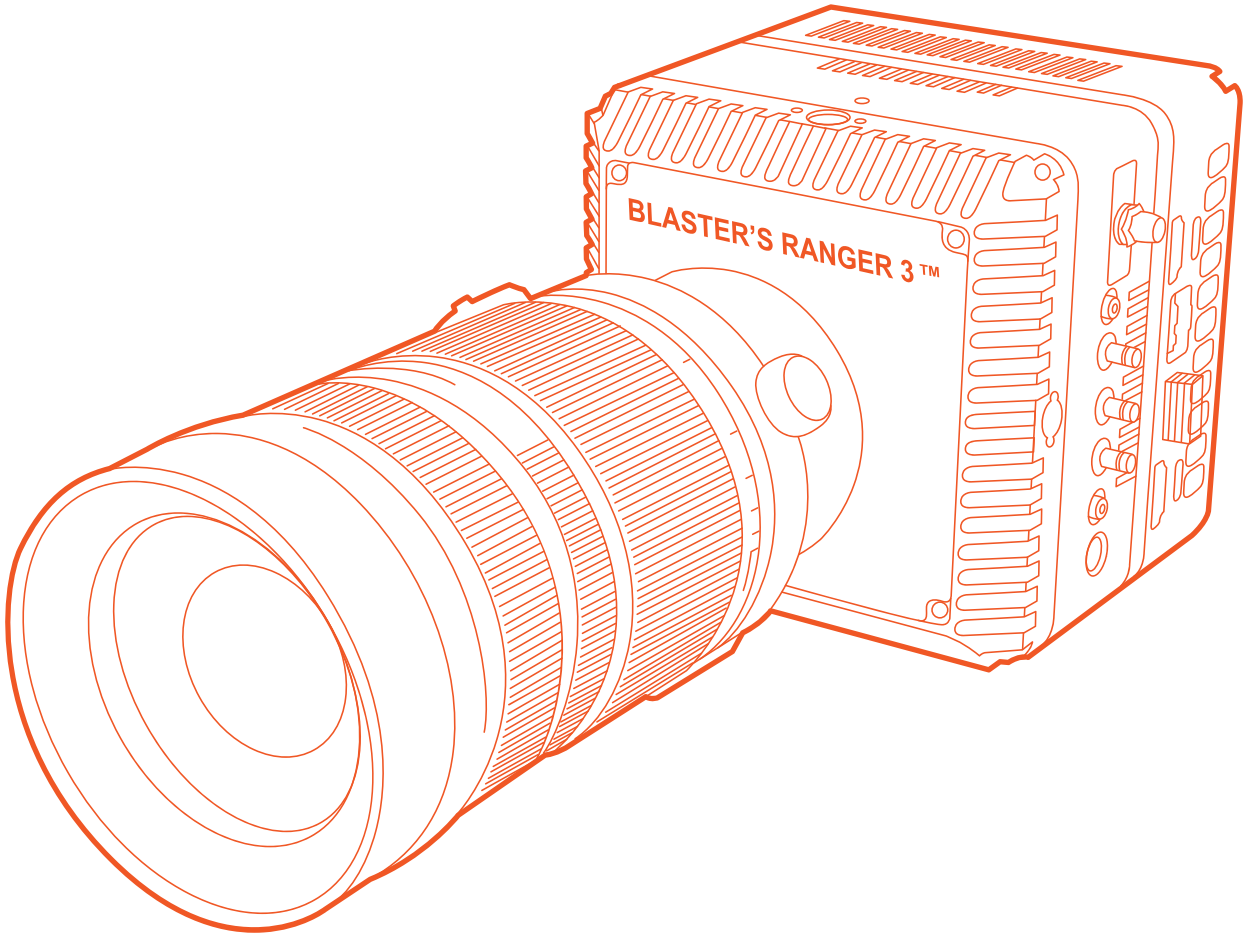
BLASTER'S RANGER 3™
HIGH SPEED CAMERA

Operations Manual

Edition 1.0



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Publication History

Edition 1.0, May 2025

First edition of the manual.

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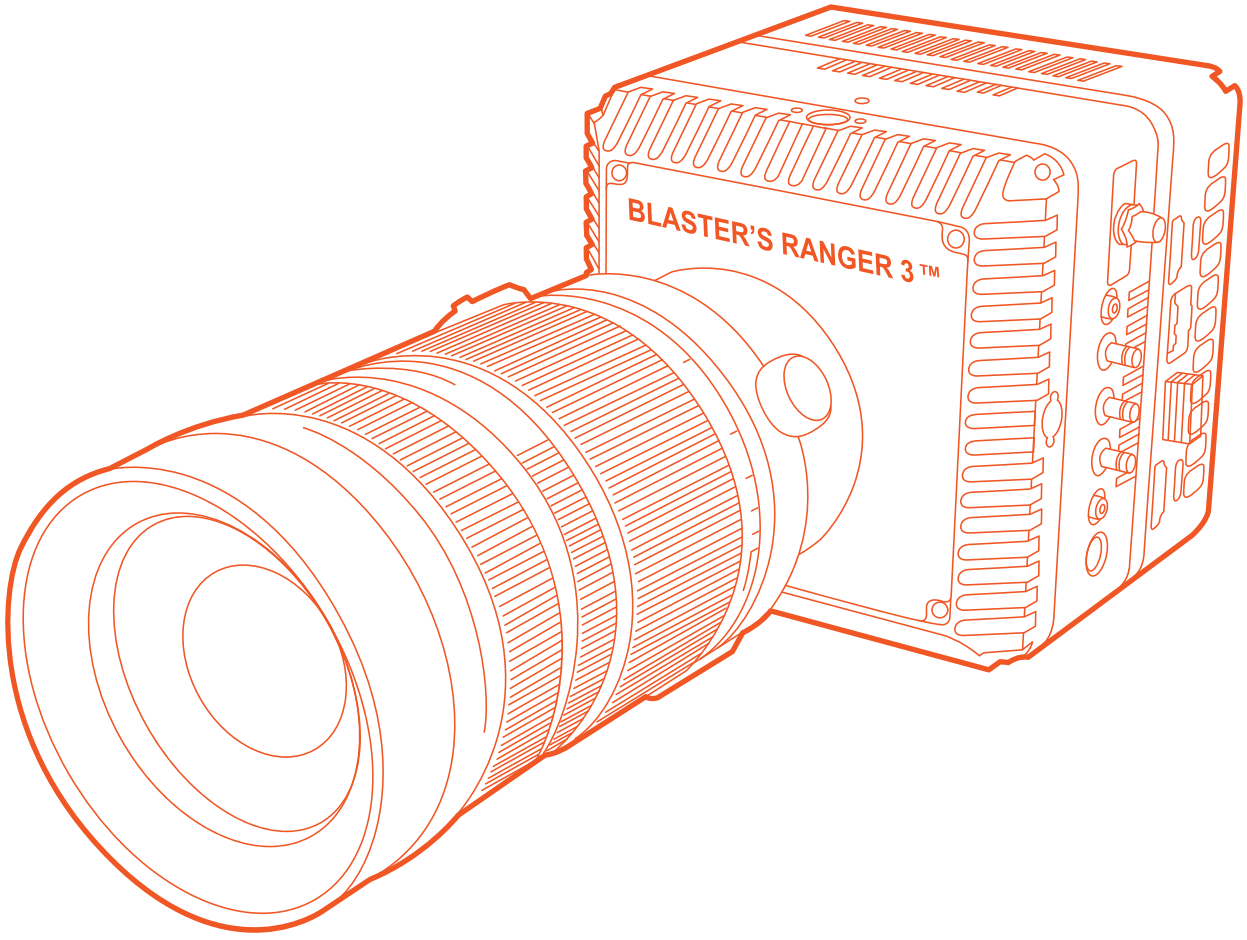
Chapter 1
Introduction



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 **Blaster's Ranger 3™ High Speed Digital Camera**. This Operations Manual provides instructions on the use of the hardware supplied with the **Blaster's Ranger 3™ High Speed Digital Camera** and **ProAnalyst® 2023 Blaster's Custom Toolbox Software**.

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 **Blaster's Ranger 3™ 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.

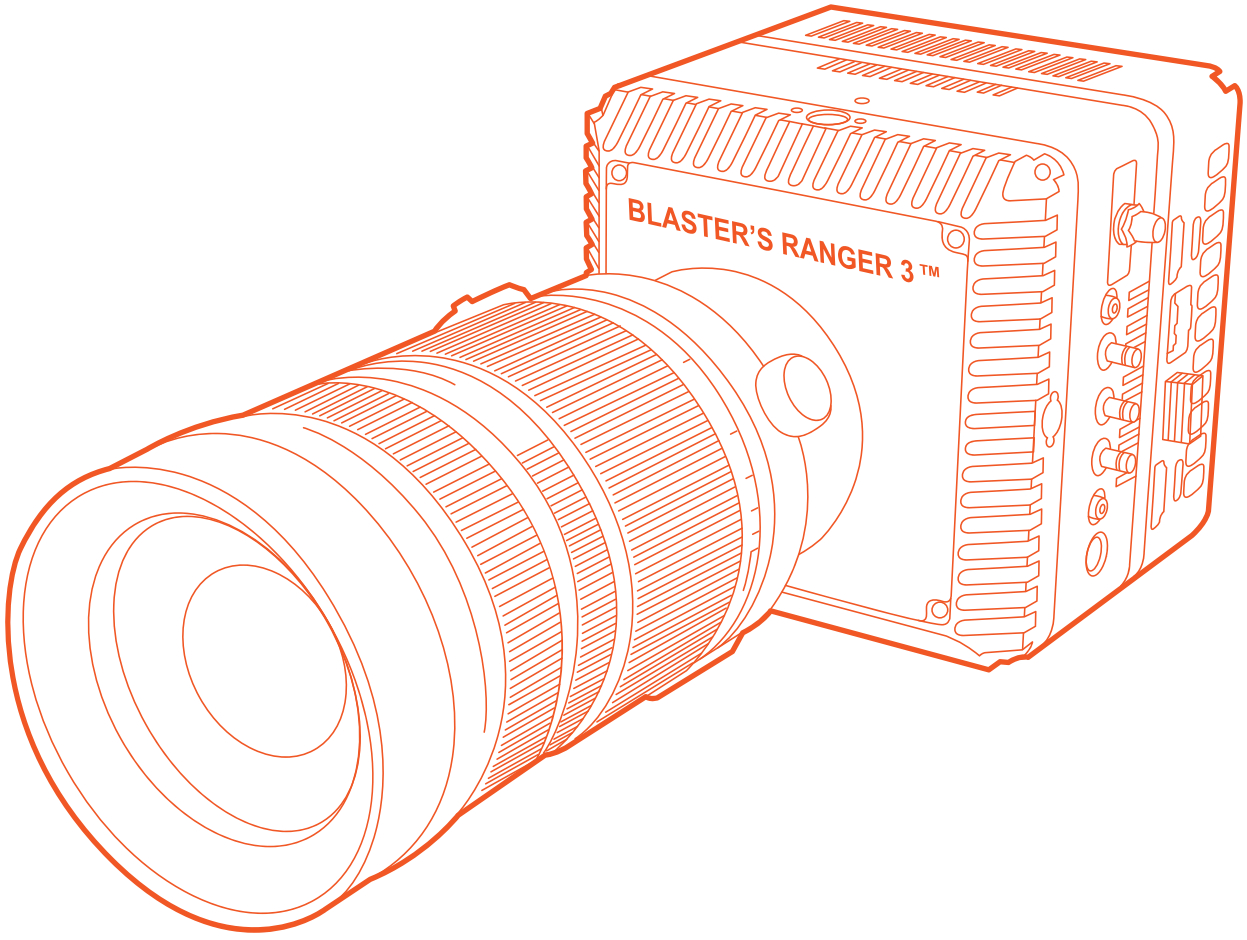
High speed video has two main uses in helping to optimize surface blasting results. The principal use is the direct photography of the blast, with the analysis of the resulting video and/or digital images representing the bulk of the optimization work. However, high speed video also can be used to analyze 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 Blaster's Ranger 3™ High Speed Digital Camera.

2.1 Blaster's Ranger 3™ High Speed Digital Camera

The **Blaster's Ranger 3™ High Speed Digital Camera** is housed in a rigid anodized aluminum housing. The housing is equipped with many connection ports:

External Input/Output via DIN1855 ports
3 configurable ports: Trigger In/Out, Sync In/Out, Arm In/Out, or General Purpose In @ 3.3v LVTTL, or 5v TTL, or switch closure

Display Ports
2x HDMI 2.0b, 2x DP1.4a via Thunderbolt 4 (USB Type-C port)

USB
1x USB3.2 (10G), 1x USB2.0, 2x USB4 (40G) via Thunderbolt 4 (USB Type-C port)

Ethernet / WiFi
2.5 Gigabit Ethernet / WiFi 6

Bluetooth 5.1

Photographs of the **Blaster's Ranger 3™** are shown below. The **Mounting Adapter** is attached to the bottom of the **Blaster's Ranger 3™** to allow the **Blaster's Ranger 3™** to be quickly mounted onto the **Tripod's Ball Head** (shown in **Section 2.2.3**). The **Mounting Adapter** and the **Tripod's Ball Head** are part of the **Blaster's Ranger 3™ Accessories Package**. The **Blaster's Ranger 3™** is equipped to accept many **MFT Mount Lens**.

2.2 Blaster's Ranger 3™ Accessories

2.2.1 Protective Carry Case

The **Carry Case** is designed to contain, for transportation and storage all the components required for setup and use of the **Blaster's Ranger 3™** in the field. The **Carry Case** is a pelican case which has water resistance capabilities.

2.2.2 Zoom Lens

The **Blaster's Ranger 3™** is supplied with a **Zoom Lens** appropriate for imaging of blasts. The standard **MFT Zoom Lens** (100-400 mm) is supplied with all of the cameras.

2.2.3 Tripod and Ball Head

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

2.2.4 Blaster's Ranger 3™ V-Mount Battery

This battery is attached to the back of the camera to the V-mount. This battery will power the camera for up to 2 hours. Using the supplied and labeled cables, this battery will power the camera and the monitor using the DTAP port and extension.

2.2.5 Blaster's Ranger 3™ Monitor

The **Blaster's Ranger 3™ Monitor** is used to configure the camera and frame the video. This monitor is powered from the V-mount battery.

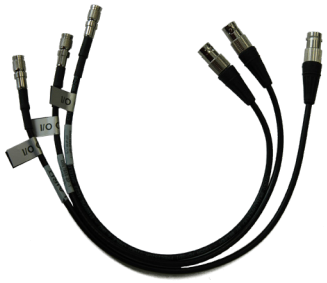
2.2.6 Blaster's Ranger 3™ Monitor Mount

The mount is attached to the back of the monitor and will then be attached to a leg of the tripod to keep the display in a convenient position during setup of the camera.

2.2.7 Blaster's Ranger 3™ HDMI Cable

This cable is used to connect the output from the camera to the input of the monitor.

