacity to store your logged data at the desired logging rate. Some instruments will allow you to choose different parameters to store. Limiting these can save storage space.
- Ensure that you have adequate battery time to conduct the monitoring that you desire.
- An instrument with poor data resolution and range may be difficult to use effectively.

- Be aware of your instrument's limit of detection with respect to your expected exposures.

Instrument setup and operation
If the instrument is not setup and operated properly, the data that you collect (or don't collect for that matter) won't allow you show what you want to show with your VEM project.

- Zero and calibrate your instrument prior to and after your fieldwork. If the post calibration is off, this may indicate that you may need to adjust the data. This can be done after you've downloaded the data file.
- Do a test data collection run to ensure that the setup of the instrument is correct.
- Ensure that the battery is charged or has been replaced with fresh batteries.
- Clear the memory so there is adequate data storage for your project.
- Program the instrument to log data at 1 second intervals, if possible.
- The instrument's clock should be set prior to sampling to ensure that it is correct. Be aware that computer clocks may not show the correct time unless they've been updated recently.
- When you turn on the instrument for your project, try to do it in view of the video camera.
- For the most part, to view worker exposure, the real-time instrument should be worn by the worker to sample from their breathing zone, but there are situations where an area or fixed monitor can be used.
- If possible, focus the video camera on the instrument's output. This way, you can try to synch the instrument's first data point with the video. If this is not possible, you will be able to synch the video and data at another point.
- Synchronizing your data and video are very important to have a meaningful VEM project. Instructions on this are found in "Start the recording" section.

Starting the recording

1. Record detailed start times of the camera **and** instrument. Times should include seconds, if possible.
2. Start the video recorder.
3. Start the instrument in its data logging mode.

Synchronization

Synchronizing the data stream and video stream is **critical** to have a meaningful end product. If you've ever seen a dubbed movie, you may have noticed that the audio may not be exactly synchronized with the video. That is what we are trying to avoid. Thus, it is very important to synch your video footage with the data that are collected. In the ideal world, the clocks on the camera and instrument could be matched up, but often times that doesn't work because they don't all keep time very well. In addition, some may have lower resolution in time than is needed, making it difficult to set them precisely. The following steps will outline a general method that can be used to synchronize the two signals.

For this method, you will expose your instrument to whatever it is measuring or a surrogate for a brief period of time while you are logging data and recording video of you doing the brief exposure. Later you will be able to line up or synch this mock exposure and the video of you introducing the material to the instrument.

1. For this step you will need a source of the contaminant that you are measuring or a surrogate that can be applied quickly and easily to the instrument. Examples of such are listed below for specific types of instruments:
    a. Photoionization detector (Total VOCs)
        i. Bottle of rubbing alcohol
        ii. "Sharpy" marker
    b. Dust monitor
        i. Clapping a dusty rag
        ii. Smoke tube
    c. Noise
        i. Clap with hands
        ii. Whistle
2. With both the video and instrument recording, hold the instrument in front of the camera and quickly expose the instrument to your bolus of contaminant. You will see this peak in your logged data and see in the video when it occurred.
3. To assist the process, if possible turn the instrument's readout toward the camera so the camera can record the numeric readout, which will help in the synchronization.
4. If it is not possible to have the camera record the instrument's numeric response, verbally mark when you are exposing the instrument, so you can synchronize on the voice cue.
5. Be sure to record on your observation log when you are exposing your instrument to your source of contaminant.
6. It may be helpful to do the synchronization at the beginning and end of a project.

Downloading data

1. Follow the instructions from your instrument to download the logged data.
2. Depending on the instrument, the data may be in a txt, csv (comma separated variable), xls, xlsx, or proprietary file format. Instruments with proprietary formats typically allow the user to export the data to an Excel, csv, or txt file.
3. The different overlay software solutions can use different file types, but both can use *.csv files.
4. Microsoft Excel can be used to alter your data and export to the various file types as needed.
5. You may need to simplify the data file to have only time in the first column and the measured data in the second column with no headers. Specific data and file formatting requirements will be discussed in the program specific sections.

Note: Some programs output the time or concentration into data into an Excel or csv file with a leading blank character. This may make the entries look like real data, but will be read as a text field. This can be changed by removing all of the spaces before the number or time.

Post processing

Important things to remember:

- It is important to have data and video that have been collected with synchronization in the filming stage to develop a meaningful VEM product. If not, there will be much head scratching in the post processing phase.
- Using a powerful computer with much hard drive space and RAM will make processing of the video easier.
- A solid-state external hard drive is an excellent option for this application.
- Remember to use full resolution video in the post processing and reduce the resolution afterward to maintain image quality.
- Prior to doing the overlay, consider what you will be using the video for because that may dictate which software product you use.

Overlay software

This manual details three software products that can be used to animate your data and overlay the animation upon your video. All products, EVADE (developed by NIOSH), RaceRender (RaceRender), and DashWare (DashWare) and are currently available for free and run on the Windows 10 operating system. NIOSH's EVADE is only available on a Windows platform. RaceRender is available on a Windows or Mac platform and has a very usable free version, but can also be purchased (<$60) if one needs more flexibility and features. "DashWare is a Windows PC application, but [the developer says that] it also runs on Macs under VMware, Parallels or Boot Camp." Each program has its own advantages and disadvantages. In the following sections, we will attempt to describe each system to allow the user to choose and apply the best system for their specific application.

Because DashWare is a legacy program, it is covered in detail in Appendix A.

Editing videos

This manual will not cover the editing of either the raw video used for the project or the end product video. A variety of Windows 10 apps have basic video editing capabilities and there are YouTube tutorials showing how to do this.

Resources

This manual, demonstration data and video, and template and project files can be found on our website at https://deohs.washington.edu/FRCG/project/VEM.

Table 1 Comparison of Overlay Software Products.

Parameter	EVADE	RaceRender	DashWare
Version evaluated	V 2.3	V 3.7.3	V 1.9.1
Source	https://www.cdc.gov/niosh/mining/Works/coversheet1867.html	https://racerender.com/RR3/Features.html	http://www.dashware.net/
Operating system tested	Windows 10	Windows 7, 8, or 10, though 64 bit Windows 10 recommended. MacOS 10.9 or higher	Windows 10 (probably iOS)
Shows past and future exposures	Yes	Yes	Possibly
Image of final product	Figure 2	Figure 3	Figure 4
Record final product to video	Need to use 3rd party software such as OBS Studio (free) or Snagit/Camtasia ($)	Done via RaceRender	Done via DashWare
Flexible display	A little	Yes	Yes
Display data directly on video	Yes, with little flexibility	Yes, with much flexibility	Yes, with much flexibility
Pro's	• Very easy to use • Little training required • Can see history and future of data • The EVADE file with synched data and video can be viewed by others with the EVADE program	• Relatively easy to use • Little training required • Can see history and future of data • Very flexible in the type of data display • More video file formats can be used • More vivid display of data • Records overlay as an output video	• Very flexible in the type of data display • More video file formats can be used • More vivid display of data • Records overlay as an output video
Con's	• Display is not really adjustable • Few display options • Does not record overlay as a video, need 3rd party software	• Synchronizing can be tricky • Need to pay ($40-$60) to be able to output longer than 3 minutes at once, have advanced gauge editing, and be able to remove the RaceRender logo.	• Requires more work and/or templates to make the flexibility • More difficult to learn • Little technical support • Is a legacy product

Figure 2 Image from the EVADE program.

Figure 3 Image from the RaceRender program.

Figure 4 Image from the DashWare program.

EVADE

This manual assumes that you have been able to download, install, and run the software correctly from NIOSH at: https://www.cdc.gov/niosh/mining/Works/coversheet1867.html. NIOSH also provides a tutorial to help you deploy their product.

EVADE is a relatively straightforward program that allows you to quickly develop a VEM system. There are not many options, but that is what makes it straightforward to use. We have developed a project file with demonstration video and data that are available to you on our website (https://deohs.washington.edu/FRCG/project/VEM) so you can quickly start a project. The readme.txt file will instruct you where these files should be located. This manual will help you understand the basics of EVADE to allow you to use these files and develop your own VEM, but will not go into details. For more information, EVADE has online resources to help you.

File requirements

The file requirements for the EVADE package are shown in Table 2.

Table 2 File requirements for EVADE

	Requirement
Video	WMV, AVI, MP4, MOV, and possibly others
Data	Generic CSV file or some instrument specific files [Airtec Diesel, AM510, AM520, Nanozen, pDR1000 and pDR1500]

The data format for input into the EVADE system, if using a generic CSV file, should have time in the first column and measured values in the second column. This could also be done using one column with the types of data separated by a comma. **No column headers or titles** should be used with either format.

Time should be in one of the following formats with no date:

hh:mm:ss, or **hh:mm,** or **hh:mm:ss.ssss**

The measured values should be formatted as an integer or floating point decimal.

Starting a Project

To start a project using NIOSH EVADE, you'll open the program, add a data channel and a video channel, synchronize them and then run the program. The sections below will step you through this process. To record to a separate video for future use, you'll need to use a 3rd party software solution.

Demo Files/Folders

To help you get started on a project in EVADE, we have made some demo files available for you to download on our website. These files and folders are shown in Figure 5.

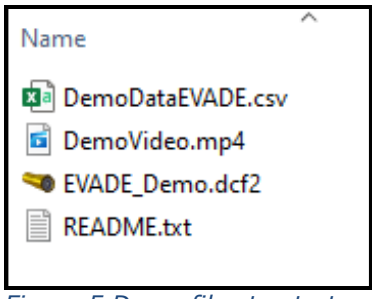

Figure 5 Demo files to start using EVADE

Adding Data and Video

To start a new project, you'll need to first make data and video channels and input those respective files. Following are the steps. We have also provided a demo project file for you to investigate (EVADE_Demo.dcf2). You can also use the demonstration video and data files that we provide.

1. Click on the "Add File" icon in the upper left corner of the program (Figure 6) and add a new channel. You can start with either a video or data channel. The manual will start with a video channel and you'll be prompted name the channel and to select a video file. This manual uses a file called **DemoVideo.mp4**.

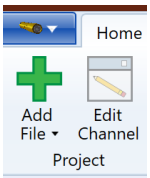

Figure 6 Add files/channels

The Project Editor (upper left hand box in the program) will look like Figure 7. Next, you will add a data channel. To do this, you'll click on the same Add File icon/New Channel, but select "Log" from the two options. It will then prompt you to name the data channel, this manual named the channel DemoData, and allows you to choose the type of data being imported. If you choose "Concentration", it will allow you to import your data directly from a proprietary data file from one of the instruments listed in Table 2, in addition to a CSV file. If you select "Generic", you will only be allowed to import a CSV file. Responses of "Light" and "Noise" will allow you to enter those respective types of files as well. If you are using a CSV file, using Generic is the least confusing way to import the data.

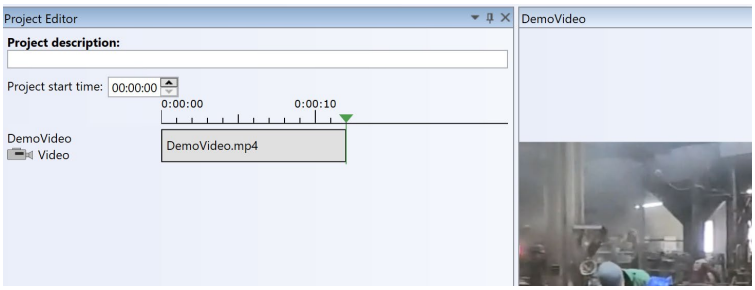

Figure 7 View of Project Editor with an added video file.

This selection will then allow you to choose your file and assign units to your measurements (Figure 8). You can press the Preview button to verify that your data

are being interpreted correctly. After adding your video and data files, the program windows will look similar to Figure 9. Now save your project by clicking on the small telescope above "Add File" (Figure 6). You can view your product by pressing the "Play" button at the top of the screen.

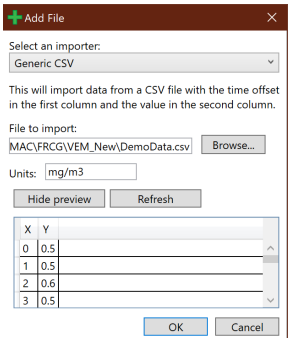

Figure 8 Window for entering the data source and units.

You will now be able synchronize and slightly alter the look of your video and data. In this processing, if you happen to delete your data file from your data channel, it is easily added back by clicking on Add File and then choosing your data channel and then reselecting your data file.

