BLASTCAM™
HIGH SPEED CAMERA

Operations Manual
Edition 3.0

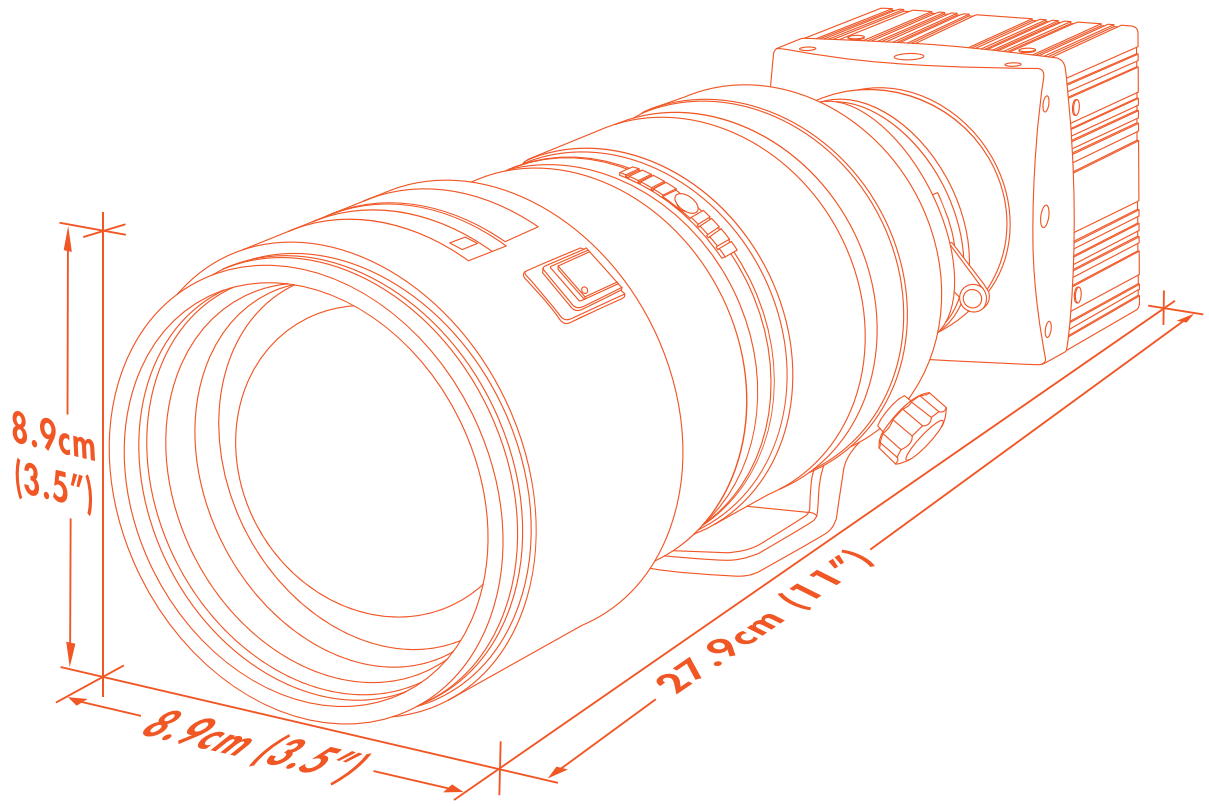

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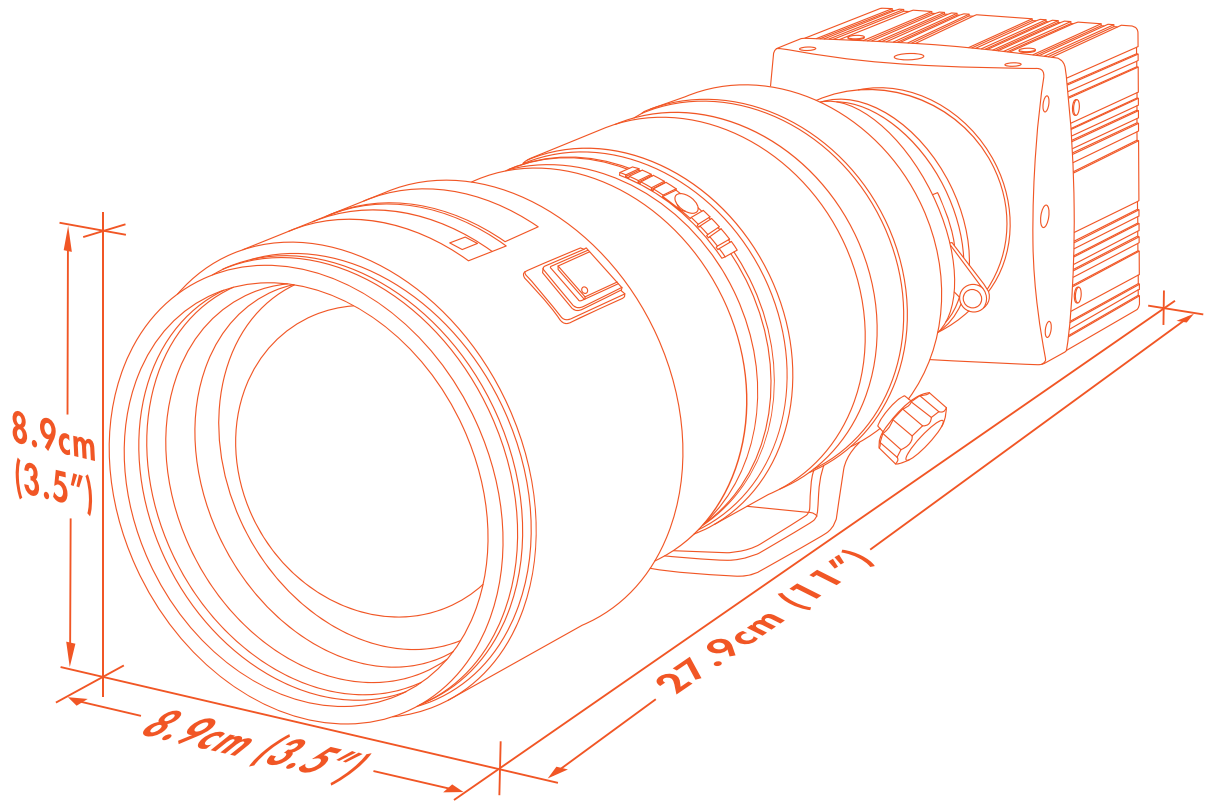
Table of Contents

Chapter 1
Introduction



Overview

This Chapter provides an introduction to high speed photography and to high speed photography of blasts.

1.1 Introduction

Congratulations on your purchase of a **BlastCam™** high speed digital video camera system. This Operations Manual provides instructions on the use of the hardware supplied with the **BlastCam™**.

This Manual is applicable to the following **BlastCam™** systems:

Model BCM2GB-F (monochrome)
Model BCC2GB-F (color)

1.2 High Speed Photography[1]

High speed photography is the practice of recording photograph images in rapid succession for playback at a lower speed. The event can then be viewed in what is commonly referred to as "slow motion". Standard video plays at a rate of 33 frames per second (fps) because standard video cameras record at 30 frames per second. However, it is possible to magnify the time scale if the playback speed is slower than the recording speed. The following is a simple equation to express time scale magnification in terms of the recording and playback speeds:

$$(1) \quad \frac{\text{Camera Recording Rate (fps)}}{\text{Viewing Rate (fps)}}$$

For example, a blast is recorded at 500 fps and played back at 10 fps. The time scale is therefore magnified 50 times, and as such the event will appear to occur 50 times slower in playback. If the event took two seconds to occur, it will now run for 100 seconds in playback.

The human eye cannot accurately resolve motion that occurs in less than 1/4 of a second. Short duration events such as a blast cannot be visually analyzed without the use of high speed photography.

1.3 High Speed Photography of Blasts[1]

High speed film cameras have been used by blasters to assist in optimizing blasts for many years. With the evolution of the high speed digital camera, blasters are now able to play, pause, and analyze a blast in perfect clarity as soon as the event has occurred!

It is the goal of the **BlastCam™ High Speed Digital Camera** to put the simplicity of digital video editing and analysis into your hands without sacrificing the resolution that has typically accompanied high speed film cameras of the past.

One of the major concerns of a surface mining operation is the high cost of drilling and blasting. In some mines operating in hard taconite-iron formations, this can account for 60% of the mining costs. In coal operations, blasting can be used to excavate nearly 50% of the overburden material. With the aim of reducing costs, mine personnel have been attempting to optimize blasting operations. In the past, blast designs have been based largely on the personal experiences of the blasting crew, and blast evaluations were done by visual observations - with changes being made on a trial and error basis. This traditional approach is gradually being replaced by a technology based on the concepts of energy input per ton of

rock, fragmentation and rock movement, along with the use of high speed video for the analysis of the blast movement.

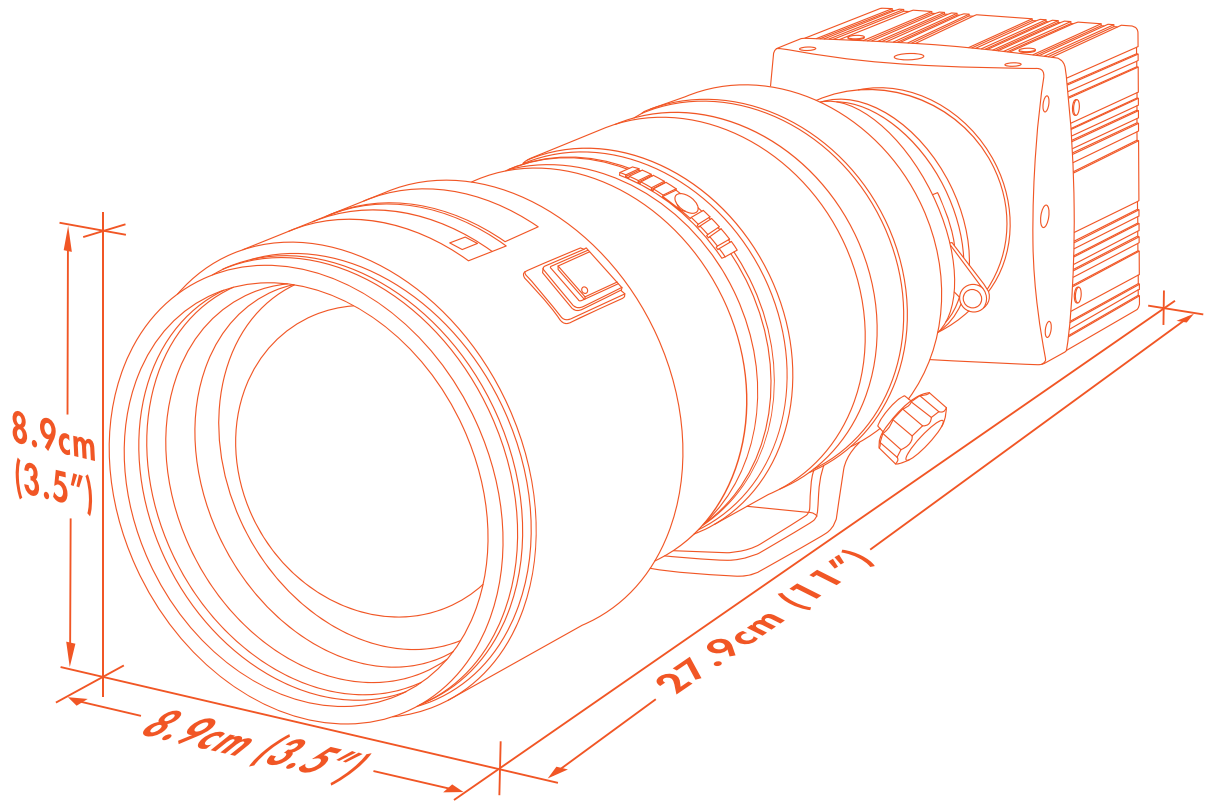
High speed video has two main uses in helping to optimize surface blasting results. The principal use is the direct photography of the blast, with the analysis of the resulting video and/or digital images representing the bulk of the optimization work. However, high speed video also can be used to analyze and inspect the performance of individual blast components, particularly the actual delay times for such accessories as detonating relays, down-the-hole delays and other delaying and initiating systems.

The information that may be obtained from high speed video includes: the firing sequence of the blast; the location of the first rock movement and the shape of the face movement; the occurrence of gas venting at the face; the degree of confinement due to stemming; the occurrence and location of misfires; the nature of the muck-pile formation; the onset time for rock movement (both at the face and at the top of the bench); the acceleration, velocity and direction of flyrock travel from the face and the top of the bench; the hole venting and stemming ejection velocities; the actual hole/deck delay times; and the casting range of the muck.

With proper preparation and care during the set-up, operation and analysis, considerable information may be obtained which can suggest where improvements may be required in the blasting operation. In addition, the video provides a permanent record of the event and allows any changes made between blasts to be easily and accurately analyzed. Before the introduction of high speed photography, what occurred during a blast had to be inferred from observing the results after the fact. With high speed digital video photography, many of these phenomena and occurrences can now be observed "as they happen".

1. "High Speed Photography in Open Pit Blasting" by Mining Resource Engineering Limited. March 1983. ISBN 0-9691314-0-2. Available from the International Society of Explosives Engineers (www.isee.org).

Chapter 2
Hardware



Overview

This Chapter describes all of the hardware components provided with the BlastCam™ High Speed Digital Video Camera.

2.1 BlastCam™ High Speed Digital Video Camera

The **BlastCam™ High Speed Digital Video Camera (BlastCam™)** is encased in a rigid steel housing. The housing is sealed to resist dirt and moisture and is equipped with two connection ports: the **Ethernet Communication** port and the **BlastCam™ Input Cable** port. The **BlastCam™ Input Cable** is comprised of a total of four cables: **Sync In, Strobe Out, Trigger In and Power**.

Photographs of the **BlastCam™** are shown below. The **Mounting Adapter** is attached to the bottom of the **BlastCam™** to allow the **BlastCam™** to be quickly mounted onto the **Tripod's Grip Action Ball Head** (shown in **Section 2.2.3**). The **Mounting Adapter** and the **Tripod's Grip Action Ball Head** are part of the Bl**astCam™ Accessories Package**. The **BlastCam™** is equipped to accept any standard F-Mount Lens.

2.1.1 BlastCam™ Camera

The **BlastCam™** contains the sensor with the lens mount on the front.
The back of the **BlastCam™** contains the two connection ports, an **Ethernet Cable Port** and a **BlastCam™ Input Cable Port**.

2.1.2 Zoom Lens

The Lens supplied with the **BlastCam™** is an **F-Mount (80-200mm) Zoom Lens** which is well suited for photographing rock blasting operations due to its versatile zooming capabilities.

2.1.3 BlastCam™ Controller

The **BlastCam™ Controller** is used to setup, control, and download the video from the **BlastCam™**. The **BlastCam™ Controller** connects to the camera via **Ethernet Cable** using a 100BASE-T or a 1000BASE-T connection. The communication speed is up to 100 Mbps (100BASE-T) or 1000 Mbps (1000BASE-T).

2.2 BlastCam™ Accessories

2.2.1 Protective Carry Case

The **Protective Carry Case** is designed to transport and store all of the components of the **BlastCam™ High Speed Camera**. The **Protective Carry Case** is constructed for industry-leading durability and water resistance.

The **Protective Carry Case** contains pre-formed foam material, which provides easy compartmentalization of the various components of the **BlastCam™**. A photograph of the **Protective Carry Case** is shown to the right. Please note that the only item that is not stored in the **Protective Carry Case** is the **Tripod**.

2.2.2 Tripod

This is an all aluminum **Tripod** with a 3/8" mounting screw. This **Tripod** is designed to support the **Grip Action Ball Head** with the **BlastCam™** attached. This is the only item that does not fit inside the **Protective Carry Case**.

