

# X-Ray Image Logger User Guide

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## I. Introduction

This guide describes the standard operating procedures for the x-ray imager (XMSL). The system is capable of collecting 2-D x-radiographs on whole round and section half cores.

### Theory of Operation

Users should review the X-ray Imager.pptx powerpoint from LeVay, 2019 for background on x-ray radiograph acquisition before operating the system.

## II. Procedures

### A. Preparing the Instrument

Double-click the **IMS** icon (Figure 1). IMS initializes the instrument. Once initialized, the logger is ready to measure the first section.



Figure 1. IMS Icon.

At launch, the program begins the following initialization process:

- Testing instrument communications
- Homing the pusher arm of the motion control system
- Verifying Dark and Light Calibration images. If the calibration images are not found, the program will ask the user to run a calibration.

After successful initialization, the main IMS-XMSL window will appear (Figure 2).

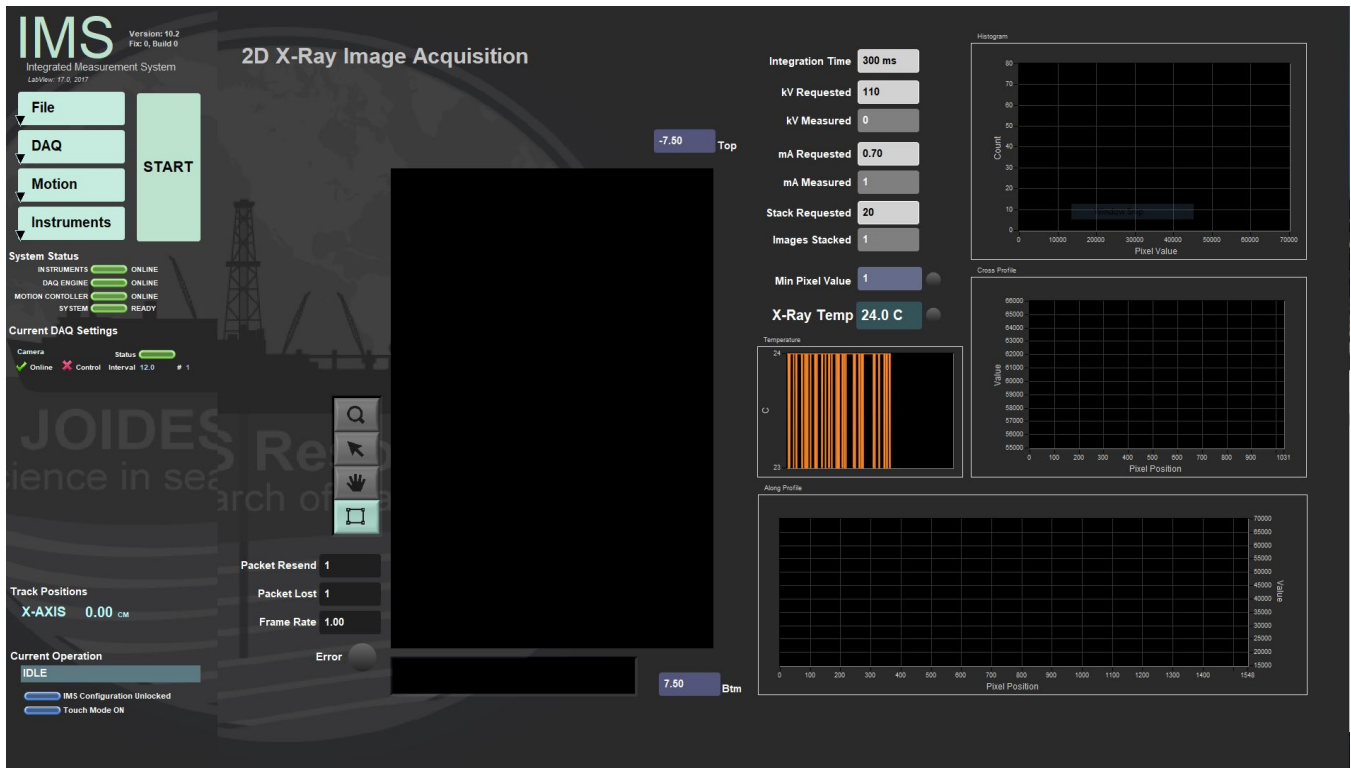


Figure 2- XMSL IMS Main Window

The **IMS Control panel** (Figure 3): Provides access to utilities/editors via drop-down menus.

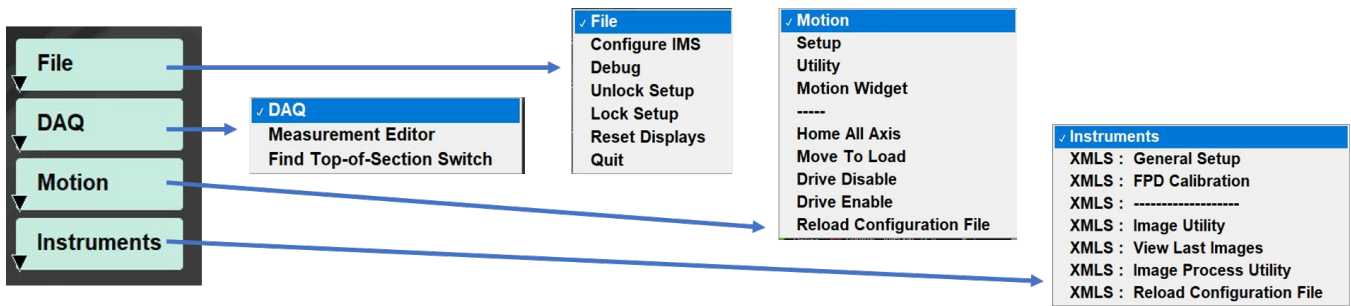


Figure 3. Control Panel Drop Down menus.

**START** button will allow the user to begin measurements. **Section Information** window (Figure 4) will pop up.

Figure 4. Section Information window. Add Image.

## B. Instrument Calibration

### Detector Calibration

Detector calibration should be done at the beginning of the expedition and whenever the exposure settings are changed significantly (integration time especially). If the detector grid becomes visible in any images, calibrate the detector and reimage the core.

To calibrate the detector select **Instruments> XMSL: FPD Calibration** from the main **IMS** menu (Figure 3). The flat panel detector (FPD) calibration utility window will open (Figure 5). The purpose of this utility is to collect images that will be used to perform offset and gain corrections for all images acquired with the FPD. The calibration process requires two images: Dark (Offset) and White (Gain).

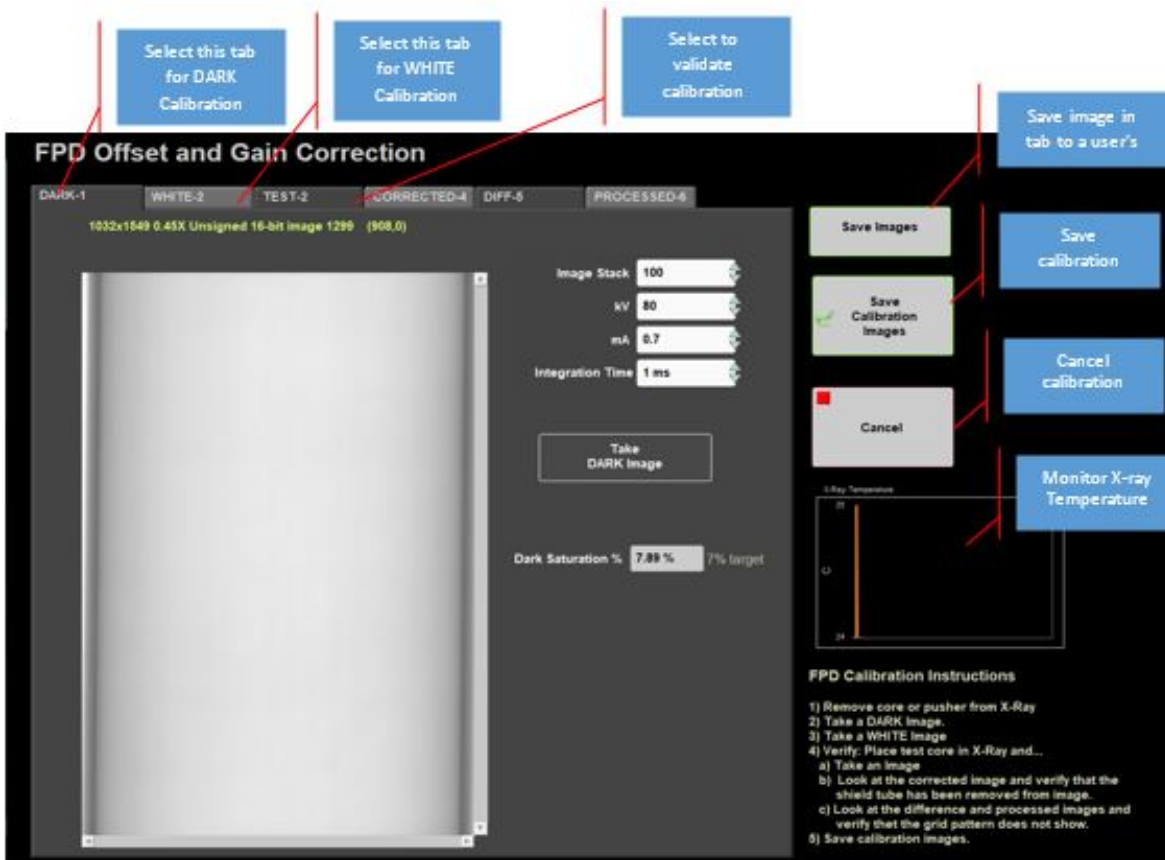


Figure 5. Detector Calibration user interface window. From this utility a user may take necessary calibration images and test the corrections prior to applying them to images.

The offset and gain correction are applied to the raw image according to this formula:

$$\text{Calibrated Image} = \left( \frac{\text{RAW Image} - \text{DARK Image}}{\text{WHITE Image} - \text{DARK Image}} \right) * \text{Mean (WHITE Image Intensity)}$$

## Dark Image Calibration

The DARK image is normally made with the x-rays off to capture the electrical background noise of the detector. Material used in the detector's construction causes a grid to imprint on the images (*Figure 6*); therefore, it is necessary to take the dark image with the x-rays on at minimal level to capture the imprint.



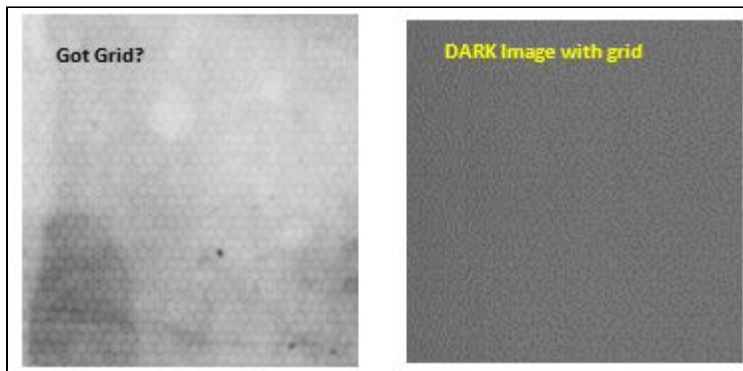


Figure 6. Example of detector grid appearing in image. If this is noted in an image, immediately stop imaging and recalibrate the detector.

To capture the DARK image:

1. Select the tab labeled **DARK-1** (Figure 5).
  - a. The default exposure values are automatically displayed and are the recommend values, but you may set other values. *Be aware that the dark saturation (image intensity saturation) must be 7% or lower and you need to capture at least 100 images for stacking.*
  - b. Recommended values are Image stack: 20, kV: 60, mA: 0.3, Integration Time: 1 ms
2. Click the **Take DARK Image** button.
  - a. The **X-Ray Image Acquisition** window will open (Figure 7). During acquisition, the image window appears black but you will see values in the histogram and in the image line profile.