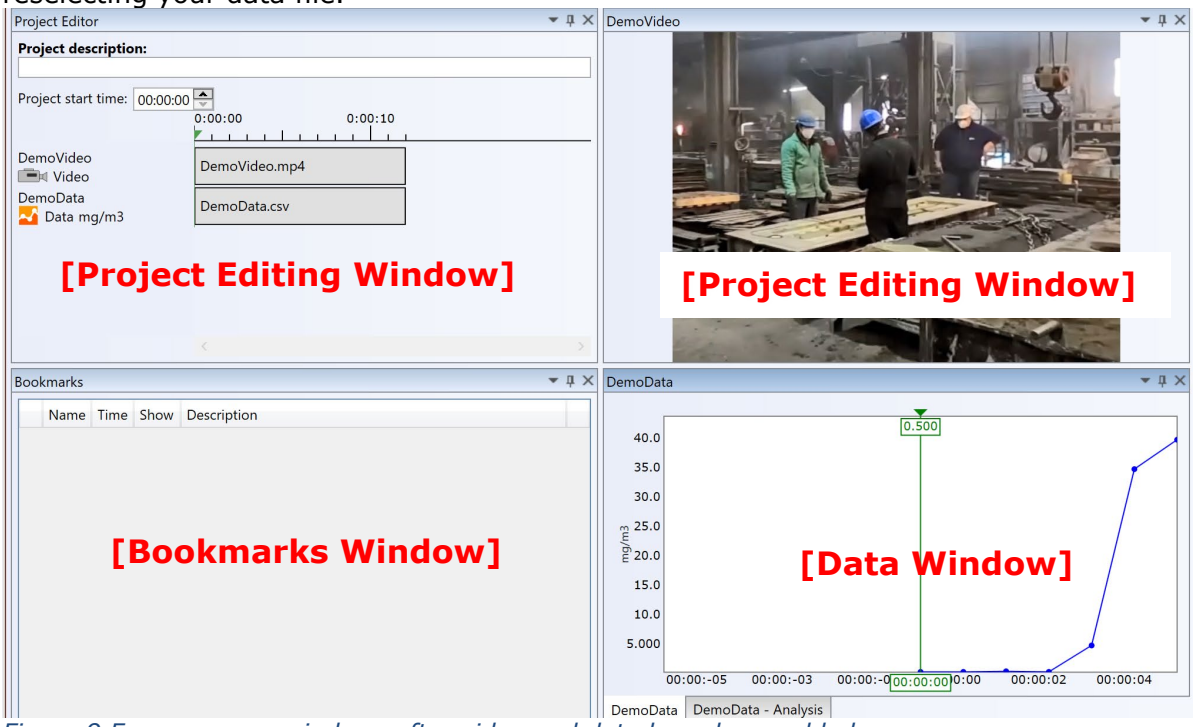

Figure 9 Four program windows after video and data have been added.

To highlight specific areas in your video, bookmarks can be added, saved and annotated at a variety of locations in your end product.

To adjust the look of the data chart, you can click on the Data Window and then click on the Options gear at the top of the screen. The window shown in Figure 10 will open. This will allow you to add a line indicating a threshold for your exposures.

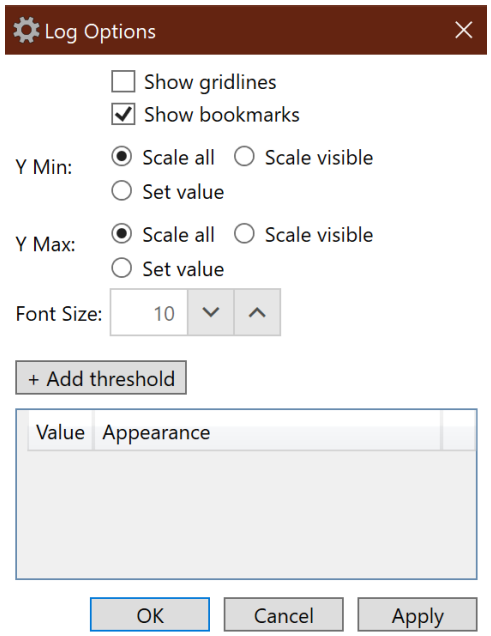

Figure 10 Options available for adjusting the look of the graph.

To add an animation of your data directly to the video channel as a semi-circular gauge, select the window with the video channel (Project Editing Window) and click the Options gear at the top of the screen. The window shown in Figure 11 will open. You will then select Add overlay at the bottom left and choose the options at the right, and click Apply. A data gauge will appear on the bottom right of your video channel window. This gauge will only show the exposure at the current time of your video.

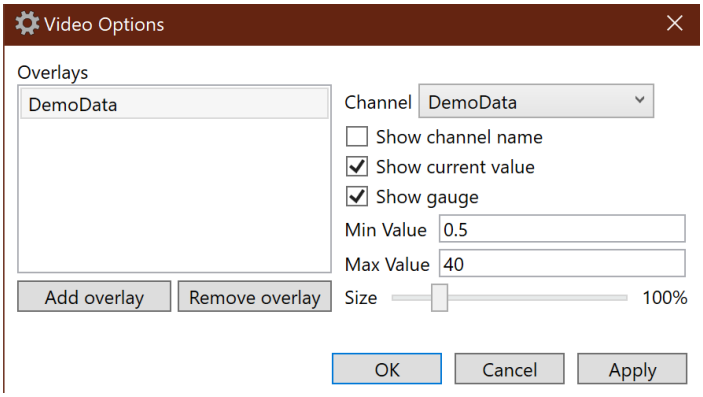

Figure 11 Options available for overlaying data directly onto the video.

EVADE also allows for basic analysis of your data. To do this, you will first click on your data window and then on the "Add Analysis" icon at the top of the screen. The windows shown in Figure 12 will pop up for your selection of options. The selected analyses will be shown in the Analysis tab of the data window.

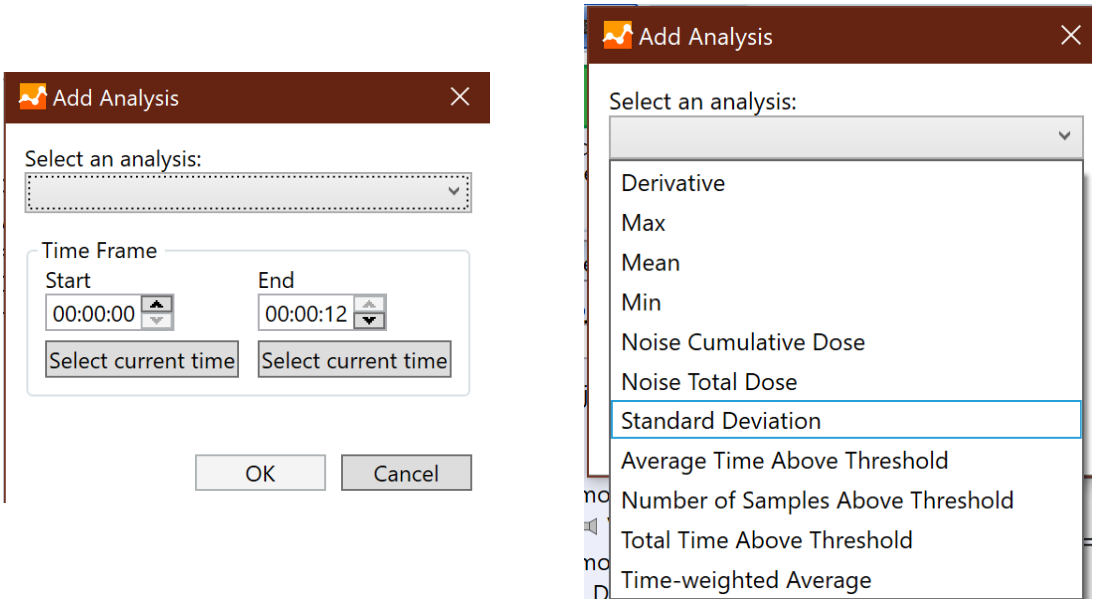

Figure 12 Options available for data analysis (left panel shows the initial window and the right panel shows the options for the analyses).

By clicking on the down arrow and the "push pin" in the upper right hand corner of each window (Figure 13), you'll be able to adjust the look of the different windows. This manual will not describe that process.

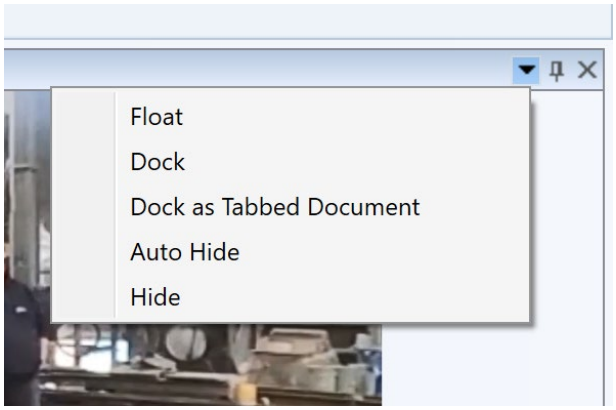

Figure 13 Adjusting the location and sizes of the windows

Synchronizing the Data and Video

After you have your project set up, you may need to synchronize your data and video. This can be done by going to the Project Editing Window and clicking on the bar labeled with your video or your data and dragging the bar so the data and video are synched. This can also be done by adjusting the "Segment start time" with the up and down arrows in the Selected segment bar that shows up after selecting one of the channel's bars (Figure 14).

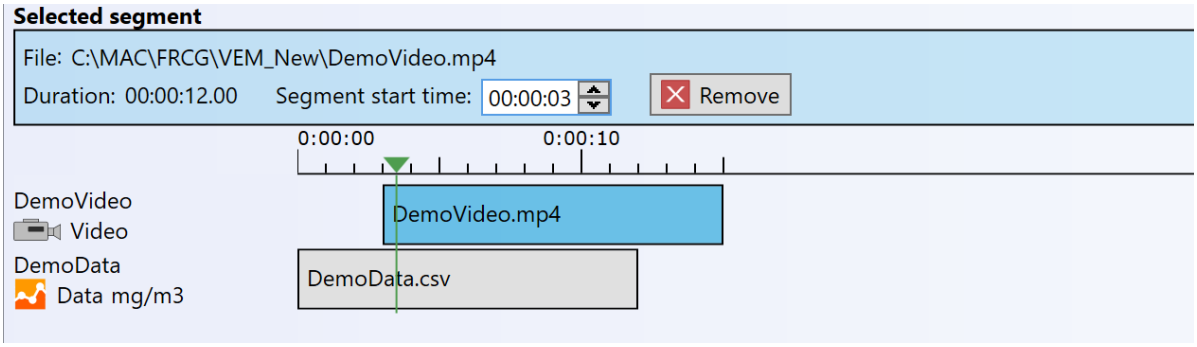

Figure 14 Editing the synchronization of the data and video.

For additional help visit:
https://www.cdc.gov/niosh/mining/Works/coversheet1867.html

Running the Overlay

After you have set up the panels with the look that you want and have synched your data, be sure to save your work. This *.dcf2 file can be shared with others who have EVADE. If you desire to share your work as a video file, you will want to capture the data and video screens using a 3rd party video capture program, such as OBS Studio or Camtasia/Snagit.

Recording the Overlay Video

OBS Studio

OBS Studio is "free and open source software for video recording and live streaming", that has been designed to operate on Windows, Mac OS 10.13+, and Linux and can be downloaded from https://obsproject.com/. This manual will only cover its operation on a Windows operating system to record an EVADE session. OBS works best with multiple monitors - one running OBS and the other running EVADE.

1. Start OBS on one monitor (if possible)
2. Start EVADE on the second monitor (if possible)
3. In OBS, ensure that there are no Sources currently listed. If there is one, you can delete it by highlighting it and pressing the "-" button below the Source list (see Figure 15).
4. Add a Window Capture Source by clicking on the "+" and then Window Capture. This will allow you to choose a window from which to capture the action. You will be given the option to choose a window to record (Figure 16). Here you can choose EVADE. You may need to close and reopen EVADE for it to be acknowledged by OBS.
5. It is recommended that you unclick, "Capture Cursor".
6. The size and location of your recorded window can be altered by grabbing the red box seen around your window and moving and resizing it (Figure 18).
7. To crop the window, right click on the Windows Capture source and click Filters. This will open a window where you can add or remove filters. Add a Crop/Pad filter and you will be able to adjust the cropping of the window (Figure 19).
8. For the example used to develop this manual on this computer, we used a cropping of Left: 1400, Top: 250, Right: 12, Bottom: 50. Depending on the size

of your computer monitor and layout in EVADE, you may need different crop settings.

9. Once you have set the crop settings, you can move or resize the window in OBS.
10. You can also adjust the size and shapes of the windows within EVADE, but that won't be covered in this manual.
11. You can now record your video by clicking on the "Start Recording" button at the bottom right. Next go to EVADE and start playing the video and data. While you are recording, a red circle will be shown at the bottom and the Start Recording button will turn to a Stop Recording button. An *.mp4 file will be saved of your recording by default in your Videos folder.
12. To change the location for saving files, go to Files/Settings/Output.
13. Depending on the memory of your computer, the output video may or may not be choppy. It may help to close as many programs as possible to reduce this issue.