2.2.3 Grip Action Ball Head

A photograph of the **Grip Action Ball Head** is shown to the right. This accessory mounts to a **Tripod** with a 3/8" mounting screw. The **Mounting Adapter** is typically attached to the **F-Mount (80-200mm) Zoom Lens**. This configuration assists in balancing the **Tripod**.

2.2.4 BlastCam™ Controller Mount

The **BlastCam™ Controller Mount** attaches to the leg of the **Tripod** and holds the **BlastCam™ Controller**. Please note that the **BlastCam™ Controller Mount** should be attached to a metal portion of the **Tripod** leg and not the padded section.

2.2.5 BlastCam™ Input Cable

The **BlastCam™ Input Cable** is comprised of a total of four cables: the **BlastCam™ Sync In**, **Strobe Out**, **Trigger In** and **Power cables**. A discussion of these functions is presented in **Chapter 3.2.4**.

NOTE: If the user does not require any of the **Sync In**, **Strobe Out**, or **Trigger In** features, the **Power cable** can be plugged directly into the back of the **BlastCam™**.

2.2.6 BlastCam™ AC Power Adapter

The **BlastCam™ AC Power Adapter** is used to power the **BlastCam™** when AC power is available. The adapter will accept **100-240 VAC** with a frequency of **50-60 Hz**.

2.2.7 BlastCam™ DC Power Cable

The **BlastCam™ DC Power Cable** will connect to an external DC power supply with a range of **10-30 VDC**. The most readily available source of power in the field is usually an automotive 12 Volt DC battery, so the **BlastCam™ DC Power Cable** is equipped with automotive battery terminal clamps.

2.2.8 BlastCam™ Controller Power Cable Adaptor

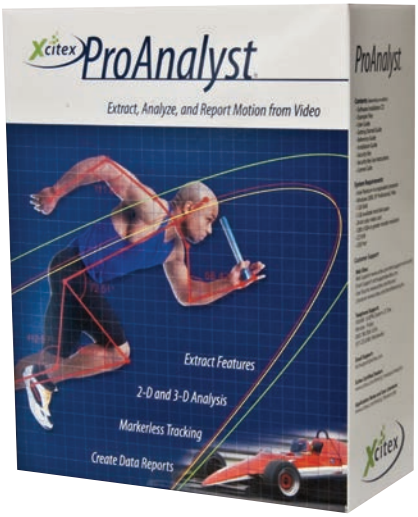
The **BlastCam™ Controller Power Cable Adaptor** is used to recharge the internal battery within the **BlastCam™ Controller**. The internal battery is rated for 8 hours of continuous **BlastCam™ Controller** operation before recharging.

2.2.9 BlastCam™ Ethernet Communication Cable

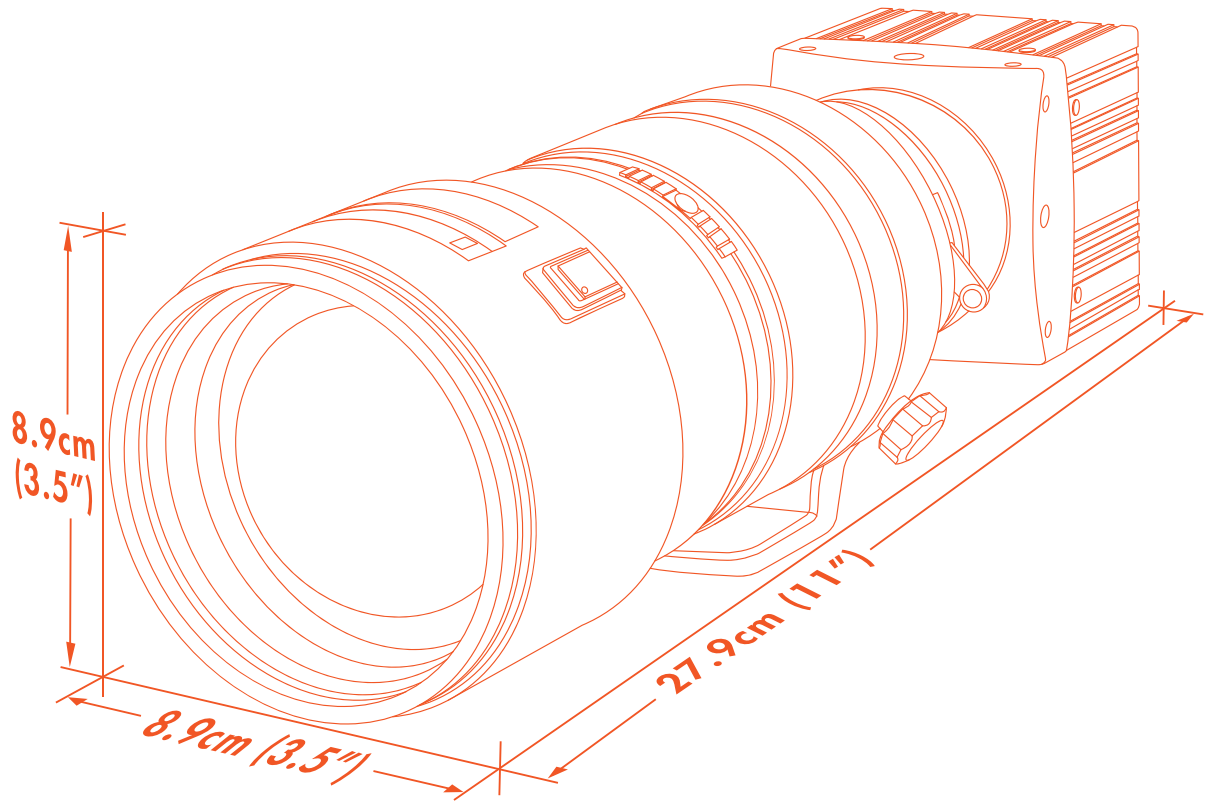
The **BlastCam™ Ethernet Communication Cable** connects the **BlastCam™ Controller** to the **BlastCam™** to support all setup, control, and download functions.

2.2.10 ProAnalyst® TrackOne Edition Software

ProAnalyst® TrackOne Edition allows auto-tracking of one feature, and manual tracking of up to 32 features. **ProAnalyst®** allows the user to export data to Excel or Matlab with ease for further analysis or graphing. This software is provided under licence from Xcitex, and as such requires the use of the included software key for installation. Instructions on using **ProAnalyst® TrackOne Edition** are included in **Chapter 6**.



Chapter 3
Getting Started



Overview

This chapter provides an outline of how to setup the BlastCam™ for recording, viewing, and saving events to the BlastCam™ Controller. This chapter assumes that the User will first want to unpack the BlastCam™ and set it up in an office environment in order to learn the camera controls.

3.1 Introduction

This chapter provides a detailed description of the setup procedure for the **BlastCam™**. **The Quick Setup Guide** is also included in **Chapter 3.3**. For instruction on using the **BlastCam™ Software**, please refer to **Chapter 4**. For Instruction on using the **BlastCam™** in the field, please refer to **Chapter 5**.

3.2 Setting Up the Equipment

The equipment required for the setup of the **BlastCam™** in an office environment is:
BlastCam™ High Speed Camera, F-Mount Zoom Lens, BlastCam™ Controller, BlastCam™ Tripod, Grip Action Ball Head, BlastCam™ Controller Mount, BlastCam™ Input Cable, BlastCam™ AC Power Adapter, BlastCam™ Controller Power Cable, BlastCam™ Ethernet Cable and ProAnalyst® TrackOne Edition.

There are several precautions that must be remembered prior to using the **BlastCam™**. The suggested procedure for assembly of the system is detailed in the following sections.

STOP

Do not allow any dust/dirt/moisture to enter the **F-Mount** connection port on the **BlastCam™** when attaching the **Zoom Lens**.

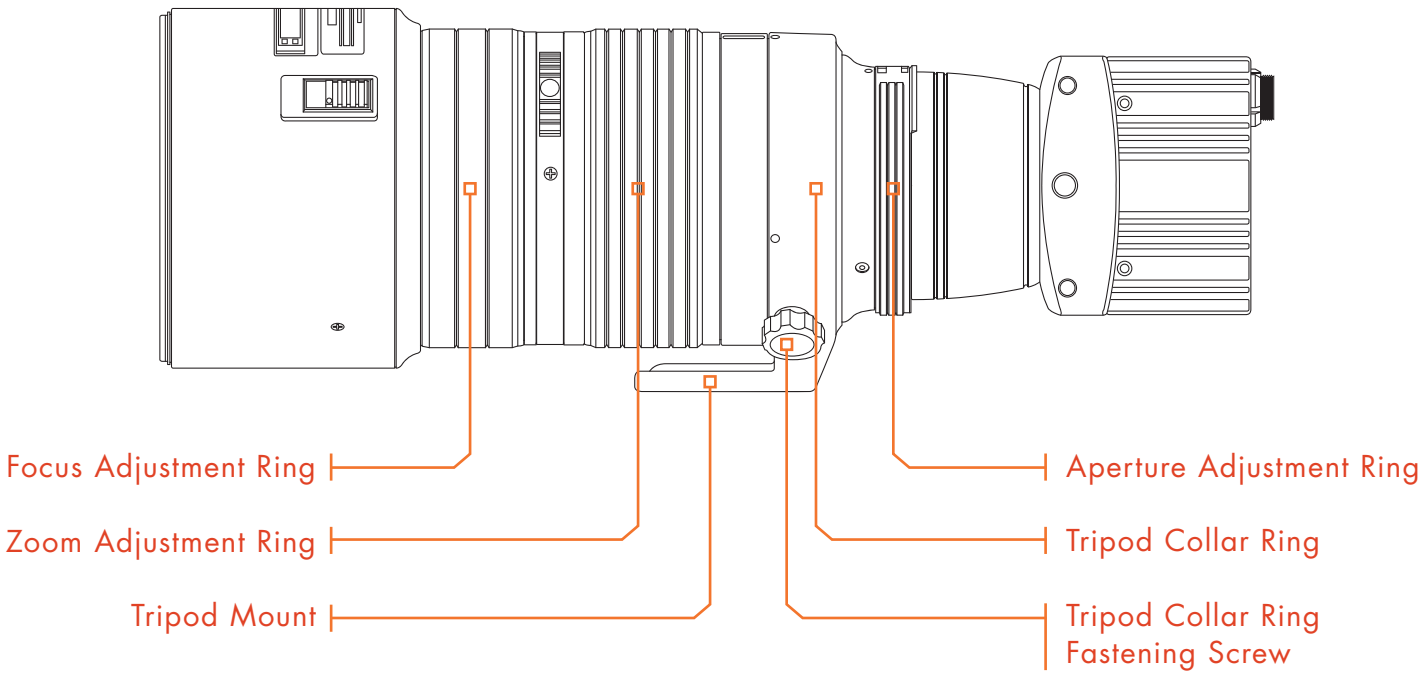
3.2.1 BlastCam™ Setup

Open and extend the **Tripod** legs. Attach the **Grip Action Ball Head** to the top of the **Tripod** using the 3/8"screw mount. Remove the **Mounting Adapter** from the top of the **Grip Action Ball Head** and connect the threaded screw of the **Mounting Adapter** to the bottom of the **Zoom Lens**. Be sure that the **Lens** arrow is pointing towards the front of the **Lens**. Attach the **Mounting Adapter** to the **Grip Action Ball Head**. Secure the **Zoom Lens** using the locking lever located on the **Grip Action Ball Head**. It is also good practice to utilize the locking lever pin ensure the locking lever does not come free during operation.

Mount the **BlastCam™** to the **Zoom Lens**. The F-Mount connection is a bayonet mount which employs three lugs to lock the **Zoom Lens**. With the **BlastCam™** rotated approximately 30° to the right, the mount will slide together. Rotate the **BlastCam™** counter-clockwise until vertical. The silver locking tab should click forward into the locked position to secure the connection. The camera will be locked to the **Zoom Lens**.

To remove the **Lens**, pull the silver locking tab backward and reverse the procedure above. Be sure to replace the lens and sensor caps as soon as possible to avoid contamination by dust or debris.

3.2.2 Zoom Lens



The **F-Mount (80 - 200mm) Zoom Lens** is assembled at the factory with a Lens cover on the front and back of the **Lens**. The **BlastCam™** also ships from the factory with a protective cover on the lens mount to protect the sensor; remove this cover by turning it 30° clockwise. Do not lose this cover, as it should be replaced whenever a Lens is not mounted on the camera. Attach the **F-Mount Lens** to the **BlastCam™** as described above. Be careful as trying to force the connection could result in damage to the **Lens**, the **BlastCam™**, or both.

NOTE: Try to avoid holding the **BlastCam™** with the Lens opening facing upward after the dust cap is removed. Any dust which settles on the face of the sensor will degrade the quality of the image captured by the **BlastCam™** until it is cleaned.

To change the **BlastCam™** rotation (i.e. vertical to horizontal picture), loosen the **Tripod Collar Ring Fastening Screw** (shown above) and rotate the **BlastCam™** and **Zoom Lens** until the desired orientation is achieved. Tighten **Tripod Collar Ring Fastening Screw** when the desired rotation is achieved.

Once the **Lens** is int he correct position, rotate the **Aperture Adjustment Ring** and **Focus Adjustment Ring** to reasonable settings. A fully opened aperture (smallest number) will provide the highest possible recording rate with the brightest picture, but the smallest **depth of field**. Depth of field is defined as the distance between the nearest and furthest objects in focus as seen by a camera lens.

Increased depth of field is achieved by a smaller aperture (larger numbered setting), however more light will be required to record at the same frame rate (exposure time). For this reason, **MREL** suggests starting with the smallest numbered aperture setting and adjusting upwards as lighting conditions allow for greater depth of field.

The **Zoom Adjustment Ring** will allow the User more flexibility in the positioning of the **BlastCam™**, with the ability to magnify the image perceived by the camera.

3.2.3 BlastCam™ Controller Mount with BlastCam™ Controller

Attach the clamp of the **BlastCam™ Controller Mount** to the metal leg (the one without foam) of the **Tripod**. Put the **BlastCam™ Controller** in the **BlastCam™ Controller Mount** by widening the spring-loaded controller tray to place the **BlastCam™ Controller** on the tray. Connect one end of the **Ethernet Communication Cable** to the right side of the **BlastCam™ Controller** and the other end to the back of the **BlastCam™**.

3.2.4 BlastCam™ Input Cable

3.2.4.1 Trigger Switch, BlastCam™ Power Adapter Plug

Connect the **BlastCam™ Input Cable** to the back of the **BlastCam™**. Align the red dot on the connector with the red dot on the **BlastCam™**. Connect the **BlastCam™ AC Power Adapter** to the **POWER** of the **BlastCam™ Input Cable** by aligning the red dots on the connectors. Connect the **Trigger Switch** cable to the **TRIG IN** connector. Note that the **BlastCam™ AC Power Adapter** can be directly inserted into the **BlastCam™** if the User does not require any other features of the **BlastCam™ Input Cable**. The **BlastCam™ AC Power Adapter** will accept both **110 Volt AC** and **220 Volt AC** power inputs. It is always recommended to plug the **AC Power Adapter** into the power source before connecting it to the **BlastCam™ Input Cable** or **BlastCam™** itself.

3.2.4.2 SYNC IN, STRUB OUT

The other connections on the **BlastCam™ Input Cable** are: **Sync In** and **Strb Out** (strobe output) which allow the User to synchronize multiple **BlastCams™**. For synchronizing multiple **BlastCams™**, the User must connect the **STRUB OUT** of the master **BlastCam™** to the **SYNC IN** of the slave **BlastCam(s)™**. This will allow multiple cameras to share the same time scale. Contact **MREL Group of Companies** to learn more about synchronizing your **BlastCams™**.