Once acquisition is completed, you will be return the **FPD Calibration Utility** window.

3. Check the saturation value and confirm that is less than 7% (Figure 5). If not, adjust the exposure values and repeat.

The Dark Max value is used during normal acquisition to warn the user that additional exposure is needed. Ignoring this warning means that image acquired will have some data clipped at zero.

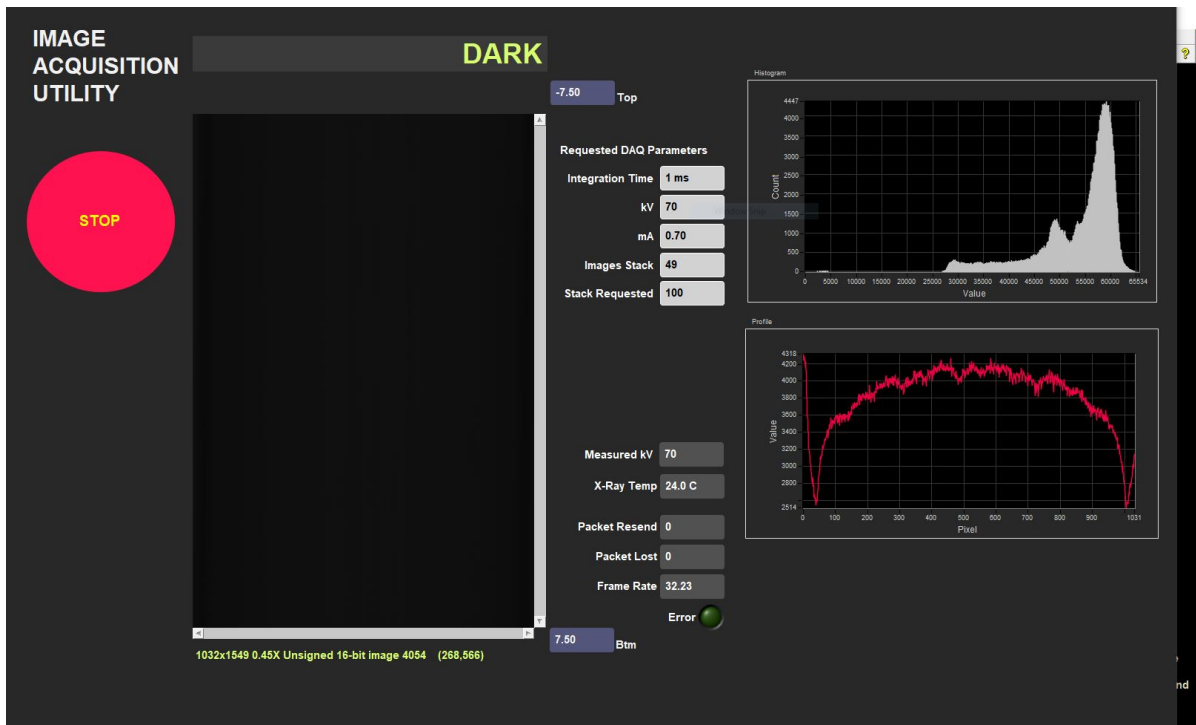


Figure 7. Dark Image Acquisition Window

# White Image Calibration

The **WHITE** image is used for the gain correction after the offset correction with the dark image is completed.

To capture the **WHITE** image:

1. Select the tab labeled **WHITE-2** (Figure 8).
  - a. The default exposure values are automatically displayed and are the recommend values, but you may set other values. *Just be aware that the maximum intensity cannot exceed 99%.*
  - b. Recommended values: Image stack = 20, kV =80, mA=1.0, Integration Time = 30
2. Click the **Take WHITE Image** button.
  - a. The **X-Ray Image Acquisition** window will open (Figure 9).
  - b. During acquisition, the image window appears white shading to darker grey on the left and right edges.

Once acquisition is completed, you will be return to the **FPD Calibration Utility** window.

3. Check the maximum saturation value and confirm that it is in the target range of 94-98%. If not, adjust the exposure values and repeat (Figure 8).

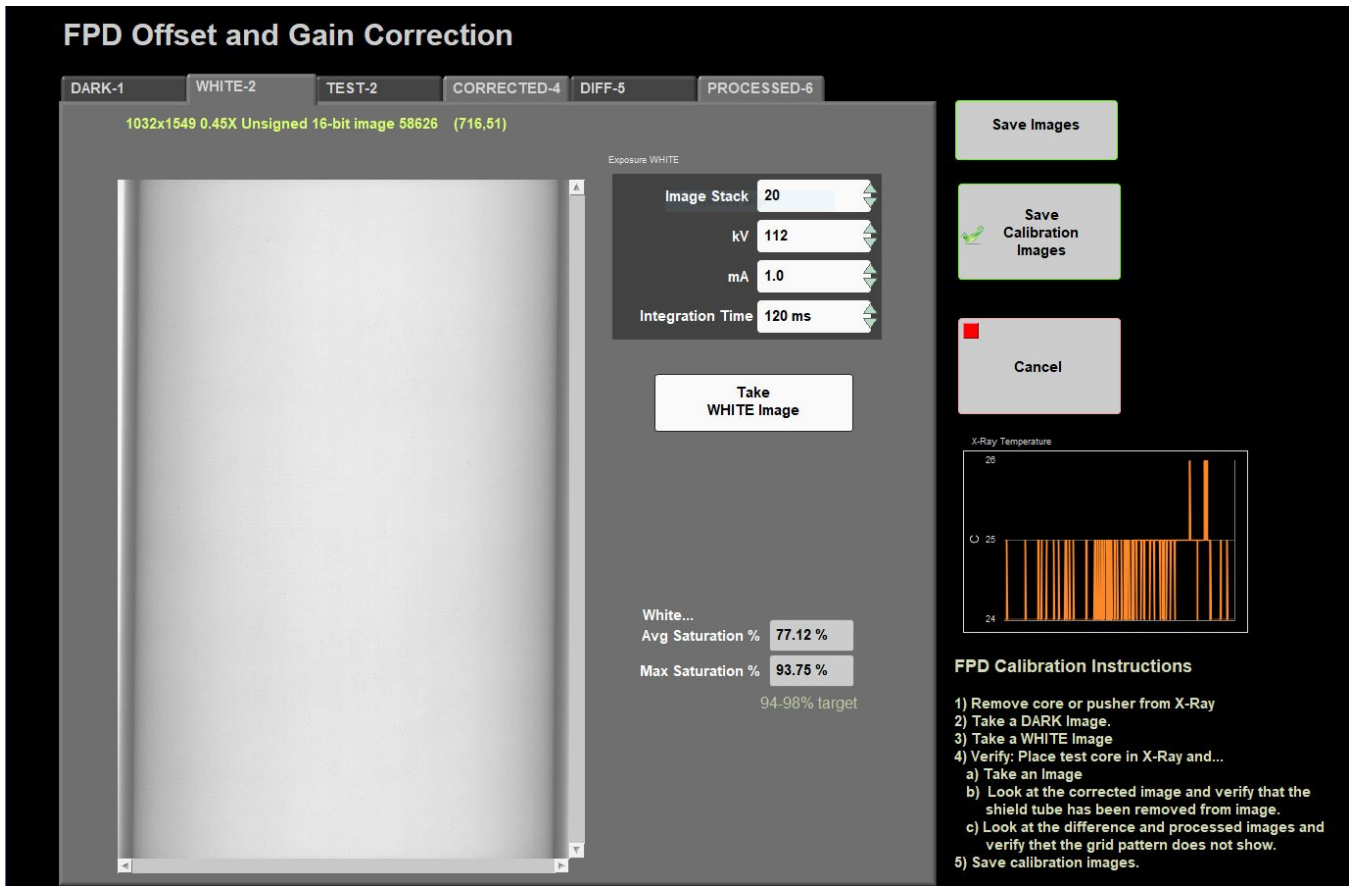


Figure 8. White Image tab in the detector calibration window

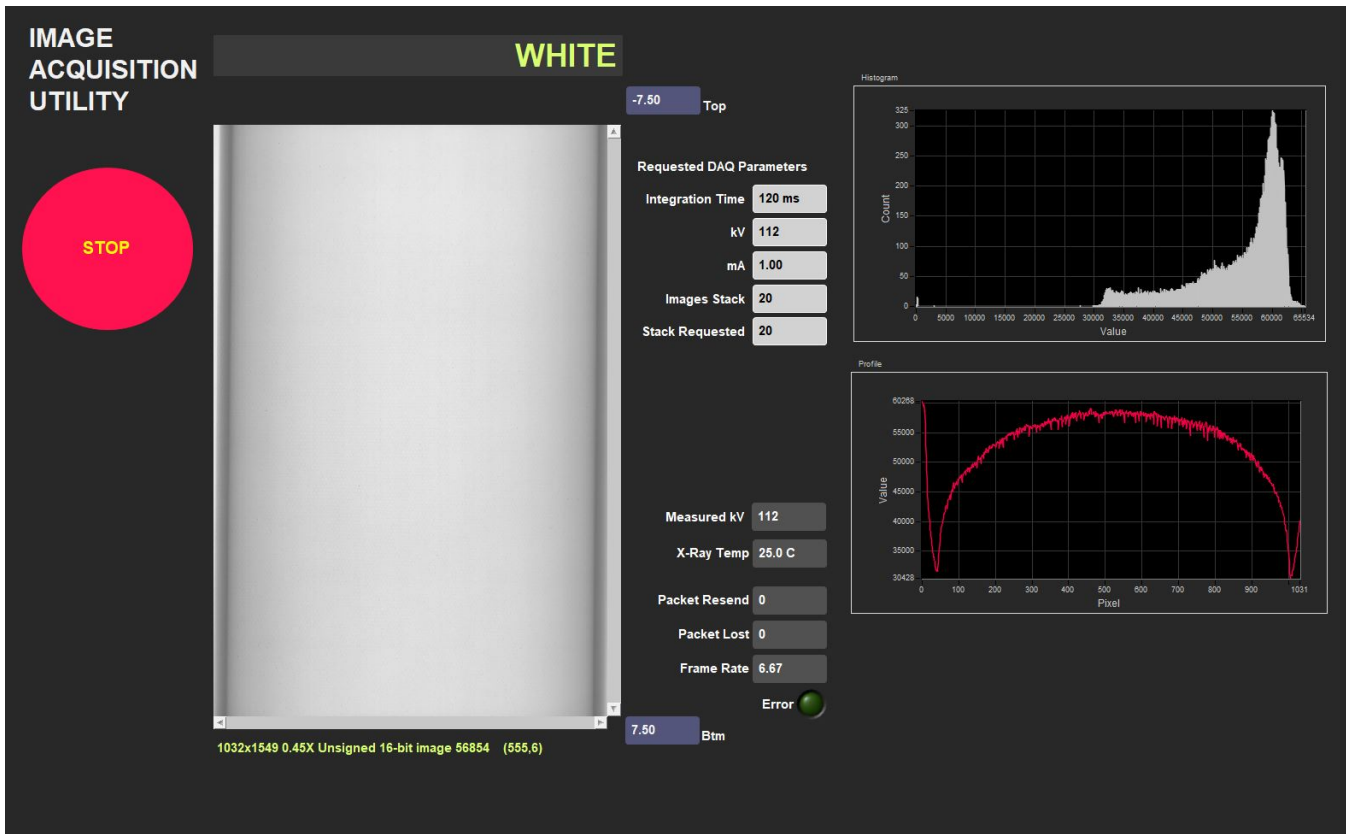


Figure 9. White Image Acquisition Window

## Validating the Calibration

To confirm that the offset and gain calibration have been done correctly, follow this procedure. Note that this is an optional step, but is a good practice to ensure quality x-radiographs will be produced when imaging core.