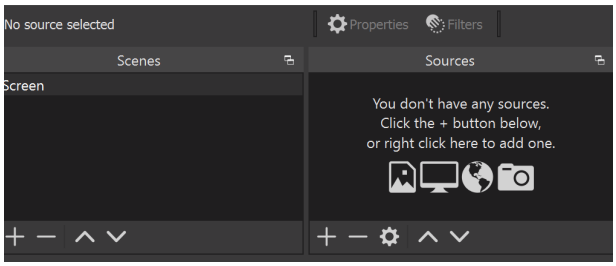

Figure 15 Editing sources for OBS.

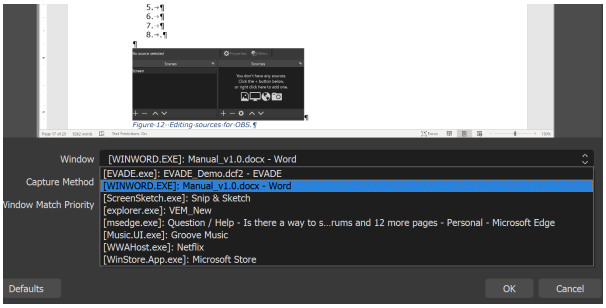

Figure 16 Choosing a window to record.

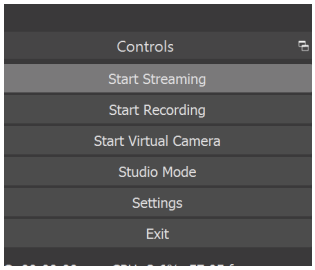

Figure 17 Start and stop recording.

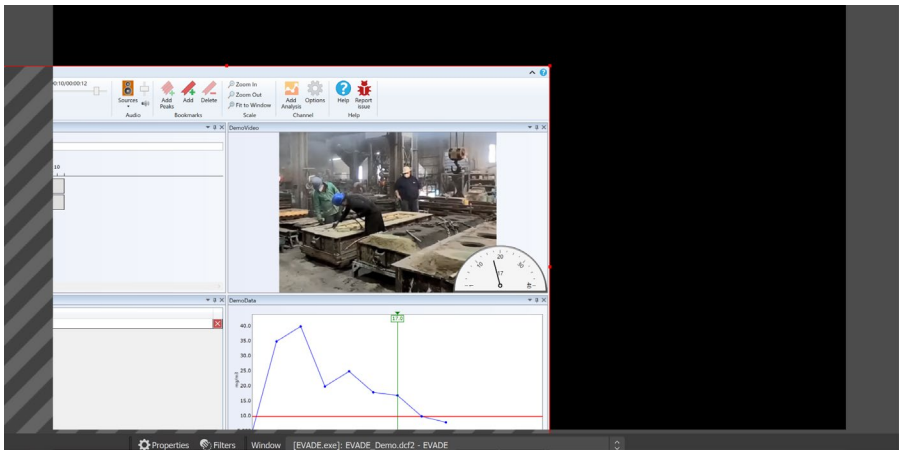

Figure 18 Recording window in OBS.

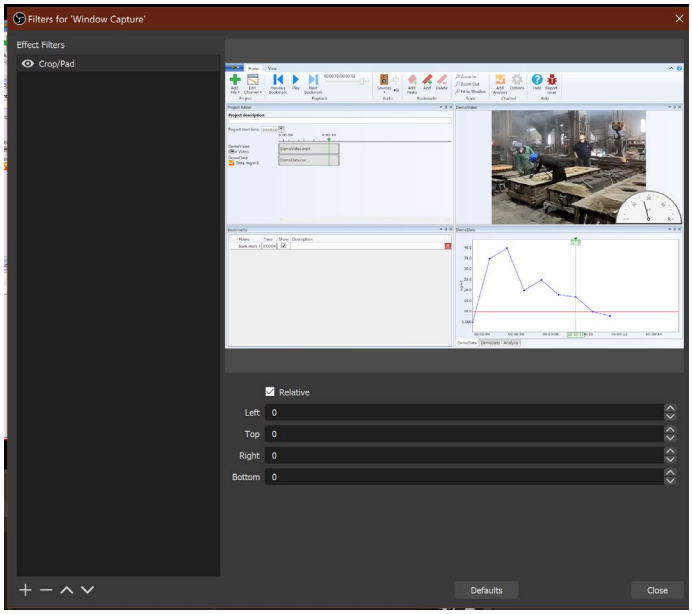

Figure 19 Cropping the window.

Camtasia/Snagit

Another alternate to capture the video is to use a screen/video capture software solution such as Snagit (Techsmith). This package allows you to highlight an area on your computer screen and capture either still images or video with audio. The following are the steps to use Snagit to capture a video from an EVADE overlay session.

1. Have your EVADE overlay session set up to your liking.
2. Run the Snagit program
3. Configure the recording as in Figure 20. If you use the settings shown in this figure, the Editor will open the video when it is done processing and this will allow you to save it to a location of your preference.
4. Maximize the EVADE window (Snagit will go into the background) and make sure that the project is at the beginning.
5. Click on the Snagit icon on the bottom task bar to bring it on top of the EVADE window
6. Click on the red "Capture" button. This will bring up the crosshairs to allow you to select the area that you would like to capture for the video. Click and hold

while you find one corner and drag the box to the opposite corner. Let go and you will have defined your recording area. The recording control panel will also pop up Figure 21.

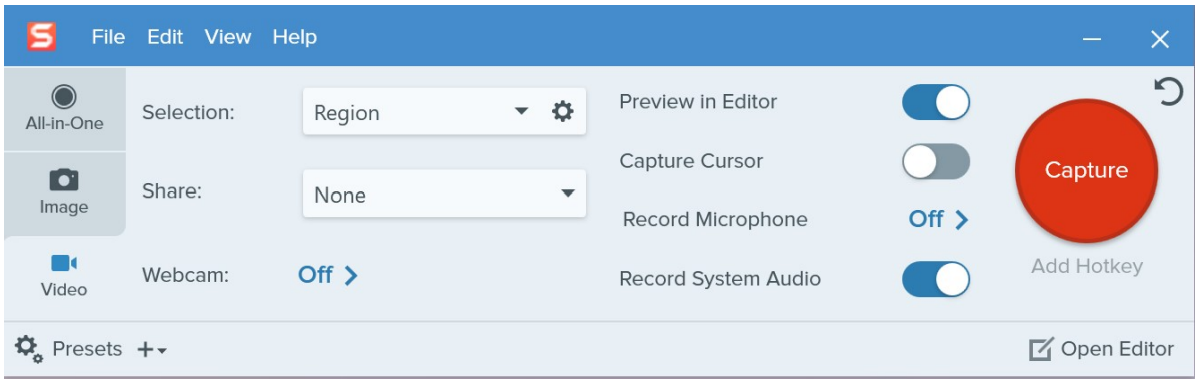

Figure 20 Control panel for Snagit.

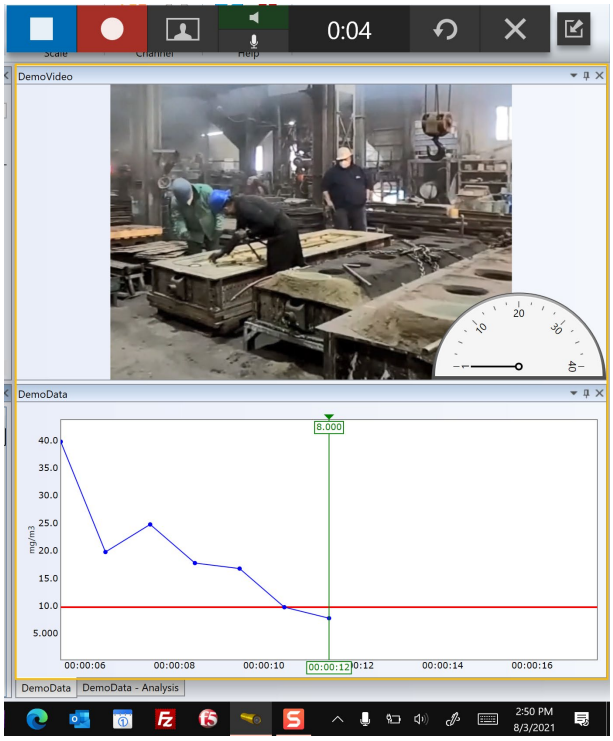

Figure 21 Control panel for Snagit recording.

7. To start the recording press the white circle in the red square. This will give you a 3 second countdown. After the countdown, you will be recording whatever you selected on your screen.
8. Now press the blue "Play" button on EVADE's control panel. This will start your overlay video playing while Snagit is recording.
9. Once your EVADE overlay has completed playing, press the Snagit stop button (white square on blue background). Your video will process for a few moments and then be opened in the Snagit Editor. This will allow you to save your video as an MP4 video file, which can be edited in your favorite video editing program, if desired.

RaceRender

RaceRender is a program that was written to allow people to overlay their auto/motorcycle racing data onto action cam videos of the racing. The following link shows an example video: https://www.youtube.com/watch?v=WeUSOmfLqiU&t=151s (Buckle up). The program can be easily adapted for use with exposure data.

This manual assumes that you have been able to download, install, and run the software correctly from RaceRender at: https://racerender.com/RR3/Download.html. The free version of RaceRender, allows you to develop a basic, short video (<3 mins). To be able to have more flexibility in the look and length of your video, you may need to purchase one of the upgrades. See Appendix B for a comparison table of the features and costs as of August 2021.

RaceRender is a highly powerful program that allows you to edit previously developed gauges. It can also be used with pre-programmed templates that contain gauges. The basic program comes with many templates, but two have been developed that show exposure data and are available to you on our website (https://deohs.washington.edu/FRCG/project/VEM) so you can quickly start a project. The readme.txt file will instruct you where these files should be located. This manual will help you understand the basics of RaceRender to allow you to use these files and develop your own VEM, but will not go into details. For more information, RaceRender has a manual in addition to a number of online tutorials to help you.

Basic terminology

1. **Project –** You will have a project file (.rrp) that will include your data, video, gauges, and settings. Unlike EVADE, the video and data files are only linked to this file, therefore the project file cannot be used on other computers unless all files have been copied onto that computer.
2. **Display Objects –** Display objects are entities that you can overlay onto your video. Categories of objects are: Video/audio, Image files, Drawings, Text, and Data Visualizations. These data visualizations are a graphical and animated visualization of your data. It can be shown in dials, bars, map tracks, numbers, etc. Objects are relatively programmable. Some basic objects have been adjusted for showing exposures and are available in the demo templates we provide for you (see below).
3. **Template –** A template is a file (.rrt) that tells RaceRender what display objects to use and where and with what data. Two demo templates have been developed for the demo data with a few different types of objects and are available on the website.

Demo Files/Folders

To help you get started on a project in RaceRender, we have made some demo files available for you to download on the website. These files and folders are shown in Figure 31.

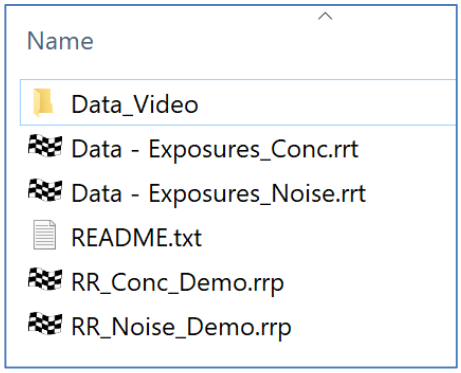

Figure 22 Demo files to start using RaceRender

Data/Video - The folder Data_Video has two files, a basic CSV file with time, concentrations, and noise data (both are made-up), and a short video clip saved as an MP4 file. This folder can be copied to anywhere on your computer. When you open the RaceRender demo project, it will prompt you for the locations of your data and video files.

Template – The *.rrt files in the folder should be copied into the folder C:\Users\XXXXXX\Documents\RaceRender 3\Templates, where XXXXXX is your profile name on the computer. Depending on your setup, this RaceRender 3\Templates folder may be in a different location. It should be noted that the files don't need to be placed in this location, but if don't copy them there, you will have to locate them whenever you open a template.

Project – The project files RR_Conc_Demo.rrp and RR_Noise_Demo.rrp can be copied to anywhere on your computer.

README file – The README.txt file has these instructions.

File requirements

The list of video and data file types acceptable for use with the RaceRender package are extensive and shown in Appendix C. The data format for input into RaceRender, if using a CSV file, should have time in the first column and measured values in the sequential columns. Figure 23 shows the format for the demo data provided to you. **Column headers or titles should be used**.

Time should be in one of the following formats with no date:

hh:mm:ss or **ss.ss**

	A	B
1	Time	Noise
2	0:00:00	74
3	0:00:01	86
4	0:00:02	91

Figure 23 Format and content of CSV data file

Starting a Project

For this manual, we will step you through starting a new project without a template and then add the template later. A template allows you make new overlay projects quickly if you have developed a set of display objects that you like. Starting a new project without a template will allow you to have a better understanding of how RaceRender works. You can also just open one of the demo project files to get going.