CAUTION

MREL does not recommend inserting the external power plug into the **BlastCam™** before attaching it to the AC outlet. Wall transformers sometimes generate power spikes that can damage electronics when the transformers are first plugged into the wall.

3.3 Quick Setup Guide

1. Tripod Setup

Open and extend the **Tripod** legs. Attach the **Grip Action Ball Head** to the top of the **Tripod** using the 3/8"screw mount. Remove the **Mounting Adapter** from the top of the **Grip Action Ball Head**.

2. Lens - Adaptor

Fasten the threaded screw of the **Mounting Adapter** to the bottom of the **Zoom Lens Tripod Collar Ring**.

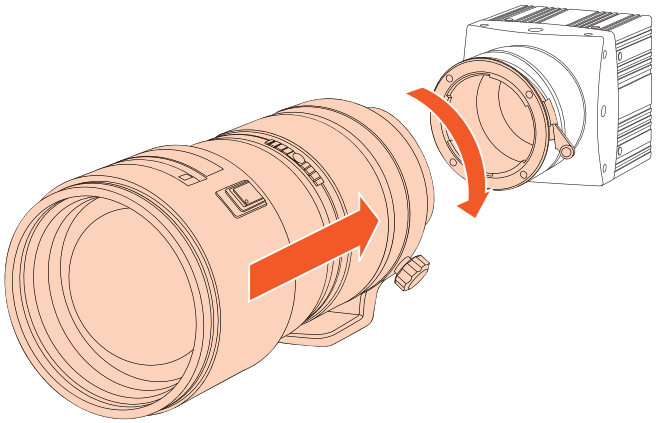
Arrow on **Mounting Adapter**

3. Lens - Mount

Attach the **Mounting Adapter** to the **Grip Action Ball Head** and secure the **Zoom Lens** using the locking lever located on the **Grip Action Ball Head**.

4. BlastCam™ - Mount

Mount the **BlastCam™** to the **Zoom Lens**. The F-Mount connection is a bayonet mount which employs three lugs to lock the **Zoom Lens**. With the **BlastCam™** rotated approximately 30° to the right, the mount will slide together. Rotate the **BlastCam™** counter-clockwise until vertical. The **BlastCam™** will be locked to the **Zoom Lens**. To remove the lens, pull the silver locking tab backward and reverse the procedure above.

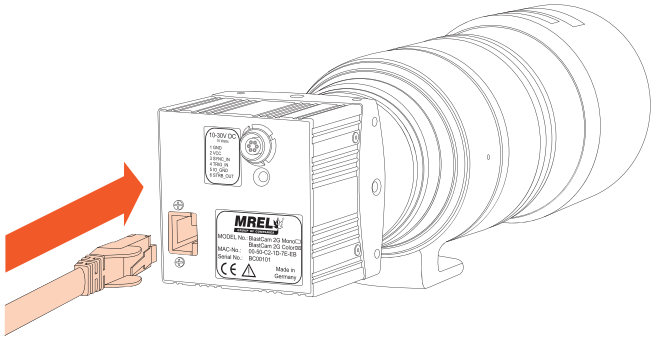


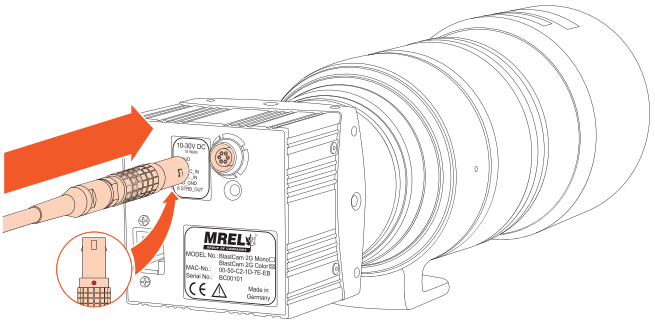
5. BlastCam™ Controller - Mount

To setup the **BlastCam™ Controller Mount** for the **BlastCam™ Controller**, tighten the clamp onto the **Tripod** leg. Next, widen the spring loaded controller tray to place the **BlastCam™ Controller** on the tray.

6. Cable Connections - BlastCam™ Controller

Connect the **BlastCam™ Input Cable** to the back of the **BlastCam™**. Connect one end of the **Ethernet Communication Cable** to the back of the **BlastCam™** and the other end to the **BlastCam™ Controller**. Connect the trigger switch cable to the **Input Cable** marked **TRIG IN** (if the User does not intend to use the **ImageBLITZ** motion trigger).





7. Cable Connections - Power

Plug the **BlastCam™ AC Power Adapter** into the AC power source, or attach the **DC Power Cable Adapter** to a 12 volt source. Next, connect the power adapter cable (either the **BlastCam™ AC Power Adapter** or the **BlastCam™ DC Power Adapter**) to the end of the **BlastCam™ Input Cable**.

STOP

MREL does not recommend inserting the external power plug into the **BlastCam™** before attaching it to the AC outlet. Wall transformers sometimes generate power spikes that can damage electronics when the transformers are first plugged into the wall.

8. Software - Power On

Power on the **BlastCam™ controller**. Start the program of **BlastCam™ Control Software**. All network adapters will be checked for available cameras. The found cameras will be listed in the "Available Cameras" section. This may take a few seconds. Next, select the camera to use by clicking on the appropriate entry in the list. Click on "Connect" in order to establish communication with this camera. The camera's status symbol will change to green when the communication is established. Now the software is ready to operate.

9. Software - Setup

Setup the recording speed, resolution, and triggering method. Click the **LIVE** button to enter **LIVE** mode, adjust the **Aperture Ring** and the **Focus Ring** to produce the desired image.

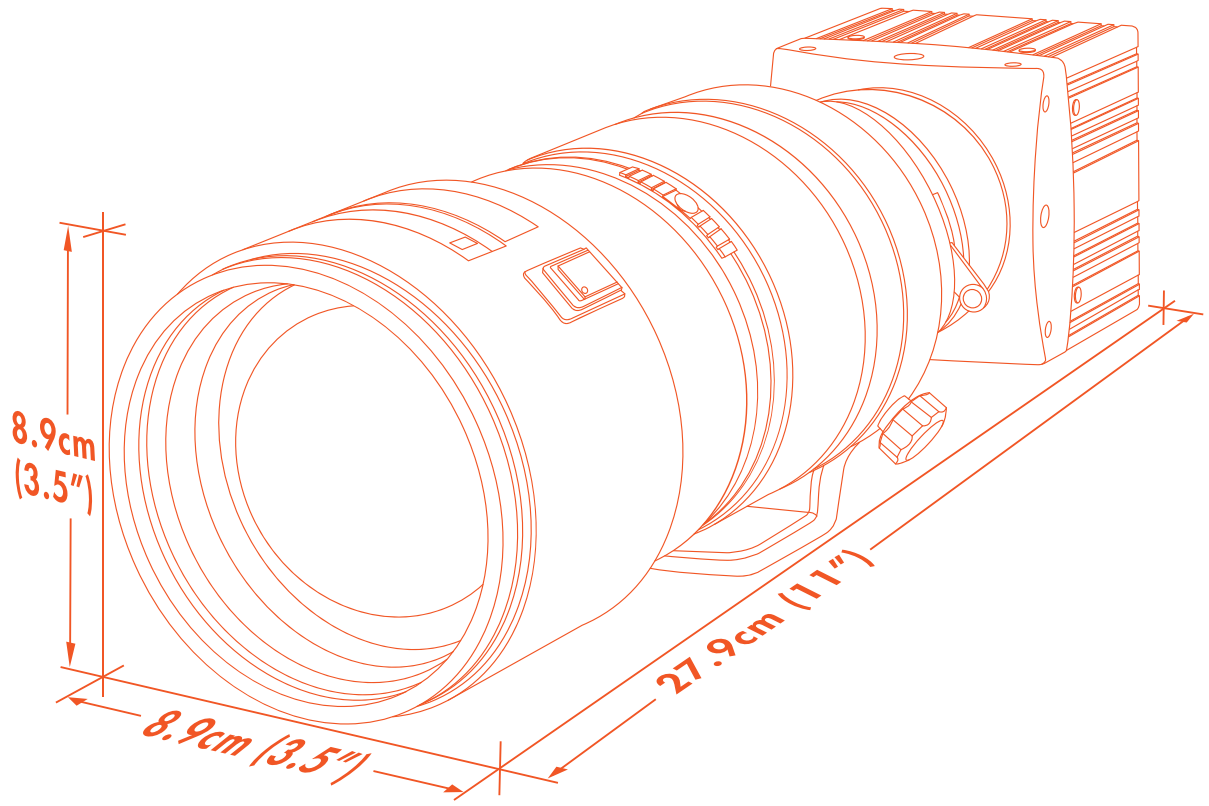
10. Software - Record

Click the **RECORD** button to start recording. Detailed instructions on **Record Mode** and associated settings are available in **Chapter 4**. The event of interest will be recorded upon triggering at this point.

11. Software - Playback

Power on the **BlastCam™ Controller** if it is in sleep mode, press **RECONNECT** button to connect if needed. The User can now playback the video, process images, and save to file in a variety of formats.

Chapter 4
BlastCam™ Software



Overview

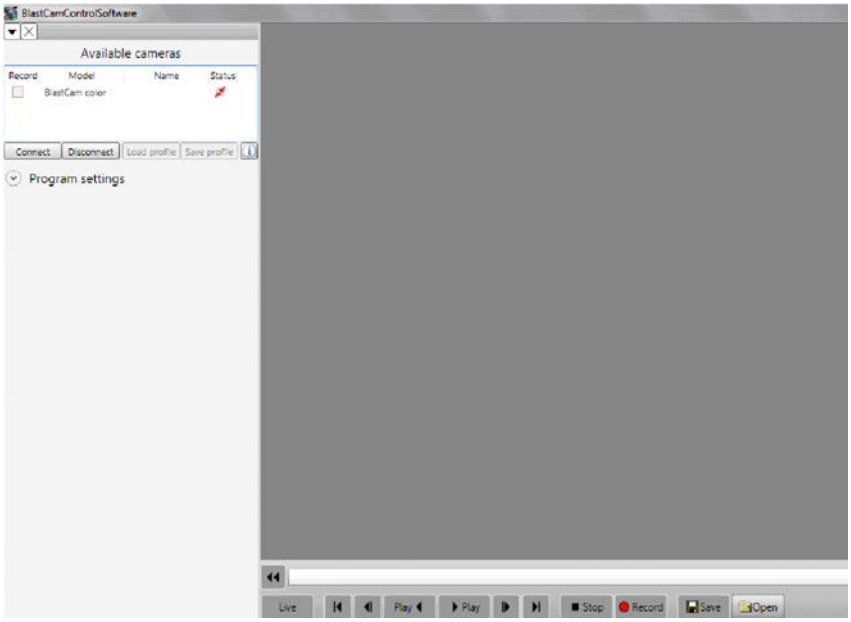
This Chapter describes all of the features of the BlastCam™ Software package that accompanies the BlastCam™ High Speed Digital Video Camera.

4.1 Introduction - User Interface

The **BlastCam™ Software** has been pre-installed on the **BlastCam™ Controller**. All of the **BlastCam™** functions and settings can be programmed with the **BlastCam™ Software**.

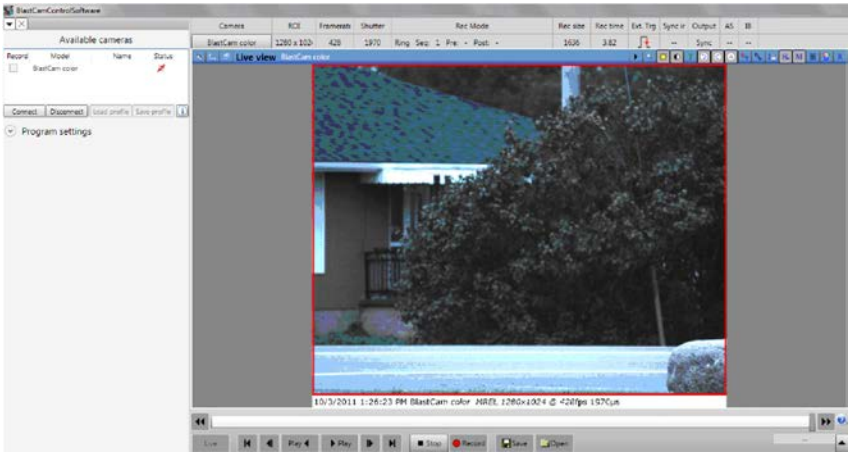
To run the software, double click on the **BlastCam™ Control software** icon on the **Controller's** desktop or select the application from the **Windows®** Start Menu. The software was installed c:\Program Files\MREL\BlastCam Control Software.

All functions of the **BlastCam™** are controlled through the **User Interface** shown below. **Recording**, **Playback**, **Editing**, and **Saving** can all be accomplished quickly by using the tools presented in this chapter.



The found cameras will be listed in the "Available Cameras" section. Next, select the camera to use by clicking on the entry of this camera, then click on "**Connect**" to get the communication established with this camera. The camera's status symbol will change to green from red when the communication is established.

Here, you can select modes of operation or change parameters by pressing a command button or by selecting an item in a context menu (e.g. **Camera Settings**). If the mouse cursor is moved slowly over some of the command buttons and symbols, information about these objects will be displayed.



4.2 BlastCam™ Software - Display Controls

All of the image processing functions are available through the display window.

Move the mouse cursor slowly over some of the command buttons and symbols. Information about this object will be displayed.

4.2.1 Dock/Undock the Display Window 

Depending on the current state of the window it can be docked or undocked. In undocked state the window can be moved and the size of the window can be changed. In docked state the window is fixed.

4.2.2 Fit to window / Display Origin Size 

The displayed image can be fit to the window size, or displayed in its original size. If the origin image is smaller than the window size the image is not fit.

4.2.3 Minimize/Maximize the Window 

Depending on the current state the window is maximized or minimized.

4.2.4 Show/Hide the Toolbar 

Depending on the current state the window is maximized or minimized.

4.2.5 Zoom 

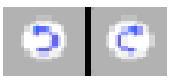
The image can be zoomed by the mouse wheel or by clicking the zoom button in the toolbar. If the button in the toolbar is clicked a control panel is shown at the bottom of the window. To reset the zoom simply click the mouse wheel over the image.

4.2.6 Change Brightness 

Change the brightness of the displayed image. The control panel is shown at the bottom of the window.

4.2.7 Gamma Correction 

If you want to exponentially adapt the percentage brightness of the image you can use the gamma correction. The adjust panel is shown at the bottom of the window. A gamma value of 1 leaves the brightness unchanged. Values greater than 1 let dark parts of the image become brighter. Values smaller than 1 let bright parts become darker.

4.2.8 Image Rotation 

Allows rotation of the displayed image, clockwise or counterclockwise. The image is rotated in 90 degrees increments.

4.2.9 Bayer Adjustment (White balance) 

Good illumination is extremely important for optimal true color display. Best results are achieved by using daylight or halogen light. For recalibrating the color correction, start the live view of the camera and the click “White Balance”. The control to adjust the white balance is

displayed at the bottom of the display window.

Adjust the White Balance Manually

To adjust the white balance manually the "Control Line Window" is needed. Adjust the size of the green check line, which is automatically displayed in the camera image when the "Control Line Window" is opened. Move this line over a white area using the mouse. (Click and hold on the line and move it). The values of the pixels along this line will be shown as three curves – red, green and blue. Using the "R", "G" and "B" sliders, move the three curves until they are nearly congruent.

Adjust the White Balance Automatically

Take a picture of a scene that contains in its middle area mostly white. Click on the "Auto WB" button in the bottom control to adjust the white balance automatically. The above-mentioned line will not be used for auto white balancing.