2.2.8 Blaster's Ranger 3™ I/O Cables



The **Blaster's Ranger 3™** I/O Cables will allow for the connection of the trigger switch to the camera.

2.2.9 Trigger Switch Cable with Button

The trigger cable with switch allows the user to trigger the camera at a distance. The user can extend this cable with the appropriate BNC connectors and a reel of RG-58 coaxial cable.

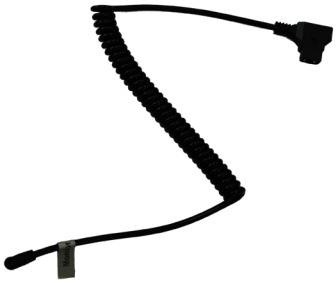
2.2.10 DTAP Power Extension Cable

The **Blaster's Ranger 3™** is supplied with an extension cable to allow the camera and monitor power cables to be connected to the V-Mount Battery.

2.2.11 DTAP Camera Power Cable

This cable will connect to the **Extension Cable** and will power the camera.

2.2.12 DTAP Monitor Power Cable



This cable will connect to the **Extension Cable** and will power the monitor.

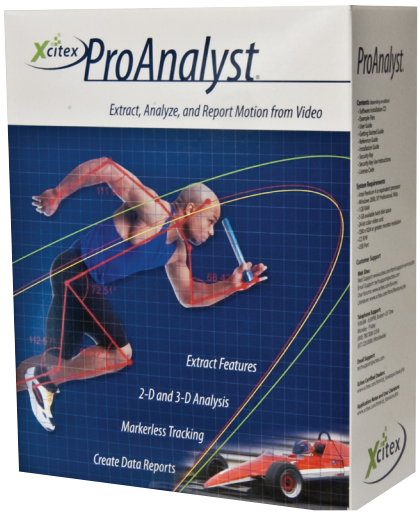
2.2.13 V-Mount Battery Charger with USB-C Cable

The **Blaster's Ranger 3™** is supplied with a battery charger that will connect to local power and charge the battery using the USB-C port on the charger and the USB-C port on the battery.

2.2.14 Wireless Handheld Mouse

The **Blaster's Ranger 3™** on-screen controls are operated using the wireless handheld mouse. This will allow for the changing of the settings of the camera or manage the saved files. This is connected to the camera using the USB dongle that has been installed in the USB port of the camera.

2.2.15 ProAnalyst® 2023 (Blaster's Custom Toolbox) Software



ProAnalyst® 2023 (Blaster's Custom Toolbox) allows auto-tracking of unlimited number of features of interest. **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 hardware key for installation. Instructions on using **ProAnalyst® 2023 (Blaster's Custom Toolbox)** are included in **Chapter 6**.

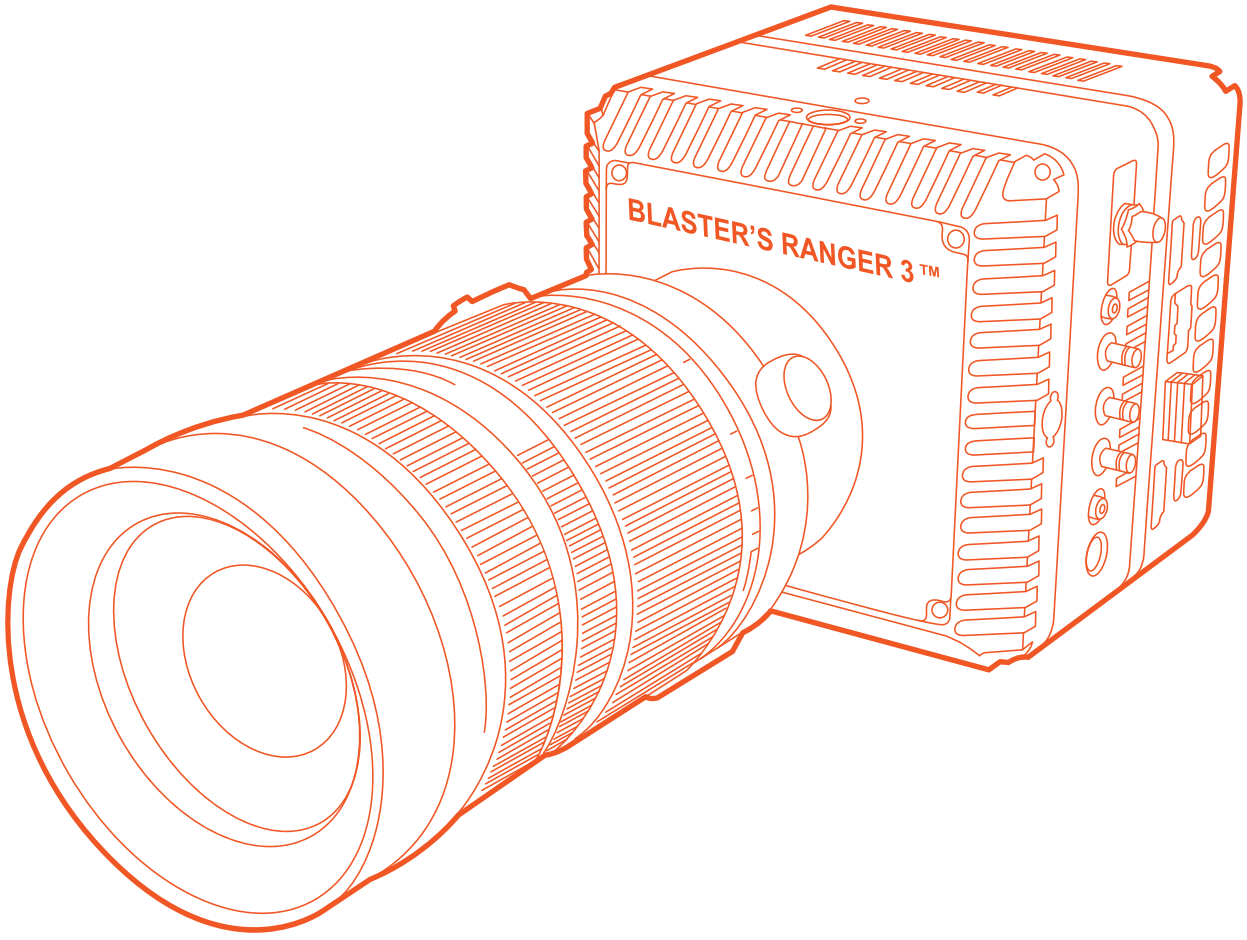
2.2.16 Optional Dust and Rain Shield

The optional **Blaster's Ranger 3™ Dust and Rain Shield** will protect the camera from inclement weather when operating in the field. This item will fit over the body of the camera and monitor while allowing the viewing port to configure the camera.

2.2.17 Optional Battery Operational Extender

The optional **Blaster's Ranger 3™ Battery Operational Extender** will allow for multiple V-Mount batteries to extend the operational time of the camera. With using two fully charged V-Mount batteries, the camera will operate for over 4 hours. This Battery Operational Extender will allow for hot swapping of more than two batteries for extended running time.

Chapter 3
Getting Started



Overview

This chapter provides an outline of how to setup the Blaster's Ranger 3™. This chapter assumes that the user will first want to unpack the Blaster's Ranger 3™ and set it up in an office environment in order to learn the camera controls.

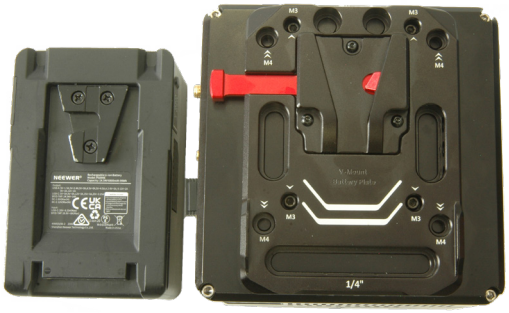
3.1 Introduction

This chapter provides a detailed description of the setup procedure for the **Blaster's Ranger 3™**. For instruction on using the **Blaster's Ranger 3™**, please refer to **Chapter 4**. For Instruction on using the **Blaster's Ranger 3™** in the field, please refer to **Chapter 5**.

3.2 Powering Up

The **Blaster's Ranger 3™** is powered by the rechargeable V-Mount Lithium Ion battery. The operating voltage of the system is above 12 volts. If the battery drops below 12 volts, the system will need to be turned off. The battery may not be fully charged when you receive the unit due to shipping regulations. To check the battery level, press the button on the front of the battery to illuminate the display. Both the voltage and the percentage will be displayed.

3.2.1 Attaching the Battery



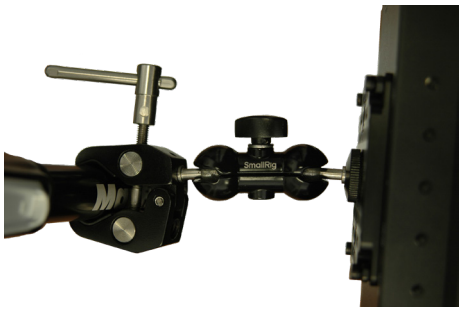
This battery will attach to the back of the **Blaster's Ranger 3™** using the V-Mount adapter plate. With the battery V-Mount facing the back of the camera, align the V-Mount and slide down until the unit clicks. To remove the battery, press the **red** button and lift the battery.

3.2.2 Attaching the Monitor

The monitor will need to be assembled in order to be mounted to the **Tripod**. Remove the **Monitor** from the case and remove the protective padding. On the back of the **Monitor**, there is a plate with a variety of threaded holes. This is called a cheese plate. This cheese plate has been pre-mounted to the monitor for your convenience. Remove the **Monitor Mount** from the case.

Thread the end of the **Monitor Mount** into the centre hole of the cheese plate. Thread onto the cheese plate until the tread meets resistance and then use the black locking plate to hold everything tight.

Use the clamp to attach to the leg of the **Tripod** that is only aluminum. Do not attach the mount to either of the legs with the rubberized grip as the **Monitor** will not be held firmly.



3.2.3 Connecting the HDMI Cable

To allow the monitor to view the output from the **Blaster's Ranger 3™**, take the supplied cable and connect to the **HDMI 1** port on the camera and the other end to the **HDMI port** on the monitor.

3.2.4 Connecting the Battery

To connect the power from the battery to the camera and monitor, open the **DTAP port** on the side of the battery. Connect the **DTAP** extension to allow for both the **Blaster's Ranger 3™ Camera** and the monitor to be connected. Using the supplied **DTAP** cables, there will be two cables that will look very similar. They have different size ends. Refer to the labels on the cable to connect to the correct device. One will be labeled for the camera and one will be labeled for the **Monitor**.

3.2.5 Charging the battery

To charge the battery, connect the battery charger to AC power. Connect the **USB C cable** to the charger and the **USB C port** on the battery. It would take 5 hours to fully charge.

3.2.6 Operation of Wireless Handheld Mouse

With the USB dongle already inserted into one of the cameras USB ports, turn on the **Wireless Handheld Mouse** by moving the power switch on the bottom of the mouse to **ON**.

This will allow for the operation of the trackball to move the curser on the screen. The trigger button is left click while the buttons beside the scroll wheel are right click.

3.3 Mass Storage

The **Blaster's Ranger 3™** camera is equipped with 8GB to 32GB of internal high speed internal memory. Images stored in this memory can be reviewed on the camera, then saved to any of four types of mass storage devices:

1. Internal Solid State Hard drive installed in the Blaster's Ranger 3™ at the factory is 1TB or 2TB according the model you ordered. BR3-HS5i-QCXX1TB has 1TB SSD installed, while Model BR3-HS5i-QCXX2TB has 2TB SSD installed. (Recommended)
2. External drive connected via USB or Thunderbolt ports
3. Mass storage device on any network-connected PC using FasMotion
4. The **Surface Go 4 Tablet** with the optional product 1-90-18

3.4 Camera Setup

There are several precautions that must be remembered prior to using the **Blaster's Ranger 3™**. The suggested procedure for assembly of the system is detailed in the following sections.

3.4.1 Blaster's Ranger 3™ Setup

Open and extend the **Tripod** legs. Attach the **Ball Head** to the top of the **Tripod** using the 3/8" screw mount. Remove the **Mounting Adapter** from the top of the **Ball Head** and connect the threaded screw of the **Mounting Adapter** to the bottom of the camera. Be sure that the **Lens** arrow is pointing towards the front of the camera. Attach the **Mounting Adapter** to the **Ball Head**.

3.4.2 Mount the MFT-Mount Zoom Lens to the Camera

Remove the lens receptacle cover from the camera's MFT-mount. This is a cover that is installed at the factory to protect the camera optics and sensor from dust contamination.

NOTE: Whenever threading lenses on or off the camera, face the camera lens down so that any contamination on the threads will tend to fall away from the camera rather than into it. Thread the MFT-mount lens into the lens mount located in the front of the camera. DO NOT over tighten the lens! The lens should be "finger tight" only–just tight enough that the lens will "click" into place.

3.4.3 Blaster's Ranger 3™ I/O connections and Trigger Switch Cable

There are three External **I/O connections** on **Blaster's Ranger 3™** that may be configured for Arm, Sync, or Trigger for controlling or synchronizing the camera.

Three 1-foot DIN to BNC (female) cables are supplied with each camera. These are push-pull cables and are very easy to connect and disconnect.

Connecting:

1. Hold the cable loosely by the heat-shrink tubing just below the connector.
2. Gently align the cable with the connector by feel. (This should be very easy!)
3. Gently push the cable into the connector until you hear a soft "click".
4. Pull gently on the cable using the same grip to confirm that it is coupled.