1. Start the RaceRender program.
2. When the program opens, click the Blank Project button at the bottom of the New Project Menu page. What you see here are project templates that incorporate data templates and well as different video views. We will not use these.
3. Now that you have a blank project open, go to Input Files on the right hand side of the screen and "Add" both your data (DemoDataRR.csv) and video (DemoVideo.mp4) files. This can be done at the same time by selecting both and clicking "Open". It will prompt you for a Data Overlay Template, "Cancel" that screen.
4. In the Input Files box, you will see both of your files. Double-click on the data file or highlight the data file and click the Config button above the file names. This will open the File Information & Settings window, as seen in Figure 24.
5. Change the Session Time pull down to "Time" from "(Automatic)" and then find Vehicle Speed (on the left in the middle) and change it to "Conc" or "Noise" from "(Automatic)", then click OK. This will allow your data to be interpreted properly.

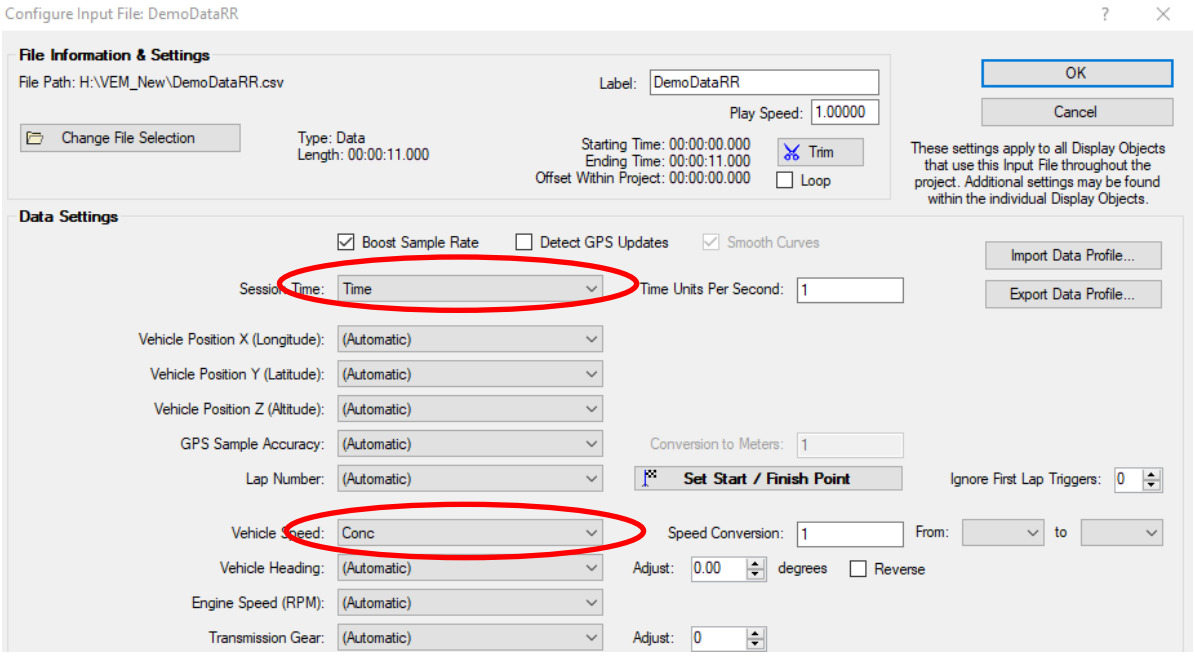

Figure 24 File Information & Settings window.

6. Next, you will need to add objects. This can be done by either clicking on "Add" under Display Options on the right side of the screen or by adding a Template via the main dropdown menu by selecting "Add Template to Project…".

Using Data Templates

If you decide to use one of the data templates that we provide for exposure assessment, you will have several different types and orientations of display objects to choose from. Each of these objects can be modified to meet your specific needs. Guidance for modifying objects can be found in the next section of this manual.

1. After you have your data and video open in RaceRender, go to the main dropdown menu item File\Add Template to Project… and scroll through the options until you find "Data – Exposures Conc" or "Data – Exposures Noise". If you can't find the templates, make sure that you have copied the template files, that we provide you (Data – Exposures_Conc.rrt and Data – Exposures_Noise.rrt) into the folder C:\Users\XXXXXX\Documents\RaceRender 3\Templates. See the Demo Files/Folders section above for more details.
2. Once you click on the template your project, it will try to connect your data to the objects. If this isn't correct, you can change it.
3. As set up, the Conc template uses the Conc field in the demo data file and the Noise template uses the noise data in the demo data file. This was done for your convenience because as you will see, it is relatively straightforward to change a template once it is set up.
4. If you've used the field names "conc" and "noise" for your data, the gauges should already be attached to your data if you have chosen the correct template for your data. If you have used other names, you will need to connect your data to the objects.
5. To connect your data to an object or change the data source, either double-click the object on the screen or it's object icon in the Display Objects box, or highlight its icon and click the Properties button. This will open the Display Object Properties box.
6. When the Display Object Properties box is open, find the pull down option called Field or Field Y (Figure 25) and select your desired field. By closing out this window (x'ing out), you will save your setting. You will also notice many, many auto racing variables that the system is looking for. You can ignore these, unless you are racing cars or motorcycles.
7. You may also need to adjust the scale for your gauges, but that will depend on the range of your data and the look that you want. To do so, open the Display Object Properties panel, Figure 26, and find Range and adjust the lower and upper values of your range. Depending on the type of gauge, you may also want to adjust the colors.
8. In the templates, you will see six different display objects that you can choose from. They all have different looks and attributes. Choose which ever one suites you needs and delete the others from you project.
9. Objects can be easily moved and resized.

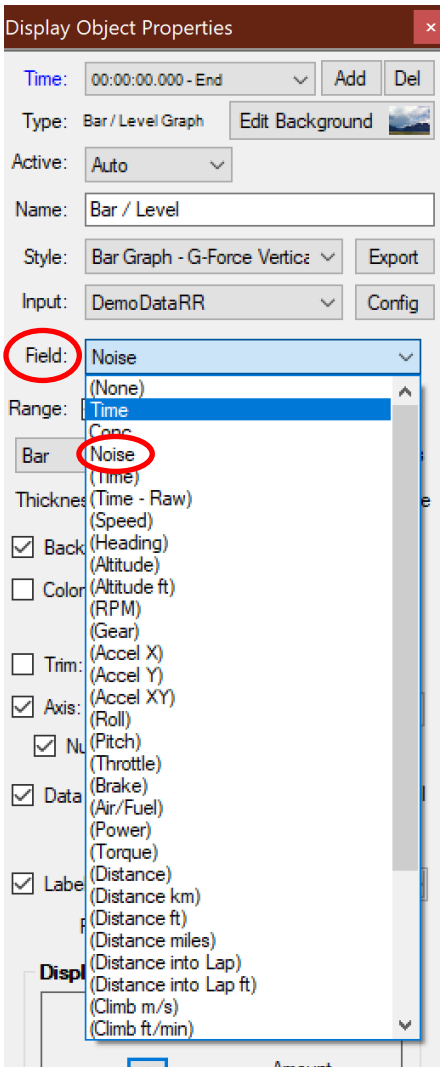

Figure 25 Display Object Properties screen

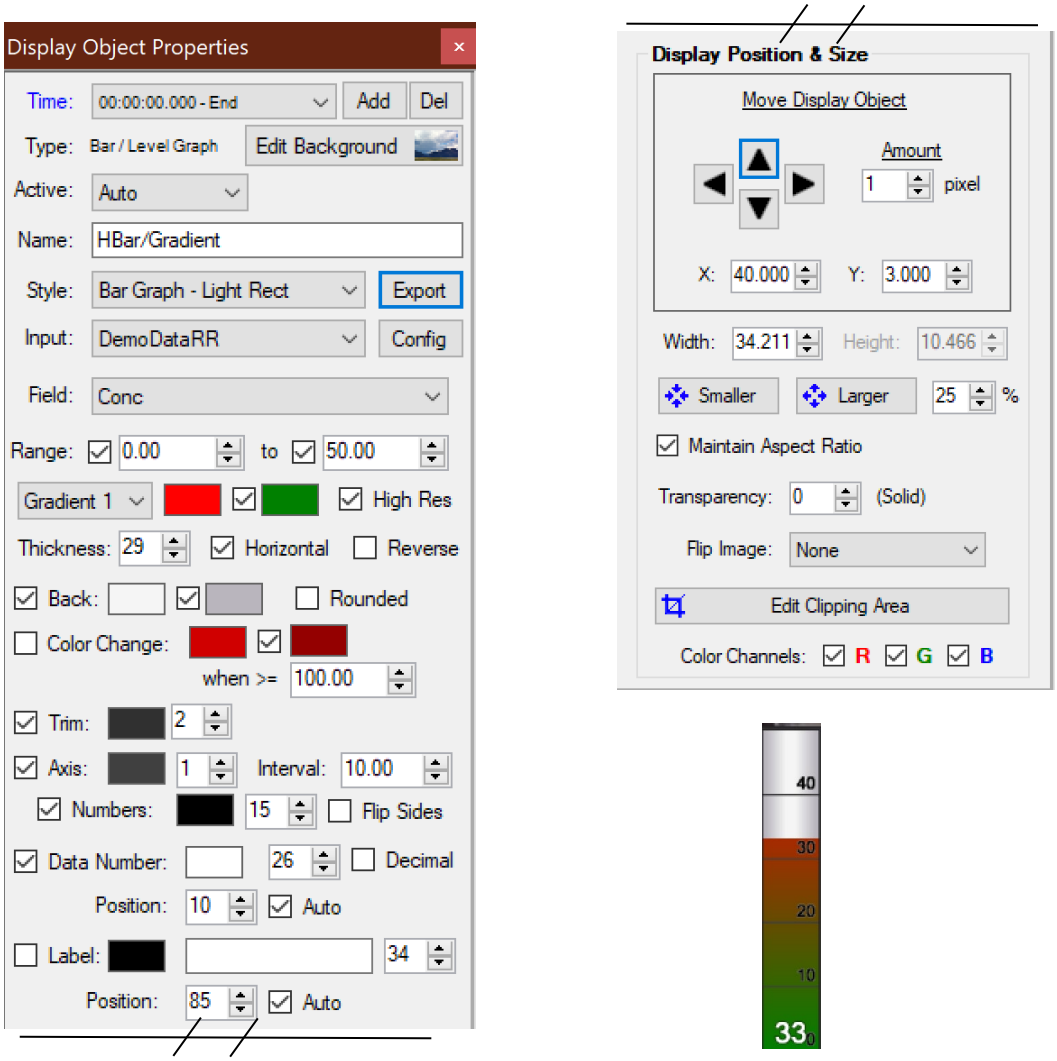

Figure 26 Editing a gauge (top [left] and bottom [right] of Properties panel) and the resultant gauge [bottom right]

Making and modifying display objects

Objects are relatively easy to make and modify using RaceRender. Depending on the version of RaceRender you have (free or one of the paid versions, see Appendix C), you will be able to edit some or all aspects of the objects. When you open Add from the Display Objects box, you will see the different options for objects and other enhancements (Figure 27). These options will differ for different types of objects. The data visualizations or objects are general layouts for which one can alter the type of data, the size, shape, text, and color amongst other options. In showing how to modify objects, we will highlight the components of a relatively simple bar / Level object, the "Bar Light Rect" object. It should be noted that the round objects have a Gauge Designer, which allows you to edit more attributes of those objects, but is only available with the more complete versions of the program. In addition, not all of the editing options are available in the free version.

From the title, you can learn that the object we are editing is a rectangular bar gauge that is light in color (Bar Light Rect). This is the object from which we developed the VBar/Gradient and HBar/Gradient objects and is shown on the bottom right of Figure

26. As an example, we will discuss the elements of this object that can be edited. For different object types, there may be different options, but they are all relatively similar. Table 3 describes the elements and what they do for a bar graph.

Table 3 Editing gauge elements in RaceRender

Parameter	**Description**
Time	You can program the gauge to have different appearances at different times in your video. You will need to use the Timeline feature to help see where things change.
Type	The Type is set when you add a gauge and can't be altered.
Edit Background	You can edit the background of a gauge.
Active	Controls whether the object is currently used.
Name	The name that you give to your gauge.
Style	This is the style of the gauge. The list given shows preprogrammed styles. If you click on one of these, it will change the look of the gauge and you cannot go back, unless you reopen the template or readjust the gauge. Ctrl-z may work.
Input	This is the input file from where the data will be pulled.
Field	This is the data field that will be used for your display.
Range	The range is the lower and upper values of your data that will be displayed. If you don't click the boxes, the program will choose automatically.
"Gradient 1"	This is an unnamed field. Along with the two color boxes to the right, this drop down allows you to design the look of the bar. Set at "Bar", the moving bar doesn't change color as it increases. With this setting the two colors are used to make a multi-colored bar. If one of the "Gradient" settings is chosen, one of two gradient styles will be used. It should be noted that the colored box on the left indicates the color for the higher values.
High Res	When this is clicked, many of the elements of the graphic become higher resolution.
Thickness	Thickness, is actually the width of the graphic.
Horizontal	Horizontal will flip the aspect ratio and have the graphic moving from left to right, instead of down to up.
Reverse	Reverse flips the movement of the data display (up to down), but be careful because the axis numbering may not change.
Back	Back will remove a background color. The current setting is a two tone white and grey. With Back unchecked, in some areas of your gauge, you will see the background video.
Rounded	This will round the corners of your bar.
Color Change	This allows the bar to change colors at a given threshold, but didn't work well for my purposes. To get a bar to change colors without a gradient, as the bar crosses a threshold, you may use two separate gauges sitting on top of one another. See the grouped gauges called HBar/Split/Green and HBar/Split/Red. They function as one gauge by adjusting the colors, ranges, and locations.
Trim	This alters presence and thickness of the trim around the gauge.