Save the White Balance Values in the Camera

The changed values are automatically saved inside the camera.

4.2.10 Display RAW Image Data 

The **RAW** camera data is displayed without any changes. Thus the image is always shown as a gray color image because no Bayer correction is done.

4.2.11 Edit the Infoline 

Option to add text to the info line.

4.2.12 Show Histogram Window 

Shows the histogram of the currently displayed image. The area which is used to compute the histogram can be changed by moving the yellow rectangle.

4.2.13 Add Image Marker 

Up to 6 markers may be added to the image. Markers are magenta colored lines that overlay the camera image. The size may be adjusted and moved with the mouse. Markers are used for tagging the position of an interesting part in the displayed sequence.

4.2.14 Show Grid Lines 

Displays a grid upon the image. The width and height of the grid can be freely adjusted.

4.2.15 View the RGB Values 

Shows the RGB values at the current mouse position. The values are displayed at the bottom of the display window. The mouse must be over the displayed image.

4.2.16 View the RGB Values 

All settings are reset to their default state.

4.3 BlastCam™ Software - Modes of Operation

Before entering any one of the three operating modes (Live, Record, Playback) of the **BlastCam™ Software**, be sure to check that the **BlastCam™** is properly connected to the **BlastCam™ Controller** and that the two units are communicating properly. If the **BlastCam™** is properly connected to the **Controller** then the **Connect/Reconnect Ethernet** button will be **Green** in colour.

Colour	LED State	Camera State
RED	Constant	Boot procedure failure. Turn the **BlastCam™** off, and then on again to retry.
GREEN	Constant	Ready for the first recording after power up.
ORANGE	Blinking	Circular recording in progress, waiting for stop.
ORANGE	Constant	Circular recording stopped. Wait for next start signal.

If the **BlastCam™** is disconnected from the **PC**, reconnect it and then wait a few seconds until the **BlastCam™** is shown in the list of available cameras, select the **BlastCam™** from the list and click the **Connect** button in order to establish the Gigabit Ethernet link.

STOP

It's very important to press the "**Connect**" button after the camera is reconnected with your system. If this button is not pressed after reconnection the chronology of a meanwhile recorded sequence may be lost!

4.3.1 Live Mode

Switch the **BlastCam™** to Live Mode by pressing the **Live** button. In **Live Mode**, one frame is continuously recorded and displayed on the screen of the **BlastCam™ Controller**. This mode is optimal for orienting the **BlastCam™**, adjusting the focus and setting up the various **BlastCam™** parameters.

The **BlastCam™** holds **2 GB** internal frame memory. From this memory, a very small part (only as much as required by one frame), is used for storing the frames for the **Live Mode**. The remaining memory is used for sequence recording.

4.3.2 Recording Mode

Once all appropriate imaging/recording parameters are satisfactory, click the red Start button in the **BlastCam™ Control Software** to enter a recording sequence.

The **BlastCam™** has two Recording modes: **Ring**, and **Single**. Each is selected from the **Record Settings** menu

Start Recording

In **Live** mode, click the **Start Recording** button in the **BlastCam™ Software**. The internal camera state **LED** will start flashing orange. This indicates that recording is in progress and the **BlastCam™** is waiting for the trigger to complete the sequence.

Stop Recording

There are three ways to stop the **BlastCam™** recording:

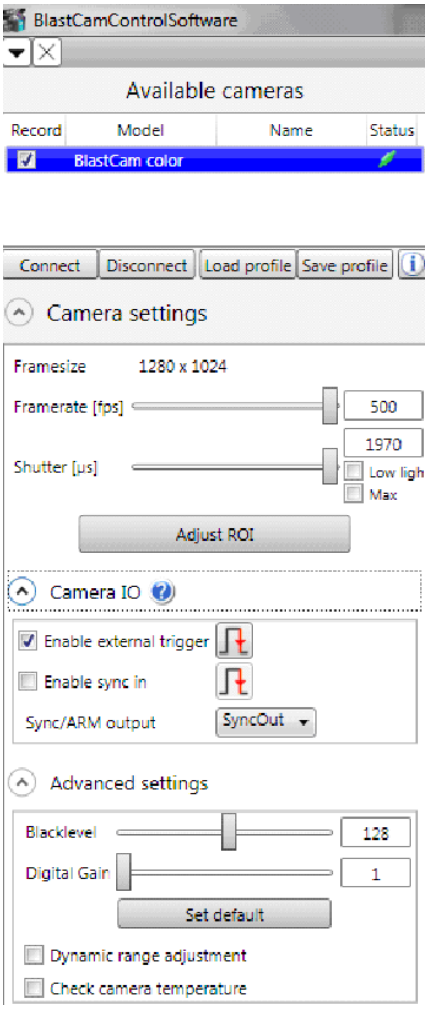
1. Apply the appropriate trigger signal to the **TRIG IN** connector.
2. Click the stop button in the **BlastCam™ Software** (or press **F12**)
3. The criteria have been met for the **ImageBLITZ** trigger.

The **BlastCam's™** internal state **LED** returns to constant orange. The sequence is complete after the post-trigger frames have been recorded.

4.3.3 Playback Mode

The sequence in the **BlastCam™** can be accessed after recording the video. If the **BlastCam™** has been disconnected from the **BlastCam™ Controller**, it must now be reconnected and the User must click the **Connect/Reconnect Ethernet** button in the **BlastCam™ Software** in order to download the recorded sequence.

The recorded sequence may be viewed using the **Play Video Control** present in the toolbar above the image, or alternatively from Play Settings in the Play drop-down menu.



4.4 Loading and Saving Camera Profiles

A profile is a set of all camera parameters that may be changed by the user. Profiles are stored in XML format. If you save a profile, the actual camera settings will be written to file. If you load a profile, the parameters in the file are read and sent to the camera. Loading and saving of profiles is accomplished by clicking on the "Load profile" and "Save Profile" button.

4.5 Camera Settings

The adjustments of the camera may be done in three groups, which are selected by the appropriate expander controls.

4.5.1 Frame Rate, Exposure Time, and Frame Size

These parameters are elements of the expander control "Camera Settings".

The frame rate and exposure time may be adjusted with the slider "Frame Rate [fps]" and "Shutter [µs]", or when you enter the values via keyboard in the corresponding input fields. The adjustments will take effect immediately.

4.5.1.1 "Low light" Mode

In low light mode the camera's exposure time is extended up to 99.9 milliseconds in order to increase the brightness of the image. This mode is good for setting up the frame size

and the focus in “Live” mode. Select your exposure time with the slider “ Shutter [µs]” or input it directly in the appropriate number-field. Low light mode will be automatically stopped if a recording is started.

4.5.1.2 Max Shutter

If this check box is activated, the maximal exposure time for the actual frame size and frame rate will be used.

4.5.1.3 Adjust ROI (changing the frame size)

Click on “Adjust ROI” button to adjust the “Region Of Interest” or image section.
The ROI can be changed by one of the three steps below:

- Inputting the values for offsetX, offsetY, Width and Height into the textboxes
- Moving and changing of the red rectangle onto the displayed image
- Moving and changing of the green rectangle in the left control

By clicking on “Apply ROI“, the adjustments will be applied.

STOP

Changes of resolution or frame rate may alter the quality of recorded images. Be sure that you have saved your recorded images to file before applying these changes because the recorded images may be destroyed or lost!

4.5.2 Camera IO

With “Camera IO” the input and output ports of the BlastCam cameras may be configured for external signals.

4.5.2.1 Trigger Input

If recording sequences should be finished by an external trigger signal, the check box “Enable External Trigger” must be activated. In this case, the “rising edge” or the “falling edge” of the signal could be selected for stopping the sequence.

4.5.2.2 Enable Sync in

With “Enable Sync In” enabled it is possible to synchronize a camera with other cameras or with an external clock generator. Connect the “Sync Out” of your master camera with the “Sync In” of the slave cameras. Connect the ground of the master camera with the ground of the slave cameras. Select a frame rate for the slave camera(s) that is slightly above the master camera’s frame rate.

4.5.2.3 Synchronizing Cameras

The slave cameras will be synchronized with the master camera now.

If you synchronize a slave camera by a master camera, then the frame rate of the slave camera must be slightly above the master cameras frame rate, otherwise the slave camera will not provide the same frame rate as the master camera.

Example:

You want to record with 1000 frames per second. Adjust the master cam-era to the desired 1000 fps, select 1004 fps for the slave camera. Then the slave camera will deliver the master camera's frame rate (1000 fps)!

4.5.2.4 ARM or "Sync Out" Signal

You may choose between "**ARM**" or "**Sync out**" signal for pin 3 of the output connector by using the combo box sync.

4.5.2.4.1 Sync Out Activated

If you select "**Sync Out**", it is possible to synchronize other cameras. The rising edge of the signal provided on pin 3 shows the beginning of the exposure of the master camera's image, the falling edge the end.

4.5.2.4.2 ARM Activated

If you select "**ARM**", you get a signal if the camera is ready for triggering in the ring mode (**Ring mode**).

With the combo box on the right side of the **Sync Out/ARM** you may define if **ARM** is active high or low.

NOTE: This does not apply to the "Sync Out" signal.

4.5.3 Advanced Settings

With "Advanced Settings" special settings like gain or black level may be performed

The **Black Level** parameter refers to the darkness or lightness correction that may be necessary to optimize the image being produced by the **BlastCam™**. The default Black Level is 128, but can be adjusted lower to darken the image, or higher to lighten it.

4.5.3.1 Black Level

When the **Black Level** is set correctly, the sensor will deliver a pixel value of zero for a feature which is completely black.

To adjust the **Black Level** correctly, make sure you have already programmed the **BlastCam™** to the correct **Frame Rate** and **Frame Geometry**, so that the intended **Shutter Speed** is activated. Next, switch to **Live Mode** and replace the **Lens Cap**. Rotate the **Aperture Ring** to the smallest aperture (highest numbered F-Stop). Click on the **White Balance** button in the **Camera Setup** menu and move the **White Balance** menu to the side of the **Camera Setup** menu. Now adjust the **Black Level** so that the histogram is reduced to zero value. This will ensure that the black features in reality are represented as black features in the image, without over-darkening the image.

4.5.3.2 Gain

(Signal) Gain may be adjusted from 1 to 4 in increments of 0.5. **Gain** is defined as the amplification of the signal received by the sensor before it is digitally recorded by the camera. High Gain values will lighten dark areas of the image but will typically also degrade the quality, or cause the image to look "grainy".

NOTE: The quality of the image will decrease with a larger **Gain** number selected.

4.5.3.3 Linear or Logarithmic

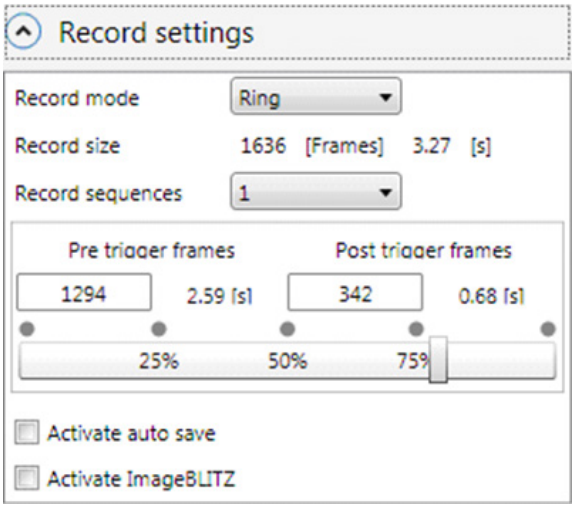
With the "Dynamic Range Adjustment" parameter you may adjust the sensor's characteristic in order to avoid overexposure of very bright parts in the image. If the slider is moved to 1, the sensor's characteristic is linear, normal illuminated scenes will be displayed well.

If there are very bright areas in the scene, then the image will be overexposed, details of the motif will be lost. In this case you should move the slider to the right, (up to 99 max.), whereby details in bright parts of the image will become visible again. The correct setup value depends on the brightness spreading of your motif. In normal illuminated scenes you should use "1".

4.5.3.4 Check Camera Temperature

After activating "Check Camera Temperature" the internal camera temperature will be measured and checked every minute. If the temperature is in the normal range, the temperature status will be shown as green circle be-side the frame size indicator. If the temperature is too high, the circles color becomes red. In this case the camera should be cooled.
After establishing the link with the camera, ("Connect" button), this feature will be always deactivated.

4.6 Record Settings



The **BlastCam™ Software** operates with three different files formats:

- **RAW** (.rec) Format
- **Bitmap** (.bmp) Format
- **AVI** (.avi) Format

RAW format is used primarily for downloading the video sequence from the **BlastCam™** to the **BlastCam™ Controller**. Files can be saved in **.rec** format but they will only be able to be read by the **BlastCam™ Software**.

Bitmap format is used primarily for saving still images directly from the recorded sequence captured by the **BlastCam™**. The **.bmp** format is a non-compressed image file that is able to be opened in most picture viewing software programs. in the **Bmp File - Save** menu, the User is able to select which frames to save, where to save them, and what the filename should be for that particular sequence. Each **.bmp** filename in the sequence will be annotated with it's own specific frame number at the end of the filename upon saving. The **.bmp** format is excellent for use in compiling reports.

AVI format is used to combine individual frames into a video with a playback speed that is selected during the creation of the file. The format is an uncompressed file structure that can be viewed by most programs, which makes the **.avi** format excellent for use in presentations.

In the **Make AVI** menu, the User is able to select which frames to use, where to save the video, and what playback speed the **.avi** will use. Please note that playback soeed (**AVI Frame Rate**) will affect the duration of the video, but not the size of the file. The User also has the option of previewing the **.avi** by clicking **Play AVI**. When satisfied, click **Make AVI** to save to this file format.

4.6.1 Ring Record Mode

There are 2 record modes available: **Ring** and **Single**.

The **BlastCam™** is most commonly used with the **Ring** recording mode, as opposed to the **Single** recording mode. When using **Ring**, the **BlastCam™** will record a continuous loop of frames in the memory, saving each loop over the previously recorded loop. When the **Trigger** is activated, the **BlastCam™** will automatically save only this final loop of images. Depending on trigger position, this loop consists of a designated pre-trigger, and post trigger amount of the camera's memory.

The User has the option of selecting how the circular memory is divided. If **Before (Frames)** is selected, the User can indicate how many frames prior to the **Trigger** event that the **BlastCam™** will keep. If Pre trigger frames is selected, the same applies in the form of what percentage of memory prior to the **Trigger** event that the **BlastCam™** will keep after recording, the frame immediately after the trigger will be displayed, the timestamps will be set in relation to the point of time of the trigger moment, i.e. the first frame after the trigger is set to 0 ms. Negative values indicate that the displayed frame was recorded before the trigger, positive values indicate frames after the trigger, called **Post Trigger Frames**.

4.6.2 Multi Sequence Mode

The frame memory may be divided into up to 16 same-sized memory units for sequences, called **Multi Sequence Mode**. Each memory unit is then filled by a trigger event, i.e., by the occurrence of the external trigger signal or the **ImageBLITZ** trigger. After a trigger event, the Post Trigger Frames will be recorded and the **BlastCam™** switches to the next sequence, beginning the recording of the Pre-Trigger Frames. You can set from record Settings…Record Sequence.

If a trigger event occurs before the predefined number of **Pre-Trigger Frames**, are recorded, the number of **Pre-Trigger Frame** will be less than predefined, whereas the number of **Post Trigger Frames** will be as expected. If a Multi Sequence recording is stopped with the **Stop** button or **F12** key, the **BlastCam™** fills the rest of the sequences that are not yet recorded.