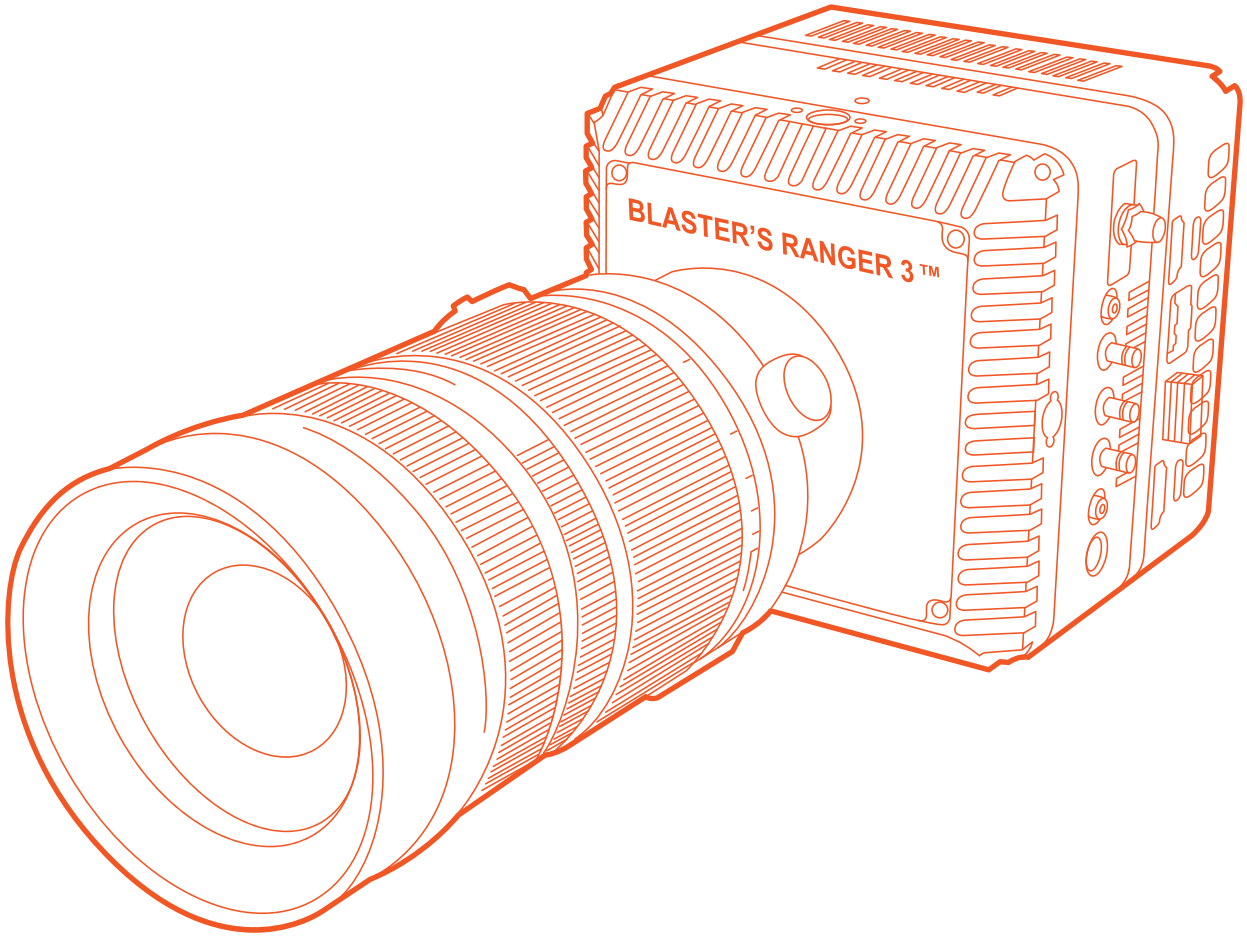
It takes very little pressure to make the connection when the connector is properly aligned. Forcing the connectors may damage them!

Disconnecting:

1. Hold the cable by the knurled portion of the connector.
2. Gently pull the cable away from the camera. The cable should disengage with very little effort.

Attach one **I/O Connection cable** to the middle connector labeled with 1. Then attach the trigger switch cable to it.

Chapter 4
Operation of the Blaster's Ranger 3™



Overview

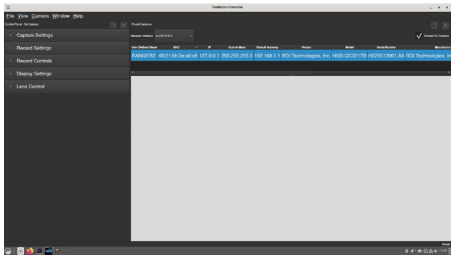
This chapter provides an outline of how to setup the Blaster's Ranger 3™ for recording, viewing, and saving events.

4.1 Starting FasMotion

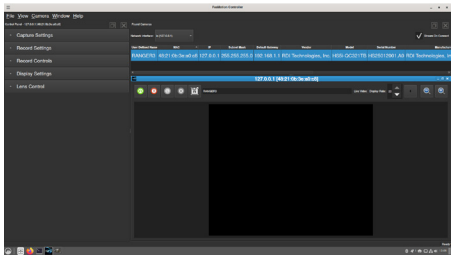
After powering up the camera and the monitor, the opening screen will show as follows:

Start **FasMotion**. The icon is displayed on the right as well as the program is on the task bar at the bottom left of the screen.

After the program starts, the first screen that you will see is shown to the right.



Inside **FasMotion**, there are different sections of the program that will allow for changing and configuring the camera. The top menu will allow for direct selection of items. The left side of the window is the tabs that will allow quick access to the different settings of the camera, including the memory, trigger point, resolution, frame rate and lens control. This section of the manual will step through the different settings while showing the recommended settings. Along the top of the screen, the found cameras will be displayed. Double click on the line of the camera to open the connection to configure the **Blaster's Ranger 3™**.

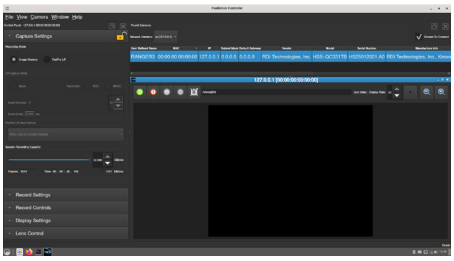


After the camera has been connected, all of the options will be available to change.
In the bottom right of the window is the live view of the camera.

Below are the camera control buttons of **Arm**, **Trigger**, **Live** and **Review**.

A T L R	**Live mode**	**A (Arm) and T (Trigger) buttons active: Camera in Live mode, waiting to Arm**
A T L R	**Recording: Armed**	**A (Arm) and T (Trigger) buttons active: Camera is Armed, waiting for the trigger**
T L R	**Recording: Triggered**	**No buttons active: Camera has been triggered and is continuing to record**
T L R	**Review mode**	**L (Go to Live) button active: Camera has been armed and triggered, in Review**
A T L R	**Live Images in buffer**	**A (Arm), T (Trigger) and R (Review) buttons active: Camera in Live mode, has a recording in the buffer**

4.2 Capture Settings



Click on the **Capture Settings** tab. The menu will drop down as shown to the right.

The standard operation of the **Blaster's Ranger 3™** camera is with **Image Memory**. If the **Long Record (LR)** option was purchased, the camera may be operated either in **Image Memory** mode or **FasFire LR** mode.

For **Image Memory** recordings (normal mode):

1. Select the **Image Memory** radio button. This will be the only possible selection for cameras without the **Long Record** option.
2. Set the **Session Recording Capacity** slider to select the required recording time or number of frames. Normally, the maximum value for the camera should be selected. Depending on the model purchased, the maximum value will be either **8**, **16** or **32 GBytes**.

The **Session Recording Capacity** slider is used to select the amount of memory used for recording. The number of frames and the time, in seconds, for the recording, will depend on the resolution, frame rate, bit depth and the memory selected shown above.

4.2.1 FasFire LR Mode (Optional)

For **Blaster's Ranger 3™** cameras with optional **Long Record (LR) upgrade**, they have the long recording ability. Below is how to enter and use **FasFire LR** long recording mode.

1. With the camera in live mode, open the **Capture Settings** tab. Select the **FasFire LR** radio button. A Mode Change message box will appear with the warning that Long Recording mode will overwrite data on the SSD. Click OK to continue. Camera will enter long recording mode. If **FasFire LR** radio button is grey, it means there is not enough space on internal SSD. Then you need copy files out from SSD, delete them or format the SSD by clicking File…Open Storage device…, check if any video files on SSD and if the videos have been saved to a secure place. If not, highlight the video, select Copy, choose destination, click OK. After all videos have been copied, click Format.

Note: All videos on SSD will be deleted after clicking Format!

2. **FasFire LR** has three modes: **Basic**, **ROC** and **BROC**. **Basic** mode works much like standard basic mode in Image Memory. **ROC** mode is convenient if multiple recordings of various durations will be made or if there are pauses in the action that need not be recorded. **BROC** mode records a specified number of frames with each trigger. It is recommended to use the **Basic** mode for blasting applications. Click **Basic** radio button.

3. Select the FasFire LR Save device

In **FasFire LR** mode **Blaster's Ranger 3™** cameras capture consecutive 4GB partitions, comprising a Partition Capture Stack automatically saved to the built in high-speed NVMe SSD and available for review as one contiguous (LR) recording. Pick the SSD from the pulldown list. If the SSD not shown in the list, format SSD from File… Open Storage Device...SSD… click Format, Ext4 is the only format used on internal SSD. Please note, all recordings will be deleted when doing Format!

4. **Session Recording Capacity**

Set the **Session Recording Capacity** slider to select the required recording time or number of frames. Normally, the maximum value for the camera should be selected. The maximum of the internal SSD is 944.00 GB. At the default settings of 1280x1014, 1000 fps, it will record 12 minutes and 58 seconds.

5. Set **Frame Rate** and **Resolution**
Setting **Frame Rates** and **Resolutions** for Long Record is done the same way as for **Image Memory** recording. Please refer **Section 4.3.1 Recommended Record Settings**.

6. Set the trigger point and enable the external trigger using the same way as in **Image Memory** recording. Please refer **Section 4.4.1 Recommended Record Control Settings**.

7. Click the **Arm** button same as in the Image Memory recording. Please refer **Section 4.7 Arming the Blaster's Ranger 3™**.

8. Click trigger switch button to trigger. Please refer **Section 4.8 Triggering the Blaster's Ranger 3™**.

Note: If you wish to stop recording before all post-Trigger frames are recorded, you may cancel the recording by clicking the **Arm** button, then select "**Yes**" to retain the current session in the **Cancel Record** dialog.

9. Save or copy files from the camera
FasFire LR mode recordings are written to the SSD, which is non-volatile media. The recordings will not be lost when the camera powers down. Image sequences are saved as 4GB CAP (Partition Capture) files. They must be loaded back into high-speed memory in the camera to be reviewed, and then converted into a downloadable file format. After the video has been clipped to the section of interest, the files will now need to be downloaded. To download, select File then Save Video File… The Save Video window will open. The next section is related to the information that will be saved into the directory on the camera and other external storages. It is recommended to download as TIF Stack.

10. Format the SSD to delete all recordings and completely clean it off to get it ready for next **FasFire LR** recording. (Deleting individual recordings is not allowed.)

11. Switching back to standard mode: **Image Memory**

With the camera in live mode, open the **Record Settings** tab. Select the **Image Memory** radio button. Then check the resolution, frame rate, trigger point and the external trigger control. Now you can start a new standard image recording.

When you save video to SSD, if the SSD is not in the list or not enough space, you need delete some videos on it or Format the SSD to get all the 944 GB available

12. **ROC** and **BROC** Mode

In the 2nd step above, if the camera is set to **ROC** or **BROC** mode, click on the Arm button. You will now see the recording timeline and a live image in the Camera Window. Click on the Trigger button. Camera is now recording and streaming images directly to the onboard SSD. The position bar goes solid red. The Arm button will become a white "X" on red, while the Trigger button remains red.

ROC mode
Click on the trigger button again. The recording will now pause, and the position indicator will alternate yellow / orange and the Arm button will turn brown, Repeated triggering will cause the camera to alternate between recording and paused states.

Press the **Arm** button. A message will appear giving you the options of exiting to Review and Save, or to continue recording.

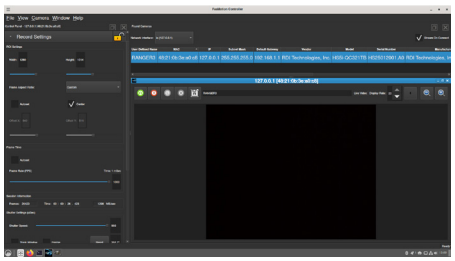
BROC mode

Use the Burst slider to select the number of frames to be recorded for each trigger. A specified number of frames will be recorded with

each trigger, then the recording will pause. The buttons and position indicators will be the same as for **ROC**.

Note: Appending to **ROC** and **BROC** recordings upon returning from Playback or a Power cycle will cause a number of black frames (up to 128) to be inserted in the recording time line.

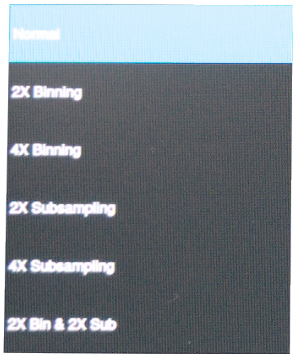
4.3 Record Settings



The frame resolution, frame rate and shutter speed can be adjusted within the **Record Settings** tab. To the right is the standard setup for the camera.

The first box that is displayed at the top is the **ROI (Region of Interest) Settings**. This will allow for the resolution to be changed. Within the **Frame Aspect Ratio**, there are the following options:

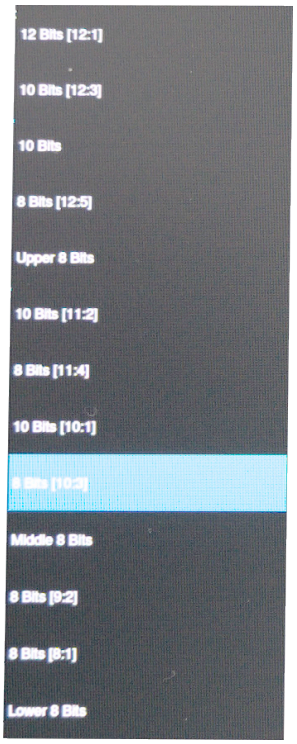
- Custom
- 1:1
- 5:4
- 4:3
- 16:9



By choosing one of these options, it will allow for the quick shaping of the size of the frame to the selected proportion. Custom will allow for any shape of the frame to be selected for the other settings selected. For a selected frame size, there is a maximum frame rate available.

The next section is the **Frame Time**. This is the number of frames per second that the camera will record. In the image above, the time between frames is 1 mSec when the camera is set to 1000 frames per second.

The **Shutter Settings** is the amount of time that the shutter will be open during the frame. The shutter cannot be open for more time than the frame will record for, therefore, during measurements, this value will be less than the time duration of the frame rate. In this example, the maximum time that the shutter can be open for each of the frames is 988 µSec. This will leave 12 µSec to process the frame and start to record the next one. This is also directly related to the amount of light that the camera will receive. The smaller the number is, the less light will fall on the sensor for each frame, the darker the image will be during playback.



The **Low Light** option will allow more light to fall on the sensor to allow for framing and focusing of very dark images. This **Low Light** option is not available during recording as the shutter is open longer than one frame.

In the **Advanced Settings**, there are some options that will allow you to adjust how the camera is viewing the image. The **Bin and Sample** will allow for multiple pixels on the sensor to produce one image pixel. There are 6 options:

- Normal
- 2X Binning
- 4X Binning
- 2X Subsampling
- 4X Subsampling
- 2X Bin & 2X Sub

For example, 2X Bin & 2X Sub will combine two adjacent pixels on a row with the two pixels on the row beneath to produce one image pixel. The pixel values are averaged together and can decrease noise.

Images captured by the camera sensor are saved in binary form. Each pixel is given a binary 8-bit value from 0 to 255, 10-bit value from 0 to 1023, or 12-bit value from 0 to 4095. All numbers represent shades of gray from very dark to very bright. The operator has the option of saving the video in 8, 10 or 12 bits per pixel for every image.