Parameter	Description
Axis	This allows you to add an axis to your bar and the following 3 attributes can also be altered.
Interval	This is the interval for your crosshatches.
Numbers	This programs whether numbers will be shown on the axis and their size.
Flip Sides	By default, the numbers show up on the right side of the bar, this will move them to the left side.
Data Number	This will show you the current value of your data and can be altered with the following two options. In addition, the number's color and size can be altered.
Decimal	This allows you to show the value with decimal places.
Position	This allows you to move the number values.
Label	This allows you to place a label on your gauge and alter its color size and position. Be aware that this may squish your label and it could be better to add a text object to your video so it can be fully seen.
Position	This alters the location of the label
Display Position & Size box	The options in this box allow you to move your object around the screen. An object can also be grabbed and dragged on the screen, if so desired.
Width	Doesn't seem to work.
Height	You can adjust the height of your object, but it also adjusts the width.
Smaller/Larger	The size of you object can be adjusted with the Smaller/Larger buttons by the percentage shown to the right.
Maintain Aspect Ratio	Doesn't work as I think it should.
Transparency	Allows you to make your object solid, invisible, or anything in between. Zero percent is solid and 100% is invisible.
Flip Image	You can flip your object horizontally, vertically, in both directions or none.
Edit Clipping Area	You can use this to show only part of a gauge. You can use this to crop you gauge.
Color Channels	You can R, G, or B to remove those colors from your image.

Adding other components

To add other components to overlay your video, simply click Add, under Display Objects and the screen shown in Figure 27 will appear. Select the type of Object you would like to use. The following describes the basic Object types that can be added:

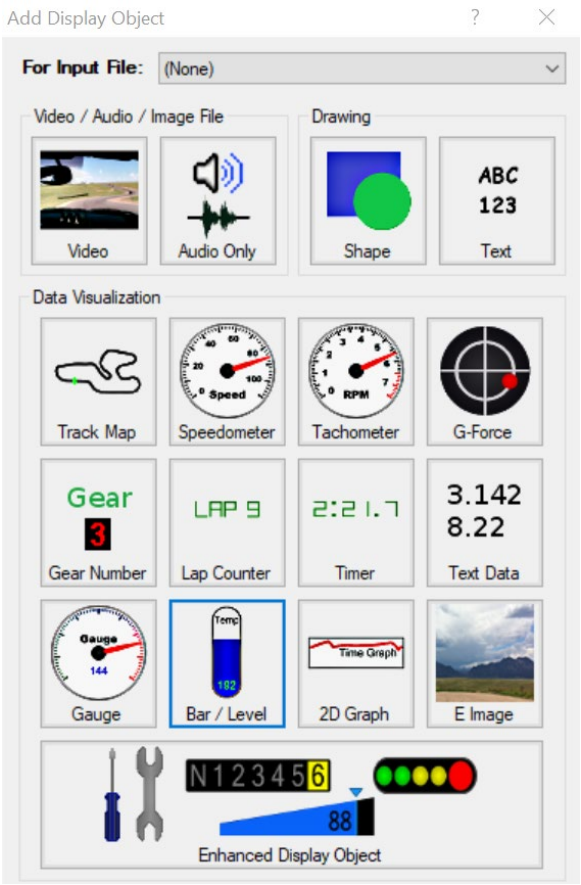

Figure 27 Display options that can be added to a project.

Video / Audio / Image File: You can add a "picture-in-picture" effect by adding another video or image onto your main video. You can also add supplemental audio. You can only add extra audio, video, and images to your project if you have already added them via the Input Files/Add process. Once you choose the style of the object, you will be able to edit the input, where you can choose the input file you wish to add to your video.

Drawing: Here you can either add a shape or text to your video. These objects can be edited to suite your needs.

Object Order: The order of objects in the Display Objects list will determine whether they are in front or behind other objects, including the video. To make text visible on top of a non-homogenous background, oftentimes, it is helpful to use an outline for your text. Generally, your video will be on the bottom of the list. To move objects front and back, select the object and click on the Move Up or Move Down buttons on the bottom right of the screen.

Synchronizing Data and Video

In order for your video and data to be effective, the animated data will need to be synchronized to the video as best you can. There are two tools that can be used to adjust the synchronization of the two streams, the Synchronization Tool and the Side by Side tool. Buttons for both tools can be found between the Input Files and Display Objects panes. The Synchronization Tool (Figure 28) can be used if you know the

duration of the offset that you would like to insert between your video and data. This is a straightforward process. If you need to view the data and video side-by-side to see where the best point for synchronization is, it is best to use the Side by Side tool (Figure 29). The Synchronization Tool will not be discussed further due to its straightforward nature. The following can be used to help you use the Side by Side synch tool:

1. In order for you to be able to use the Side by Side synch tool, you will need to ensure that your input file is configured. To do this, double click the icon for your data file in the Input Files panel. This will open the Configure Input File panel (Figure 24). If you don't have time set and either Conc or Noise in this panel, see the previous section on Sarting a Project. With both of those variables set appropriately, you should see a line graph of your data in one panel and the video in the other panel, as seen in Figure 29.
2. Once in this panel, you can either pull either the data's or video's slider to advance that scene until it corresponds with the appropriate location in the other panel. This can also be done numerically by typing in the time difference that you would like. You can also click on the forward or backward arrows with no number beneath it, a 2 or a 3 beneath it. These will advance or reverse the scene by 1, 2, or 3 frames. Standard video is about 30 frames per second.
3. Press the play button on the right to check the synchronization.
4. If you don't see your data presented in a graph, check the value you have for Data Display, in the middle of the panel. If you assigned your concentration or noise values to be the Vehicle Speed, the Data Display value should be Speed Graph.
5. There are other ways to synchronize your data which will not be covered here.

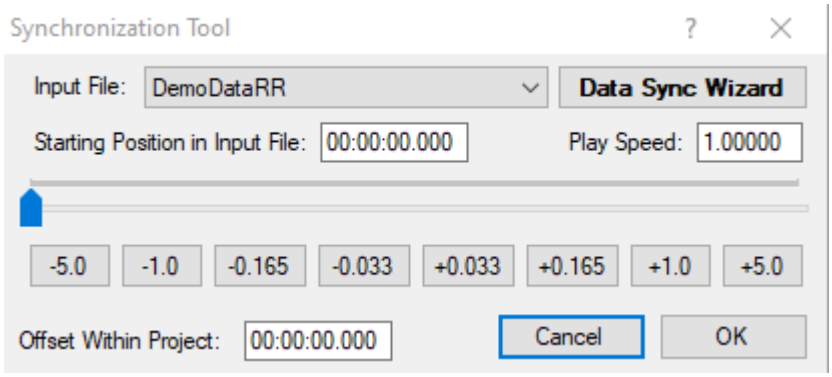

Figure 28 Synchronization Tool panel.

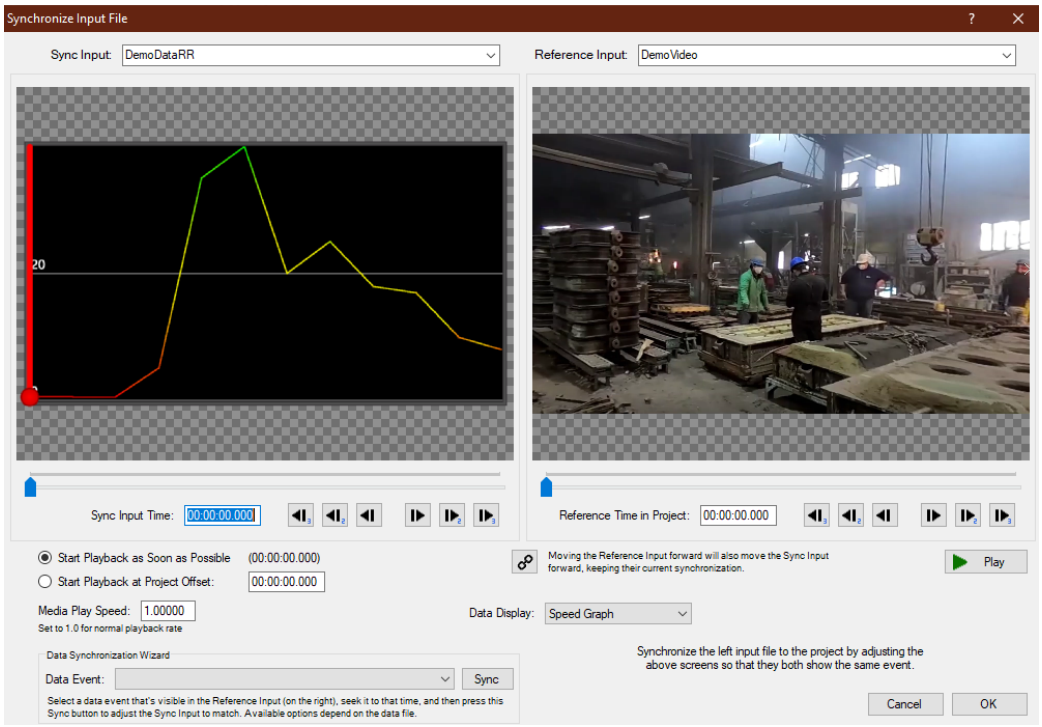

Figure 29 Side by side synchronization panel.

The Timeline

Each of the objects that you have placed in your overlay and in the Display Objects panel can have its timeline adjusted. You can have gauges, text, or other objects appear or disappear and predetermined times. To help control this, you can use the Timeline. To activate this feature, click the Timeline button at the top of the screen. The floating panel seen in Figure 30 will appear and can be moved and sized as needed. Here you can adjust the duration of the project as well as each object. If you adjust the synchronization, the adjustments will show here.

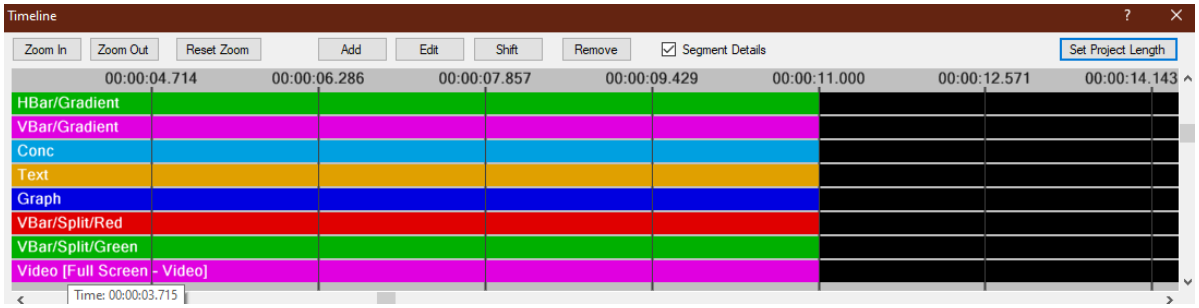

Figure 30 Timeline tool.

With the Display Objects panel and Timeline, you can also adjust how the different objects are seen. If an object is selected in the Display Objects panel, you can move it Up or Down using the Move Up and Move Down buttons at the bottom of this panel. Objects at the bottom of this list are used as background layers and those at the top are in the foreground of your composite video. These layers can also be seen in the Timeline.

NOTE: It should be noted that the RaceRender Logo will show on your videos unless you have purchased the software. The different purchase levels allow you to shrink, shrink and make transparent, or remove this logo. It will always be at the top of the stack of objects.

Recording the Overlay Video

Now you are ready to record your overlay video.

1. Click File>Create Video File from Project.
2. You will have a few options to choose here. First, pick the Output Profile. This will determine the general size and quality of your file. For most common situations, "Local File: Full High-Def (1080p) is a good selection for a high quality video.
3. Next you can choose the aspect ratio for your video. This may depend on your input video. Newer computer screens are 16:9 Wide-Screen, but older monitors are 4:3 Standard.
4. You can click on "Show Advanced Settings" to be able to do more fine tune adjusting.
5. In "Step 2", you can dictate what part of the video to capture.
6. In "Step 3", you can balance speed and quality. It is recommended that you select Better or Maximum quality.
7. Click the "Start Rendering!" button and select the name and location for your file and click Save.
8. Sit back and your video will be created.