4.6.3 Activate Auto Save

If Activate **Auto Save** is selected, the **BlastCam™** will automatically save the recorded sequence to the hard drive of the **BlastCam™ Controller**. After saving is completed, the **BlastCam™** will automatically resume the specified recording mode. This will continue until interrupted by the User (by pressing **F12** or **STOP**) or until the hard drive is full.

When **Activate Auto Save** is selected, the User will be presented with several options, including the desired Export directory, file format and selected frames before trigger and after trigger to be saved to hard drive.

NOTE: In **Single record** mode, no pre-trigger amounts are recorded and therefore only what is actively recorded will be stored.

4.6.4 Start an Auto Save Session

If the User has clicked on the check box **Activate** auto save, the next recording sequence, that will be started (either by clicking on the red **Record** button or by pressing the key **F5**), will be an **Auto Save** session. This will be indicated by the green check mark on the top of the picture under AS.

4.6.5 Trigger with ImageBLITZ

When selected **Activate ImageBLITZ**, the User can use motion within the **BlastCam's™** view frame to trigger recording. When **Trigger** with **ImageBLITZ** is checked, a variety of options become available to the User. After you select **Activate ImageBLITZ** , you will see a small red box on the top right corner in the picture. Drag that window to the place where you will use it to trigger.

Keep in mind that the **ImageBLITZ** trigger area should be placed in an appropriate location on the image so that the appropriate pre-trigger and post-trigger amounts will be captured during the recording. For instance, if the object of interest is expected to move from left to right across the frame and the **ImageBLITZ** triggering area is far to the right - you will need to be sure that you have allowed for a sufficient pre-trigger recording in the circular buffer.

The colour of the **ImageBLITZ** border is used for indicating the current state of **ImageBLITZ** trigger:

- Yellow **ImageBLITZ** is not active, (the system is not in Live or Recording mode).
- Green **ImageBLITZ** is active and waiting for a trigger situation.
- Red **ImageBLITZ** is active and has triggered.

4.6.6 Gray Difference

This value represents the difference in lightness or darkness that will cause the **ImageBLITZ** to trigger. It is dependent only on the pixels that are within the **ImageBLITZ** border on the screen. Lower values are more sensitive, higher values are less sensitive. See **Auto Adjust** below. The **ImageBLITZ** trigger will compare each frame during the **Circular Recording** to a reference frame that is stored the moment that the recording is started.

4.6.7 Relative Object Size

This value represents the fraction of the **ImageBLITZ** trigger area that must exceed the **Pixel Value Difference** criteria in order to trigger the recording. Lower values are more sensitive, higher values are less sensitive. See **Auto Adjust** below.

4.6.8 Auto Adjust

Located below **Release Parameters** is the **Auto Adjust** function. Click this button to automatically set the **Pixel Value Difference** and **Relative Object Size** to reasonable values for the Live image on the screen. Monitor the status of the **ImageBLITZ** border colour for a short while after clicking **Auto Adjust** to be sure that it is not liable to trigger prematurely. **MREL** recommends increasing either **Pixel Value Difference** and **Relative Object Size** slightly to avoid this problem.

4.7 Program Settings

4.7.1 Changing the Playback Speed

The playback speed of a recorded sequence may be adjusted by the slider "**Playback speed**". The unit is frames per second. If the speed is too high, some frames will be omitted during playback.

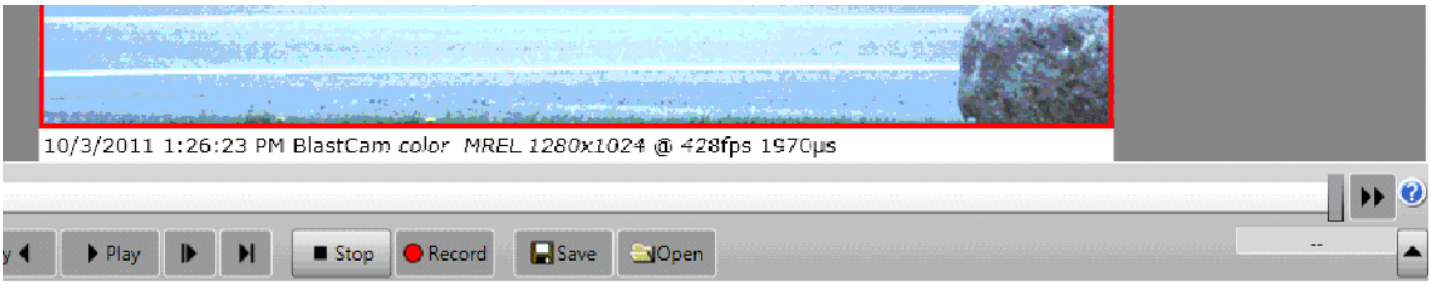
4.7.2 Start Live View on Connect

With this check box you may control, if live mode is active after connecting a camera. If the camera holds a recording sequence, live

mode will not be active but a frame of the recorded sequence will be shown.

4.7.3 Display Info line

Shows an info line at the bottom of the camera's image:



The above info line will be created for recorded sequences. In live mode it will differ slightly.

4.8 Supported Export Formats

4.8.1 BMP

All images are stored uncompressed as **BMP**.

4.8.2 JPG

The images are stored in **JPG** format. It's possible to select the compression quality.

4.8.3 TIFF

The images are stored in **TIFF format** (Tagged Image File Format). You can choose between the following compression algorithms:

- Uncompressed.
- LZW(Lempel-Ziv-Welch-Algorithms), lossless compression.

4.8.4 AVI

The images are stored in the **AVI** container format. The **AVI** format allows compressed or uncompressed storage. All available CODEC's on the system can be used.

4.8.5 DNG (RAW format)

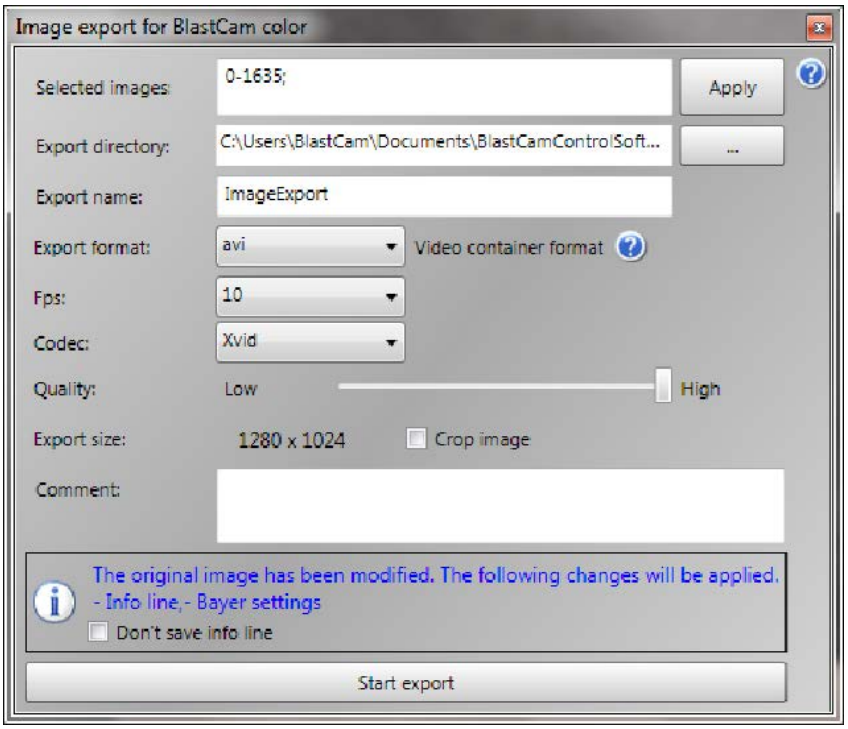
All images are stored in **Adobe DNG**, (**Adobe Digital Negative**), format. **DNG** is a **RAW** format which can be directly imported into **Adobe Photoshop** to post process the data. Many other image processing tools also support **DNG** since it's a common file format for raw camera data.

4.8.6 REC (RAW format)

Stores the images as a **REC** file. The **REC** file is a "**Fastec Imaging Proprietary**" container format. All the raw image data is stored in one

file. Additionally all image information needed to post process the data is stored in the header of the file.
The **REC** file is written faster to disc compared to the other formats. There-fore it should be used whenever the record needs to be read out fast. The post processing of the raw image data can be done within the software or by external software. The **REC** file can be easily integrated since the specification of the format is freely available.

4.9 Image Export



The "**Image Export Dialog**" can be open by clicking the **Save** button of the bottom control.

4.9.1 Select the Images to be Exported

Image range to be exported. To change the export image range edit the text field and click apply.

Values are separated by a semicolon e.g. 10-100; 200-300; Alternatively close this window and select the images on the bottom scrollbar.

4.9.2 Select the Export Directory

The export directory can be selected arbitrary. Within the export directory a new folder is created each time images are exported. The name of the export folder is composed by the entered export name, date and time of the export.

File naming: **EXPORTNAME_IMAGECOUNT**

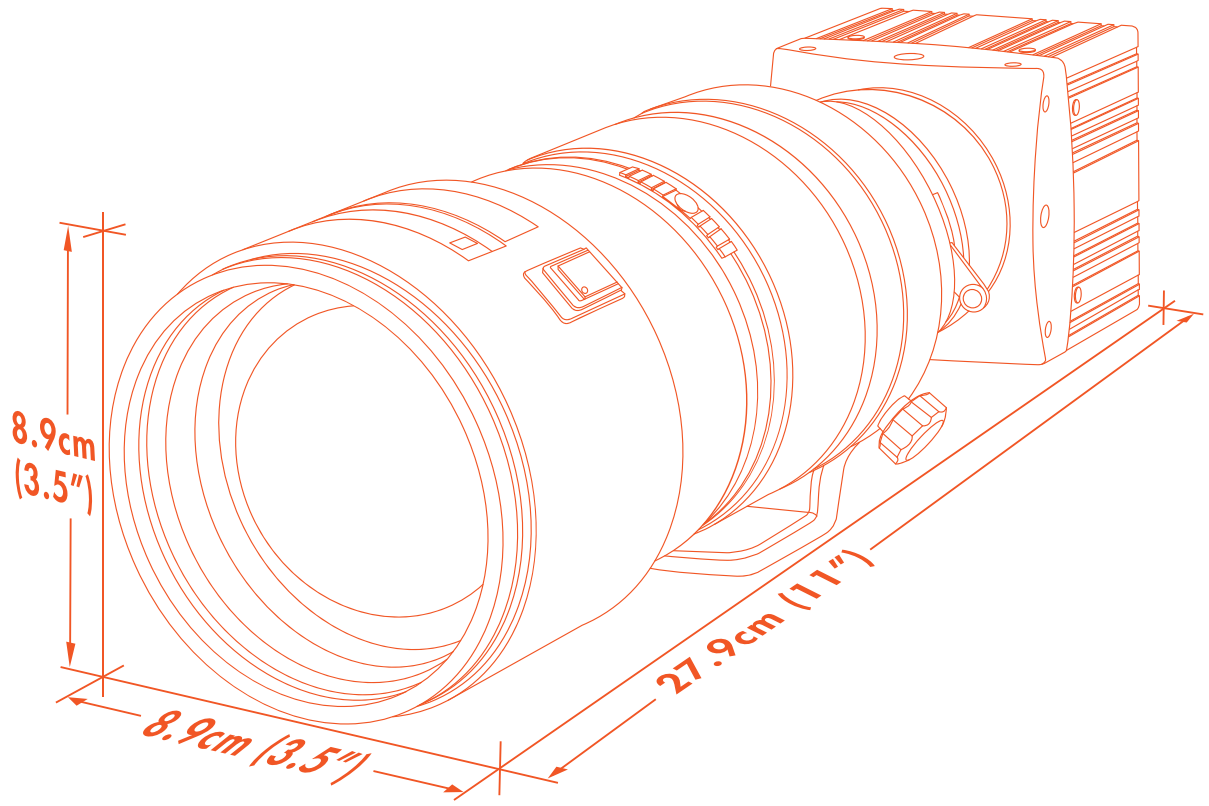
4.9.3 Select the Export Format

The used export format can be selected within the combo box.

4.9.4 Image Cropping

If you want to store only a part of the image it can be cropped before export. The "**Crop image**" button displays a rectangle on the image which can be freely moved. The rectangle defines the selected export area.

Chapter 5
Field Operations



Overview

This chapter provides instructions on using the BlastCam™ to record blasts in the field.

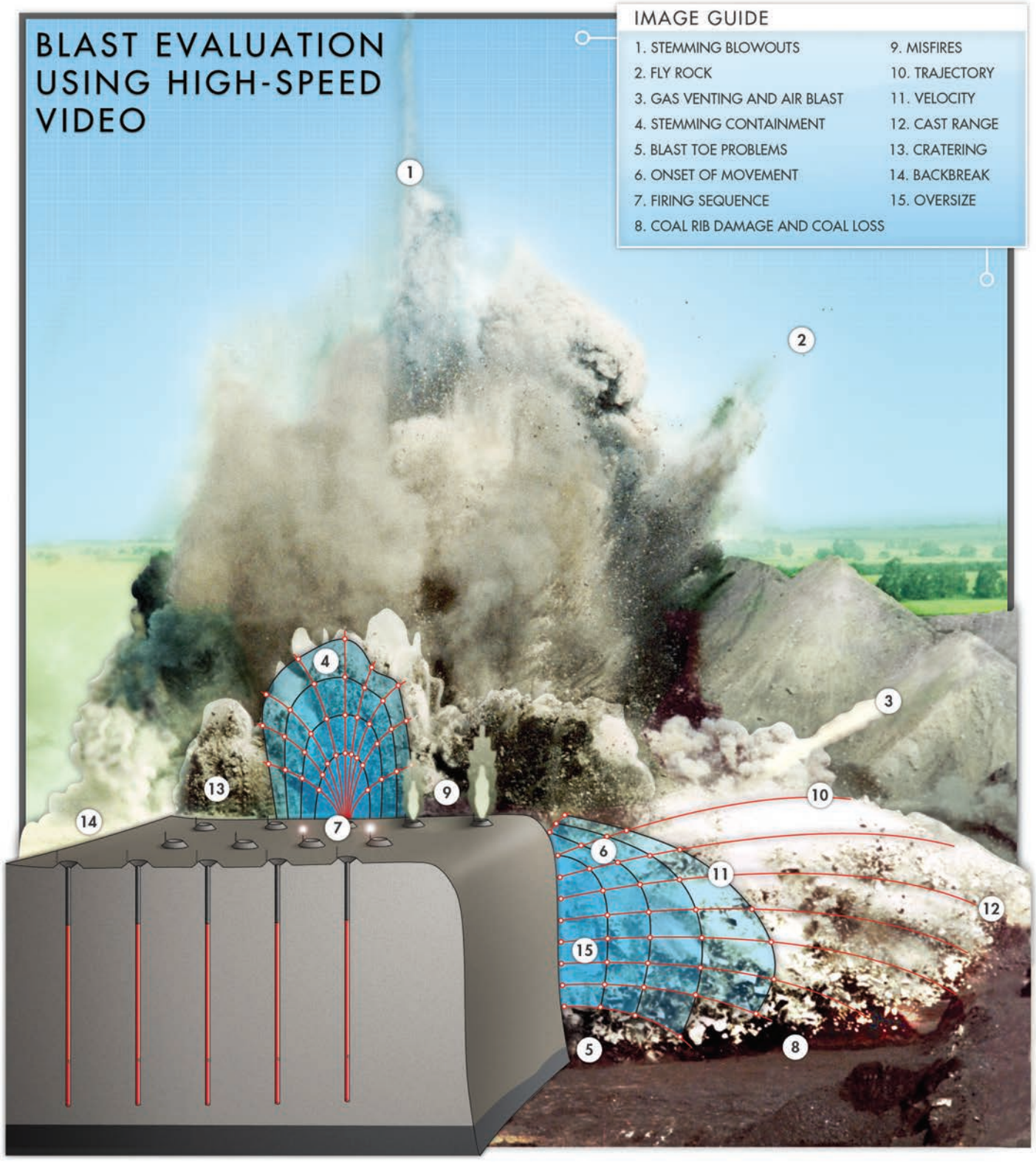
5.1 Introduction

High speed photography has proven to be a very useful tool in the field. High speed photography can provide valuable information for troubleshooting and feedback for blast design.