Blaster's Ranger 3 cameras record and save 8- 10- or 12-bit data. The advantage of recording higher bit depths is greater fidelity when enhancing the images. The disadvantage is that it takes more memory to record or save 10- or 12-bit data.

Note: CAP, DNG, and TIFF (raw) are the only saved file types that preserve more than 8 bits, so these file types should be used if you are planning to do post-processing.

When saving 10- or 12-bit data (to a mass storage device) in TIFF (RAW) format, the actual file type is a 16- bit file, so it is substantially larger than an 8-bit mono file. The 10-bit (RAW) colour image is not colourized - it is a RAW Bayer image (not "colourized," which would make it about 3x as large), so it is about 2/3 the size of the 24-bit colour file (8 bits per each of 3 color channels).
To choose the recording bit depth:

1. In the Advanced Settings, click the drop down list of "Bit Depth".
2. Select the desired bits.

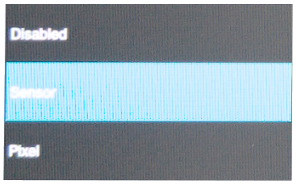
Table 5: Frame Rates and Resolutions

	Bit:	12	11	10	9	8	7	6	5	4	3	2	1
Selection	10 Bits	X	X	X	X	X	X	X	X	X	X		
	Upper 8 Bits	X	X	X	X	X	X	X	X				
	Middle 8 Bits			X	X	X	X	X	X	X	X		
	Lower 8 Bits					X	X	X	X	X	X	X	X
	12 Bits [12:1]	X	X	X	X	X	X	X	X	X	X	X	X
	10 Bits [12:3]	X	X	X	X	X	X	X	X	X	X		
	8 Bits [12:5]	X	X	X	X	X	X	X	X				
	10 Bits [11:2]	X	X	X	X	X	X	X	X	X	X	X	
	8 Bits [11:4]		X	X	X	X	X	X	X	X			
	10 Bits [10:1]			X	X	X	X	X	X	X	X	X	X
	8 Bits [10:3]			X	X	X	X	X	X	X	X		
	8 Bits [9:2]					X	X	X	X	X	X	X	
	8 Bits {8:1]					X	X	X	X	X	X	X	X

Lastly in the **Advanced Settings** is the Fixed Pattern Noise (FPN) section. This section will allow for the setting of the lowest (blackest) pixel to have a value of 0. Therefore, there will not be any clipping of the data on the darkest side. Within this option, there are three settings:

- Disabled - means that no FPN correction is used
- Sensor - means that the on-board sensor correction is being used
- Pixel - means that the 'black frame' taken during calibration is being used

It is recommended that the setting of Sensor is used.



Calibrate Black Level:

To be assured that you are getting the best possible images, perform a calibration:

- When you first boot the camera up.
- If you change **Shutter Speed**, **Bit Depth**, **Frame Rate**, **Resolution**, or **Offset**.

To Calibrate the Camera:

1. Set the camera to Live.
2. Shut out all light to the sensor. **Blaster's Ranger 3™** cameras do this automatically using the built-in mechanical shutter.
3. Select **Black Level Calibration** from the **Camera Menu**.

Note: If you make a setting change that makes the stored black frame incompatible, you will notice an asterisk next to Pixel on the FPN Selection button: "Pixel*" ... this is a reminder to do another calibration.

Analog Gain

Analog gain or "sensor gain" is applied via the **Advanced Calibration Dialog**.
The settings available for **Blaster's Ranger 3™** are as follows.
Gain 1.0, 2.0, 4.0

4.3.1 Recommended Record Settings

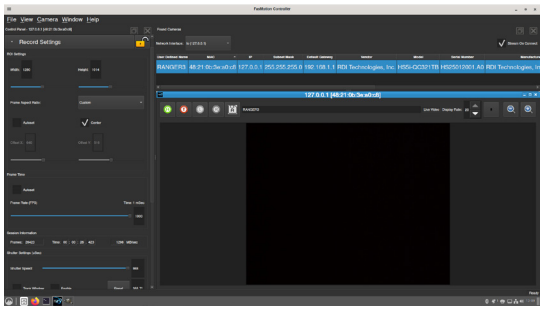
The items should be adjusted in the following order for the standard setup:

Within the ROI Settings section

1. Frame Aspect Ratio: Custom
2. Autoset

Within the Frame Time section

3. Frame Rate (FPS): 1000
   a. You can slide the bar to get close to 1000. To get it precise, double click on the number at the end of the slider and then use the scroll wheel on the **Handheld Mouse** to get the number precise. After the number has been selected, move the mouse off the number to the black area and click once.



Within the Shutter Settings (µSec)

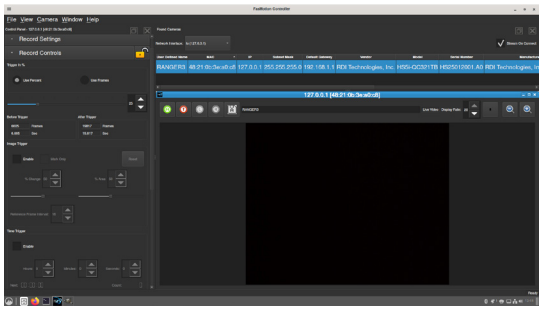
4. Move the **Shutter Speed** slider all the way to the right
   a. The displayed value should be 988.

Confirm in the **ROI Settings** at the top of the tab that the resolution is as follows:

Width: 1280
Height: 1014

Scroll down the tab to the **Advanced Settings** box. For maximum light, it is recommended that the **Bit Depth** of 8 Bits [10:3] is selected.

4.4 Record Controls



This tab in the software will control how the memory is divided around the trigger point. With changing the settings, the number of frames that is kept before the trigger point and after is able to be set. In this menu, the **Trigger In %** can be set by percentage or by number of Frames. Generally speaking, it is recommended to use Percent. It is recommended to use 25% for the number of frames that will be kept before the trigger point as shown in the image to the right.

With the slide bar moved to 25%, with this camera having the maximum 32 GB of memory using the recommended settings from the previous section, this camera will record 6605 frames (6.605 seconds) before the trigger point and will keep 19817 frames (19.817 seconds) after the trigger point. This camera is also capable of using an **Image Trigger**. This is not recommended for a mining application. As well with the **Time Trigger**, it is not recommended to be used in a mining application.

Configure I/O

The I/O portion of the Record Controls tab includes dialogs for each of the I/O signals.

I/O connections may be used in either of two ways:

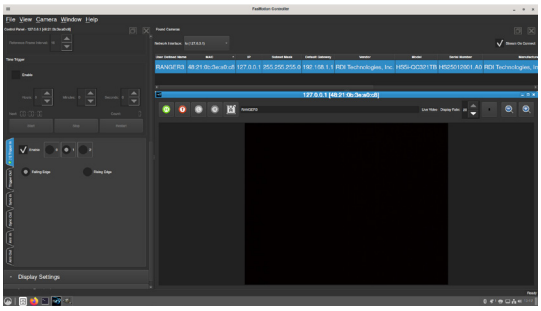
1. As a control I/O signal for the camera, which include **Trigger-In**, **Trigger-Out**, **Sync-In**, **Sync-Out**, **Arm-In**, **Arm-out**.
2. As an input for an external signal for creating Markers.

Blaster's Ranger 3™ cameras have three external I/O ports, which can be configured for any of these purposes via radio buttons, simply select any of the I/O tabs in Record Controls and select the I/O port you wish to use for that function.

I/O Voltage

I/O voltage is selectable (3.3v or 5V) on **Blaster's Ranger 3™** cameras in the camera preferences dialog.
To enable the external trigger:
For greater precision, you may activate the trigger electrically.

1. Click on the Trigger-in Tab.
2. Click Enable.
3. Choose "Rising" for rising signals or a switch opening and "Falling" for a falling signal or switch closure (Standard setting and recommended for the included **Trigger Switch**).

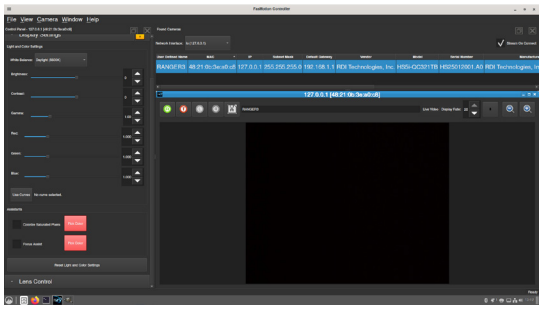


4.4.1 Recommended Record Control Settings

For the **Trigger In %**, it is recommended to use 25% for the number of frames that will be kept before the trigger point.

In order to use the supplied **Trigger Switch Cable**, the **Trigger In** tab will need to be selected and then **Enabled**. As shown in the previous section of the cable attached to the center port (1), this port will need to be selected in the menu. Also, for the use of the trigger switch, **Falling Edge** must be selected as shown in the right image.

4.5 Display Settings



The display settings will adjust the frame of the camera. The settings can be seen in the right image:

Light and Colour Settings:

The **Display Settings** tab has settings that affect the appearance of Live and Saved images.

When using these controls, keep in mind:

- These settings will make changes to the image data (pixel values) for saved JPG, AVI, BMP, MP4, and TIF images.
- JPG, AVI, BMP, MP4, and TIF are all 8-bit file types. If 10 or 12 bits were recorded, a 10:8 LUT is used to maintain intermediate pixel values for these images.

These settings will not change the image data (nor the appearance) of DNG, TIF(raw), and CAP(Partition) files.
DNG, TIF (raw), and CAP (Partition) files will preserve 10- and 12-bit image data.

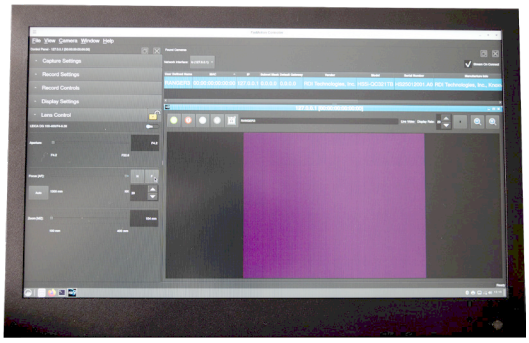
If you wish to do post-processing on your image data, and especially if you wish to do your processing on 10- or 12-bit images, it is best to save DNG colour cameras or TIF (raw) for mono cameras.

The Curves feature gives you more flexibility to adjust the image from within **FasMotion** than the sliders. These features are mutually exclusive, you may use one or the other but not both.

Curves on the **Colour Blaster's Ranger 3™** cameras have separate controls for Red, Green, and Blue channels as well as a lock to adjust all together. Curves on Mono cameras have only one channel.

If 10 or more bits are recorded, the Curves function will write a 10 - 8 - bit LUT that is used by the image processor when saving 8-bit file types, JPG, AVI, BMP, MP4, and TIF. If no post-processing is intended, using Curves is the best way to enhance imagery on the camera system.

4.6 Lens Control



The settings of the lens can be controlled in the **Lens Control** tab. To the right is shown the screen.

When using the standard 100-400mm **Zoom Lens**, the camera will be able to control the aperture and the focus. This lens has a manually operated zoom portion that will be controlled by the operator.

Aperture of the lens can be set as low as *f*/4.2. This controls the amount of light that will be available on the sensor. When working with high speed cameras, the operator will normally want to use the lowest number possible. This will produce the brightest image possible. The focus for this lens can be adjusted manually on the lens but also digitally on the screen.

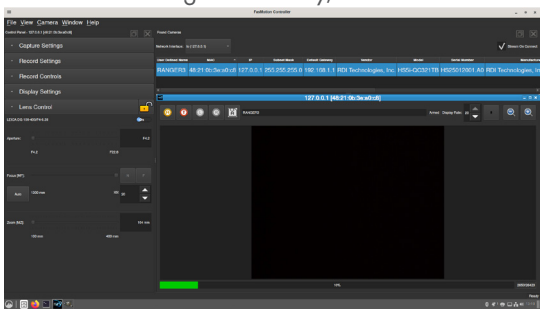
The slide bar can be used for course focusing and when the image is almost in focus, the N and F buttons can be used to perform smaller adjustments. The N will adjust the focus nearer to the camera whereas the F will adjust the focus farther from the camera. Under the

N and F buttons, there is a number displayed with an up and down arrow. This is the increment that the lens will move when the N or F button is pressed once. Normally, it is recommended to set this value to approximately 20 to get closer to the focus and then can be reduced if required.

The zoom level of the lens will be shown but will not be able to be adjusted from the screen.

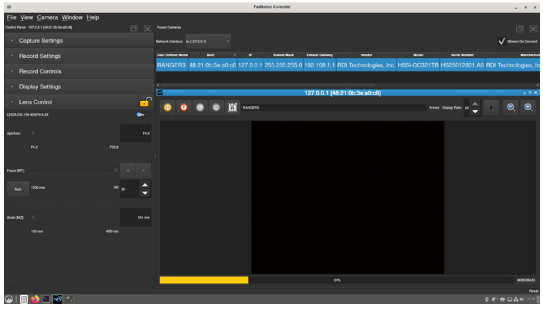
4.7 Arming the Blaster's Ranger 3™

To prepare the camera to record a video after all of the above settings have been adjusted, the camera can be armed. The arming process will start the memory loop to be recording. To have the camera start filling the memory, the arming button will need to be selected as shown in the image to the right.



After the button has been selected, the colour will change from Green to Orange as shown in the image to the right.

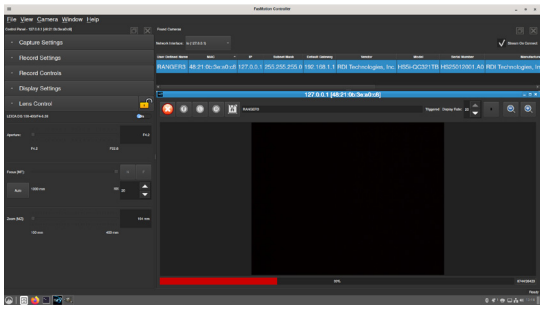
As the buffer fills to the selected amount of trigger in percentage (recommended 25%), the bar along the bottom of the live image will begin to fill as shown to the right.

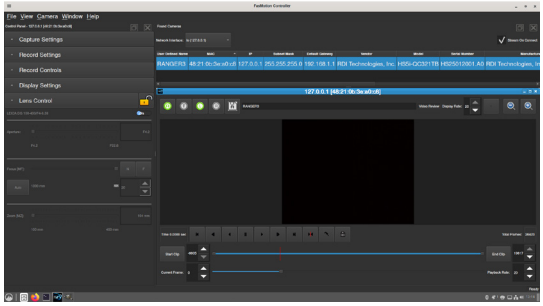


With the buffer has filled to the selected amount, the colour will change from green to yellow and will stop filling at the selected value as shown to the right.