NOTE: Some video players have difficulty with some video files (or more precisely their encoders). If one doesn't work for you try again. If it still doesn't play the video, try a different video player.

Styles:

You can define the style for your objects so they can be shared with future projects, but this will not be covered here.

Appendix A DashWare

DashWare is a program that was written to allow people to overlay their "adventure data" onto GoPro videos of them in the act of their adventure. The following link shows an example video: http://www.dashware.net/videos/flytec-wingsuit-jump/ (Hold onto your seat).

This manual assumes that you have been able to download, install, and run the software correctly from DashWare at: http://www.dashware.net/dashware-download/. DashWare is a high power program that allows you to develop your own gauges to show your data in the manner in which you want. It can also be used with pre-programmed gauges and templates. These computer resources are available to you on our website (https://deohs.washington.edu/FRCG/project/VEM) so you can quickly start a project. The readme.txt file will instruct you where these files should be located. This manual will help you understand the basics of DashWare to use these basic files, but will not go into details. For more information, there are a number of online tutorials to help you.

Demo Files/Folders

To help you get started on a project in DashWare, we have made some demo files available for you to download on our website. These files and folders are shown in Figure 31.

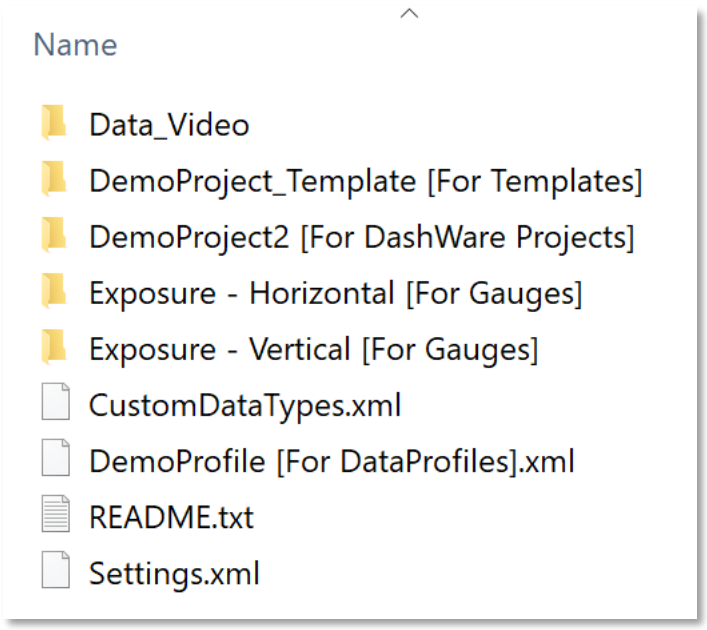

Figure 31 Demo files to start using DashWare

Data/Video - The folder Data_Video has two files, a basic CSV file with time and concentrations data (made up), and a short video clip saved as an MP4 file. This folder can be copied to anywhere on your computer. When you open the DashWare demo project, it will prompt you for the locations of your data and video files.

Template – The folder DemoProject_Template [For Templates], should be copied into the folder C:\Users\XXXXXX\Documents\DashWare\Templates and delete "[For Templates]" from the folder name. Depending on your setup, this DashWare/Templates folder may be in a different location.

Project – The folder DemoProject2 [For DashWare Projects], should be copied into the folder C:\Users\XXXXXX\Documents\DashWare Projects, and delete "[For DashWare Projects]" from the folder name. Depending on your setup, this DashWare Projects folder may be in a different location.

Gauges – The two folders Exposure – Horizontal [For Gauges] and Exposure – Vertical [For Gauges], should be copied into the folder C:\Users\XXXXXX\Documents\DashWare\Gauges, and delete "[For Gauges]" from the folder name. Depending on your setup, this DashWare/Gauges folder may be in a different location.

Data Profile (file) – The file DemoProfile [For DataProfiles].xml, should be copied into the folder C:\Users\XXXXXX\Documents\DashWare\DataProfiles, and delete "[For Data Profiles]" from the file name. Depending on your setup, this DashWare/DataProfiles folder may be in a different location.

CustomDataTypes.xml and Settings.xml (files)– These two xml files will add concentration and noise data types to your projects. These files should be copied into to folder C:\Users\XXXXXX\Documents\DashWare\Settings. You will be replacing the original settings.xml file with this one. The file, CustomDatTypes.xml is new. If you wish, you can preserve the old Settings.xml file by renaming it in case you want to use that file again.

README file – The README.txt file has these instructions.

File requirements

The file requirements for the DashWare package are shown in Table 4.

Table 4 File requirements for DashWare

	Requirement
Video	WMV, MP4, AVI, MOV, QT, MPG, MPEG, and MTS
Data	CSV and TXT files (other formats are also accepted but their use will not be covered here)

The data format for input into DashWare, if using a CSV file, should have time in the first column and measured values in the second column, as shown in Figure 32. Column headers should be used.

	A	B
1	Time	Noise
2	0:00:00	74
3	0:00:01	86
4	0:00:02	91

Figure 32 Format and content of CSV data file

Time should be in one of the following formats with no date:

hh:mm:ss or **ss.ss**

The measured values should be formatted as an integer or floating point decimal.

Basic terminology

1. **Project –** You will have a project file that will include your data, video, data profile, and gauges. Unlike EVADE, the video and data files are only linked to this file, therefore the project file cannot be used on other computers unless all files have the same locations.
2. **Data Profile –** The data profile is a file that tells DashWare how to interpret your data. The profile tells DashWare whether there are headers at the top of you data columns, which column has a time variable, and which column has your data variable. A demonstration profile has been written, called DemoProfile that will allow a basic data file to be read. The profile can be edited to allow data with a different structure to be read.
3. **Gauge –** A gauge is the graphical visualization of your data. It can be shown in dials, bars, map tracks, numbers, etc. Gauges are highly programmable. Two basic colored moving bars have been developed for showing exposures. One is horizontal and called Exposure – Horizontal and the other vertical and called Exposure – Vertical. Both go from green to red from 0 to 50 mg/m^3 with the numeric value beneath the graphic. Both the scale and units can be easily modified.
4. **Template –** A template file will tell DashWare what gauge to use and where and with what data profile. A demonstration template has been developed, called DemoProject_Template.

Starting a Project

For this manual, we will step you through starting a new project without a template. A template will allow you make new overlay projects quickly if you have developed a set layout. Starting without a template will allow you to have a better understanding of how DashWare works.

1. Start the DashWare program
2. Start a new project by clicking on File>New Project and naming the project to your liking. By default the project is located in your User folder in Documents/DashWare Projects. This can be changed in the Menus settings

Tools>Options. When you start a new project, this is where you will be able to apply a template. We have developed a template for you use called DemProject_Template, which can be found with the files on our website. To start a project with no template, select the <none> option in the Project Template pull down list in the New Project window. Click OK.

3. Once you have a new project started, you'll see both a standard Windows program menu on the upper left, but also a tabs on the right for Project, Synchronization, Analysis By Time, Analysis By Position, and Gauge Toolbox. We will only use the first two and last tabs for our project.
4. Clicking on the Project tab will allow you to set up your project (Figure 33).
5. First you can enter information in the Project Information area. Here you can enter some notes about your project, which won't be seen on your production. You can also set up starting title and ending credits. Note that if you use a Start Title and End Credits, they will be played over your video so you will need extra footage at the beginning and/or end.

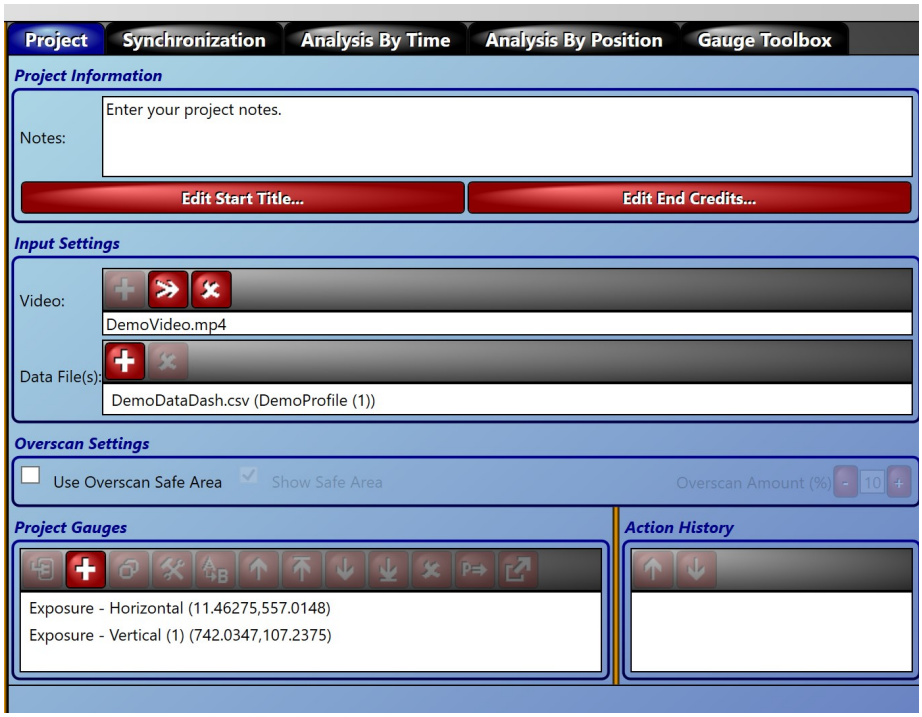

Figure 33 Project set up panel of DashWare.

Adding Data and Video

1. Next, in the Input Settings area, you'll tell DashWare what video and data files to use and how those data should be read (Data Profile).
2. Click on the plus sign next to Video: and find and choose the video file you want to use. If your video camera split your video into multiple files because of length issues, you will be able to merge the files here by clicking on the right arrow button next to the plus sign.
3. Now you will select your data file by clicking on the plus sign next to Data File(s): Browse to find your CSV file and click on it. You will then need to choose a data profile to read your data. If you have formatted your file as shown in , you should be able to use the DemoProfile that has been provided for

you. To verify that your data are being interpreted correctly, you can click on the Edit Profiles button. A data profile can also be edited by clicking on File>Edit Data Profiles. If you use the data file DemDataDash.csv and the data profile, DemoProfile, you should be good to go without editing the profile. If you wish to learn about basic editing of profiles, you can go to that section of this manual.

Visualizing the Data

Next you will need to create a visualization for your data by choosing a gauge for your data.

1. Click on the Gauge Toolbox tab. This will reveal all of the gauges that have been developed that you can use to show your data (Figure 34).
2. Scroll down to the E's for the Exposure – Horizontal and Exposure – Vertical gauges. These have been developed to show exposure data in a relatively meaningful manner.
3. Click on one of the exposure gauges and drag it onto the video where you would like it placed. You can move and resize the gauges as you like.
4. These gauges should already be connected to your data, if you are using the provided data profile and spreadsheet.
5. The look of the gauge, numbers, and units can be altered. Those operations will be discussed later. Figure 4 shows a basic data overlay with DashWare using the gauge, video clip, data, and data profile provided.

Figure 34 The Gauge Toolbox and 30 of the many gauges.

Synchronizing the Data and Video

Next, your data will need to be synchronized with your video.

1. Click on the Synchronization tab and a blue Synchronization Map will appear, ignore that. At the bottom of the screen is a red oval scroll bar that can be pulled to show the exposure over time and control buttons.
2. Make sure that the oval is at the far left and the "Sync with Video" (SWV) box is not checked. This will allow you move the data over time without advancing the video. When this box is checked, both the video and data will progress when the video's play button is pressed.
3. If your video and data are synchronized from the very start, you'll pull both the video and data screens' ovals to the far left, click the Sync with Video box and you're good to go. The video and data provided are pre-synched, so there is no need to adjust.
4. If you need to adjust the synchronization and have a synchronization point (see the following section in this manual: Starting the recording/Synchronization), with the SWV box unclicked, scroll your video to the sync point. Next, scroll your data to the sync point. You should be able to see you data moving in your gauge. If your gauge is not showing up, ensure that you have the "Show Gauges" box clicked below your video.
5. When you have your data and video synchronized, click the SWV box. Now when you scroll through your video your data should be synched to the appropriate point in the video.
6. Save your project.

Recording the Overlay Video

Now you are ready to record your overlay video.

1. Click File>Create Video.
2. This will bring up a dialog box that will allow you to name and locate the Destination Video file and assign it a Quality, which I leave on Auto, which is the highest quality. At the current time, you don't have an option for the Encoder to be used (Microsoft Media Foundation) or the file type (MP4).
3. Click Create Video and you video should be complete.

Potential Issues with the Output video

One issue seen in outputting video is that if the input video is the wrong resolution, the output video may be distorted, though the data gauge looks fine. To resolve the situation, I have captured my video in 1080p HD (1920 x 1080), which is standard HD video. If you are going to use Snagit to clip a video from another video, when outlining the area for capture, you'll need to adjust the screen capture size/resolution after you select your capture area to 1920 x 1080. See Figure 35 for the location of this setting in Snagit. Simply type in 1920 and 1080 instead of the selected resolution. By doing this, it will change the size and aspect ratio of your selection, but it will allow DashWare to output your video. A work around to this would be to use your video at whatever resolution you had chosen and use Snagit to capture your session within DashWare.