Typical **Frame Rates** for capturing open pit blasts range from **250 - 1000 fp**s for the reason that satisfactory

- Immediate availability of the blast for review
- Confirmation of the firing sequence of holes
- Measurement of the firing time and scatter in detonators
- Assessment of the degree of confinement, stemming blowouts, and flyrock zones
- Confirmation of the functioning of explosives, primers, and accessories
- Determination of the location, time, and duration of gas venting
- Assessment of the locations responsible for flyrock or other projectiles
- Evaluation of the extent of backbreak
- Determination of the location, time, and duration of nitrogen oxide emissions
- **Sensor Fusion™** Combinatory analysis of video data with VOD data or other sensors allows live visualization of issues perceived from other data acquisition methods such as those captured by the **MREL DataTrap II™** or **MREL MicroTrap™**.

The Figure on the following page illustrates the various high speed video photography applications.


BLAST EVALUATION USING HIGH-SPEED VIDEO
IMAGE GUIDE
1. STEMMING BLOWOUTS
2. FLY ROCK
3. GAS VENTING AND AIR BLAST
4. STEMMING CONTAINMENT
5. BLAST TOE PROBLEMS
6. ONSET OF MOVEMENT
7. FIRING SEQUENCE
8. COAL RIB DAMAGE AND COAL LOSS
9. MISFIRES
10. TRAJECTORY
11. VELOCITY
12. CAST RANGE
13. CRATERING
14. BACKBREAK
15. OVERSIZE

5.2 Selecting a Camera Position

The position of the **BlastCam™** is very important It can sometimes be difficult to select an ideal location due to a lack of suitable elevation above the height of the blast, or obstructions in the line of sight. This can usually be overcome by careful combination of a suitable location and **Lens** parameters. When selecting a location it is of utmost importance to ensure the safety of all personnel on-site, and to ensure the survivability of instrumentation.

MREL always recommends the use of proper sheltering from flyrock to protect the **BlastCam™** from damage. The User has the option of using a **Remote Trigger, ImageBLITZ** triggering, or a trigger that is associated with the blast event (i.e. a **Make Trigger** wrapped over the end of a detonator). If the User intends to trigger the recording manually, the push-button trigger device is available from MREL with any desired length of cabling.

Finally, the location should also ensure that during the blast, the first boreholes to fire do not obscure the line of sight of other boreholes. For this reason, it is best to choose a location so that the first boreholes are at the opposite end of the blast from the **BlastCam™**.

For observation of surface movement, the **BlastCam™** should be positioned behind the blast so that rock movement does not obstruct the view of the surface of the bench. For observation of the free face of the bench, position the **BlastCam™** directly in front of the face, at a safe distance and preferably at an elevated location. For typical overall analysis of a bench blast, position the camera in front and to the side of the blast, at an elevated location a safe distance from the free face

To analyze face velocities, the **BlastCam™** should be located to the side of the blast, parallel with the free face. Brightly coloured targets should be used as reference points for measuring distance in the **ProAnalyst® TrackOne Edition Motion Analysis Software** when the sequence is being analyzed. These markers should be positioned exactly perpendicular to the line of sight of the **BlastCam™** and the distance of separation from marker to marker should also be known exactly. This will allow for convenient and accurate velocity measurement. Remember to use markers that are easily visible at distance (vivid colours, generally one square foot or larger). Targets should be three-dimensional as they are likely to rotate out of orientation during the blast. Pay special attention to to targets that are lowered from the free face, so as they are correctly positioned and are able to snap free from their suspension when the face begins to heave.

5.3 Field Setup

5.3.1 System Setup

The **BlastCam™** has been designed to assembly quickly and easily in the field. The complete setup of the system is detailed in **Chapter 3**.

1. Setup the **Tripod**.
2. Connect the **Mounting Adapter** to the Lens and attach the assembly to the **Grip Action Ball Head**.
3. Attach the **BlastCam™** to the back of the **Lens**.
4. Attach the **BlastCam™ Controller Mount** and setup the **BlastCam™ Controller**.
5. Attach the **BlastCam™ Input Cable**.
6. Attach the **Trigger Switch** (or other trigger) to the **Trig In** connector of the **BlastCam™ Input Cable**.
7. Attach the **Ethernet Communication Cable** to the Ethernet port of the **BlastCam™ Controller** and the other end to the back of the **BlastCam™**.
8. Attach the appropriate power supply adapters (AC or DC) to the **BlastCam™** through the **BlastCam™ Input cable** and to the power supply source (120/240 VAC, or 12 VDC battery).

   If the **Tripod** is unstable, it is suggested that a weighted object be suspended from the center of the **Tripod**. The **Tripod** legs should be set as short as possible to increase stability and to mitigate camera movement as a result of ground vibration.

Turn on the **BlastCam™ Controller** and run the **BlastCam™ Software**. Remove the **Lens** cover and click the **LIVE** button to establish the desired image in the **Display Screen** using the **Grip Action Ball Head**, exposure controls (**Zoom Lens F-Stop**, **BlastCam™ Shutter Speed**), zoom, and focus (commonly set to infinity for very distant shots).

5.3.2 Power Supply Options

If no AC power is available, the **BlastCam™ DC Power Adaptor** has been provided with alligator clips to connect to a typical **12 VDC Lead-Acid Battery**. These batteries are very common and can be found in most passenger vehicles.

If AC power, such as a generator or a power inverter is used, then the **BlastCam™** can be powered through the **BlastCam™ AC Power Adapter**. Photographs of these accessories are shown in **Chapter 2**. The **BlastCam™** will draw 0.46 Amps at 12 Volts.

5.3.3 BlastCam™ Software

Set up the **Resolution**, **Recording Speed**, **Shutter Time** and other parameters by clicking on the menu item **Camera > Camera Setup**. Once the changes to the parameters for resolution and frame rate are set, click on **Apply**.

NOTE: Changes of **Resolution** or **Frame Rate** may alter the quality of recorded images. Now the new parameters will be sent to the **BlastCam™**. All other parameters e.g. shutter time or analog gain, will be sent immediately to the **BlastCam™** after entering. If there is no connection to the **BlastCam™**, an error message will appear. Please make sure the **BlastCam™** is connected correctly.

Set up the **Recording Mode** by clicking **Record > Record Setting**. For high speed photography of blasting operations, it is recommended to use the **Circular Buffer** recording mode.

Remember to double check your triggering criterion, pre-trigger and post-trigger amounts, and **AutoSave** features if selected.

5.3.4 Start Recording

To start the **Circular Buffer**, press the red **Start Recording** button in the **BlastCam™ Software**. the **BlastCam™** can be disconnected now from the **BlastCam™ Controller** and recording can be triggered externally by **ImageBLITZ**.

5.3.5 BlastCam™ Controller SLEEP Mode

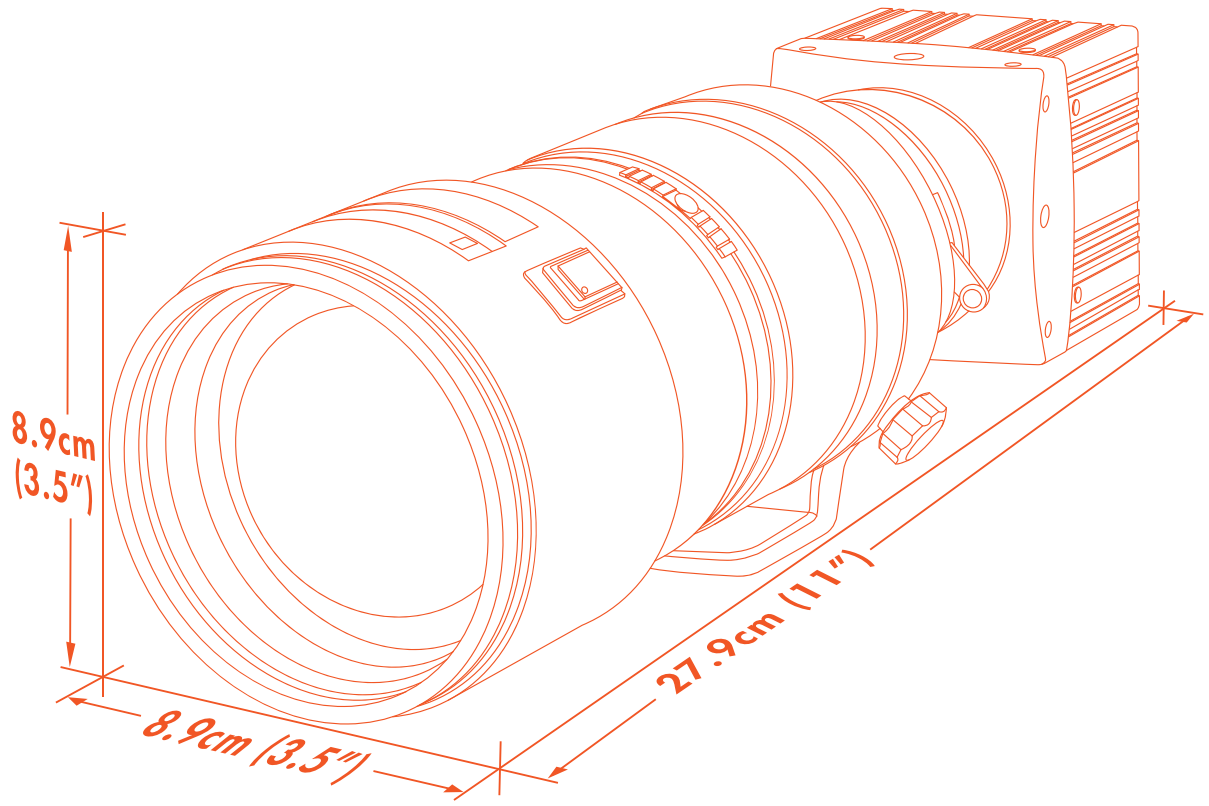
When running on internal battery power, the **BlastCam™ Controller** will go into **Sleep Mode** after the system idles for 15 minutes. **Sleep Mode** is a power-saving state that saves all open documents and programs and allows the **BlastCam™ Controller** to quickly resume full-power operation (typically within several seconds) when you want to start working again. While your **BlastCam™ Controller** is asleep, its hardware lights flash slowly. You can resume working by pressing the **Power** button, connecting the **Ethernet Cable** to the **BlastCam™** and clicking the **Connect/Reconnect** button to download the sequence currently stored on the **BlastCam™**.

5.3.6 Save the Video

After downloading the video sequence from the **BlastCam™** by clicking the **Connect/Reconnect** button, the User may store the any or all of the recorded frames in **AVI**, **BMP**, or **RAW** format. See **Chapter XX.XX.XX** for details.

The User is now ready to analyze the motion of the blast using the **ProAnalyst® TrackOne Edition Motion Analysis Software**. Please see the **ProAnalyst® TrackOne Edition** help in **Chapter 6** for details.

Chapter 6
ProAnalyst® TrackOne Edition Software



6.1 About ProAnalyst® TrackOne Edition

ProAnalyst® TrackOne Edition allows auto-tracking of one feature and/or manually tracking of up to 32 features. Will allow the User to quickly export to Excel or Matlab for further analysis and graphing. If you need to track more than one point at the same time, please contact MREL to upgrade to **ProAnalyst® Professional Edition**. **ProAnalyst® Professional Edition** includes all the analysis features and engines for **Auto Tracking** objects in 1-D and 2-D, data reduction and report generation. Optional toolkit **Image Stabilization** can work with the **ProAnalyst® Professional Edition**.

Please follow the **ProAnalyst® TrackOne Edition Installation Guide** to install **ProAnalyst® TrackOne Edition** software on your computer. The **ProAnalyst® TrackOne Edition Installation Guide** is in the box of the **ProAnalyst®**.

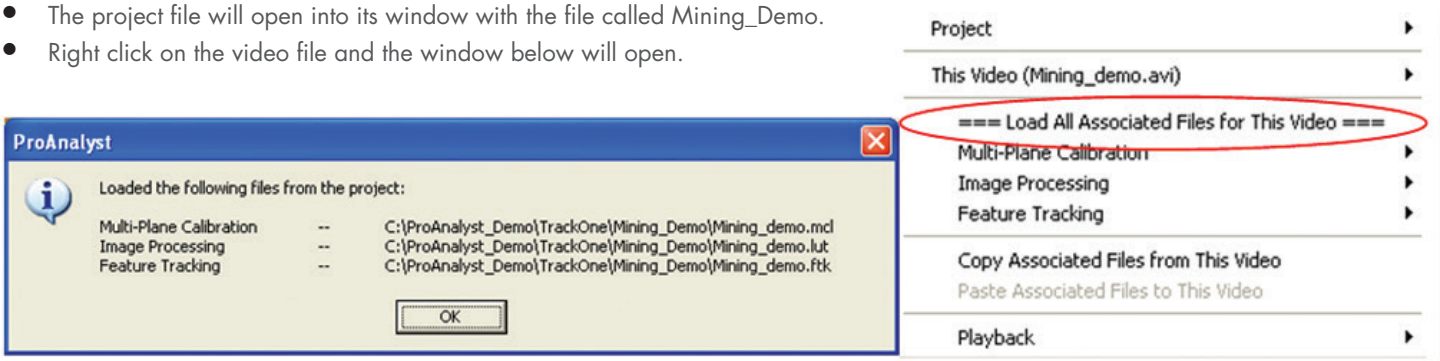
Now you can open **ProAnalyst® TrackOne Edition**, and find the **ProAnalyst® TrackOne Edition Reference Guide** from the menu **Help**, or the User can follow the instructions in the **Getting Started Guide** and **User Guide** to do the video analysis.

6.2 Example Demonstration File Explanation – Mining Example

This Mining example is for the purpose of learning **ProAnalyst® TrackOne Edition**. The example file can be found in the Mining_Demo directory.

This example file was captured at **250** frames per second. The calibration of the video is as shown in the calibration tab with the distance between the two green markers is **12** meters. This summary is **ONLY** describing the items directly used for this example. All other functions within the software, please refer to the manual that came with the software.

- Open **ProAnalyst® TrackOne Edition**. Select File, Open Project…
- Navigate to the directory where the files are stored and select Mining_Demo.mpj then click Open.
- The project file will open into its window with the file called Mining_Demo.
- Right click on the video file and the window below will open.



  - Click on === Load All Associated Files for This Video ===
- This will load all of the data files associated with the example. When the file opens, it will have loaded a **Multi-Plane Calibration** file (.mcl), **Image Processing file** (.lut) and a **Feature Tracking file** (.ftk) as shown below with the directory tree.
- Once the operator clicks **OK**, the window can be maximized with the video.
- To confirm the frame rate in entered into the software correctly, right click on the video and select **Modify Recorded Parameters**. This will allow the user to calibrate the time of the video. The user can also modify in this menu the used shutter speed and the modification of the zeroth frame.
- With the window maximized, the user will notice along the left edge of the video there are three tabs: **Raw**, **Processed** and **Thumbnail**.
  - The **Raw** tab is the original video with no modification which will be, in this example, the original coloring.

- The **Processed** tab is same video with the Image Processing applied.
- The **Thumbnail** tab is the video with thumbnails at particular points in the video.
  - Pressing **Z** decreases the size of the thumbnail while **A** increases the size.
  - Pressing **X** decreases the time between thumbnails while **S** increases the time.
- On the right side of the frame is a vertical tab of items to be used to perform the measurements required.