4.8 Triggering the Blaster's Ranger 3™

The camera will stay in this state until trigger signal received. When the blast starts, the camera can be triggered by the supplied **Trigger Switch Cable**, clicking on the trigger button on the screen or use optional Portable Wireless Triggers (PWT) that will allow the camera to be triggered from up to 500m (1640 ft.) line of sight. When the trigger is received, the remaining part of the memory will start to be filled with the events as shown in the image to the right.





The timeline will continue to fill until the memory is full. Shown to the right is the playback menu.

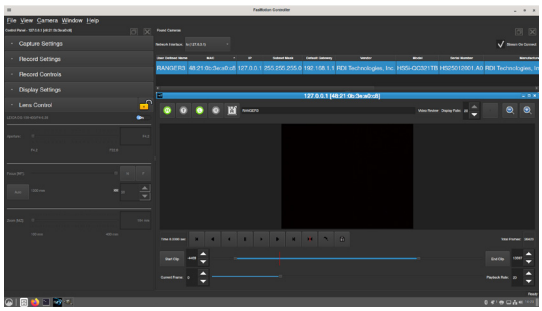
4.9 Playback and File Clipping

In the top bar, there are two options available. The camera can be armed again (which will erase the current video in memory) or can be changed back to Live mode (to be able to see the current live image and change settings). The video can be reviewed and will have the playback speed that is displayed in the bottom right side. In this image, the playback speed is 20 frames per second.

Below the image is a line of buttons. From the left to the right, the buttons are as follows:

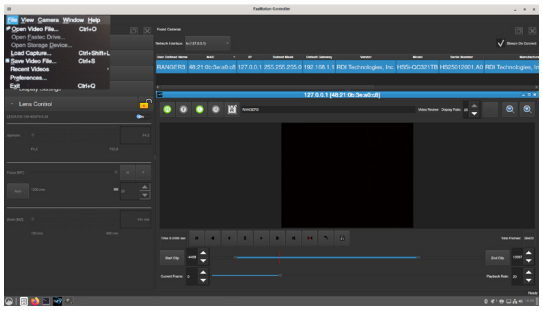
- Rewind the video to the beginning
- Play a single frame backwards
- Play the video backwards
- Pause
- Play the video forward
- Play a single frame forward
- Fast forward to the end
- Jump to the trigger point
- Jump to a manually selected time point
- Truncate video

The top bar is the total video while the bottom bar is the current viewing position. In this example, the video is from -6605 frame to 19817 frame with the current viewing frame at the trigger point, or the zero frame.



The video can be viewed by playing the video from the buttons above or move the slider on the bottom. As well, to reduce the file size to download, a primary clipping of the video can be done before saving. The easiest way is to watch the video and at a point before the motion occurs, pause the video. At this point, click Start Clip. This will move the beginning of the video to the start point and change the starting frame. In the image below, this video was clipped to start at frame -4469. The same will occur at the end of the video. Continue to watch the frames until the area of interest is no longer visible and then click End Clip. This will move the end point. In the image to the right, this video will end at frame 13597.

4.10 Downloading Images

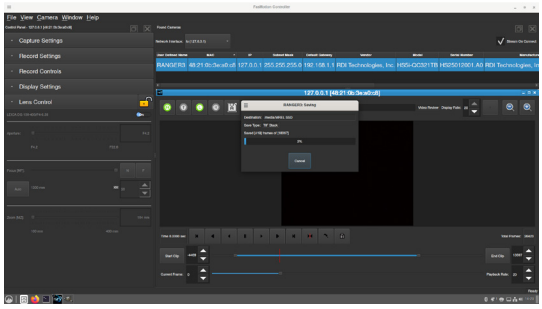


After the video has been clipped to the section of interest, the files will now need to be downloaded. To download, select File then Save Video File…

The Save Video window will open to display the following image.

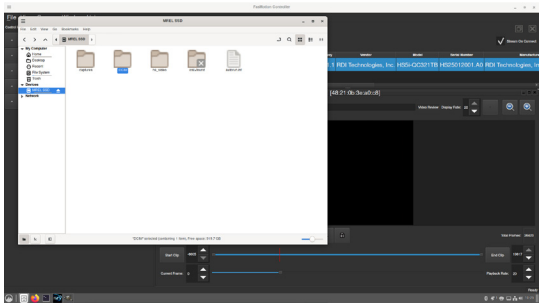
It is recommended to save the video to the internal SSD. The next section is related to the information that will be saved into the directory on the camera. All of the items that are selected will be included in the download. Also, the Start and End frames are listed as these are the values that were selected in the previous section. It is also recommended to download as TIF Stack. These are individual images that will be related to each frame. This will make it easier for reviewing and selecting an individual frame to be placed in reports. If a video file is required, it can be created in a later step if required. After the sections are made, click Save.

The individual files will now start saving to the internal SSD. The progress of the saving will be displayed in the following screen.

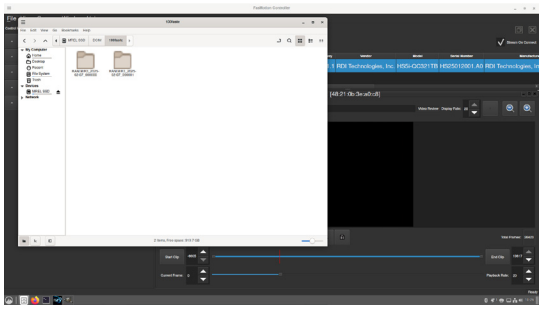


To view the saved files on the camera, open the file explorer Nemo. The icon is shown on the task bar and is highlighted to the right.

With Nemo open, the file structure for the camera will be shown in the image to the right.

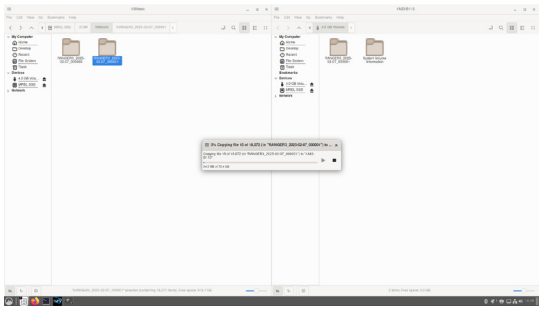


The video is recommended to have been saved to the SSD drive. In the image above, open the drive. In this drive, the video will be saved into the directory of DCIM if saving to TIF Stack. Inside this directory, there will be another directory called 100fastc shown to the right.

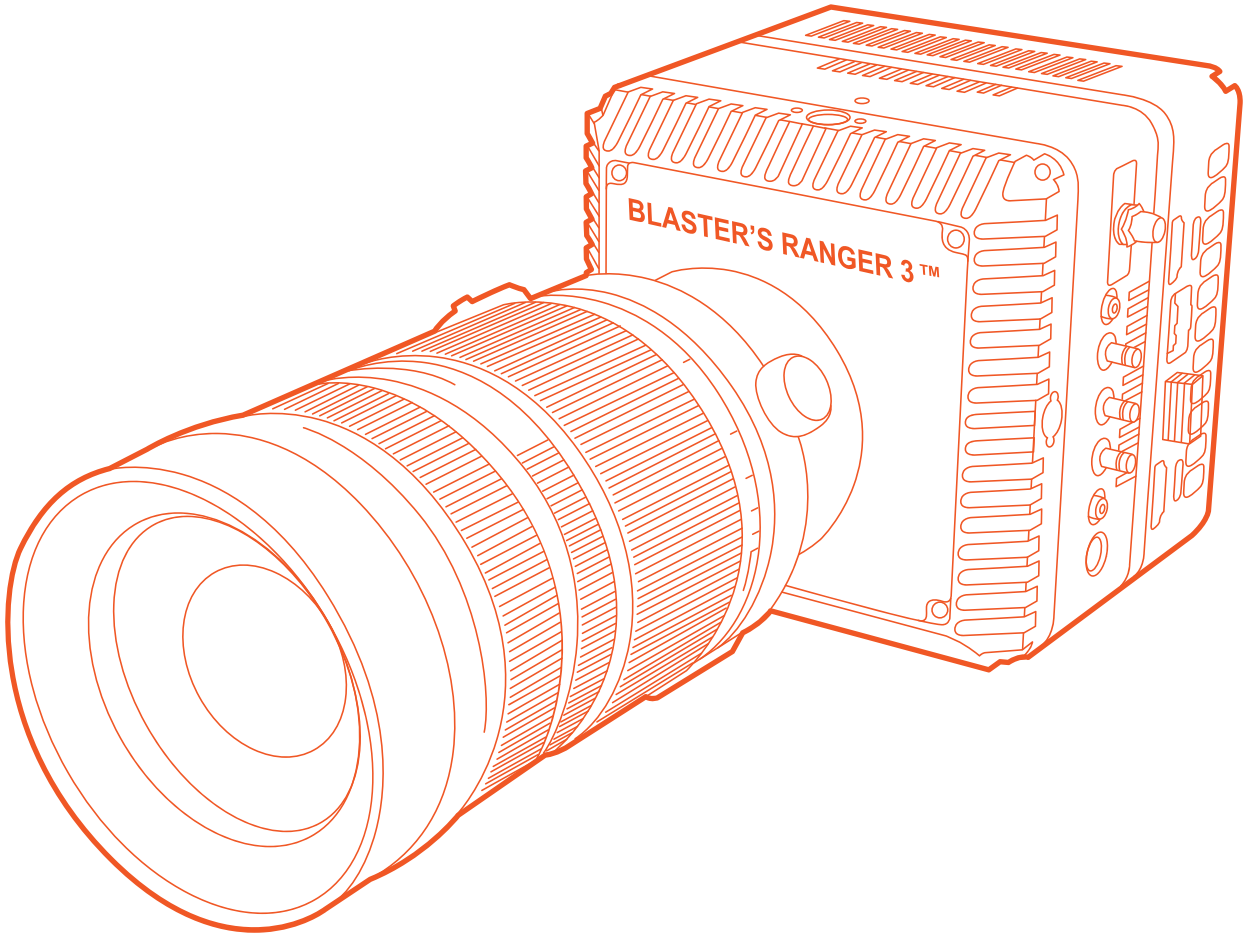


Within this directory, the folder containing all of the TIF images with the directory name as selected in the download process is shown to the right.

This directory can either be copied to an external hard drive that is connected to the USB 3.2 or USB C ports of the camera (recommended) or if you place the camera on the same local network as your computer, you can connect to the camera and copy the files directly. When the files are being copied, the following screen will be shown to the right.



Chapter 5
Field Operations



Overview

This chapter provides instructions on using the Blaster's Ranger 3™ to record blasts in the field.

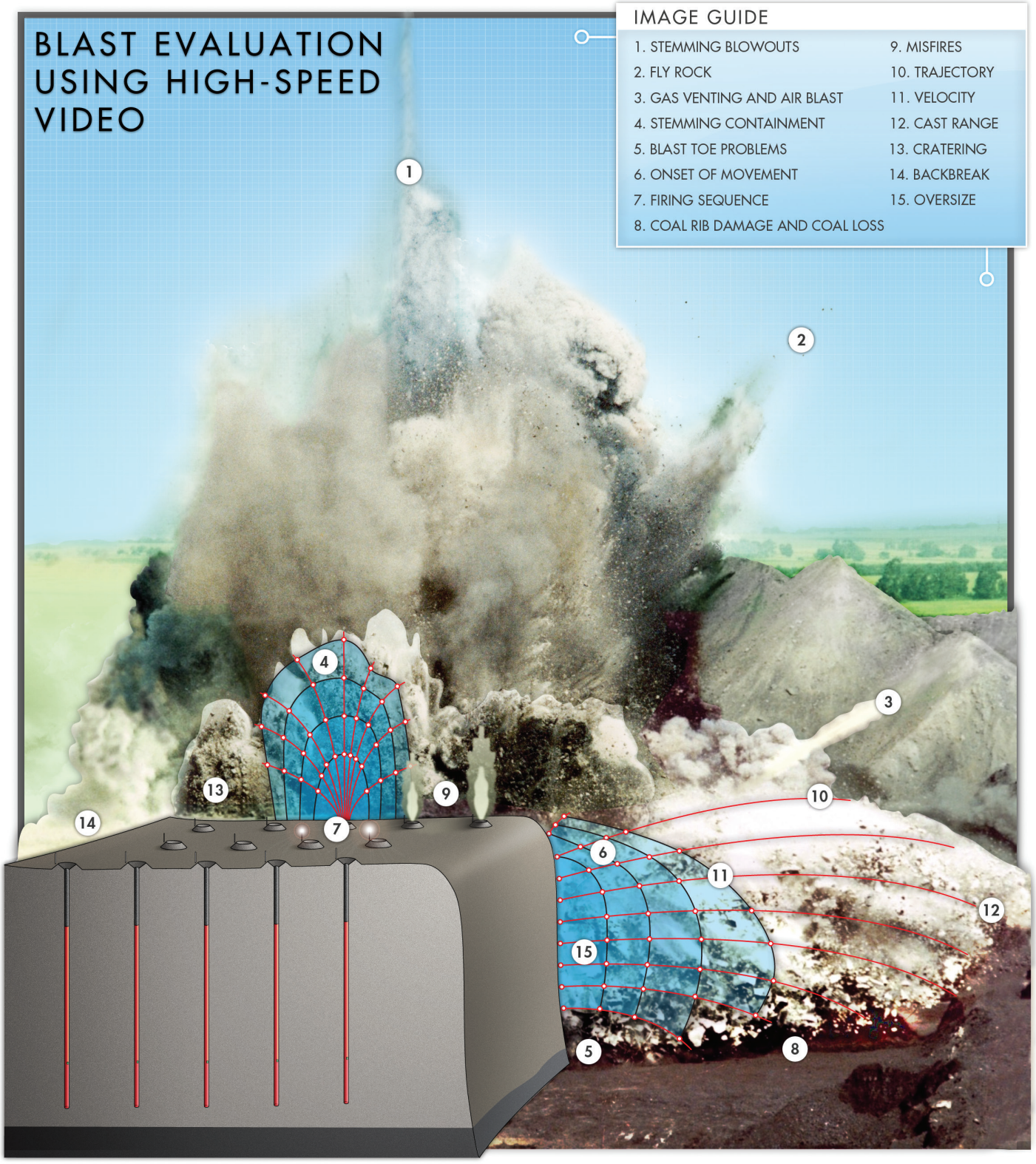
5.1 Introduction

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 **500** to **2000 fps**

- 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

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 **Blaster's Ranger 3™** 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 **Blaster's Ranger 3™** from damage. The User has the option of using a **Remote Trigger,** 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 **Blaster's Ranger 3™**.