1. Select tab **TEST-2** (Figure 10)
2. Place a core over the detector and take an image.
  - a. Adjust the exposure for the material being imaged
3. Once the exposure is completed, you'll be returned to the **FPD Calibration Utility** window (Figure 10).
4. Select tab **CORRECTED-4** (Figure 11).
  - a. The image shown is the raw image with the gain and offset correction applied.
  - b. The background on either side of the core should appear as a flat white area.
  - c. The shading seen in the **WHITE** image should be nearly gone.
5. Select the **DIFF-5** tab to view the DIFFERENCE image (Figure 11)
  - a. This image includes the image mask
  - b. Everything in the image should be black, except the core
  - c. If the core itself is covered by the mask, then there is an issue with the calibration
6. Select the **PROCESSED-6** tab to review the automatically processed image (Figure 12).
  - a. Evaluate the images. Do they appear flat grey? Are the images highly eroded?
  - b. If there is an issue with the processed image, return to the Image Processing utility and adjust the processing parameters. Then return to the Calibration Utility.
7. If the Calibration is determined to be acceptable, select **Save Calibration Images**

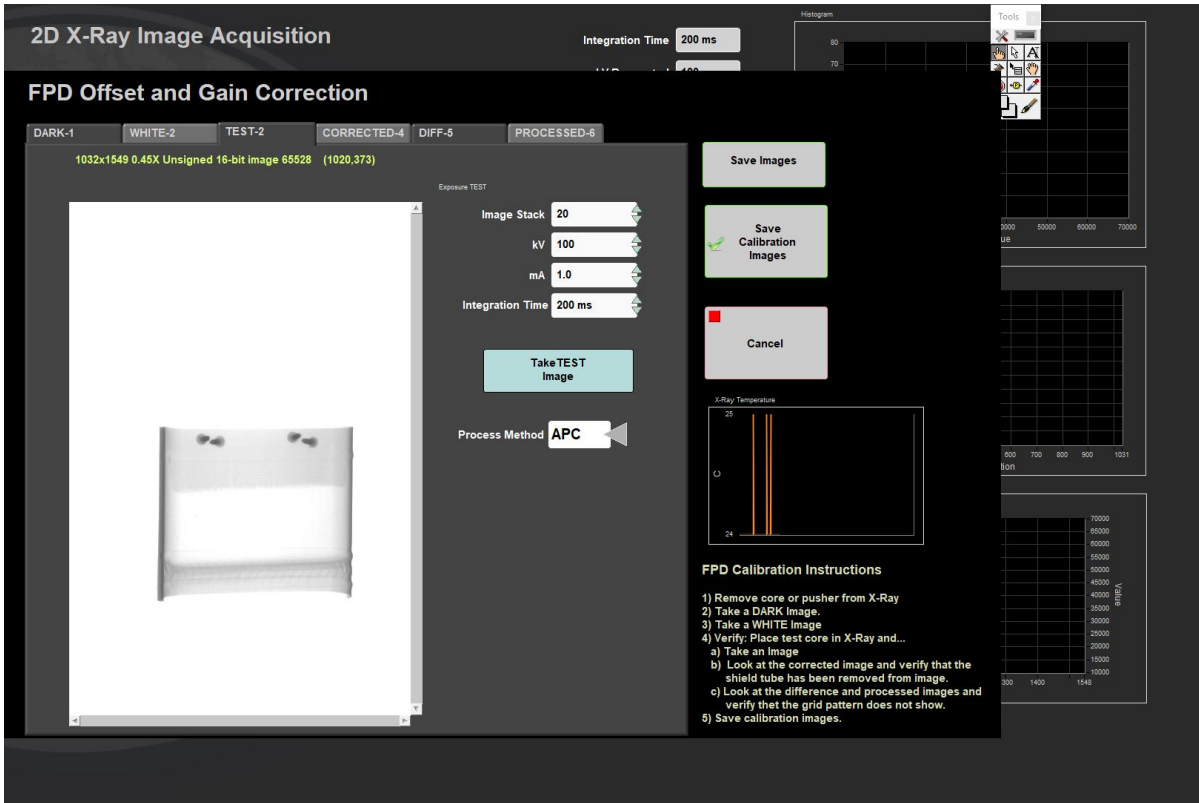


Figure 10. Test Image Tab after selecting take test image

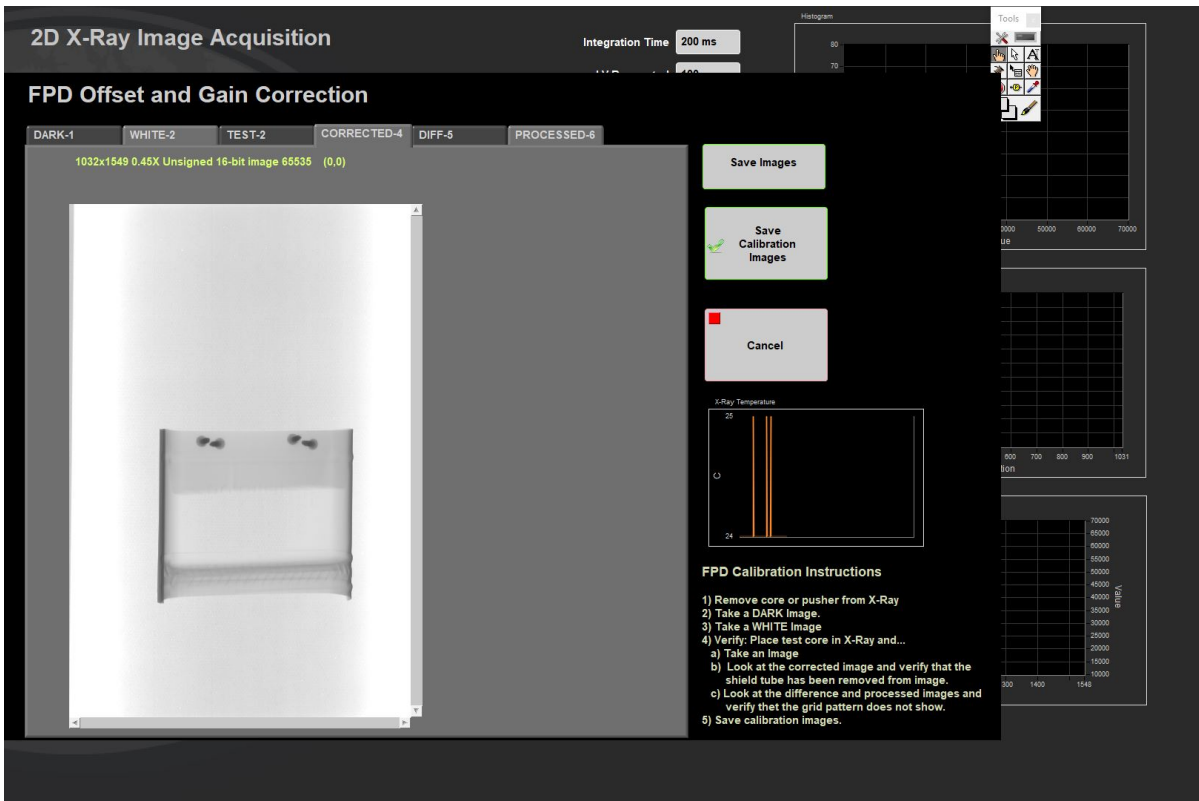


Figure 11. Corrected Image Tab

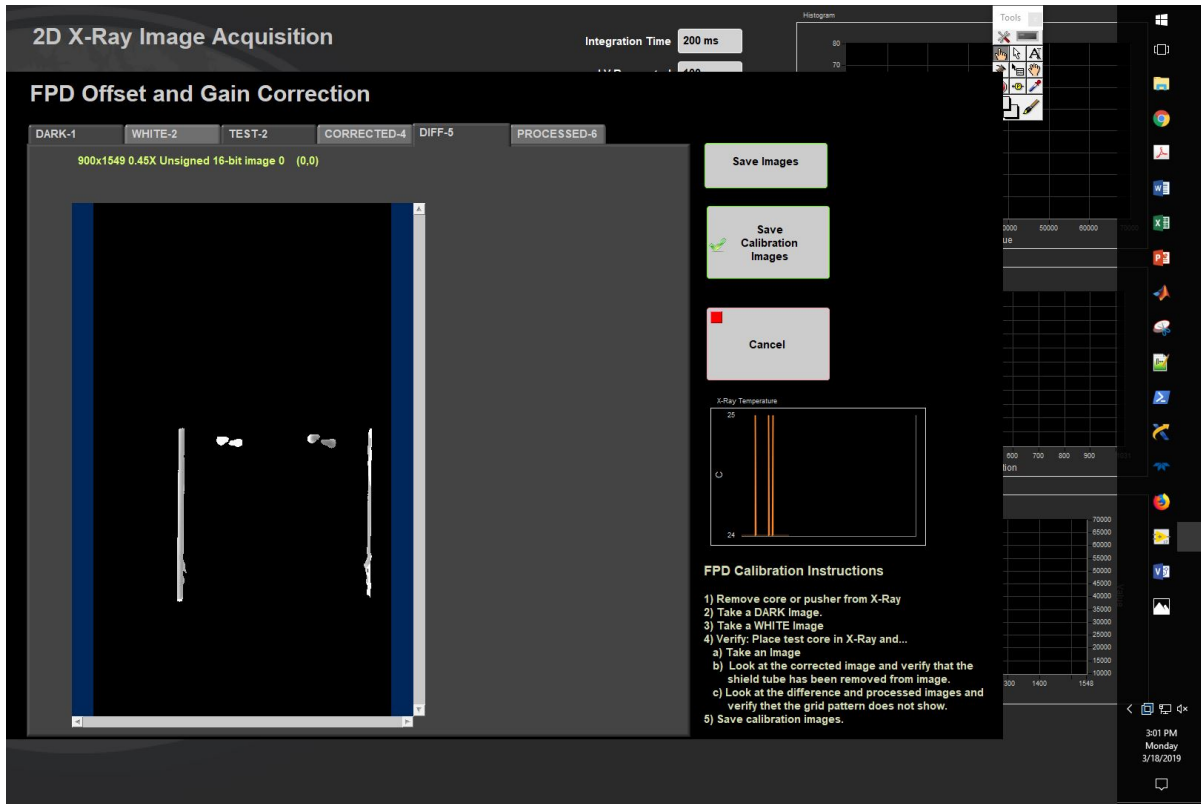


Figure 12. Difference Image Tab

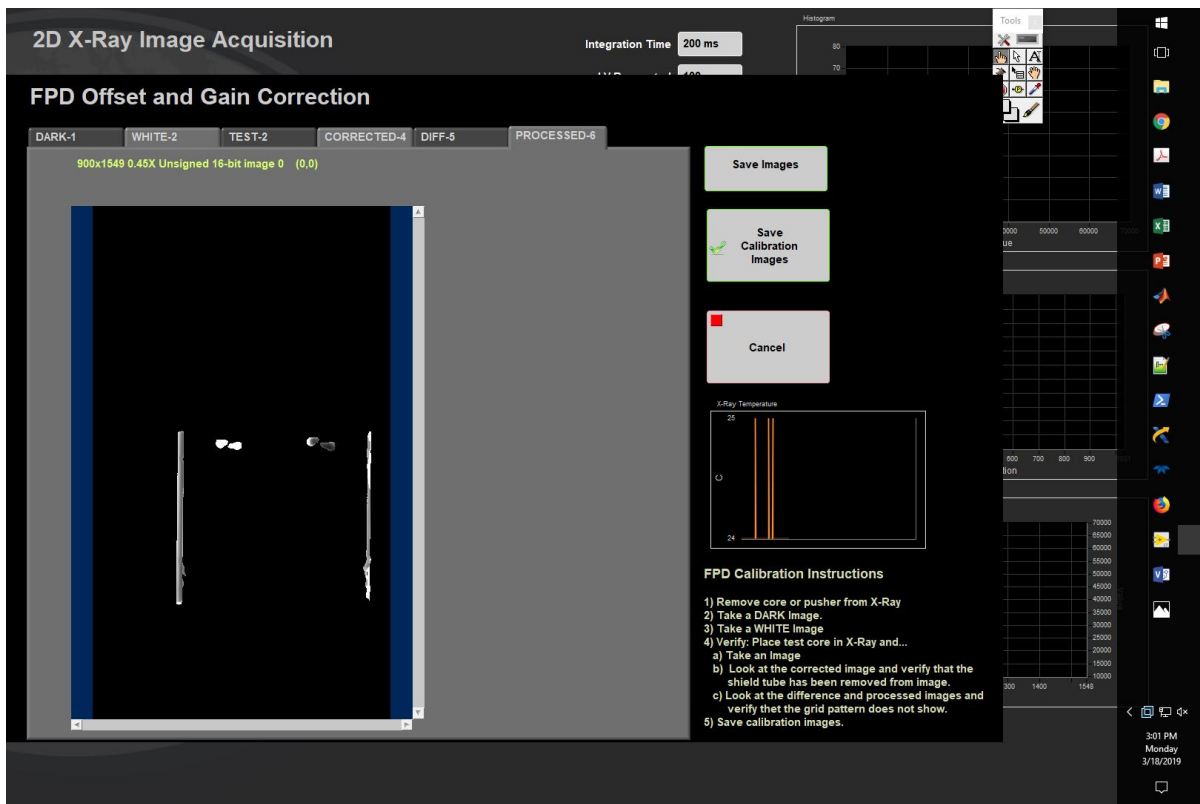


Figure 13. Processed Image Tab

### Saving the Calibration Images

When you have completed acquiring both images and validating the calibration, click **Save Calibration Images**. These images will be automatically applied to the images. Or select **Cancel** and revert to the previous calibration images. The filenames of the **DARK** and **WHITE** image files are stored in the **I\_PL\_GOSCAN.ini** configuration file. When the **IMS** program is initiated, these images are opened and the data is extracted. If these files are missing you will be notified and will have to complete the calibration process before any images can be acquired.

### Other Utility Features

- **Saving individual images:** Images shown in the tabs can be saved as TIF image files by selecting **Save Image**. A file dialog box will open and the user is prompted to select the location and name of the file. *This does not update the calibration information.*
- **Source temperature:** A graphical temperature display is provided to monitor the temperature of the X-rays source.

### Comments

- During and after acquisition of a new DARK image, the DARK image display will be black. But when the utility first opens and displays the previous image, it appears brighter. We have confirmed that the data in the image has not been altered from its initial acquisition and have no explanation as to why the display has been lightened.
- **Never alter the DARK and WHITE image with other programs.**
- The grid pattern is not fully eliminated from the image but is suppressed by the DARK image subtraction. Under certain conditions and processing parameters it may still be detected in the images.

## C. Set Measurement Parameters

### a) Instrument Setup

Configuration values should be set during initial setup and configuration by the technician or scientist(s). There should be no need to change these values unless the configuration file is corrupted or the hardware setup is changed.