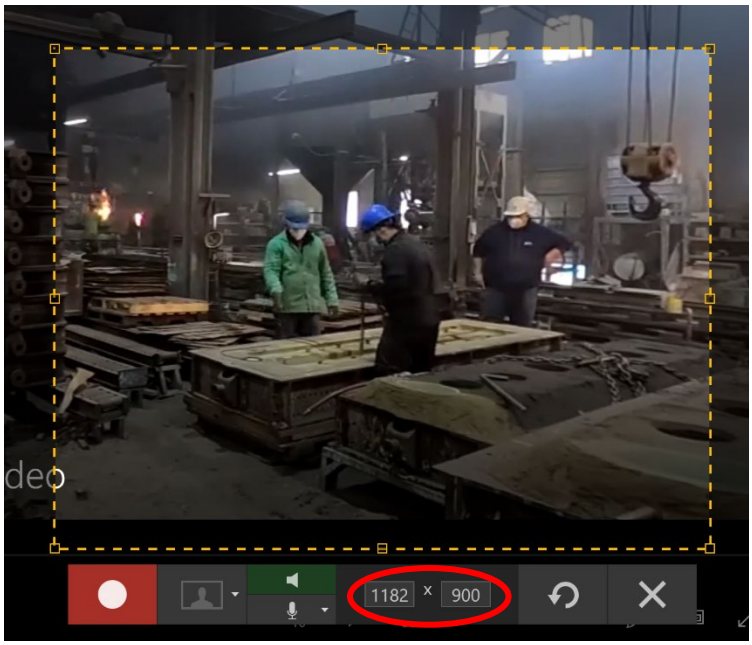

Figure 35 Adjusting the capture area size/resolution in Snagit.

DashWare – the details

Use as a non-administrative user:

Depending on your system, you may need administrative rights to install and possibly run DashWare. As installed, the program will want to run from an administrator's login account on the computer. There may be ways to run it without getting administrative permissions by moving files to a different location, but you will need to discuss with your IT staff.

Data Profile:

Potentially any source of logged data could be used with this software, but DashWare needs to know how to read and interpret the data files. The data profile gives DashWare those instructions.

1. To create a new data profile, add your data file as previously described and click "Edit Profiles…". This will open with a default profile with your data.
2. At the top of the Data Profile Editor, you'll see Data Profiles and will be able to add a new data profile by clicking on the large plus sign. You'll be asked to name your profile and then add it. Then you will get the Data Profile Editor screen (Figure 36).
3. Next, select Comma for the Separator Settings and select your appropriate decimal format. The Other Settings are advanced and won't be covered here (because I don't know what they are).
4. When you first open the data profile editor with your data, the three red headers in the middle of the screen, Mark Header Line, Mark Data Start, and Use Line to auto-Choose Profile… will be greyed out. To activate them click the first row of your file.

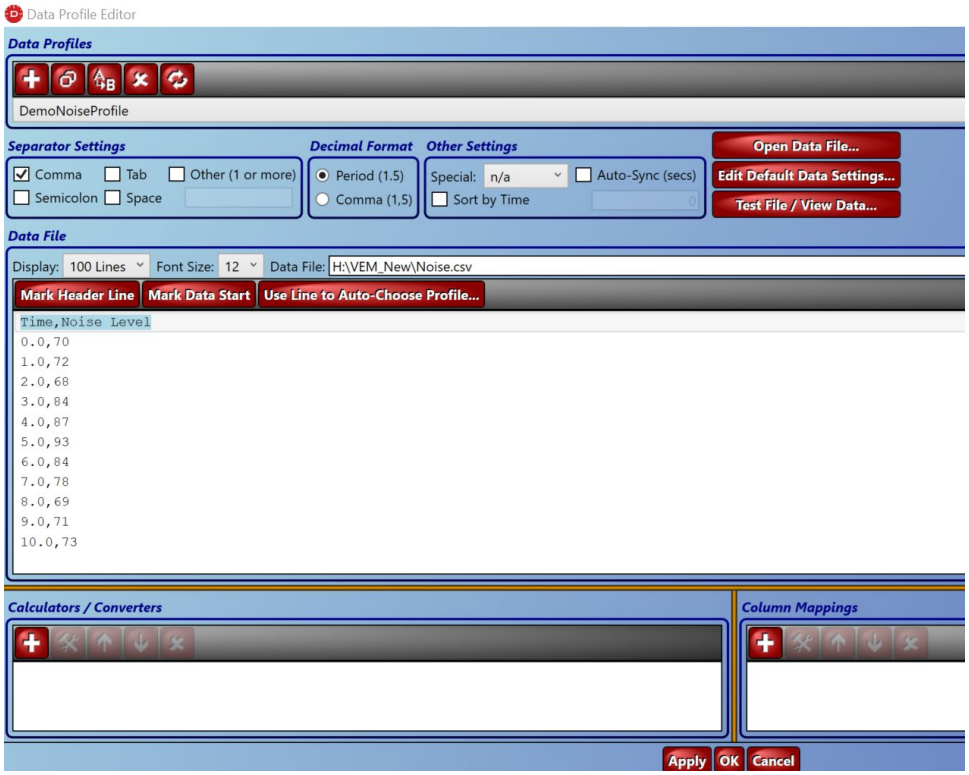

Figure 36 Data profile editor

5. With the first row still highlighted, click Mark Header Line. This will tell DashWare that your first row is the titles for your columns.
6. Next, highlight your first row of data and click, Mark Data Start and Using Line to Auto-Choose Profile. These setting will tell DashWare where your data start and what they look like.
7. Next, go to the bottom right panel and click the Plus sign in Column Mappings. Here you will tell DashWare what type of data are contained in your file.
8. As specified earlier (Figure 32), you should have time in your first column and your measurements in the second column.
9. In Figure 37, in the Input Column box, you will select the Input Data Column pull down and that will give the options from the header line that you have on your data. Select your time header.
10. In the Column Mapping box, set Map to Data Category to "<Required>". This should automatically set Map to Data type to "Data Running Time, Seconds". Click Add.
11. Click the Plus sign again in the Column Mappings box to tell DashWare what to do with your other column.
12. For the Input Data Column pull down, select the header name of your data column.
13. In the Column Mapping box, set Map to Data Category as "Environment" and Map to Data Type as "Concentration (units here)" or "Noise". If you're using a different unit of measure (e.g. ug/m3), you'll be able to change the display of the gauge to reflect your reality. Click Add, Apply, and OK.
14. Now your overlay should be ready to view.

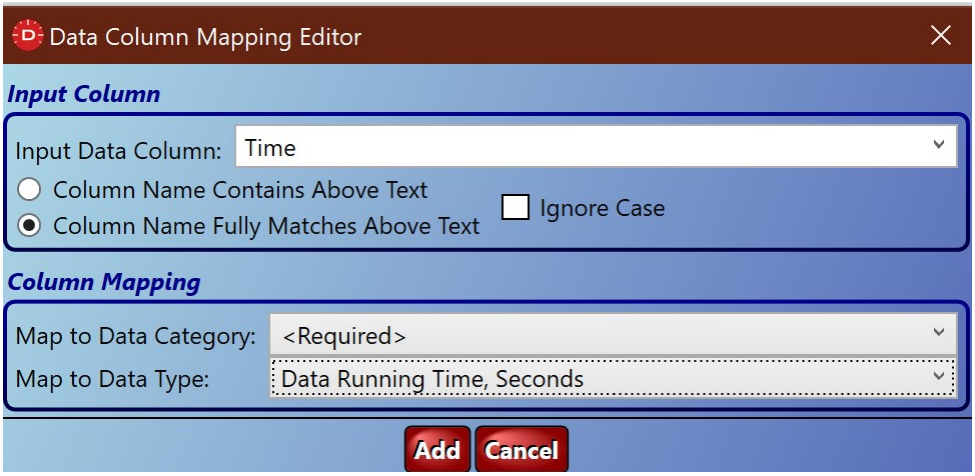

Figure 37 Data mapping editor.

Gauges:

There are many available gauges in DashWare. Simply click the Gauge Toolbox tab at the top right of the program to see all of them. The function of the out-of-the-box gauges vary greatly, but none of them were built to display exposures. I have developed 4 gauges for use with exposures that you can copy to your gauges folder (see the Demo Files/Folders section above for more detail). These gauges are named:

1. Exposure – Horizontal
2. Exposure – Vertical
3. Exposure – Noise – Horizontal
4. Exposure – Noise - Vertical

Once the files have been copied into your gauges folder, they will appear in the Gauge Toolbox.

You can clone, delete, and edit any gauge. You can set/change data files and data types, manipulate colors, and change text. You can consider these gauges as templates that you can customize to reflect the data that you are presenting.

> **Note:** When you double click on the gauge in the Gauge Toolbox, you will be editing that gauge. When you double click on a gauge that has been dropped onto the project screen, you can only edit that version of the gauge being used for that project.

Components - A gauge can be considered to be a cluster of components, which can be static or dynamic (animated). Examples of static components are unchanging text such as units and titles and shapes that don't move or change such as background shapes. Dynamic text would include numeric display of your data and animated shapes would be moving bars or arrows visually showing the value of the data.

Gauge Inputs – A gauge must also be connected to a data source and that is done via its inputs. If your gauge shows up and your data are present but not animating when they should, the first thing to check is to ensure that the gauge's input is correct. The

link to the data source is through the data profile and the data type. For dynamic components, you're able to assign a Value input to that component.

Gauges can be complex. The gauge shown in Figure 38 has 33 different components, with about half of them being dynamic.

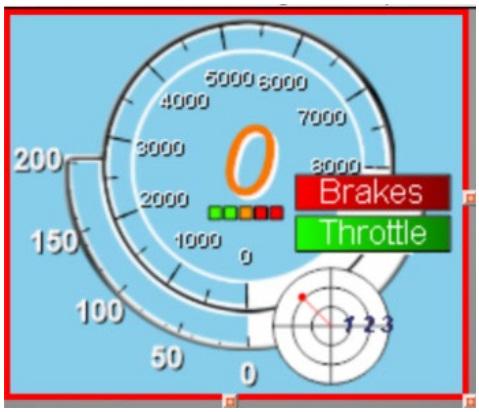

Figure 38 Example of a complex gauge.

We will use the Exposure – Vertical gauge (Figure 39) to highlight how to edit your own gauges in Gauge Designer. Basic properties (size, transparency, and rotation) of a gauge can be controlled in the Gauge Size area of the Gauge Designer. You can define the data category and type for your gauge in the Input Name panel by double clicking on the entry under Gauge Inputs. This needs to be consistent with the data and data profile.

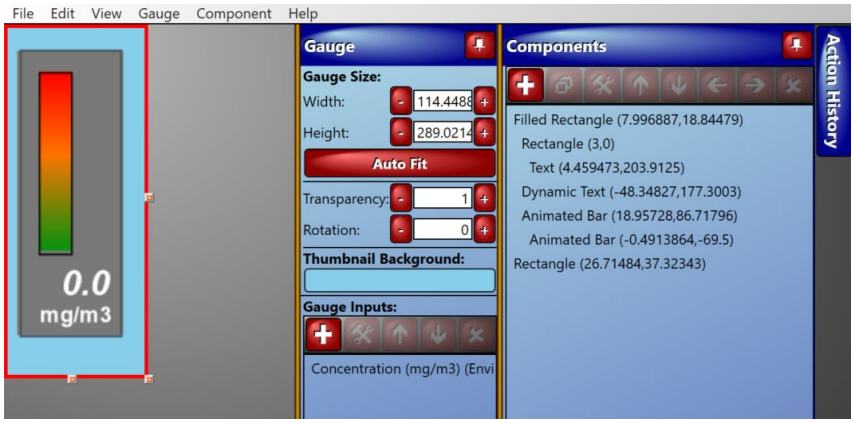

Figure 39 Exposure – Vertical gauge.

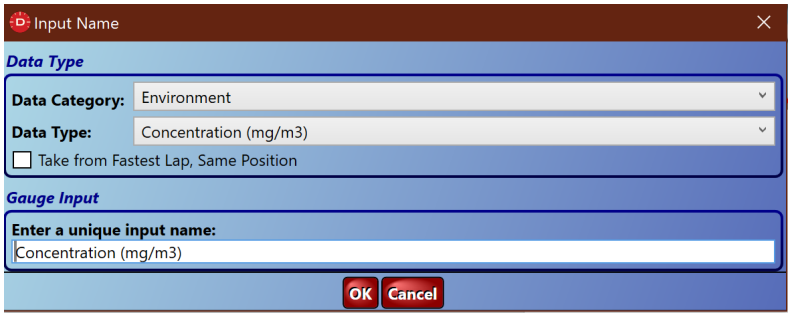

Figure 40 Gauge Inputs screen.