For observation of surface movement, the **Blaster's Ranger 3™** 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 **Blaster's Ranger 3™** 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 **Blaster's Ranger 3™** 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 2023 Blaster's Custom Toolbox** when the sequence is being analyzed. These markers should be positioned exactly perpendicular to the line of sight of the **Blaster's Ranger 3™** 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 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 **Blaster's Ranger 3™** has been designed to assemble 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 Camera body and attach the assembly to the **Ball Head**.
3. Attach the Lens to the **Blaster's Ranger 3™**.
4. Attach the I/O Cable to Port 1 (the center port) on the side of the **Blaster's Ranger 3™**. Attach the **Trigger Switch** (or other trigger) to the connected I/O Cable on the **Blaster's Ranger 3™**.
5. Attach the V-Mount battery to the back of the camera by sliding the "V" on the back of the battery downward into the receptacle on the back of the camera until it clicks into place. (To remove the battery, press the red lever inward and lift out the battery.)
6. Attach the **Monitor Mount** to the back of the Monitor in the center hole of the cheese plate.
7. Attach the **Monitor Mount** to the tripod to allow the Monitor to be in a convenient location for viewing.
8. Attach the HDMI cable from the **Blaster's Ranger 3™** HDMI 1 port to the input on the bottom of the monitor.
9. Attach the DTAP Power Extension Cable to the battery.
10. Attach the DTAP Monitor Power Cable to the DTAP Power Extension Cable. This is the cable labeled as Monitor.

11. Attach the DTAP Monitor Power Cable to the bottom of the Monitor.
12. Attach the DTAP Camera Power Cable to the DTAP Power Extension Cable. This is the cable labeled as Camera.
13. Attach the DTAP Camera Power Cable to the input of the camera. The camera will power on at this point.
14. Take the Wireless Handheld Mouse and turn on the power. The switch is located on the front of the trigger guard.

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.

5.3.2 Standard Power Supply Options

The **Blaster's Ranger 3™** camera can be powered for 2 hours from its V-Mount battery. If more time is required, the use of the optional **Blaster's Ranger 3™** Battery Operational Extender can be used. This will allow for two V-Mount batteries to be attached to the camera. This will extend the operational time of the camera to 4 hours. These batteries can be hot swapped to allow for indefinite operational time.

If AC power is available, such as a generator or a power inverter, then the **Blaster's Ranger 3™** and **Monitor** can be powered with their AC power adapters.

5.3.3 Operation of Optional Battery Operational Extender

The optional **Battery Operational Extender** for the **Blaster's Ranger 3™** will allow for the camera to run for over 4 hours on two **V-Mount** batteries. This option will allow for the camera to run indefinitely with more batteries as they can be exchanged during use to keep the power flowing into the camera.

The optional **Battery Operational Extender** will connect to the back of the camera just like a **V-Mount** battery. A **V-Mount** battery can then be mounted to each side of the blade on the back. The optional **Battery Operational Extender** will monitor each of the batteries and draw power as needed. To monitor the power in each battery, press the button on the battery and a power level will be displayed. At any time, one battery can be removed and replaced with a fully charged unit to add 2 hours of operation to the camera running from battery power.

To connect power to the camera and the monitor, connect the DTAP plug from the cable for each of the camera and the monitor to one of the DTAP plugs on the optional **Battery Operational Extender**.

On the side of the optional **Battery Operational Extender** is an ON/OFF switch. This will control the power to the plugs on the unit. When everything is connected, move the power switch to the ON position. The camera and monitor will turn on.

On the back of the optional **Battery Operational Extender** is an LED light for each of the batteries. If the LED light is green, the power level is good. If the LED light is red, the power level is low and will soon stop being able to supply power. If the LED light is blue, the battery is supplying power to the plugs.

5.3.4 Camera Setup

Set up the **Resolution**, **Recording Speed**, **Shutter Time** and other parameters. These are the recommended default settings to record a typical mining blast.

NOTE: Changes of **Resolution** or **Frame Rate** may alter the quality of recorded images. Now the new parameters will be sent to the **Blaster's Ranger 3™**. All other parameters e.g. shutter time or analog gain, will be sent immediately to the **Blaster's Ranger 3™** after entering. If there is no connection to the **Blaster's Ranger 3™**, an error message will appear. Please make sure the **Blaster's Ranger 3™** is connected correctly. Confirm the camera is in Live mode before making changes. The menus will be gray and can not make changes if camera is not connected or is not in Live mode.

Using **FasMotion** to adjust the camera settings, below is a summary of **Chapter 4** and will itemize the required items to check and confirm.

1. Start FasMotion
2. Double click on RANGER3 line item to connect to the camera. The default IP address is 127.0.0.1.
3. With the live image of the camera being displayed on the screen, the software has connected to the camera.
4. Click on the menu Capture Settings on the left panel.
   a. Confirm Image Memory bubble selected.
   b. Confirm Session Recording Capacity is set to the maximum of the camera.
   c. Click on the menu Capture Settings to collapse.
5. Click on the menu Record Settings.
   a. Confirm ROI Settings are 1280 x 1014. If not, adjust Frame Aspect Ratio to Custom. Adjust the width to 1280. Move the slide bar to get close to the value. The camera will adjust to the current value selected with the number greyed out. When they have adjusted, click on the number displayed in the width box. Use the wheel on the mouse to adjust the number to 1280. When complete, click off the number to set it. The same can be done for the height value.
   b. Confirm Frame Rate is set to 1000 frames per second (fps). If not, the same method above can be used to adjust the value to 1000 fps.
   c. Confirm Shutter Speed is set to 988 microseconds (µs).
   d. Confirm Bin & Sample is set to Normal.
   e. Confirm Bit Depth is set to 8 bits [10:3].
   f. Confirm that FPN is set to Sensor.
   g. Click on the menu Record Settings to collapse.
6. Click on the menu Record Controls.
   a. Confirm the Trigger In is using Percent bubble.
   b. Confirm the trigger percentage is set to 25%.
   c. Below this slider bar will display both the number of frames and the amount of time that will be recorded before and after the trigger point.
   d. Continue down to the Trigger in section. Ensure that the button is Enabled and Port 1 (the center circle) is selected.
   e. Confirm that the trigger is set to Falling Edge.
   f. Click on the menu Record Controls to collapse.
7. Click on menu Display Settings.
   a. This menu will allow for the adjustment of the white balance. When operating outdoors, it is recommended to use Daylight.
   b. Click on menu Display Settings to collapse.

8. Click on menu Lens Control.
   a. Confirm that the Aperture setting is set to the lowest value of F4.2. If not, adjust to F4.2.
   b. In the Focus section, this area will allow for the finer control of the focus of the lens. When the image is very clear on the screen, the N (Near) and F (Far) buttons can be used to fine tune the focus. The value under the N and F buttons is the increment that the lens will move when the N or F buttons are pressed. It is recommended to use approximately 20 for this setting to allow for more movement during the adjustment.
   c. The Zoom shown at the bottom is not adjustable in the software. This lens is manual adjustment only for zoom. This section will show the current zoom level. Moving the zoom on the lens manually will adjust this number on the screen.
9. With the camera now configured, ensure that it is pointed at the area of interest. Use the Ball Head to adjust the camera to ensure that it is pointed as desired. Adjust the lens to ensure that the image is framed and focused as clearly as possible.
10. Arm the camera by pressing the Arm button.
    a. A green bar will start on the bottom of the image as the memory buffer is filling. When the buffer is full, the bar will stop moving and change shades of yellow.

NOTE: The camera may remain Armed for an indefinite period of time because it is overwriting its circular buffer, it never runs out of space, but only retains the newest images.

1. Trigger the camera via the Trigger Switch cable attached to complete the recording. The **Blaster's Ranger 3™** will enter Review mode when finished recording unless it is set to Autosave, in which case the camera will download the recording, then revert to Armed Mode.
2. Use the playback icons to play forward, backward, or jump to points of interest in the movie. Use the Cut In and Cut Out icons to select a portion of the movie to review or save.
3. Save video from Image Memory. Select the Save Icon from the playback controls. This will bring up a dialog that allows selection of the following: Start and Stop points of the clip.
4. Select the destination to save the video to the included built-in SSD.
5. Set the file Format to TIF Stack. When the movie clip is set up as desired, press the Save icon on the Save dialog. A new dialog will open with the heading Copy in Progress. This dialog indicates the status of the file save operation.
6. When the file save is complete, the dialog will display a message indicating Copy completed successfully.
7. Press the OK icon to set the camera back into Review Mode.
8. Click on the Live button to put the camera back into Live Mode. From here a new recording can be made or the camera's configuration can be changed.

5.4 Saving the Video in the Field

After the video has been captured in the field, it is critical that the images be saved before turning off the camera. The video is stored in high speed volatile memory and will be erased if the camera is turned off. The data will need to be saved to the SSD in order to keep the information.

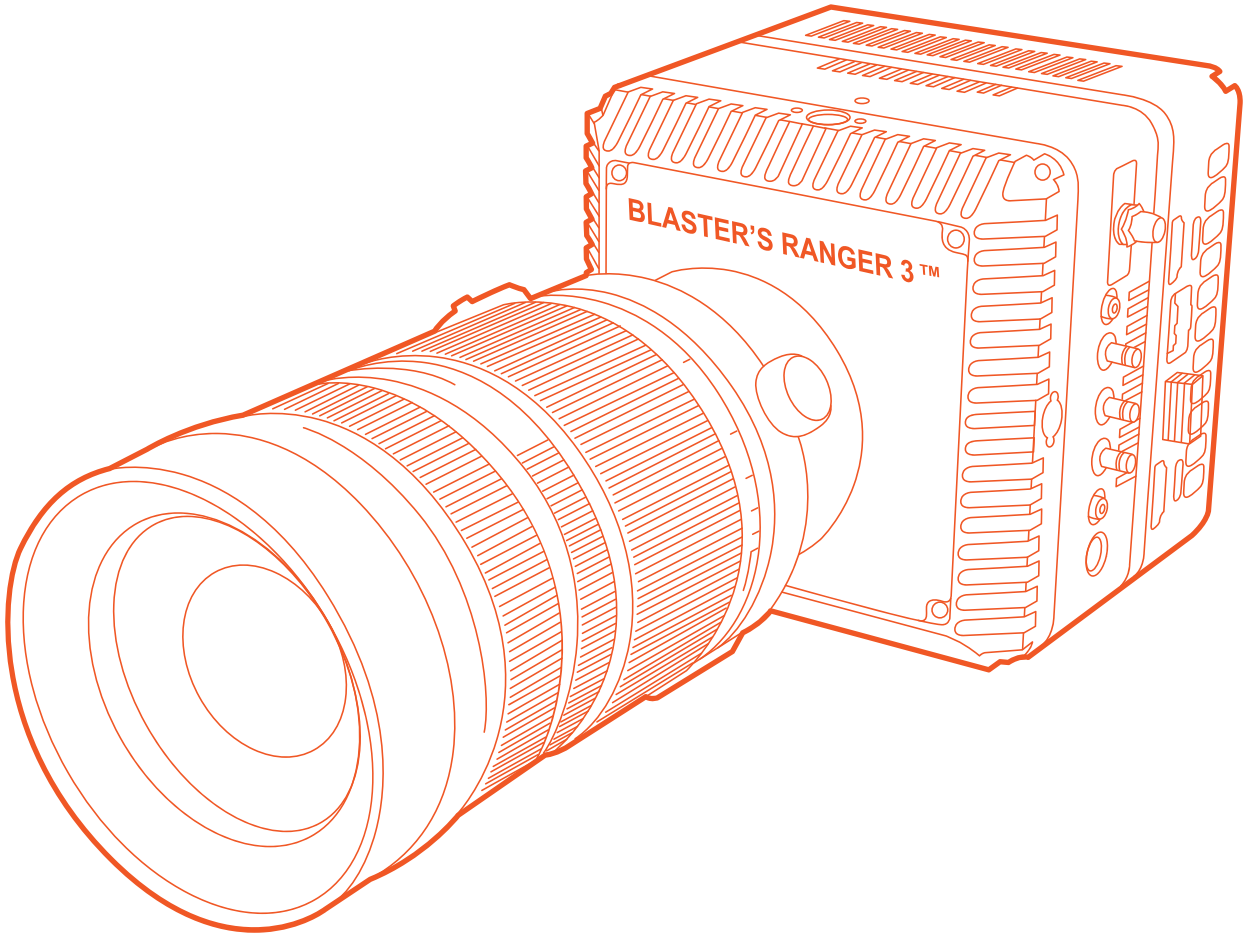
IMPORTANT

The **Blaster's Ranger 3™ Camera** image memory is volatile memory and images will be lost if a new recording is initiated or the **Blaster's Ranger 3™ Camera** is powered off . Be sure to save important videos before initiating a new recording or turning off the **Blaster's Ranger 3™ Camera.**

From the Review Mode of the camera (the mode that the camera will enter after finishing recording), it is important to save the video. The video can be reviewed on the screen and can be clipped to reduce the downloading of unwanted or not useful frames. To see how to trim the downloading images, refer to **Section 4.9**. This section will deal with the immediate requirement to save the data before it is lost. Therefore, this will download all of the frames for quick field action.

In the main menu, click File then Save Video File…. In this window, the important items to confirm are that the video is saving to the MREL SSD. It is recommended to confirm the selection of Use Camera Name and that the creation of XML, CFG and PM files are generated. As well, the Save Type is Tif Stack. Click Save. This will download all of the frames to the SSD after the action is complete. At this point, the camera can be turned off and the data will have been saved. To move the files from the SSD, refer to **Section 4.10**.

Chapter 6
ProAnalyst® 2023 Blaster's Custom Toolbox Software



6.1 About ProAnalyst® 2023 Blaster's Custom Toolbox

ProAnalyst® 2023 Blaster's Custom Toolbox allows auto and manual tracking of unlimited number of features. Will allow the User to quickly export to Excel or text for further analysis and graphing.

ProAnalyst® 2023 will allow for toolboxes to be added to the software to accomplish different tasks. To analyze a typical mining blast, a Blaster's Custom Toolbox has been generated to incorporate the specific items that will be needed to analyze the video.

The specific toolboxes that are included in **ProAnalyst® 2023 Blaster's Custom Toolbox** are as follows:

- Standard Feature Tracking
- Adaptive Feature Tracking
- Standard Calibration
- Orthonormal Calibration
- Look-Up Table (LUT)
- Image Processing
- Image Stabilization
- Standard Data Graphing
- Reports and Presentation

Each toolbox is saved independent of the video. This will allow for each layer to be added to the video when it is reloaded. This is the reason for the Load and Save features in the top of every toolbox.

6.1.1 Standard Feature Tracking

Standard Feature Tracking will automatically track one feature by defining a template, or manually track up to three features by placing track points. Allows for limited search parameter adjustment and importing/exporting of tracking data.

6.1.2 Adaptive Feature Tracking

Adaptive Feature Tracking will track unlimited features of interest. It will allow for feature rotation, interpolation through obstructions, and constructing stick models between features with distances and angles.

6.1.3 Standard Calibration

Standard Calibration will calibrate the scale of normal planes in your video.