**XMSL Instrument General Setup**

To open the XMSL instrument setup window (Figure 14), select **Instruments > XMSL: General Setup** from the **IMS** panel menu (Figure 3). These settings are related to the detector only.

1. Ensure the values in the window are set as shown in Figure 14.
  - a. The instrument X-offset is measured from the home switch to the center pixel of the detector (Figure 15).
  - b. This value must be updated should the detector position change or if the home switch on the track is modified.
2. Click **ACCEPT** to save the changes and write them to the configuration file. Click **Cancel** to revert to previous values.

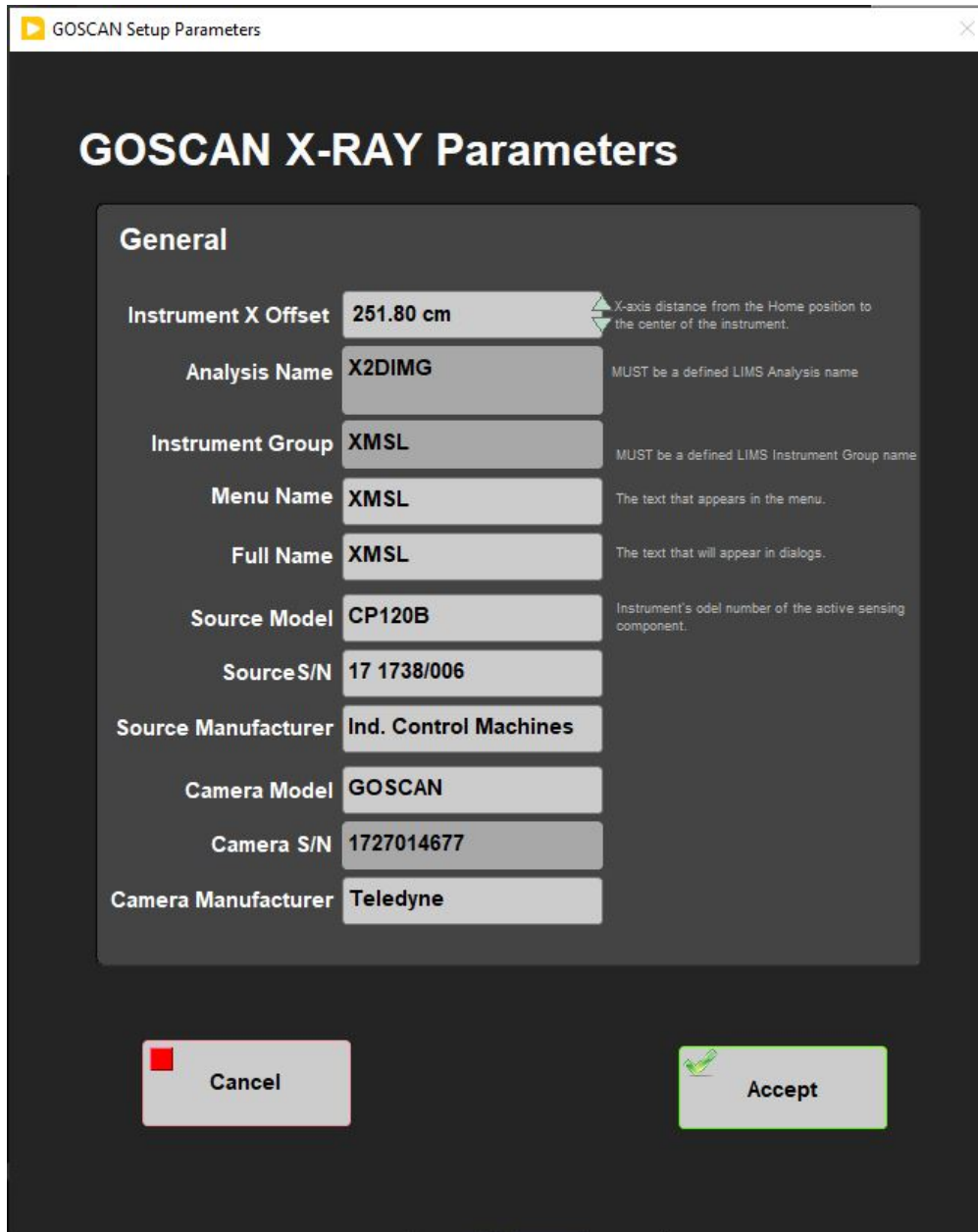


Figure 14. XMSL Parameters Window.



Figure 15. Position of detector center from the track's home switch.

## b) Set Measurement Parameters

Prior to collecting x-radiographs on whole rounds or section halves in the XMSL, the user must set the imaging parameters (voltage, exposure, current). For explanation on how to test exposure parameters prior to imaging, see the **Image Utility** section. For explanation on how to test image processing parameters, see the **Image Process Utility** section.

To open the Measurement Editor (*Figure 15*), select **DAQ > Measurement Editor** from the IMS panel menu (*Figure 3*). This window allows the user to view and adjust the XMSL DAQ parameters.

- **Interval:** Number of centimeters the core will move between each image. This value is hardcoded in the IMS software and cannot be changed in this window. This interval guarantees image overlap, but maximizes system efficiency.
- **Width:** This is the fixed length of the image produced. This value is dependent on the detector and hardware setup. Each image is 15 cm in length, but due to projection, we see less than 15 cm of the core section in the image. For example, with 12 cm of motion, we are seeing 12 cm of core in a 15 cm image.
- **Stack:** The number of x-radiographs to take at each position. These images are stacked and averaged to produce the final raw image. Twenty images is the standard as stacking more images does not appear to improve the image quality further. See *Image Stacking* section for more explanation.
- **Exposure Time:** The duration of each exposure in milliseconds.
- **X-Ray on Time:** Time needed to image a full section keeping the x-rays on between images. Recommended: 300 ms. This time helps to avoid black images.
- **kV:** X-ray tube voltage. Maximum voltage for the source is 120 kV. Lowering the voltage while maintaining the number of x-rays penetrating the core (longer exposure or higher current) will increase image contrast.
- **mA:** X-ray tube current. Maximum current for the source is 1 mA. Increasing the current will increase contrast if voltage is kept constant.

Each of the stacked images is taken with the exposure time, kV, and mA set in this window. To estimate the length of time it takes for each image at specific settings, multiply the exposure time by the number of stacked images.



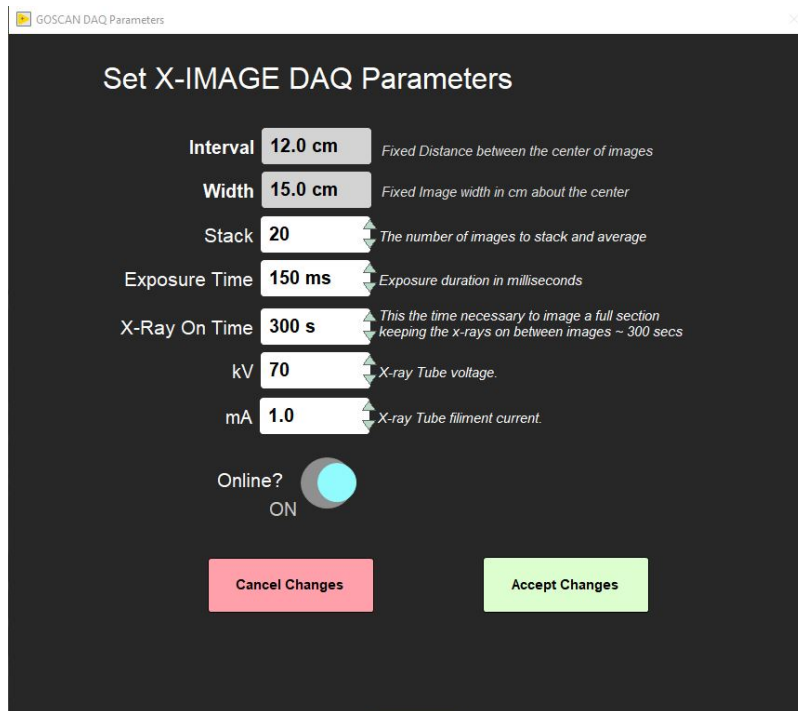


Figure 15. XMSL Measurement Editor Window.

## D. Preparing Sections

1. Wipe off excess moisture and/or mud from the core liner.
2. Tape any drill holes, when applicable.

**Note:** All core sections entering the XMSL must be completely dry. Any moisture or liquid present will DAMAGE the instrument.