To edit specific gauge components, you can either click on the text describing it beneath "Components" or you can double click on the component itself on the graphic. Table 5 gives a description of the components used for this moving bar chart for exposures shown in Figure 39.

Table 5 Description of Components in Exposure – Vertical gauge

Component	Static / Dynamic	What it is	What can be altered
Filled Rectangle	Static	Solid grey rectangle serving as a background	Size, location, color of fill, rounded corners
Rectangle	Static	Open rectangle as border (can't have both line and shading on shapes)	Size, location, color of line, rounded corners
Text	Static	The units of measure	Location, the text, font (the font, size, and type), color, and defining rectangle
Dynamic Text	Dynamic	This shows the exposure value and changes over time	Value Input, location, text settings, display format, decimal precision, Test Value*, etc.
Animated Bar	Dynamic	Changes color based on the value. The first animated bar shows the lower part of the concentration range and goes from green to orange.	Value Input, location, size, data range, color gradient settings, Test Value*
Animated Bar	Dynamic	Changes color based on the value. The second animated bar shows the upper part of the concentration range and goes from orange to red.	Value Input, location, size, data range, color gradient settings, Test Value*
Rectangle	Static	Open rectangle as border outlining the colored bars	Size, location, color of line, rounded corners

*Test Settings/Value – This value can be used while designing the component to see if/how it works before completing the gauge.

It should be noted in Figure 39 that some components are indented from others. These indented components are "child" components of a parent "component". Child components are grouped with their parent and can be moved with their parent.

To quickly alter the data source of a gauge, you can go to the Projects Gauges in the Project tab (Figure 33), highlight the gauge you want to alter and the press the Edit Gauge Input Assignment button (). This will allow you to change the Data Value used for your gauge.

Synchronization:

Begin by clicking the synchronization tab at the top of the screen. Your data file will be indicated at the top. Moving the slider at the bottom should change your data value, but not the video location. This is a way you can test that your gauge is working. Move the slider to correspond with what is happening in the video. Once you have the video and data synched visually, press the checkbox in the bottom left of this pane to sync your data and video. The slider in this pane will immediately gray out. When you press play on your video the data will now follow along.

Templates:

The last thing about DashWare is that it makes it easy to repeat a project style. Click file at the top left and save as template. This will save the gauge, layout, and data profile for the next time you need it. You will only need to import your video and data then synchronize everything and you will be finished. Templates can also be shared between DashWare users for ease of use and consistent displays. Templates are stored at \\ThisPC\USERID\DashWare.

Saving:

For some computers it may be possible to go to File --> Create video. This will save your video file directly. This function is often reported broken, so you can use a screen capture method (OBS Studio) if DashWare video export fails.

For additional help visit: http://www.dashware.net/faq/

For DashWare, there are many helpful videos made by other users on YouTube and within the forums on the above site.

Appendix B Race Renders Details
Race Renders File Formats

Video / Audio / Image File Formats

Format Description	File Extensions	Compatible Platforms
MPEG-4 and H.264 Video GoPro, 360fly, Replay XD, Sony Action Cam, Contour, and many others	.MP4 .MOV .M4V .3GP	Windows + Mac Windows 7: Larger than 1080p may require Apple's QuickTime Player to be installed
H.265 (HEVC) Video GoPro and others	.MP4 .MOV	Windows + Mac Requires Windows 10 or macOS 10.13 "High Sierra" or newer. Your system may also need to have hardware support for HEVC. Windows 10 users may need to install Microsoft's HEVC Video Extensions.
AVCHD within MPEG Transport Stream	.MTS .M2TS	Windows + Mac Requires Windows 8 or macOS 10.12 "Sierra" or newer
QuickTime® Video	.MOV .QT	Windows + Mac Windows: May require Apple's QuickTime Player to be installed
Windows Media Video	.WMV .ASF	Windows only
MPEG-1 and MPEG-2 MPEG-1/2 are old formats and are not recommended for new video	.MPG .MPEG	Mac only
Audio Video Interleave (AVI) AVI is a very old and problematic format, and is not recommended for new video	.AVI	Windows only System must have compatible VfW codecs installed
360° Panoramic Video Supports common 2:1 equirectangular format (used for YouTube, Facebook, and others) Supports raw footage from 360fly and similar fisheye 360 degree cameras *See compatible video file formats above*	*Various* Typically .MP4 or .MOV	Windows + Mac Windows 10 or macOS 10.10 "Yosemite" are required for certain capabilities Windows 7: Video input may require Apple's QuickTime Player to be installed
MP3 Audio	.MP3	Windows + Mac
MPEG-4 Audio	.M4A	Windows + Mac
Wave Audio	.WAV	Windows + Mac

Windows Media Audio	.WMA .ASF	Windows only
Common Image File Formats JPEG, Bitmap, GIF, PNG	.JPG .JPEG .BMP .GIF .PNG	Windows + Mac

Please also see the system requirements for information on supporting these media formats and codecs. RaceRender may not be compatible with DRM-protected or other restricted-use media.
Windows Users: RaceRender's 64-bit option may have different media support than 32-bit. Please try the 32-bit version of RaceRender if encountering problems.

Data File Formats

Format Description	File Extensions
GPS Loggers - NMEA, GPX, TCX, and FIT Formats Common GPS recording formats used by Garmin and many other products Known Compatible Product List Additional Information	.NMEA .GPX .TCX .FIT .TXT .LOG
GPS-Enabled Cameras - NMEA Embedded in Video File GPS data inside an MP4 or MOV file Known Compatible Product List Additional Information	.MP4 .MOV
Motorsports and Other Dataloggers - CSV and Text Formats Many data acquisition systems and dataloggers Known Compatible Product List Additional Information	.CSV .VBO .TXT .LOG

Compatibility and available data features will depend on the format, data, and functionality provided by these other products, which may change at any time and without notice.

Output File Formats

Name	Extension	Platforms	Notes
MPEG-4 H.264	.MP4	Windows + Mac	Supports Google 360 degree spherical metadata (for YouTube, Facebook, and others) Windows Version Up to 4K is supported on Windows 10 High Profile is supported on Windows 8 and newer Windows 7 may have limited quality macOS Version Up to 4K is supported on macOS 10.10 (Yosemite) and newer High Profile is supported on macOS 10.9 (Mavericks) and newer
Windows Media Video	.WMV	Windows Only	Uses Windows Media 9 codec Up to 4K is supported
Audio Video Interleave (AVI)	.AVI	Windows Only	Up to 720x480 video, audio is PCM format, Xvid codec is recommended if using AVI AVI is not recommended for normal use

System Requirements

Please note that processing larger than 1080p video (such as 4K) will naturally consume more system resources, take longer to render, and may require the latest operating system version for some capabilities. Whenever you double the video height and width resolution, it quadruples the number of pixels that need to be decoded, loaded into memory, processed, and finally re-encoded. Similarly, high video frame rates can greatly increase how often this needs to be performed. As a result, increased video resolutions and frame rates can have a large impact on performance and practical system requirements. *See Chart*

In other words, for the latest and greatest video resolutions and features, you may find that you want to be using a computer with the latest and greatest performance, or something close to that.

Windows Version

- **OS:** Microsoft Windows® 7, 8, or 10
  Windows 10 64-bit is strongly recommended.
  Windows RT, S, and Phone are not supported. Must be desktop version for Intel and AMD CPU's (x86 or x86-64 / x64).
  Windows 7 has less media support and capability than newer versions.
- **CPU:** Intel i5, i7, or Xeon E5 CPU recommended
  Intel i7 or better strongly recommended for video larger than 1080p (ie 2.5K, 4K, etc.), or when using multiple 1080p videos.
  Actual requirements and performance will vary depending on use.

- **RAM:** 4 GB or more recommended
  Actual requirements will vary depending on use
  Use the 64-bit version of this software to make full use of your system's memory.
- **Display:** 1280 x 720 (720p) or larger screen resolution
  1920 x 1080 (1080p) or larger is recommended.
  More needed if using screen size scaling or "Large Fonts" (common for high-DPI screens).
- Windows 10 users may need to install Microsoft's HEVC Video Extensions, and have compatible hardware, in order to use H.265 / HEVC videos.
- Windows 'N' or 'KN' edition users need to have installed Microsoft's Media Feature Pack
  This applies to certain European and Korean versions of Windows that come without media support.
  You may need to locate the correct media feature pack for your version of Windows. Please refer to Microsoft's website for assistance.
- Windows 7 users need to have installed Microsoft .NET Framework 4
- *Optional:* Apple QuickTime® 7 Player
  Mostly helpful for boosting media format support on Windows 7.
  QuickTime can only be utilized while using the 32-bit version of this software.
- 32-bit and 64-bit versions are included
  64-bit is recommended for normal use on Windows 8 and newer. This requires a 64-bit version of Windows.

- The 32-bit option can be useful for better media compatibility on Windows 7, and for users with 32-bit versions of Windows.
  32-bit may experience problems with projects that use a very large amount of memory (RAM). Please use 64-bit if you can.

Macintosh Version

- **OS:** Apple macOS® 10.9 (Mavericks) or newer
  macOS 10.14 (Mojave) is recommended.
- **CPU:** Intel i5, i7, or Xeon E5 CPU recommended
  Intel i7 or better strongly recommended for video larger than 1080p (ie 2.5K, 4K, etc.), or when using multiple 1080p videos.
  Actual requirements and performance will vary depending on use.
- **RAM:** 4 GB or more recommended
  Actual requirements will vary depending on use.
- **Display:** 1280 x 720 (720p) or larger screen resolution
  1920 x 1080 (1080p) or larger is recommended.
  More needed if using screen size scaling (common for high-DPI screens).
- This is a 64-bit application

Appendix C Different version and features of RaceRender

	Free Edition Download	Deluxe Edition Buy Now!	Advanced Edition & Ultimate Edition Buy Now!
Price	**Free!**	39.95 USD	Advanced: 49.95 USD Ultimate: 59.95 USD
Maximum Output Video Length	* 3 Minutes	✓ Unlimited	✓ Unlimited
RaceRender Logo on Videos Small logo can be moved to a position of your choice	✗ Full Logo	* Flexible Reduced size Up to 40% transparent	* Advanced: Flexible Reduced size Up to 40% transparent ✓ Ultimate: Optional Can be removed entirely
4K Ultra High Definition Video (subject to increased system requirements)	✓ Yes	✓ Yes	✓ Yes
360° Panoramic Video Support	✓ Yes	✓ Yes	✓ Yes
Multiple Video Cameras Picture-in-Picture, Split-Screen, Quad, etc.	✓ Yes	✓ Yes	✓ Yes
Customizable Layouts & Sizes	✓ Yes	✓ Yes	✓ Yes
Trimming and Synchronization Tools	✓ Yes	✓ Yes	✓ Yes
Picture Mirroring / Flipping	✓ Yes	✓ Yes	✓ Yes
Basic Chroma Key	✓ Yes	✓ Yes	✓ Yes
Transparency / Watermarking	✓ Yes	✓ Yes	✓ Yes
Add Your Own Logos and Images	✓ Yes	✓ Yes	✓ Yes
Deluxe Capabilities	* **Basic**	✓ **Full Features**	✓ **Full Features**
Custom Text Overlays	* Limited	✓ Yes	✓ Yes
Audio Volume & Balance Adjustments	✗ No	✓ Yes	✓ Yes
Picture Cropping & Digital Zoom	✗ No	✓ Yes	✓ Yes
Picture Rotation	✗ No	✓ Yes	✓ Yes
Picture Adjustments Brightness, Contrast, Color, Hue, and others	✗ No	✓ Yes	✓ Yes
Maximum Input Files / Objects (subject to system and other technical limitations)	* 6	✓ 128	✓ 128
Maximum Display Objects	* 32	✓ 256	✓ 256
Maximum Timeline Segments	* 3	✓ 64	✓ 64

Data Overlay Customizations	✱ **Basic**	✱ **Basic**	✓ **Full Features**
Support for Auxiliary Data Channels	✓ Yes	✓ Yes	✓ Yes
Import Realistic Background Images (available for most data display objects)	✱ Limited	✱ Limited	✓ Full
Track Map & Position	✱ Basic	✱ Basic	✓ Full
Speed Display	✱ Basic	✱ Basic	✓ Full
Engine RPM Display	✱ Basic	✱ Basic	✓ Full
Traditional Gauges	✱ Basic	✱ Basic	✓ Full
Enhanced Displays Shift Lights, Gear Knobs, Unique Gauges, and more! (scriptable for an advanced level of customization)	✱ Basic	✱ Basic	✓ Full
Bar / Level Graph	✓ Full	✓ Full	✓ Full
2D Graph	✱ Basic	✱ Basic	✓ Full
G-Force Plot	✓ Full	✓ Full	✓ Full
Text Data Display	✱ Basic	✓ Full	✓ Full
Lap Number & Timer	✱ Basic	✱ Basic	✓ Full
Gear Indicator	✱ Basic	✱ Basic	✓ Full