6.1.4 Orthonormal Calibration

Orthonormal Calibration is used for videos where the optical axis of the camera is perpendicular to the plane of motion. Set the scale, origin, and coordinate axes of the scene. Create a moving origin and change the rotation & chirality of the coordinate axes.

6.1.5 Look-Up Table (LUT)

The Look-Up Table will apply a LUT to your image; make standard brightness, contrast, gamma, and exponential/log adjustments, invert the image, or convert it to grayscale. All adjustments can be made to individual colour channels.

6.1.6 Image Processing

Image Processing has 60+ advanced image processing filters, from arithmetic operations and binary thresholds, to edge detection and background removal, all with adjustable parameters. It will combine filters in different orders to produce different results.

6.1.7 Image Stabilization

Image Stabilization will remove unwanted shake and vibration from video. It will allow the tracking of features in the image to produce a stabilized video for better analysis. This feature can remove the ground shaking of the camera caused by the ground roll produced by the detonation of the pattern.

6.1.8 Standard Data Graphing

The Standard Data Graphing Toolkit will allow for the creation of a 2-axis graph of one motion data quantity against time. Choose from quantities created in other toolkits, like feature velocity, angle, etc. The data can be saved as a graph playback using a bitmap sequence.

6.1.9 Reports and Presentation

Reports and Presentation will add frame-by-frame or global notes to your videos. It will allow for the annotation with shapes and text. It can export data, analysis, notes, and annotations to a multi-slide PowerPoint presentation or an HTML web page, or send them directly to a printer.

6.2 Installing ProAnalyst® 2023 Blaster's Custom Toolbox

To install the software on your computer, please visit the following website:

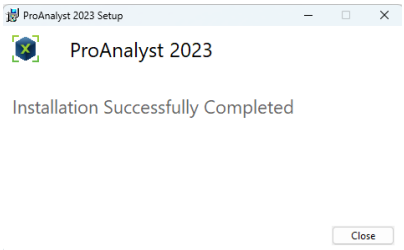
www.xcitex.com/download-proanalyst

In order to download the latest software release, please complete the form on this page. After completing all of the required fields, click on **Download ProAnalyst 2023** at the bottom of the page. The Key ID number is on the packaging that the USB dongle is attached to when it was received. If you have received an error in the format of one of the required fields, correct the issue in the field highlighted in red and then click the download button again.

The downloaded file will be approximately 300 MB.

After download, open the file and start the installation. This will be installed on the local computer.

After the file has been installed, the following screen will be displayed.



6.3 Operation of ProAnalyst® 2023 Blaster's Custom Toolbox

The following sections will describe the step by step procedure to make quantitative measurements for the objects on screen.

6.3.1 Opening the Video Files

ProAnalyst® 2023 operates with projects. To get started, click File then New Project. This project will open as an empty project. To add the files to the project, right click in the project window then select Project then Add Files. With TIF Stack, only the first file will need to be selected and the others in the sequence will then be opened. With saving all of the different files from the camera, the majority of the camera settings will be imported. The file position from the camera and the frame rate should be imported. This can be confirmed in the bottom left of the scroll bar. It will show the frame number on the top and the time (in seconds) on the bottom. The frame rate can be confirmed by clicking Tools and then Modify Recorded Parameters. The record rate should display the frames per second that the camera was set to. After it is confirmed, select Apply.

6.3.2 Image Stabilization

One of the biggest features of **ProAnalyst® 2023** that will assist the users when analyzing a video of a blast in a mine is the Image Stabilization. This feature will remove the shake of camera that is induced by ground movement or overpressure. As the camera moves, the objects on the screen that are of importance will be moving relative to the frame. To get a proper measurement on the item's motion, the motion of the camera will need to be removed. Therefore, there will need to be an object that will remain visible throughout the video that is not obscured by the rock. For example, if there is a rock or a puddle on the ground that will remain visible, these items can be used to track. **Image Processing (6.1.6)** can become very useful. One thing that can be helpful to ensure that the box will track the object is to use an Edge Detector filter. This will highlight the object for the software to 'see' it clearly. The Image Stabilization will work by measuring the relative motion of the stationary object to allow for this motion to be subtracted from the frame. With the Edge Detector filter, the object can be tracked easier.

To stabilize the video, select the Image Stabilization button on the right side of the screen. It is the fourth button from the top and looks like this:

First, the toolkit will need to be Enabled. When the toolkit is enabled, the first Feature (Feature 1) will be created. This is the item that will be used to track the stationary object in the frame. Next, click on Define Template, then draw a box around the stationary object. The cross-hair will move to the center of the box that was just drawn. The box can be moved by clicking and dragging it into place. This box should be a little larger than the object of interest. If the box needs to be re-drawn, click Define Template again. After the box has been created, the next item is to click Set Template. This will change the colour of the box and then have a larger box shown with just the corners. This is the search box size that will be used in the next frame to locate the object of interest. The default size is 250% of the template. This can be changed by clicking on the small wrench beside Feature 1. It is not recommended to change these values. When the Processed tab is selected, the item of interest should stand out against the background. This will allow the software to follow the object. When the feature is ready, the next button to click is Track. This will start moving the video forward frame by frame. The Feature 1 box on the image should be following the object on the screen. If it is not, then the image is not being stabilized. Click Abort and adjust the filters. If the Feature 1 item is moving with the object of interest, allow it to continue processing until the end of the video. If the tracking stops by itself before the end of the video, it has lost the image that it is tracking. You can click track again but it is recommended to adjust the filter to have it run all the way to the end. When the end of the video has been reached, the Stabilize button can be clicked to stabilize the video. A new tab will be generated called Stabilized.

After the stabilization has been completed, it is recommended to save the file by selecting Save. This will generate a .stb file. Provide it with a file name that will be related to this video. It is recommended to save in the same directory as the location of the images.

If the file is being opened and the stabilization has been loaded, the video may not have been stabilized. If this is the case, click the Stabilize button and the correction will be completed.

It is important to Export the stabilized video by clicking Save Stabilized Video. This will allow all of the next steps to be preformed on the stabilized video to track the motion of the object and not the motion of the object plus the camera.

6.3.3 Adjusting the Look-Up Table (LUT) Settings

Along the right side of the window is buttons that will allow for the opening of each of the tools. To assist in making the image easier to see the items of interest, the Look-Up Table (LUT) can be selected by the second button from the top. It will also look as the following:

Inside of this menu, the adjustment of the brightness, contrast, gamma and exponential/logarithmic controls for the image. On the left side of the window of the image is the Raw, Processed and Thumbnail tabs. In order to see the changes made in the LUT, the Processed tab will need to be selected as the Raw will always show the original image.

After the LUT has been adjusted, it is recommended to save the settings by clicking Save. This will generate a .lut file. Provide it with a file name that will be related to this video. It is recommended to save in the same directory as the location of the images.

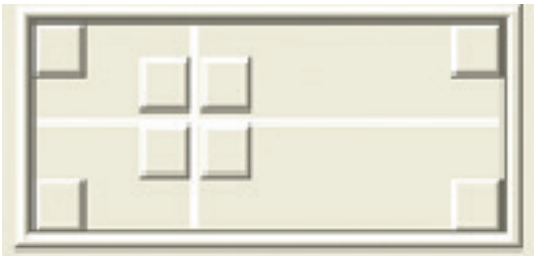
6.3.4 Calibration of the Image

In order to measure motion in the image, the motion will need to be moving perpendicular to the view of the camera. This is why the position of the camera is very important in order to make proper measurements. As well, the perspective of the item in the view will determine the size in the software. For example, when an object is of constant height (like a bench height), it will measure more pixels in height the closer it is to the camera due to perspective. The farther the item is away from the camera, it will measure less pixels in height for the same actual value. Therefore, it is important to perform the calibration of the image at the correct location. With this, multiple velocities of burden moving outward can be taken in the same image. Each measurement location will require its own calibration as the height may be the same, the height to pixel ratio will change.

Along the right side of the window, the Scene Calibration is the top button and it will look as follows:

Ideally, when setting up to make measurements, it is important to have objects that are clearly visible with a high contrast colour that are at known distance apart from each other. In smaller blasts, smaller markers can be used. In very large blasts, large targets are required in order to remain visible on the screen.

In order to make a calibration, select the Scene Calibration button. Under Calibrations, add Normal (this is a perpendicular view to the objects that will be measured). This will open Calibration1. Select the small wrench at the end of the line. This is the window that will allow for changing of the settings for the calibration. If the plan is to have multiple calibrations in this image, it is a good idea to label them so the correct calibration can be selected when tracking. To set the two points, click on the first object on the screen. When the cross-hair is on the object in the correct location, select Set Point #1. Now click on the second object that the distance is known. When the cross-hair is on this point, select Set Point #2. In the box below the set points is a text box. Enter the distance between the two points. Then in the pull down menu, select the correct units for the distance that was just entered. Next, click Apply Scale. This will be the conversion between the number of pixels and the engineering unit. With the calibration, the positive direction of both the X and Y axis is required. The default is in the top left corner with positive X is to the right and positive Y is downward. This is not normally the best for this application. To set the axes for the application, place the cross-hair on one of the markers, click Set Origin. This will move the origin of the coordinates to the marker with positive X to the right and positive Y downward. The box below shows the quick setup of the coordinate system.



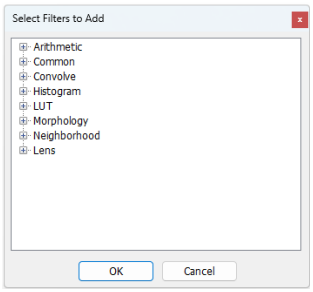
The corners of the box will set the coordinate system in that corner. Generally, the blasting videos will be taken with positive Y pointing upward and positive X in the direction of rock movement (either right or left depending on the video setup). Therefore, the two most common buttons that will be clicked are the two that are above the cross-hair in the image above. The one on the left if positive X is to the left or the one on the right if positive X is to the right. If the X direction is not parallel on the screen, you can tilt the X direction by placing the cross-hair on a line that is parallel to the origin and the X-axis. Then click Set X Direction and this will be positive X. After the calibration is complete, click Apply Origin and Tilt then Apply. When the information appears below in the description box, then click close. The calibration is set.

After the calibration has been completed, it is recommended to save the file by selecting Save. This will generate a .mcl file. Provide it with a file name that will be related to this video. It is recommended to save in the same directory as the location of the images.

6.3.5 Image Processing

Image Processing will allow for the filters to be added to the image. This is the third button from the top on the right side of the screen. The button looks like this:

In order to start using the Image Processing features, this item will need to be enabled. To add an image filter, click the Plus button. A list of different groups of filters will be displayed as shown below.



Each of these filters will modify the Processed image. The order of the filters will matter as well. They are applied from the top to the bottom. As well, some of the filters will have modifiers that can be changed by selecting the small wrench at the end of the line item.

More filters can be added by selecting the Plus button. If a filter is selected, the Minus button will delete the filter. The Up arrow will move a filter up the list while the Down arrow will move the filter down the list. The X at the end of the row will delete all of the filters.

After the image processing has been completed, it is recommended to save the file by selecting Save. This will generate a .imp file. Provide it with a file name that will be related to this video. It is recommended to save in the same directory as the location of the images.

6.3.6 Feature Tracking

Feature Tracking will allow for the tracking of the objects of interest. This now can be performed from an image that has been stabilized. Therefore, the only motion of the objects is the motion of interest. The Feature Tracking button on the right side of the window looks like this:

To start tracking an object, Enable Feature Tracking. This will work very similar to Image Stabilization except the motion is not used to correct the stability of the frame. Using the Image Processing, use filters to allow the object to stand out from the background. An Edge filter should work very well. Zoom into the region of the object of interest and select Define Template. Draw a box around the object of interest. When the box is of sufficient size and position, click Set Template. After the template is defined, the small wrench at the end of the line for the Feature that is being tracked will need to be selected. In this menu, the name of the feature can be changed but more importantly, the proper calibration can be assigned to the feature.

With the template defined, the next step is to track the unlocked features forward. To reduce time, in the display options, the show can be

set to current track points to speed up the tracking. After, this can be set back to All Track Points or normally, Past Track Points. If multiple features have been created, it is important to lock them by clicking the lock button in the line item beside the small wrench. The Track Unlocked Features Forward is the arrow pointing to the right in the Tracking section. If the point is not tracking the object as desired, click the stop button in the Tracking section. The video can then be rewound until the tracking point is back on the desired object. At this point, the template can be reset by placing the box around the object and clicking Set Template. As well, in the small wrench at the end of the feature line, the tracking features can be adjusted. If the automatic tracking is finding a target that is more like the original then the item of interest, the Search Area can be reduced. The standard is 250%, but with frame rates of 1000 fps or higher, the object will not move very quickly. Therefore, the search area can be reduced to 150% to keep the area of interest smaller. When the objects have been tracked, it is best to set the Display Options to Show: Past Track Points and the track of the object will be shown.

When the end of the track of the object of interest has come, the automatic tracking may continue on an object that is not the one of interest. The best way is to stop the tracking and rewind the video to the last frame that is tracking properly and then delete the forward tracking points. This is done by clicking the Clear Selected Track(s), All Frames Forward in the Clear Selected Section. This will clear all the points forward of the selected frame for the unlocked Features.

6.3.6.1 Feature Tracking - Manual

If the automatic tracking is not working by tracking the object consistently, it is possible to track the object manually. With the Feature selected, the Track Mode can be changed from Automatic to Step Manual. This will advance the frame by one after the point has been marked. To mark the point of the object, left click. If the point is not in the correct position, left click on the new point to move the tracked point. When it is in the correct position, hold the Control button and then right click. This will set the point for this frame and then advance the video to the next frame. Each frame can be selected, but when tracking manually with an object that is moving relatively slowly on screen, what can happen is the Frame step rate can be increased. This is at the bottom of the window under Playback controls. If the step is changed to 2 frames, every time that the point is marked, the video will move forward two frames. This will allow for tracking every second point. When the tracking is complete, the points in between the frames can be interpolated using the Interpolate Tracks button under Interpolation. On the video, the marked points will be of the marker shown in Features while the interpolated points will have the same marker in the background with a white circle overlayed. This will show that it is an interpolated point.