## E. Making a Measurement

Prior to imaging cores, especially at the start of an expedition, the user must:

1. Perform a detector calibration. (**Calibration Section**)
2. Test the exposure parameters in the imaging utility (**Imaging Utility Section**)
3. Set the exposure parameters in the Measurement Editor (**Set Measurement Parameters section**)
4. Adjust the automatic image processing settings. (**Image Processing Section**)

**Note:** Recalibrate the detector if the detector grid pattern becomes visible in the images.

Once these steps are complete, the user may begin imaging.

1. Click **START** on the IMS panel (Figure 2) to open the **sample information** window (Figures 16). This is where the user enters the sample ID for a section and initiates the measurement. There are three tabs available on the sample information screen. Each provides a different method for entering the sample ID information.

- **Scanner:** Scan the IODP barcode to enter the sample's Text ID and Label ID values.
- **LIMS:** Select expedition, site, hole, core, and section values from a series of list boxes that are populated with data from the LIMS database.

- **Manual:** Manually enter the sample's Text ID and Label ID values and a length. The name fields will accept any name, so the user must be careful to enter the name properly. *If the name is incorrect a file will be created, but it may not upload properly.* Use the section ID for whole round images and the section half ID for section half images.

Get Sample Information

## XMSL Section Information

Select Input Method

Scanner LIMS Manual **LIMS Web Services**

This Sequence Step **First**

Core Status **Full**  
"FULL" returns SECT  
 "HALF" returns SHLF

Missing Top **0.00** cm

Max Length **0.00** cm  
Positions greater than this value  
 will be ignored.

Measure Control Set

Fix My Scanner

Expedition	Site	Hole	Core	Section
379	U1532	A	1	1
999	U1533	B	2	2
		C	3	3
		D	4	4
		E	5	CC
		F	6	
		G	7	
			8	
			9	

SAMPLE ID required 379-U1532A-1H-1

LIMS ID required SECT9710051

Comment optional

RESTORE TRACK

Label Length **0.00** cm

LIMS Length **150.00** cm

PUSHER END SEQUENCE

MEASURE

CANCEL

Get Sample Information

## XMSL Section Information

Select Input Method

Scanner LIMS Manual **LIMS Web Services**

This Sequence Step **First**

Core Status **Full**  
"FULL" returns SECT  
 "HALF" returns SHLF

Missing Top **0.00** cm

Max Length **0.00** cm  
Positions greater than this value  
 will be ignored.

Measure Control Set

Fix My Scanner

SAMPLE ID required 379-U1532A-1H-1

Don't forget to add -A for Archive or -HW for the Working Section Half

LIMS ID required SECT9710051

Use Me

**Caution, there is no error checking AND NO GURANTEE THAT THE DATA WILL UPLOAD when you use this method, but a local data file will be made!**

SAMPLE ID required

LIMS ID required

Comment optional

RESTORE TRACK

Label Length **0.00** cm

LIMS Length **150.00** cm

PUSHER END SEQUENCE

MEASURE

CANCEL

Get Sample Information

## XMSL Section Information

Select Input Method

Scanner LIMS Manual **LIMS Web Services**

This Sequence Step **First**

Core Status **Full**  
"FULL" returns SECT  
 "HALF" returns SHLF

Missing Top **0.00** cm

Max Length **0.00** cm  
Positions greater than this value  
 will be ignored.

Measure Control Set

Fix My Scanner

SCAN

SAMPLE ID required

LIMS ID required

Comment optional

RESTORE TRACK

Label Length **0.00** cm

LIMS Length **0.00** cm

PUSHER END SEQUENCE

MEASURE

CANCEL

Figure 16. Sample Information Window- Scanner entry (left), LIMS entry (middle), and Manual Entry (right).

2. Enter the Sample ID Information on the sample information window (Figure 16).

- Any entry will be accepted, but that does not guarantee the data will upload. The Text ID information must match an actual section in order for the data to upload.
- Select **USE ME** to update the IDs and enable the **MEASURE** button.

3. Ensure the **Core Status** (left side of window) is set to match the type of core being imaged

- a. Full= Whole round
- b. Half= Section half

4. Ensure the section half is inside the load end door and that all doors are closed.

- a. The green and yellow light on top of the lead box should be illuminated

5. Select **MEASURE**

- a. The motion control pusher will move until the section breaks the top of core switch beam.
- b. The x-ray source will ramp up and a window with the x-ray source status will appear (Figure 17). Once the mA and kV are stable, the window will close and image acquisition will begin. The user may abort at any time by clicking the **Abort** button.
  - i. Once the top of core is located, the pusher will automatically move the section to the proper location over the detector and begin imaging. The user interface will have a display as shown in Figure 18.
  - ii. The system will automatically take images along the section until the actuator reaches its limit switch, at which time it will return to the home position and the source will ramp down.

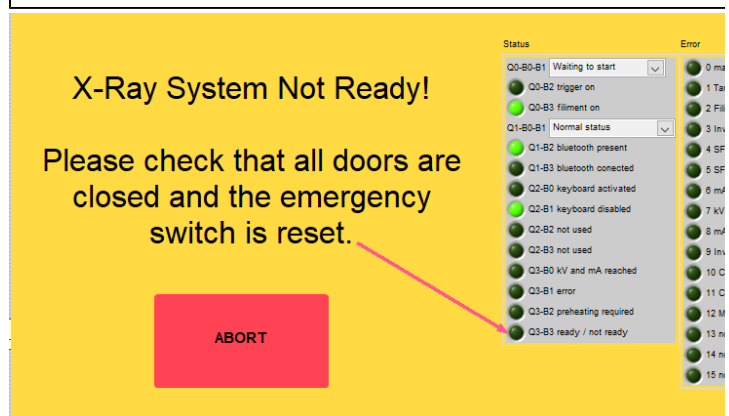
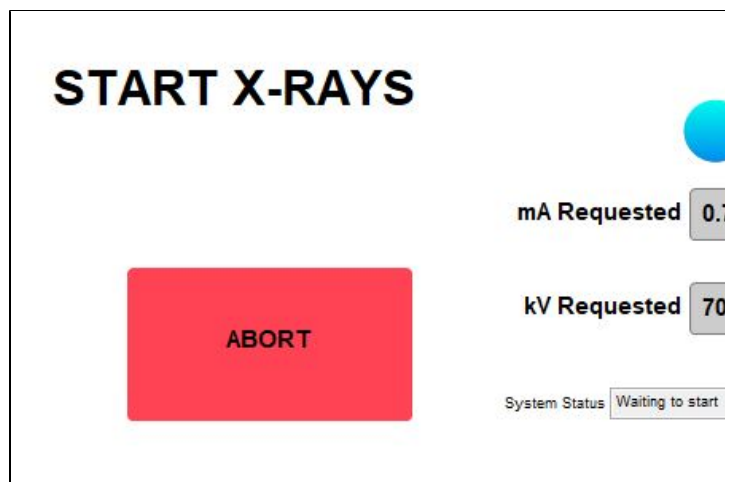


Figure 17. X-ray Status Window (left). As the source ramps up, the measured values will update. X-ray system not ready window (right). If the source is not ready to ramp up this window will be displayed. Normally, this indicates that a door is open. If the doors are not open, look at the values in the status displays and refer to the vendor's manual to determine the issue. As soon as the issue is cleared, this window will close and the x-ray start process will resume.

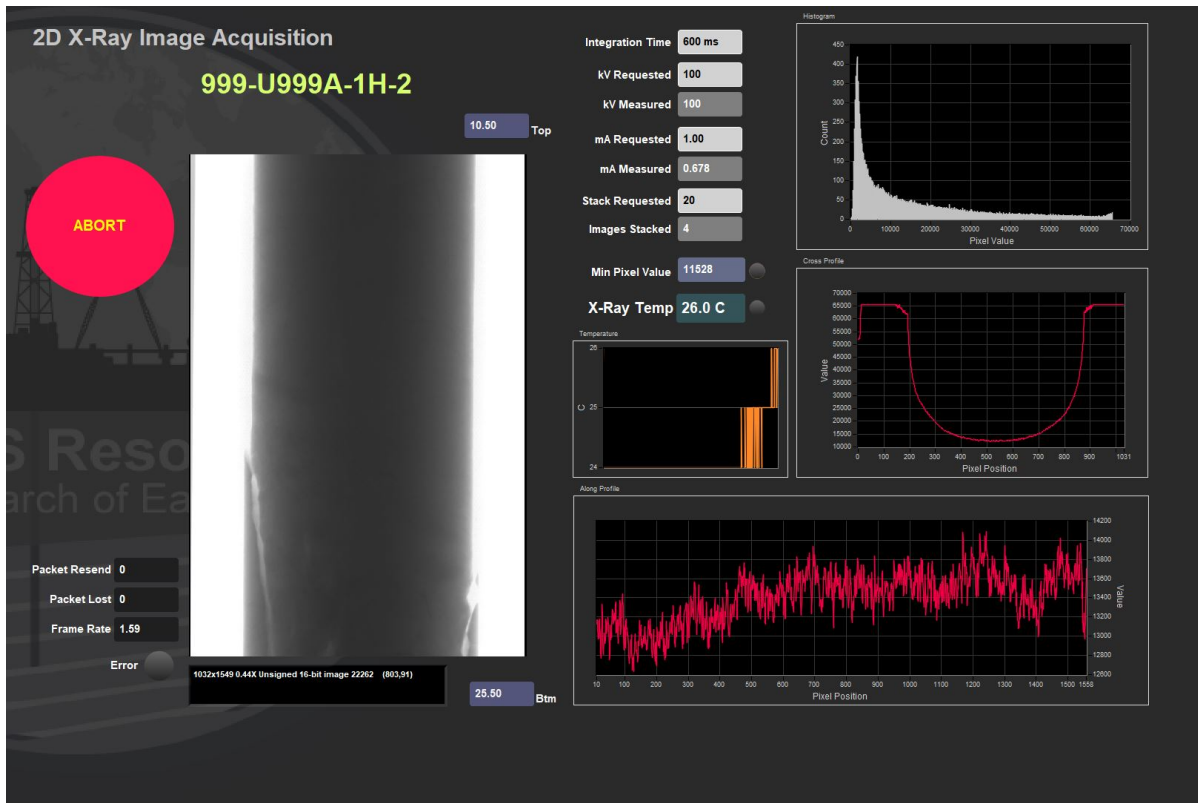


Figure 18. IMS Display During Imaging. Main features of this window include: Abort button, raw image display, imaging parameters display, X-ray source temperature graph, histogram of pixel value and displays of the pixel values along the length and width of the image.

6. The Sample ID information window will reappear on the screen (Figure 19).

- a. Place the Pusher section onto the track.
  - i. The pusher should be an empty liner with tape along the top and bottom edges, not the water core from the WRMSL track.
  - ii. Close the load end door.
  - iii. Select Pusher end sequence in the Sample ID window. The source will ramp back up and the motion control system will continue to push the section through the x-ray system.