In order from the top to bottom: **Image Processing, Image Filtering, Multi-Plane Calibration, Display Layers, Notes, Annotations, Feature Tracking, Graph Configuration, Save All Associated Toolkits.** All of the changes will only be visible in the **Processed** tab because the **Raw** tab will remain unchanged.

In **TrackOne Edition**, only some of the tabs can be used to manipulate the video, but can open all of the modifications from other versions of **ProAnalyst®**.

6.2.1 Image Processing 

Allows the operator to change the color of the video which includes the **Brightness**, **Contrast**, **Gamma and Exponential** / **Logarithmic**.

Below the sliders, the buttons can invert (reverse) the individual colors.

The **Convert to B&W** (Black and White) can change the color image to a grey scale. The sliders above the button can change the intensity of the individual colors. Once in **B&W**, the sliders below will be able to be changed as above.

The **Load** and **Save** buttons will load a previously saved **Image Processing file** (*.lut) while **Save** will generate a lut file from the current settings.

The Reset All will return all of the setting to the default location.

6.2.2 Multi-Plane Calibration 

This tab will allow the user to calibrate the video file.

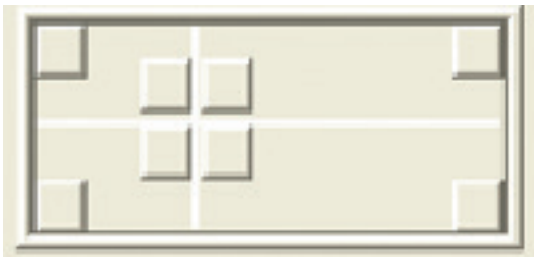
The software needs to relate the number of pixels to a known distance. The **TrackOne Edition** can not use a perspective calibration as can the other versions of the software.

The Normal calibration can be performed within **TrackOne**. A Normal calibration is able to measure items that move at right angles to the camera view.

To add a calibration, click on **Add Normal** and another line item will appear on the screen. Throughout this software package a standard convention will repeat. For example, on the calibration line on the right, there is an eye either open or closed. If the eye is open, the object is visible on the screen. If the eye is closed, the object will not be shown on the screen.

The wrench to the right of the eye will open a configuration menu. In the calibration wrench menu, it is labeled as Calibration # Settings where # is the number of the calibration. When the operator clicks on the screen, the reticle (cross hair) will move to the position clicked. If the operator then clicks on **Set Point #1**, the first point of the calibration will be set. The second point can be selected in a similar method. After the two points are selected, the user can enter the value between the two points selected and then select the units of measurement of the number from the pull down menu. After the units are selected, the **Apply Scale >>** button **MUST** be clicked. This will change the box beside the button to xx pixels/"units selected".

The origin of the coordinate system can be set in a similar method. Point the reticle to point were the operator requests the coordinate origin to be (0,0). This will be the reference point for all of the measurements. After the origin is set, the orientation of the axes must be set. As shown below, each of the buttons in the picture will set the orientation of the axes.



Each of the corner buttons will set the origin of the coordinate system in the respective corner. The positive orientation of the two axes will be along the edge of the frame. For example, the top left button will set positive X direction to the right and the positive Y direction down while the bottom right button will set the positive X direction to the left and the positive Y direction up. The four buttons around the reticle will set the positive orientation around the button pressed from the reticle position. If the orientation of the X axis is not horizontal, from the origin of the coordinate system place the reticle on the horizontal line and then click Set X Direction. Once the Origin and positive axes are set, the user MUST click **Apply Origin and Tilt >>** button. After the button is clicked, the pixels (origin) will be displayed as well as the degrees (tilt).

The user MUST then click **Apply** to set the changes and then **Close**. The user can then remove calibrations if they were made in error.

6.2.3 Display Layers

This menu allows the user to change which layers are displayed and the information displayed on the screen.

6.2.4 Notes

This will allow the user to make notes on the video file. The area labeled Video Notes is information about the displayed frame while the Global Notes area pertains to the whole video.

6.2.5 Annotations

The tab allows the user to draw and place text on the video frame.

6.2.6 Feature Tracking

This tab will allow the user to track a point on the video.

In the top left of the tab, **Feature Tracking** must be enabled. If user can not change any other part of the menu structure, click on **Enable**.

The user needs to decide whether a **Manual** or **Automatic mode** will be used to track an object.

In **Manual Mode**, the operator will manually select each and every point that will be used in the calculations. In **Manual Mode**, less video manipulation (Image Processing) is required because the human eye can distinguish the difference when tracking an object better than a computer algorithm. The operator can switch between **Manual** and **Automatic** while tracking a single object. When the user is in **Manual mode**, the user can click on **Add** and add a feature that can be used to track an object. This is the simplest way to track. Click to place the reticle on the object the user wishes to track and click **Set Point**. This needs to be done in every frame the operator wishes to track. This can be a long and tedious task if a lot of frames need to be

In **Automatic Tracking**, a feature can be added just as in Manual tracking but now the user needs to define a region of the video that

they wish to track by clicking **Define Region** and drawing a rectangle around the object. The way that the user can select an area, the computer is looking for that exact defined area in the next frame. Therefore, the user should try to select an object that stays defined throughout the time of interest. This is where the Image Processing is very important to help distinguish the tracking object from the background image.

Within **TrackOne**, the user only can use the **Image Processing** while **Image Filtering** is not available. Once the user can separate the tracked object from the background and the area around the object has been defined and set, the grey box will turn a shade of cyan.

After the user clicks of the wrench, the settings box opens. The operator needs to give the **Feature** a name that makes sense for future reference. Then the correct **Calibration** needs to be selected from the pull down menu.

Within the Search Parameters section, the **Search Region Multiplier (%)** is the increased search area around the defined region. This area can be displayed around the defined area by right clicking on the video, **Feature Tracking> Show Search Regions.** This is the area that the **Defined Region** is looked for in the next frame of the video.

The larger the area, the larger the possibilities of the Automatic Tracking will follow something else in the area.

Too small of an area and the tracked object may not be within the area in the next frame.

The **Threshold Tolerance (0.0 – 1.0)** is the type of match from frame to frame where 1.0 is a perfect match. Normally, the tolerance is between 0.75 and 0.95. The **Frames to Search After Loss** is the number of frames the software will look ahead if it has lost the tracked object. Normally, it is set to 0.

The other important setting is the **Feature Rotation**. If the tracked object is rotating in the frame the software can loose the Automatic Track on the object. The operator can Enable and set the **Angular Range (deg)** to the maximum expected rotation between two frames. This is a positive as well as the negative rotation angle. The **Step Size (deg)** is the number of degrees between the iterations. The larger the number, the higher the possibility of missing the object, while too small of a number will take a long time to process.

The **Show Points** selection will display on the video the points.

6.2.6.1 Show All

Display every point created.

6.2.6.2 Show Past

Display only past point created in the video.

6.2.6.3 Show Current

Display only the current point.

6.2.6.4 Show None

This will not display any points.

6.2.7 Under the Tracking box

The buttons from left to right are: **Track Backwards**, **Track One Frame Backwards**, **Stop**, **Track One Frame Forward** and **Track Forward**.

The software takes an image of the **Defined Region** when the **Set Region** button is pressed. At some points, the **Automatic Tracking** may loose the item of interest, the user **MUST** stop the tracking by pressing the middle Tracking button and play the video back (not track backwards) to the point of the tracking failing and reset the **Set Region**.

The operator can then continue the track in the same direction (forward or backwards) and the previously tracked points will move to the new location.

Once the object is tracked, the lock between the eye and the wrench should then be closed (to the locked position) to avoid and changes to the points.

The **Units & Export** section will allow the user to select the units to export the data to as well as the form that the file will be.

In this example, the setup was Meters and Text. The text file was placed in the same directory labeled **ProAnalyst_Demo.txt**.

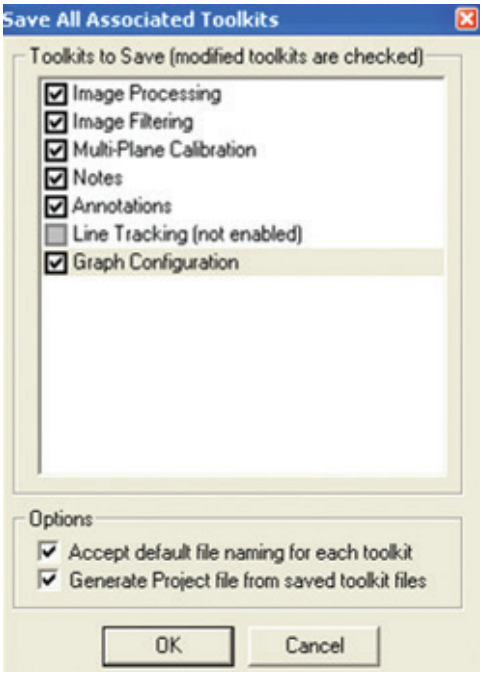
The TrackOne Edition does not offer graphing, therefore, for this example the data was imported and graphed in Excel. The file is labeled as **ProAnalyst_Demo.xls**.

6.2.8 Save All Toolkits

After all of the analysis has been performed, it is very important to associate the files to the video. This will allow in the future, opening the analyzed video as easily as this example. It is important to select all of the boxes because the software will save everything.

The bottom two boxes under **Options** are also very important because the file names will be the same as the video file name. This will make it easier for the user in the future.

The Generate Project is also very important because it will be the overall association. This is the *.mpj file which will keep everything neat and tidy.



6.3 Excel Spreadsheet – Mining_Demo.xls

This spreadsheet was generated from the exported file from **ProAnalyst® TrackOne**. On the first sheet (Mining_demo) displays the data from the text file with a Red shading. Everything with the Red shading of the cell was imported from the **ProAnalyst®** text file. All of the white (unshaded) cells were calculated within Excel.

6.3.1 Explanation of the Unshaded Cells

Feature 1 Values:

Since the values of X and Y start at zero, there is no requirement to correct them back to zero as in the Disruptor Demo.

Feature 1 (Top_Marker) Vector (column E): This column is the vector sum of the X and Y.
Equation: E# = √ (C#2 + D#2) where # is the current cell in the E column

The Graphs tab has all of the measurements in a graphical solution.

The graph on the left is the final solution produced by MREL to show the user what a completed graph could look like. The two white lines and text boxes were manually generated by hovering the cursor over the graph to record the values. This can be done on the graph on the right.

The points used in this example are:

Lower Line:
Point #1: (0.984, 2.034001316)
Point #2: (1.600, 9.266355494)
Therefore, the average velocity between these two points is:

Velocity = (9.266355494 – 2.034001316) meters / (1.600 - 0.984) second = 7.232254178 / 0.616 = 11.74 m/s

Upper Line:
Point #1: (1.656, 9.650500598)
Point #2: (2.956, 23.96412087)

Therefore, the average velocity between these two points is:

Velocity = (23.96412087 – 9.650500598) meters / (2.956 - 1.656) second = 14.3162027 / 1.300 = 11.01 m/s

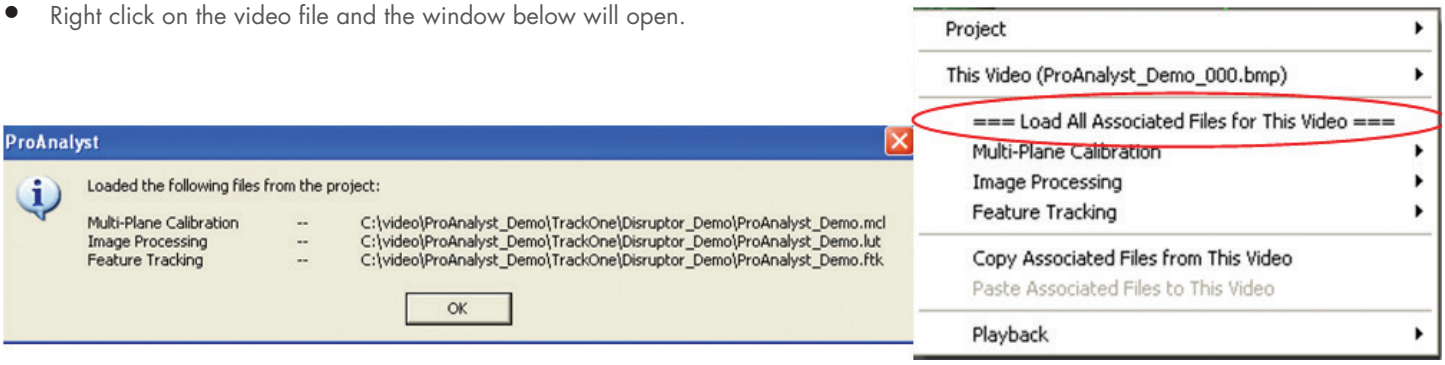
Two lines were chosen because of the 'bump' in the data graph near 1.6 seconds. As well, the slope of the line needs to match the data.

6.4 Example Demonstration File Explanation – Disrupter Example

This Mining example is for the purpose of learning **ProAnalyst® TrackOne Edition**. The example file can be found in the Disrupter_Demo directory.

This example file was captured at 1000 frames per second. The calibration of the video is as shown in the calibration tab with the distance from the edge of the blue container to the third sensor (which is a third of the distance from the tip to the pole) is 5 meters. This summary is ONLY describing the items directly used for this example. All other functions within the software, please refer to the manual that came with the software.

- Open **ProAnalyst® TrackOne Edition**. Select File, Open Project…
- Navigate to the directory where the files are stored and select ProAnalyst_Demo.mpj then click Open.
- The project file will open into its window with the file called ProAnalyst_Demo_000.bmp.
- Right click on the video file and the window below will open.



  - Click on === Load All Associated Files for This Video ===
- This will load all of the data files associated with the example. When the file opens, it will have loaded a **Multi-Plane Calibration** file (.mcl), **Image Processing file** (.lut) and a **Feature Tracking file** (.ftk) as shown below with the directory tree.
- Once the operator clicks **OK**, the window can be maximized with the video.
- To confirm the frame rate in entered into the software correctly, right click on the video and select **Modify Recorded Parameters**. This will allow the user to calibrate the time of the video. The user can also modify in this menu the used shutter speed and the modification of the zeroth frame.
- With the window maximized, the user will notice along the left edge of the video there are three tabs: **Raw**, **Processed** and **Thumbnail**.
  - The **Raw** tab is the original video with no modification which will be, in this example, the original coloring.
  - The **Processed** tab is same video with the Image Processing applied.
  - The **Thumbnail** tab is the video with thumbnails at particular points in the video.
    - Pressing **Z** decreases the size of the thumbnail while **A** increases the size.
    - Pressing **X** decreases the time between thumbnails while **S** increases the time.
- On the right side of the frame is a vertical tab of items to be used to perform the measurements required.

In order from the top to bottom: **Image Processing, Image Filtering, Multi-Plane Calibration, Display Layers, Notes, Annotations, Feature Tracking, Graph Configuration, Save All Associated Toolkits.** All of the changes will only be visible in the **Processed** tab because the **Raw** tab will remain unchanged.

In **TrackOne Edition**, only some of the tabs can be used to manipulate the video, but can open all of the modifications from other versions of **ProAnalyst®**.

6.4.1 Image Processing

Allows the operator to change the color of the video which includes the **Brightness**, **Contrast**, **Gamma and Exponential** / **Logarithmic**.

Within this example, the user will notice that the individual colors can be adjusted be double clicking on the slider in question.

Below the sliders, the buttons can invert (reverse) the individual colors.

The **Convert to B&W** (Black and White) can change the color image to a grey scale. The sliders above the button can change the intensity of the individual colors. Once in **B&W**, the sliders below will be able to be changed as above.