6.3.7 Graph Configuration

With all of the objects of interested tracked with the proper calibration on a stabilized image, the creation of the output of the velocity can be created. In the Graph Configuration button on the right side of the window, graph lines can be created. In the Graph Lines window, click the Plus button. A window will open to add a graph. Since this is a two-dimensional video, the 2D line will appear. Click the plus beside the 2D row and the different options will appear. In this window, any of the features that have been crated can have its properties displayed. Each feature will have 9 different options. In this example, I will use Feature 1. The items will be listed below with the descriptions:

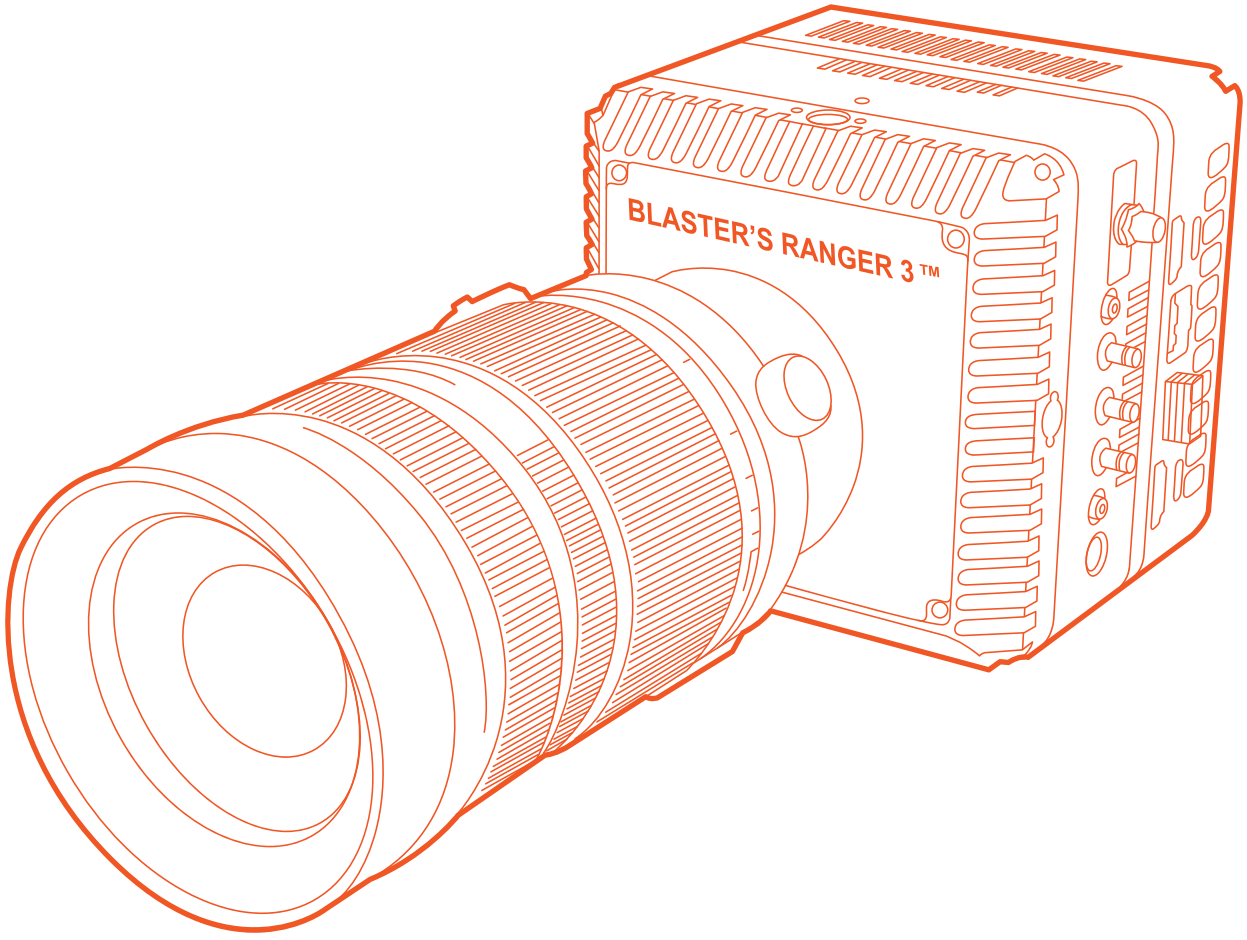
- Feature 1 – X: From the coordinate system, this will graph the X component of the distance
- Feature 1 – Y: This will graph the Y component of the distance
- Feature 1 – Distance: This will graph the vector distance of Feature 1
- Feature 1 – Speed: This will graph the vector velocity of Feature 1 (most used)
- Feature 1 – X Velocity: This will graph the X component of the velocity
- Feature 1 – Y Velocity: This will graph the Y component of the velocity
- Feature 1 – Acceleration: This will graph the vector acceleration of Feature 1
- Feature 1 – X Acceleration: This will graph the X component of the acceleration
- Feature 1 – Y Acceleration: This will graph the Y component of the acceleration

When all of the Features have been graphed, right click on the graph. Under Graph Menus, select Export Displayed Data. From this option, the data can be exported into the following formats:

- Text
- Excel
- Excel Template
- C3D

It is recommended to export to Excel if Excel is installed on the computer. If not, then it is recommended to export to Text to be imported into the analytics program of choice.

Chapter 7
Contacting MREL for Technical Support



7.1 Contacting MREL

MREL Group of Companies Limited

Blasting Instrumentation Team

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Kingston, Ontario K7L 1H3
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Toll Free Canada/USA: +1-877-544-MREL
Tel: +1-613-545-0466

Email: support@mrel.com

Webpage Support: www.mrel.com/contact.html

MREL looks forward to providing you with assistance.

Appendix A: Definition of Terms

Arm

When armed, the camera will capture and write images into a partition of camera memory, and then overwrite it continually until it receives a trigger.

Arm/Record Bug

The Arm/Record Bug is the small vertical line used in conjunction with the Record Bar to indicate the progress of the camera while acquiring pre- and post-trigger images.

AVI

Audio Video Interleave (AVI) is a popular file type for electronic video. AVI files may include certain types of image/video data (compressed or un-compressed), audio data, and metadata.

Bit Depth

Images captured by the **Blaster's Ranger 3™** sensor are read in binary form. Each pixel is given a binary 8-bit value from 0 to 255, 10-bit value from 0 to 1023, or 12-bit value from 0 to 4095—all numbers in between are shades of gray from very dark to very bright. The camera operator has the option of recording all ten bits (1024 shades) or 8 bits (256 shades). If the operator chooses to record 8-bit data, they must choose which 8 bits of the ten to record. They may wish to record the Lower 8 bits, which will greatly enhance the dark areas of the image, tend to saturate the bright areas, and will expose more noise; or the Middle 8 bits, which will somewhat enhance the dark areas wash out the brighter areas, and expose some noise; or the High 8 bits, which will be the cleanest image, but with the least definition in the darker areas.

BMP Stack

BitMaP (BMP) files contain un-compressed image data. Each file contains one image. A BMP Stack is a collection of images. The BMP Stack produced by the **Blaster's Ranger 3™** is a collection of frames, written as BMP files representing a captured video sequence.

Brightness

Linear image control that boosts all pixel values without disturbing the slope of the curve.

Colour Temperature

The Colour Temperature of an ideal black body is defined as its surface temperature in kelvins (K). The Colour Temperature of a light source is an assigned value that closely approximates what a human would perceive as a match between that light source and an ideal black body at that Temperature (K). High colour temperatures are seen bluish, while lower color temperatures are seen reddish.

Config

Camera Configuration that can be saved and reloaded. Includes settings for Frame Rate, Resolution, Shutter Speed, Trigger, bit depth, and Auto Save.

Contrast

Linear image control that enhances the difference between pixel values by changing the slope of the curve, while maintaining the mean value.

Cursor

The cursor may be any graphic indication of where the current focus is within the user interface. This may be anything from a blinking vertical line as used within a dialog box when the user is entering text, or it may be a change in the colour of a button as when navigating through menus.

Custom Camera Control Application

Camera control software compatible with the **Blaster's Ranger 3™**.

DHCP

DHCP is a utility by which a server dynamically assigns IP addresses to clients on a network. When DHCP is selected in the Network Menu, the camera will allow a server on a connected network to assign it an IP address.

Dialog

A Dialog is a box that requires user input such as the selection of an option, or the entering of a number or text.

Download

Electronically moving image data from a camera to a "remote" device, i.e. a PC or other mass storage.

Enable Raw

A raw image is one where all image processing including colourization, white balance, brightness, contrast, and gamma, are all bypassed.

File Type

Digital files are commonly identified by their extensions. Familiar types include PDF, TXT, JPEG,TIFF, DOC, MP3, etc. Each of these files has a specified format that usually includes information in the file header and specially formatted data that applications on PCs, Cameras, Printers, Smartphones, and other electronic devices can read, write, and decipher for human viewing, editing, listening, etc.

Gain

In imaging the term Gain is most often used as a multiplier applied to a pixel value.

Gamma

Gamma encoding of images is required to compensate for properties of human vision - to maximize the use of the bits or bandwidth relative to how humans perceive light and colour. Human vision under common illumination conditions (not pitch black or blindingly bright) follows an approximate gamma or power function. If images are not gamma encoded, they allocate too many bits or too much bandwidth to highlights that humans cannot differentiate, and too few bits/bandwidth to shadow values that humans are sensitive to and would require more bits/bandwidth to maintain the same visual quality.

HDMI

HDMI, High-Definition Multimedia Interface, is used to transmit digitized video (and audio) data from the camera to a remote display. This is a popular method for connecting consumer products such as televisions, cable TV boxes, DVD players, etc.

Image Memory

Image memory is the internal memory in the camera reserved for raw image data. This is volatile memory that is erased when the camera is shut down.

JPEG Stack

Joint Photographic Expert Group (JPEG) file format is a highly compressed file format, capable of reducing image files to a fraction of the size of a BMP or lossless TIFF. The image quality of JPEGs is excellent, although there may be some discernible noise in the displayed image, often referred to as JPEG artifacts.

Menu

Once an item in the Menu Bar is selected, the corresponding Menu appears below.

Menu Bar

The Menu Bar is the bar across the top of the camera display that lists the Menu Items.

Network	The camera may be connected to a computer via its RJ45 GigE (Gigabit Ethernet) connection.
NTP Time	Network Time Protocol: Network Protocol for synchronizing time clocks of devices attached to a given network or internet, within a few hundredths of a second.
Play/Review Bug	In Review there is a progress bar that graphically indicates the position of the currently viewed frame within the image sequence. The small vertical line that is used as the indicator is referred to as the Review Bug.
Record	The camera is acquiring images and storing them in internal memory. This begins when the camera is armed, and ends after a trigger is received.
Record Bar	When the camera is Armed and it commences capturing images, the Record Bar presents a graphic indication of the progress of filling the buffer.
Refresh Rate	Rate at which image data is re-painted on the display. For CRTs this is analogous to the vertical frequency.
Review	Review is a camera utility for viewing image data while it resides in camera memory. It includes options for playing the imagery as a movie, forward or backward, or stepping through the frames one at a time, or stepping through every 10th frame. It also allows the user to adjust starting and ending points for an image sequence for viewing or saving. The user may adjust image properties such as brightness, contrast, gamma, colour balance when reviewing the images. If 10 bit images have been saved, the user may also select which 8 bits to display. It is important to note that image adjustments made while using Review do not alter the image data in camera memory although they do alter the viewed and saved images.
Save	Moving image data from a camera's internal memory to some other mass storage device. This mass storage may be local, such as the SSD drive within the camera, or remote, such as a PC.
SD	This is Secure Digital memory, such as the SD Card used as a plug-in mass storage device for the camera.
SSD	Solid-state drive that is located inside the camera. This is a non-volatile mass storage device retains its data when the camera is powered down.
Static IP	In order for one networked device to "talk" to each other, they need to have compatible IP addresses. One way to assure this is for the user to assign unchanging (static) IP addresses to each device.
Status Menu Bar	The Status Bar is a line of text at the bottom of the display that appears when the camera menus are turned on.
Sub Menu	Within each Menu, there may be additional Sub Menus from which to select.

TIFF Stack

Tagged Image File Format (TIFF) is a much more flexible format than the BMP, in that it may use one of several compression schemes, may be used to store multiple images (multi-page TIFF), and may include metadata in the form of Tags. Developers may apply for their own block of private Tags. The TIFF is the only file format used in the **Blaster's Ranger 3™** that is compatible with 8-bit, 10-bit, or 12-bit images. The TIFF Stack produced by the **Blaster's Ranger 3™** is a collection of frames, written as TIFF files representing a captured video sequence.

Trigger

The trigger is a signal sent to the camera either via the trigger switch on the camera or from an external source applied to the camera's trigger input connector. When an armed camera receives a trigger, it will capture and write a prescribed number of frames into camera memory, then stop capturing images. If the **Blaster's Ranger 3™** receives a Trigger while in Live Mode, it will take a still image.

Update Rate

The rate at which the **Blaster's Ranger 3™** or a PC can process a new frame of video and send it to the display.

USB

A thumb drive or some other mass memory device may be attached via the USB port of the camera.

USB OTG

When a PC is connected to the USB OTG (USB On The Go) port of the camera, the camera appears as a mass storage device to the PC, much like plugging a thumb drive into a PC's USB port. The camera is automatically a slave to the PC.

Web Application

Camera control software that runs via web browser such as Windows Internet Explorer, Safari, Firefox, etc.

White Balance

Many different kinds of illumination may be used with high speed cameras. Typical colour temperatures for common types of illumination are used to compute RGB gains, which, when applied to captured imagery, should approximate what a human would perceive as accurate colour. The term White Balance refers to the idea that, presented with a white card under a given light source, the camera should produce a white image.

Appendix B: Blaster's Ranger 3™ Specifications

System Design	Stand alone, battery powered, portable with multiple PC I/O ports
Sensor	12-bit CMOS sensor with 5µm square pixels, colour or monochrome
Resolution	2560 x 2048 pixel maximum
Light Sensitivity	ISO 1600 to 12,800 (mono)
Record Resolution @ Max Frame Rate / Recording Time 8 GB / 16 GB / 32 GB	2560 x 2048 @ 253 fps / 6.25 sec / 12.5 sec / 25 sec
	1920 x 1080 @ 634 fps / 6.25 sec / 12.5 sec / 25 sec
	1280 x 1014 @ 1001 fps / 6.25 sec / 12.5 sec / 25 sec
	1280 x 500 @ 2004 fps / 6.25 sec / 12.5 sec / 25 sec
Long Record Max frame Rate at Max Resolution by Model	2560 x 2048 @ 253 fps;
	1920x1080 @ 634 fps;
	1280x1024 @ 991 fps;
	800x600 @ 1677 fps
Shutter	Global electronic shutter from 3µsec to 41.654ms
Image Memory	8GB (std.); 16GB / 32GB (optional)
Multi-Sequence Mode	1, 2, 4, 8 or 16 individual recording partitions
File Formats	Stacks – BMP, DNG, JPEG, TIFF (processed or raw); Video – AVI, CAP (raw), MP4, RDI
Lens Mount	MFT-Mount
Monitor	12" Monitor
Ports	1x USB3.2 (10G), 1x USB2.0, 2x USB4 (40G) via Thunderbolt 4 (USB Type-C port)
Control Software	MAC, Windows or Linux OS compatible
Trigger	Externally by trigger switch or TTL trigger signal
Sync	External sync inputs via BNC
Video Out	HDMI
Construction	Machined Aluminum Housing
Power	External power pack supplied, 110/220 AC adapter and external battery connection cables are provided
Operating Environment	+0 to 40 °C (+32 to +104 °F)

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