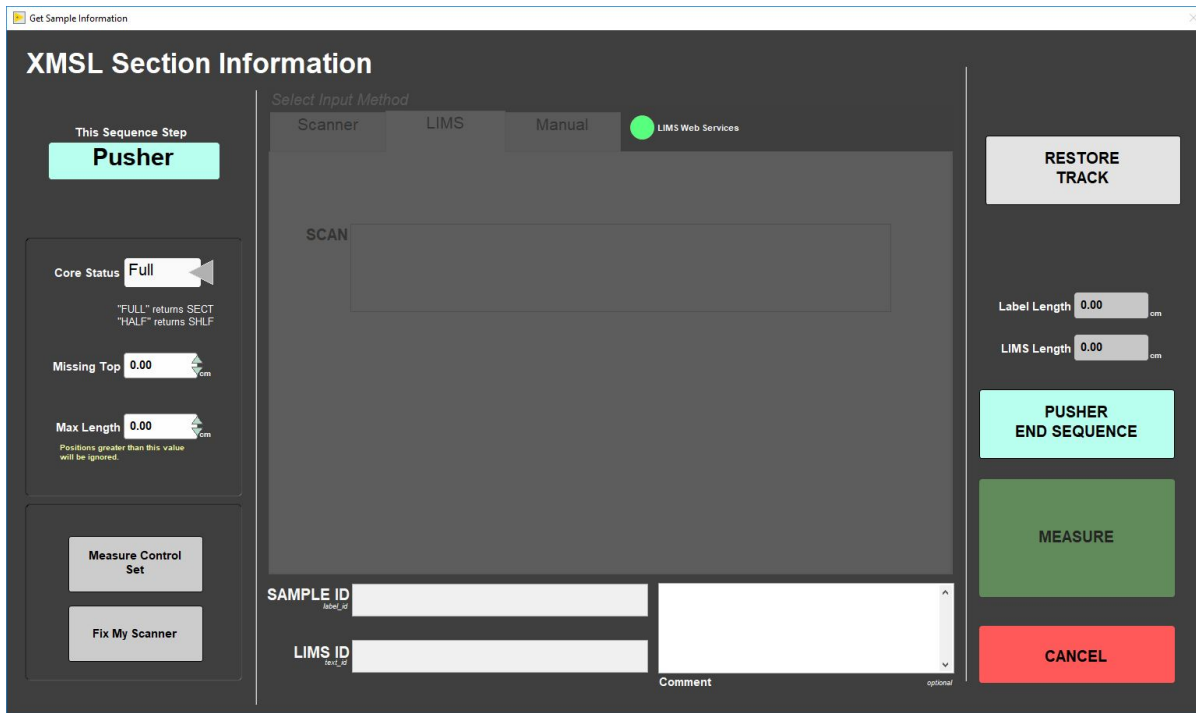


Figure 19. Sample Information Window- Pusher End Sequence View.

7. When the imaging is complete, **IMS** will automatically process the raw images and output them to the **AUX\_DATA** folder. These are not the primary processed images, but are available for quick image evaluation. For more information on **IMS** image processing, see the **Automatic Image Processing** section.

8. The raw **.tif** **IMS** images are automatically saved during image collection to the **DATA** folder.

**IMPORTANT:** IODP provides two methods for processing the raw images:

- a. **Automatic Image Processing:** A program written in LabVIEW. Processing is automatically completed by the software after images are collected. User is able to make adjustments using the Image Process Utility under the Instruments menu. The processed image is given a scale bar with the correct offset and the core identification information is overlaid at the top of each image.
- b. **Manual Image Processing:** A program written in "GO". User must initiate and control the image processing settings. Scale bar provided is 1 cm black and white lines along the left side of the image. A stitching guide is also provided on the processed image.

### X-Rays OFF

Figure 20 will be displayed when the X-ray Off command is sent to the CP120. The window will be displayed until the kV has been confirmed to be at zero.

You will also see this window flash on during X-Ray START when the CP120 fails to respond to the start command. The X-ray off will reset communications with the CP160 and bring it to a known state which will clear any communication issue.



Figure 20. X-ray Off Status Window

**NOTE:** During imaging, the user can use the software abort button to end the imaging process and ramp down the source. The abort button is available when the x-ray source is ramping up and during the imaging process.

If the abort button is used, a dialog window will appear (Figure 21). Once pressed, imaging will end and the user will need to start imaging the section from the beginning. Dialog window options are:

**Return to Load Position:** Actuator returns to the home position. User will need to manually remove core.

**OOPS! Please Continue:** The software will continue with the measurement.

**Stop and Do Nothing:** Actuator will remain in place. Use this option if the section had jammed in the XMSL or is there is a hardware issue..

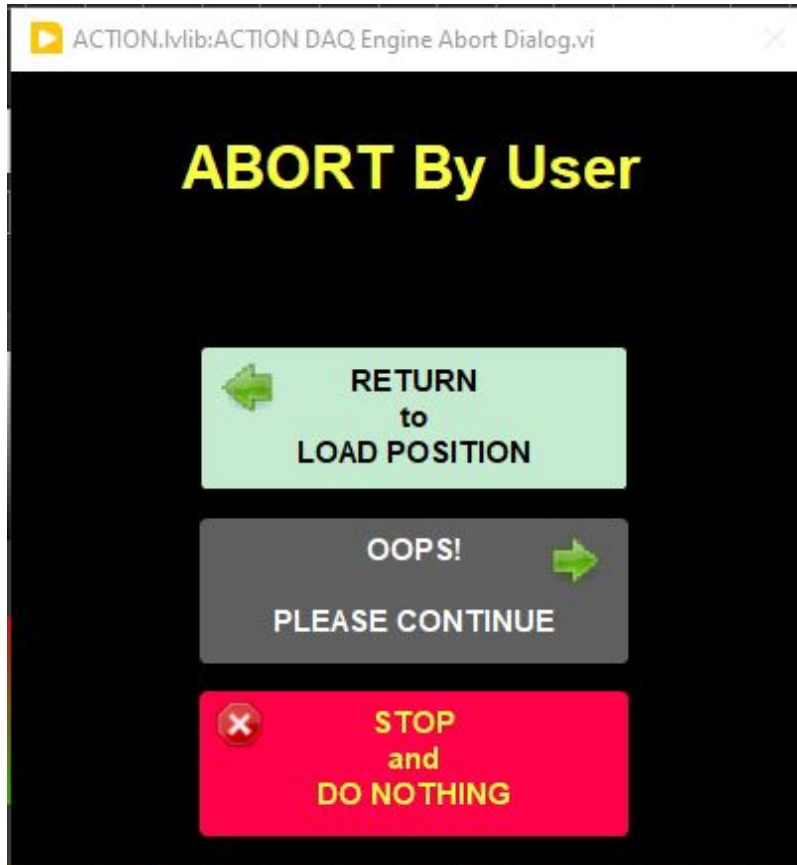


Figure 21. Dialog when after user selects abort during imaging. The x-ray source will automatically ramp down once abort is selected. The section in the imager will need to be restarted from the beginning once abort is selected.

## G. IMS Utilities

### a) XMSL: Image Utility

The image utility can be found under **Instruments > XMSL: Image Utility** (Figure 22). This utility is useful for determining the proper voltage, current, and integration (exposure) time for imaging cores. User can also review the processed images in this utility.

1. Adjust the integration time, number of images to stack, kV, and mA on the right side of the window (Figure 22).
  - a. **REMEMBER:** Lower voltage with a longer exposure time may increase image contrast. High voltage does not equal better images.
2. Select **Take TEST Image**
3. Wait for the x-ray source to ramp up and collect x-radiographs
4. Review the test images
5. Repeat process until image is acceptable
6. Note the settings. For these settings to be used, the user needs enter them under **DAQ > Measurement Editor**

7. Select **Close** to return to the main IMS window.

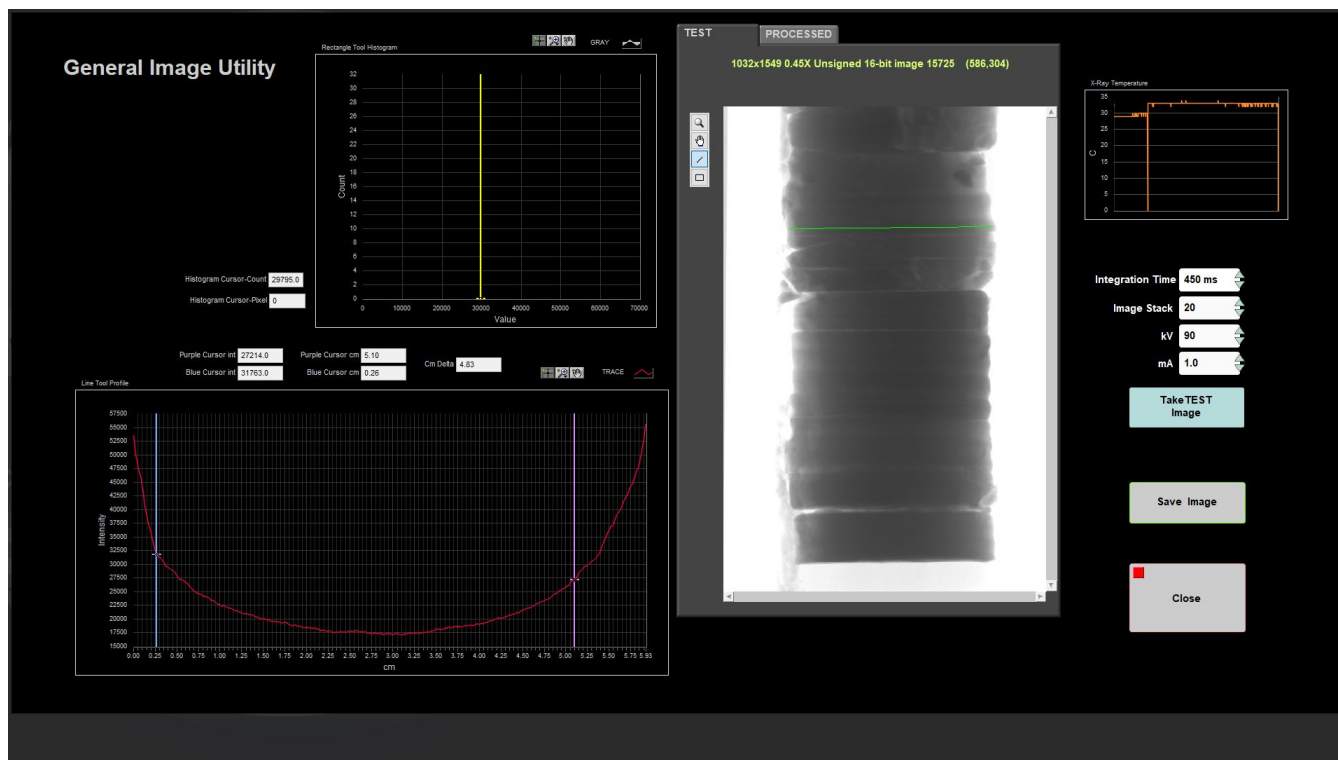


Figure 22. General Image Utility User Interface Window. This utility is used test exposure settings before imaging a section. The histogram (upper left) will be displayed when the ROI box tool is used and the line profile (lower left) is displayed when the ROI line tool is used.

## b) Automatic Image Processing - XMSL: Image Process Utility

Image Processing Utility has the following purpose:

1. It allows the user to experiment with the processing parameters to determine the correct setting for the desired processed results. The values can then be saved and use for all subsequent in-line image processing.
2. The utility can be used to mass reprocess images.

Select **Instruments > XMSL: Image Process Utility** from the **IMS** panel menu (Figure 3). The user interface will open (Figure 23).