The **Load** and **Save** buttons will load a previously saved **Image Processing file** (*.lut) while **Save** will generate a lut file from the current settings.

The Reset All will return all of the setting to the default location.

6.4.2 Multi-Plane Calibration

This tab will allow the user to calibrate the video file.

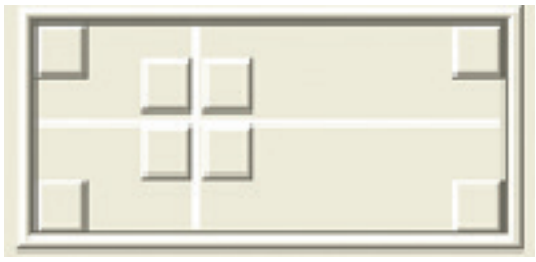
The software needs to relate the number of pixels to a known distance. The **TrackOne Edition** can not use a perspective calibration as can the other versions of the software.

The Normal calibration can be performed within **TrackOne**. A Normal calibration is able to measure items that move at right angles to the camera view.

To add a calibration, click on **Add Normal** and another line item will appear on the screen. Throughout this software package a standard convention will repeat. For example, on the calibration line on the right, there is an eye either open or closed. If the eye is open, the object is visible on the screen. If the eye is closed, the object will not be shown on the screen.

The wrench to the right of the eye will open a configuration menu. In the calibration wrench menu, it is labeled as Calibration # Settings where # is the number of the calibration. When the operator clicks on the screen, the reticle (cross hair) will move to the position clicked. If the operator then clicks on **Set Point #1**, the first point of the calibration will be set. The second point can be selected in a similar method. After the two points are selected, the user can enter the value between the two points selected and then select the units of measurement of the number from the pull down menu. After the units are selected, the **Apply Scale >>** button **MUST** be clicked. This will change the box beside the button to xx pixels/"units selected".

The origin of the coordinate system can be set in a similar method. Point the reticle to point were the operator requests the coordinate origin to be (0,0). This will be the reference point for all of the measurements. After the origin is set, the orientation of the axes must be set. As shown below, each of the buttons in the picture will set the orientation of the axes.



Each of the corner buttons will set the origin of the coordinate system in the respective corner. The positive orientation of the two axes will be along the edge of the frame. For example, the top left button will set positive X direction to the right and the positive Y direction down while the bottom right button will set the

positive X direction to the left and the positive Y direction up. The four buttons around the reticle will set the positive orientation around the button pressed from the reticle position. If the orientation of the X axis is not horizontal, from the origin of the coordinate system place the reticle on the horizontal line and then click Set X Direction. Once the Origin and positive axes are set, the user MUST click **Apply Origin and Tilt >>** button. After the button is clicked, the pixels (origin) will be displayed as well as the degrees (tilt).

The user MUST then click **Apply** to set the changes and then **Close**. The user can then remove calibrations if they were made in error.

6.4.3 Display Layers 

This menu allows the user to change which layers are displayed and the information displayed on the screen.

6.4.4 Notes 

This will allow the user to make notes on the video file. The area labeled Video Notes is information about the displayed frame while the Global Notes area pertains to the whole video.

6.4.5 Annotations 

The tab allows the user to draw and place text on the video frame.

6.4.6 Feature Tracking 

This tab will allow the user to track a point on the video.

In the top left of the tab, **Feature Tracking** must be enabled. If user can not change any other part of the menu structure, click on **Enable**.

The user needs to decide whether a **Manual** or **Automatic mode** will be used to track an object.

In **Manual Mode**, the operator will manually select each and every point that will be used in the calculations. In **Manual Mode**, less video manipulation (Image Processing) is required because the human eye can distinguish the difference when tracking an object better than a computer algorithm. The operator can switch between **Manual** and **Automatic** while tracking a single object. When the user is in **Manual mode**, the user can click on **Add** and add a feature that can be used to track an object. This is the simplest way to track. Click to place the reticle on the object the user wishes to track and click **Set Point**. This needs to be done in every frame the operator wishes to track. This can be a long and tedious task if a lot of frames need to be

In **Automatic Tracking**, a feature can be added just as in Manual tracking but now the user needs to define a region of the video that they wish to track by clicking **Define Region** and drawing a rectangle around the object. The way that the user can select an area, the computer is looking for that exact defined area in the next frame. Therefore, the user should try to select an object that stays defined throughout the time of interest. This is where the Image Processing is very important to help distinguish the tracking object from the background image.

Within **TrackOne**, the user only can use the **Image Processing** while **Image Filtering** is not available. Once the user can separate the tracked object from the background and the area around the object has been defined and set, the grey box will turn a shade of cyan.

After the user clicks of the wrench, the settings box opens. The operator needs to give the **Feature** a name that makes sense for future reference. Then the correct **Calibration** needs to be selected from the pull down menu.

Within the Search Parameters section, the **Search Region Multiplier (%)** is the increased search area around the defined region. This area can be displayed around the defined area by right clicking on the video, **Feature Tracking> Show Search Regions.** This is the area that the **Defined Region** is looked for in the next frame of the video.

The larger the area, the larger the possibilities of the Automatic Tracking will follow something else in the area.

Too small of an area and the tracked object may not be within the area in the next frame.

The **Threshold Tolerance (0.0 – 1.0)** is the type of match from frame to frame where 1.0 is a perfect match. Normally, the tolerance is between 0.75 and 0.95. The **Frames to Search After Loss** is the number of frames the software will look ahead if it has lost the tracked object. Normally, it is set to 0.

The other important setting is the **Feature Rotation**. If the tracked object is rotating in the frame the software can loose the Automatic Track on the object. The operator can Enable and set the **Angular Range (deg)** to the maximum expected rotation between two frames. This is a positive as well as the negative rotation angle. The **Step Size (deg)** is the number of degrees between the iterations. The larger the number, the higher the possibility of missing the object, while too small of a number will take a long time to process.

The **Show Points** selection will display on the video the points.

6.4.6.1 Show All

Display every point created.

6.4.6.2 Show Past

Display only past point created in the video.

6.4.6.3 Show Current

Display only the current point.

6.4.6.4 Show None

This will not display any points.

6.4.7 Under the Tracking box

The buttons from left to right are: **Track Backwards**, **Track One Frame Backwards**, **Stop**, **Track One Frame Forward** and **Track Forward**.

The software takes an image of the **Defined Region** when the **Set Region** button is pressed. At some points, the **Automatic Tracking** may loose the item of interest, the user **MUST** stop the tracking by pressing the middle Tracking button and play the video back (not track backwards) to the point of the tracking failing and reset the **Set Region**.

The operator can then continue the track in the same direction (forward or backwards) and the previously tracked points will move to the new location.

Once the object is tracked, the lock between the eye and the wrench should then be closed (to the locked position) to avoid and changes to the points.

The **Units & Export** section will allow the user to select the units to export the data to as well as the form that the file will be.

In this example, the setup was Meters and Text. The text file was placed in the same directory labeled **ProAnalyst_Demo.txt**.

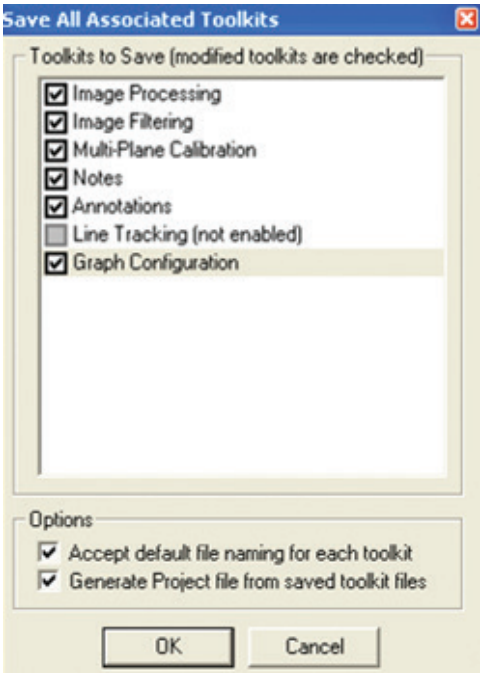
The TrackOne Edition does not offer graphing, therefore, for this example the data was imported and graphed in Excel. The file is labeled as **ProAnalyst_Demo.xls**.

6.4.8 Save All Toolkits

After all of the analysis has been performed, it is very important to associate the files to the video. This will allow in the future, opening the analyzed video as easily as this example. It is important to select all of the boxes because the software will save everything.

The bottom two boxes under **Options** are also very important because the file names will be the same as the video file name. This will make it easier for the user in the future.

The Generate Project is also very important because it will be the overall association. This is the *.mpj file which will keep everything neat and tidy.



6.5 Excel Spreadsheet – ProAnalyst_Demo.xls

This spreadsheet was generated from the exported file from **ProAnalyst® TrackOne**. On the first sheet (ProAnalyst_Demo) displays the data from the text file with a Red shading. Everything with the Red shading of the cell was imported from the **ProAnalyst®** text file. All of the white (unshaded) cells were calculated within Excel.

6.5.1 Explanation of the Unshaded Cells

Feature 1 Values:

Feature 1 (Right_Side) X (corrected) (column D): This column is used to correct the offset of the data points from the origin of the coordinate system. Equation: D# = (C# - C12) where # is the current cell in the D column.

Feature 1 (Right_Side) Y (corrected) (column F): This is the same process as X (corrected).

Feature 1 (Right_Side) Vector (column G): This column is the vector sum of the X (corrected) and Y (corrected).
Equation: G# = √ (D#2 + F#2)

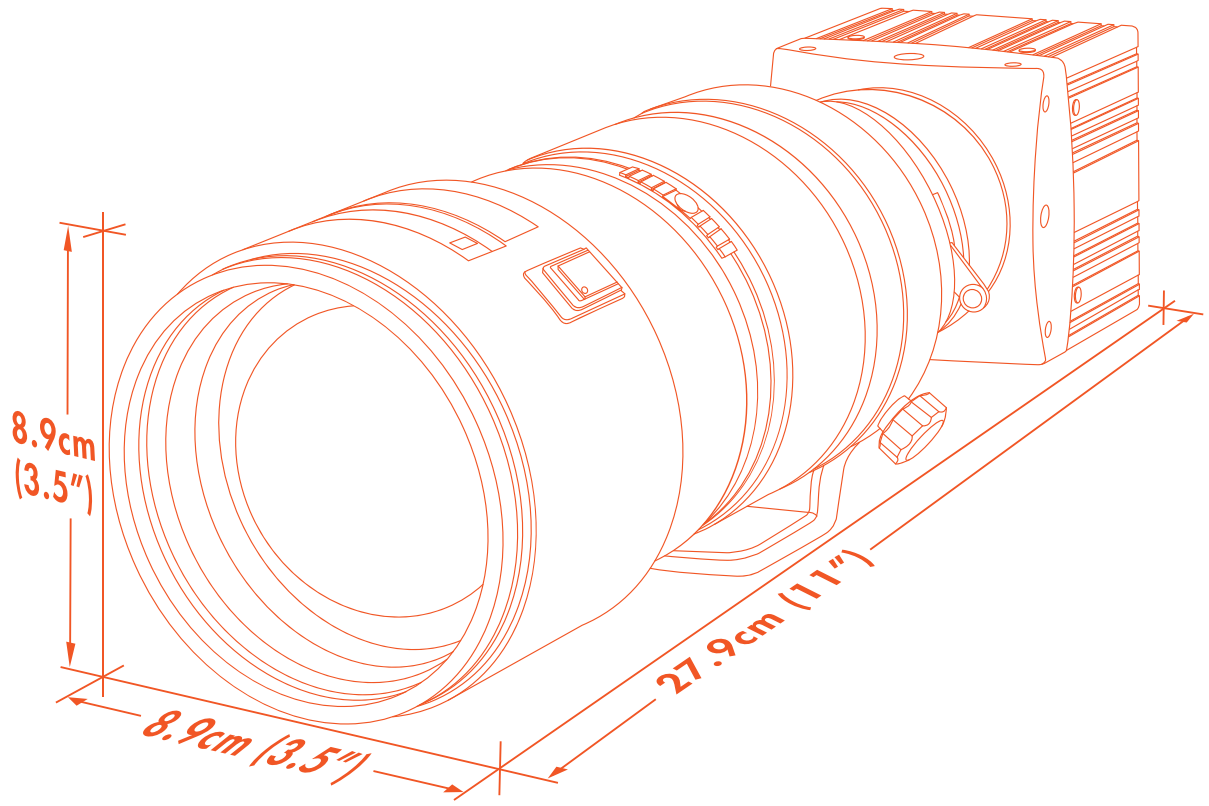
Feature 2 Values:

Feature 2 (Left_Side) X (corrected) (column J): This column is used to correct the offset of the data points from the origin of the coordinate system. Equation J# = (I# - I12)*(-1) where # is the current cell in the J column. The values are required to be multiplied by negative 1 (-1) because the coordinate system was defined with Positive X to the right, the left side positive motion is to the left. The other solution is to define another calibration for the Left_Side measurement.

All of the other measurements are as described above.

The Graphs tab has all of the measurements in a graphical solution.

Chapter 7
Contacting MREL for Technical Support



7.1 Contacting MREL

MREL Group of Companies Limited

Blasting Instrumentation Team

1555 Sydenham Road
Kingston, Ontario K7L 4V4
Canada

Toll Free Canada/USA: +1-877-544-MREL
Tel: +1-613-545-0466
Fax: +1-613-542-8029

Email: support@mrel.com

MREL looks forward to providing you with assistance.

Glossary

Aperture

An aperture is a hole or an opening through which light travels through the lens.

Auto Tracking

Auto Tracking monitors the change of pixels generated by the video chip in the **BlastCam™**.

AVI Format

Audio Video Interleave, known by its acronym AVI, is a multimedia container file format for Windows™ technology.

Bayer

A Bayer mosaic is a colour filter array (CFA) for arranging RGB colour filters on a square grid of photosensors.

BMP

Audio Video Interleave, known by its acronym AVI, is a multimedia container file format for Windows™ technology.

Depth of Field

The depth of field (DOF) is the portion of a scene that appears acceptably sharp in the image.

F-Mount

The F-Mount is a type of interchangeable lens mount for the camera.

F-Stop

The F-Stop (sometimes called focal ratio, F-Ratio, F-Stop, or relative aperture) of an optical system expresses the diameter of the entrance pupil in terms of the focal length of the lens.

Focus

Focus is the point where light rays originating from a point on the object converge to a sharp image.

Frame Rate

Frame Rate, or frame frequency, is the frequency (rate) at which the **BlastCam™** produces unique consecutive images called frames.

Gain

Gain increases the intensity of available light in an optical system to allow use under low light conditions.

Glossary

GB

Gigabyte is a multiple of the unit byte for digital information storage.
1 Gigabyte = 1,073,741,824 (1024^3 or 2^{30}) bytes.

LED

A light-emitting diode (LED) is a semiconductor light source.

Make Circuit

Make Circuit is an open circuit that closes when initiated.

MB

Megabyte is a multiple of the unit byte for digital information storage.
1 Megabyte = 1,024,000 (1024^2 or 2^{20}) bytes.

Pixel

A pixel (or picture element) is a single point in a raster image. The pixel is the smallest addressable screen element; it is the smallest unit of picture that can be controlled.

RAW Format

A raw image file structure that contains minimally processed data from the image sensor of the **BlastCam™** Camera.

Resolution

Resolution is the number of distinct pixels in each dimension that can be displayed.

Shutter Speed

Shutter speed represents the time that the shutter remains open when taking a video. Along with the aperture of the lens (also called F-Stop), it determines the amount of light that reaches the sensor.

Zoom

Zoom is the mechanical ability of a camera to vary its focal length through the lens elements.

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