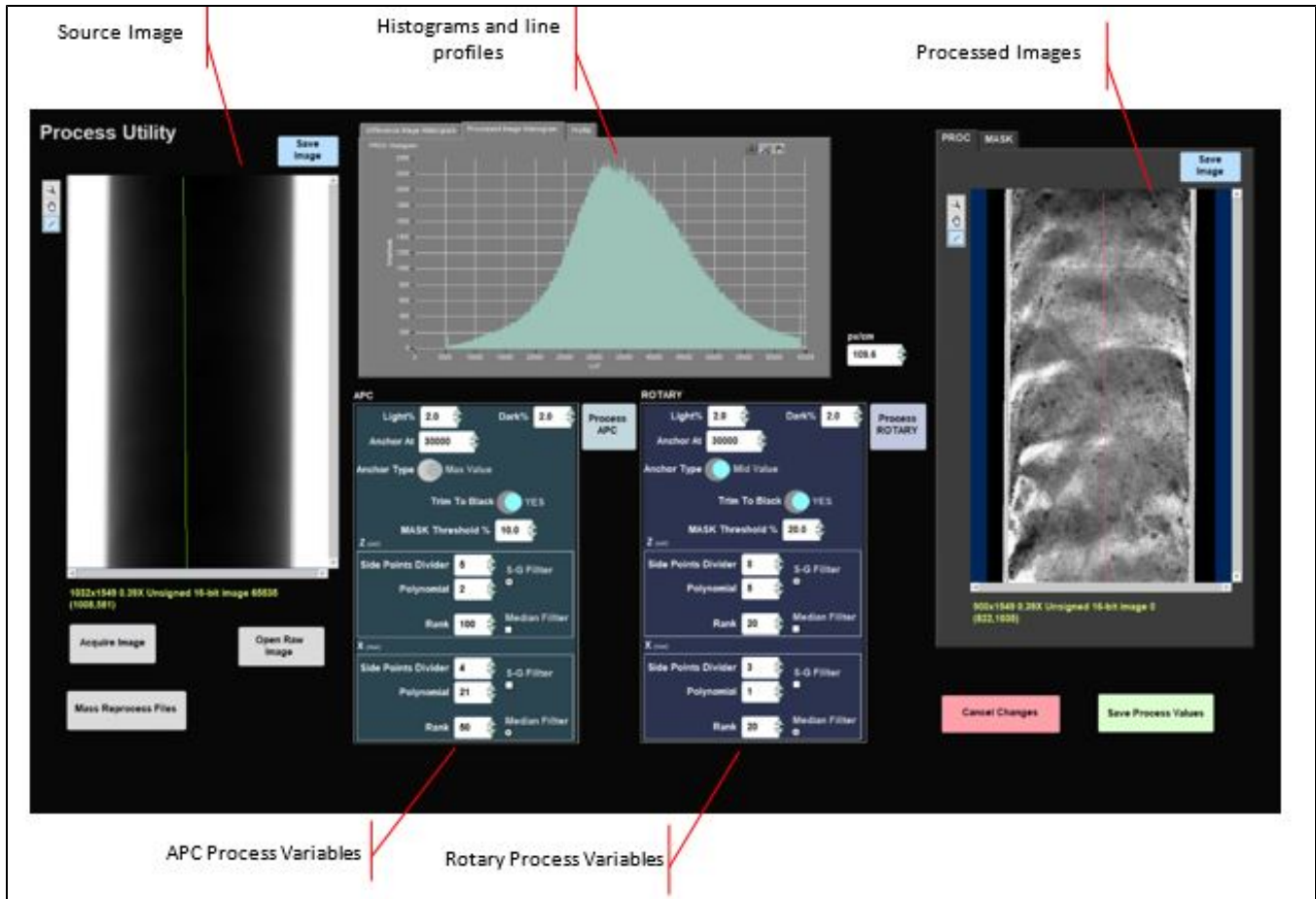


Figure 23. Image Processing User Interface Window. The screen is divided into 4 main sections. The user may test image processing settings and apply them to any previously collected images or subsequent images.

Note this is the display after an image has been selected. If no raw image has been selected or acquired, this window will be blank.

### User Interface Layout

The user interface window is divided into four areas.

1. On the left is a window that will contain the raw source image for the process testing. This can be load from an existing raw image (click **Open Raw Image**) or a new acquired image using the x-ray source (click **Acquire Image**). The raw image used should be an image taken with the planned exposure parameters. (Figure 23)
2. On the right-hand side is a tab control that will display either the masked image or the final processed image.
  - a. All three image displays will allow you to draw a profile line across the image using the ROI image tools. (Figure 24 and 25)
  - b. Any line drawn on one image display will be shown on the others but the content of line profile will only be from the image where the line was drawn.
  - c. In the center top of the user interface window is a tab control which allows the user to view the line profile, histogram of the difference image, or the expanded histogram of the processed image.
  - d. In the bottom center of the user interface window are the controls for image processing. The software provides for two process variable groups. The APC parameters are applied to core types "H" and "F" and ROTARY is applied to all other core types. The **Light%**, **Dark%**, **Anchor Type** and **Anchor At** controls apply to the histogram expansion and will apply to the images immediately as their values are changed. The other control values apply to the smoothing process and require that you click either **Process APC** or **Process ROTARY** buttons to apply the changes to the processed image displayed. You'll to set process variables for both types when drilling an APC/XCB hole. How the process parameters work will be discussed later in this document.

If you wish to safe a copy of either source or processed image, there is a **Save Image** button just above the display you can click.

Once you are satisfied with the processing outcome, you may apply these to an existing set of raw images by clicking **Mass Reprocess Files**. A file dialog box will open where you will select a folder that contains images. All images found in the folder will be processed. The reprocessed files will be saved to C:\Reprocessed\_ *timestamp*. You will be given the option of retaining the original file timestamp or a current timestamp in the file names. If you plan to replace existing processed files in LIMS, then you should use the original timestamp. Use the current timestamp to create duplicates.

If you want save the process parameters and use them on newly acquired images, click **Save Process Values**; otherwise click **Cancel Changes** to revert to the existing values.

Figure 23 Image Processing Utility User interface. The user may test image processing settings and apply them to any previously collected images or subsequent images. Note this is the display after an image has been selected. If no raw image has been selected or acquired, this window will be blank.



Figure 24. ROI tool available in the image processing utility. The histogram or line profile will be displayed when the ROI tool is used. A line will produce a line profile. A box will produce a histogram.



Figure 25. Example of ROI tool used on a raw image and the resulting intensity profile.

### Getting An Image

Before you can begin experimenting with the settings, you need to open an existing image or acquire a new image. If you are opening an existing image make sure that it is a "raw" image. If you are acquiring an image make sure that the FPD calibration has been done and the exposure parameters set appropriately. Click either the **Open Raw Image** or the **Acquire Image** button.

### Processing Parameters

The processing parameters can be set in any order after completing the "Getting An Image" steps. But the Mask Threshold value must be valid; otherwise subsequent processing steps may fail or produce undesirable results. Also, keep in mind not all combinations of parameters will work.

MASK threshold.

The image mask is used to isolate the core image from the empty detector's background, which normally is made up of overexposed pixels that we do not want to process (Figure 26). The mask is very dependent on the exposure settings, so any time the exposure values (kV, mA or integration time) change, the Mask Threshold value needs to be reviewed.

We create an image mask by setting pixel intensity to zero where their values lie in the upper range based on a user selected percentage. The formula is as follows:

$$Threshold = MaxPx - ((MaxPx - MinPx) * n)$$

Where **MaxPx** and **MinPx** determined from the entire image ignoring values equal to 65534 (oversaturated pixels) and **n** is the user set percentage.

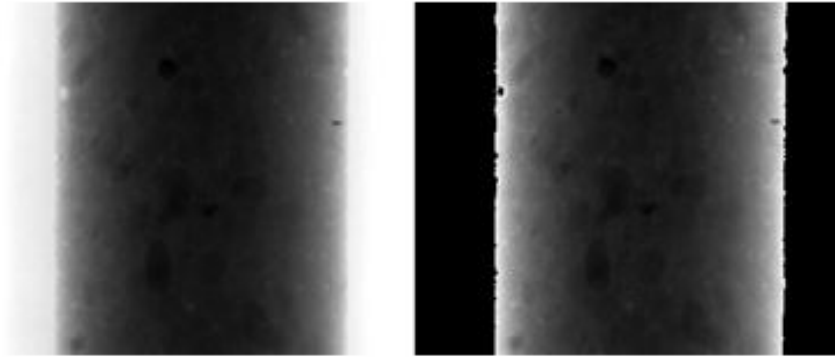


Figure 26. Example image before the mask is applied (left) and after (right)

#### Image ROI

Using the mask, we locate the right, left, top and bottom edges of the core in the image (Figure 27). Using these values we center the core left-to-right and crop the bottom and top as necessary. This is repeated for the original mask, as well.

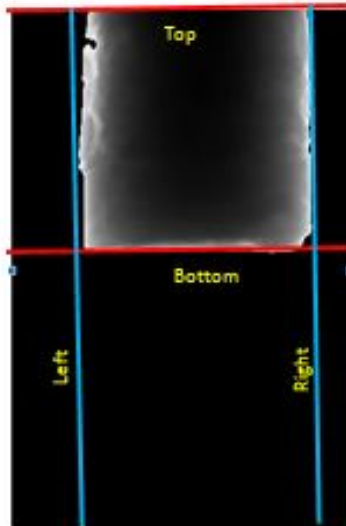


Figure 27. Selecting the region of interest to exclude the blank detector

#### Image Smoothing: Flattening

The best way to understand the image smoothing process is to look at the pixel intensity profile across the core (Figure 28). The black line is the profile of the original image. The variation due to the core thickness is greater than the variation due to internal sedimentary structure/particles. The red line is the same profile after smoothing.

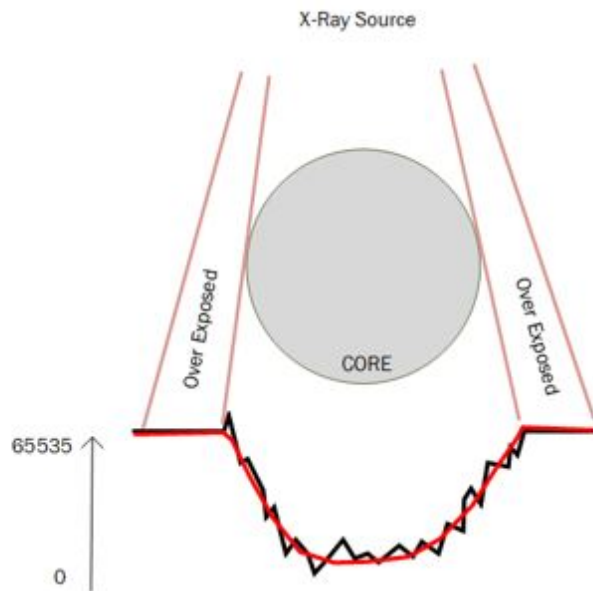


Figure 28. Pixel intensity profile across the core (black line). Note that the variation due to core thickness is larger than the variation due to sedimentary structure. The red line is the smoothed profile.

Subtracting the smoothed intensities from the original intensities will produce a difference image that ranges across zero with the resulting profile shown in Figure 29, removing the effects of the core's thickness on the image.



Figure 29. Difference Image profile

Next, the difference image is offset by subtracting its minimal value. This step is necessary to insure that we are working with only positive values. The above profile shifts as shown in Figure 30.



Figure 30. Difference Image profile offset to positive values.

The following is description of the image processing in detail:

1. The masked image is cast to a 2-dimensional array of floating-point values.
2. The array is indexed to process each column first, which is the parallel to the core's Z-axis (along core). Each column of pixels is processed by using the Savitzky-Golay FIR or Median smoothing filter. Different methods may be used for the row (X) and column (Z) smoothing passes.
  - **Savitzky-Golay FIR smoothing:**
    - Side-point divider: The length of the row or column is divided by this value to determine the length of the side points used by the smoothing operation. A large value means shorter side point length. **Note**, using values below 3 for the Z axis will significantly increase the processing time!
    - Polynomial: Determines how close the smooth curve fits the original data. For the X-axis this should be set high to conform to the whole or half-round attenuation pattern. Low values will cause "ripples" on the side edges. For APC cores, the Z-axis value should be set near two. For rotary cores, the Z-axis value should be set closer to seven. The value will depends on how disturbed the core is and experimentation is needed to get good results.
  - **Median Filter:** Rank is the length of values used in the filter operations. Small rank values are more responsive to shape changes but will cause fine details to disappear.
3. The resulting array is then processed by row using the values set for the X-axis settings. This results in an array of "smoothed" values.

4. This array is then subtracted from the original and offset into positive values by subtracting the minimal value of the entire array.
5. The resulting 2D array is cast back to U16 image (Unsigned 16 bit format), referred to as the **difference** image.

#### Trim to Black

This effects how the smoothing operators (above) are applied. If this value is set **false**, then the above process is applied to the entire mask image including the mask. If it is set to **true**, then the mask is not processed. This is important for rotary cores where the edges are irregular and core gaps are common.

#### Image Contrast Expansion:

- The difference image is unusable as the final processed image. The contrast range is very small, its histogram is narrow and the image is nearly uniform gray (*Figure 31*). To create a usable image, the contrast must be expanded.
- U16 images have an intensity range of 0 to 65354 and we will expand the contrast into a 5000 to 60354 intensity interval.
- All of the information is contained in a narrow band of intensities. To locate this band, we need to determine 3 points in the histogram: the first two points are the indices the histogram values exceed a user specified percentage of the maximum intensity. These indices are found by searching from the dark side of the histogram (blue cursor) and then the light side (red cursor). The user sets these values using the **Dark%** and **Light %** controls (*Figure 23*).
- The third point is either the index of the histogram maximum or the index of the mid-point between the dark and light indices as selected by the user using the **Anchor Type** control.
- The user then selects the new intensity value to anchor 3<sup>rd</sup> point too in the histogram using the **Anchor At**. The dark side intensities are expanded from this value to 5000 and light side expanded up to the 60353 values.
- Intensity values below and above the threshold percentage will be compressed into the 0-5000 and 60354-65354 ranges respectively.

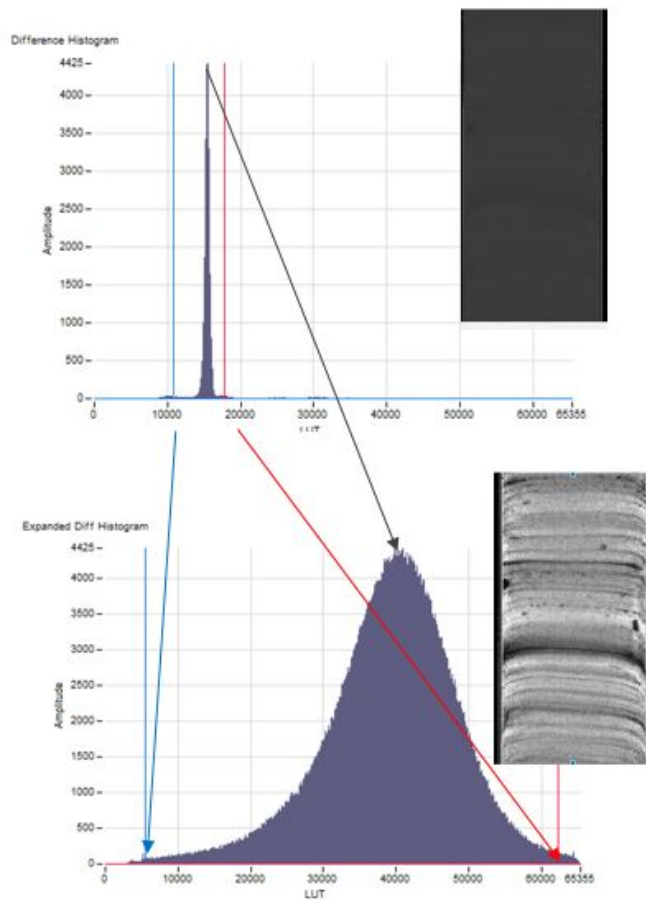


Figure 31. Image Contrast Expansion example. The top image is the difference image prior to the expansion. Note the overall grey raw image. In the lower image, the contrast range has been expanded. The sedimentary structures are now visible within the image.

With the expanded histogram the same cross-core profile shown in *Figure 30* will now look like *Figure 32*. Example images of the processing steps are shown in *Figure 33*.



Figure 32. Cross core profile after expanding the histogram

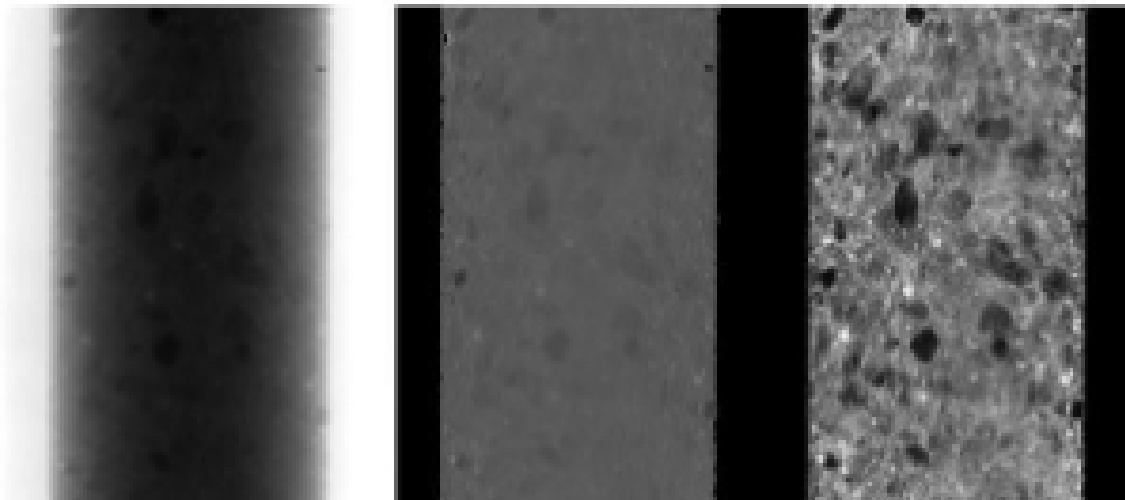


Figure 33. Original image (left), difference image (raw-smooth) (middle), and the difference (flattened) (right) image with the expanded histogram.

#### Final Touches

Before saving the image, a scale is generated based on the image center offset and a scaling factor of 109.6 pixels/cm is added to the left-hand side of the image. A header is then added to the top of the image with the label id, text id and the exposure parameters (kV, mA, integration time and number of images stacked) (Figure 34). Processed images are saved to the C:/AUX\_DATA folder on the host computer.

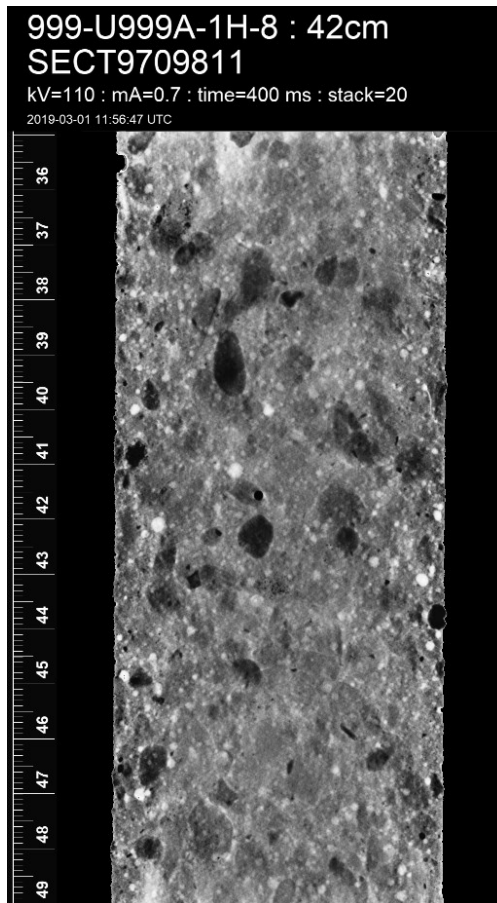


Figure 34. Final processed image with header and scale

#### Considerations:

This process does not require geometry of the system but is based solely on the content of the image to produce a processed image. This technique is very good at showing fine scale changes in the image. That means it very good at showing noise and the irregular surface of rotary cores! To produce a good image you need to consider the following:

**Image Stacking:** You must take a sufficient number of images to suppress the random noise that is common to X-ray images. It is recommended that you stack at least 20 image.

**Offset and Gain Calibration:** Seeing a grid pattern or fine streaks in the image? This indicates that the gain and offset calibration was not done or done incorrectly. Remember that the dark image is not truly "dark" but "dark grey". Use minimal exposure to capture the grid pattern and the thermal noise of the detector. Also, make sure that the "white" image is not oversaturated.

**Exposure Setting:** As lithology changes, you will need to properly adjust the kV, mA of the source and the integration time of the detector. As this is a new system, we have no hard guidelines yet, so it is necessary to experiment with different setting using the **Image General Utility**. Your goals are to capture an image where: 1)the minimal intensity value is greater than 5,000 and 2)there is enough contrast between the core edge and the empty detector so that the masking process can identify the core boundaries in the image. The core liner should nearly disappear in the raw image without eroding the edges of the core.

**Rotary Cores:** XCB and rotary cores are often damaged by the coring process. The rough surfaces will be seen in the images and will often obscure sedimentary structures. There is also cuttings and other muck between the core and liner that will degrade the image. Imaging the section-half instead of the whole-round sections may improve the image. Also, keep in mind that the values used in the processing are selected to produce the best APC core images where the core material fills the entire liner. Rubble and pieces will often show halos (areas of dark) around the edges.

**Greyscale Changes:** Each image is processed alone based on its content and this will result in greyscale shifts between images. This will be noticed if you attempt to splice the images together.

**Scale:** The scale in the final image is only as accurate as the information used to create it.

1. The axis of the source's x-ray beam must centered on the detector and perpendicular to its surface.
2. The pixel to centimeter scaling factor must be determined. As of X379 this value was determined to be 109.6px/cm when measured at the half-core height. A grid standard is available for use to repeat the measurement
3. In IMS, you must set the instrument offset to the center row of pixels of the detector.

### c) XSCAN Automatic Image Processing

This utility was designed to be used on the XSCAN. During X396T it was implemented on the XMSL with the purpose of testing it in subsequent expeditions.

The utility allows the user to have greater control over the process that is being applied to the images.

### d) Manual Image Processing

The IODP processing algorithm is available in a Linux and PC version and can easily be placed on any work station. This program allows the user to adjust the contrast and change settings related to instrument setup and geometry. The processing software files must be placed in a directory above the location of the images to ensure file navigation will work.

These instructions will work for Sherlock (vendor proprietary software for collecting images) or IMS collected .tif images as long as the program is properly configured. If you are switching between software packages, beware! The raw images are not identical and settings must be adjusted. For a more in depth explanation of the math behind this program, follow the **Math Documentation** link once the program is open in a web browser. For ease of processing, it is best to have the raw files sorted into the groups that you wish to process together (whole core, single section, etc).

Prior to processing, ensure that the xrayImgProcessing\_1.0.1 executable, the static folder, and the setup.cfg are in a folder one level above the location of the images to be processed (Figure 35). It is recommended that the processing software be placed in the Data folder, (C:\Data). The images will be saved to the C:\Data\In folder.

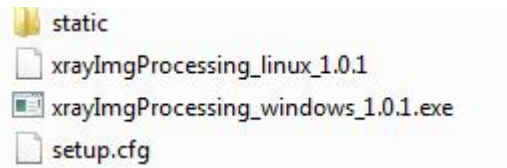


Figure 35. X-ray image processing software files needed for image processing

#### Process a raw image

1. Open xrayImgProcessing\_windows\_1.0.1.exe on a PC (or Linux version on a MAC)
  - a. This will trigger a command window to open (Figure 36). This command window will display the program status as images are processed. Refer to this screen to review what the processing software is doing or to check for any errors.

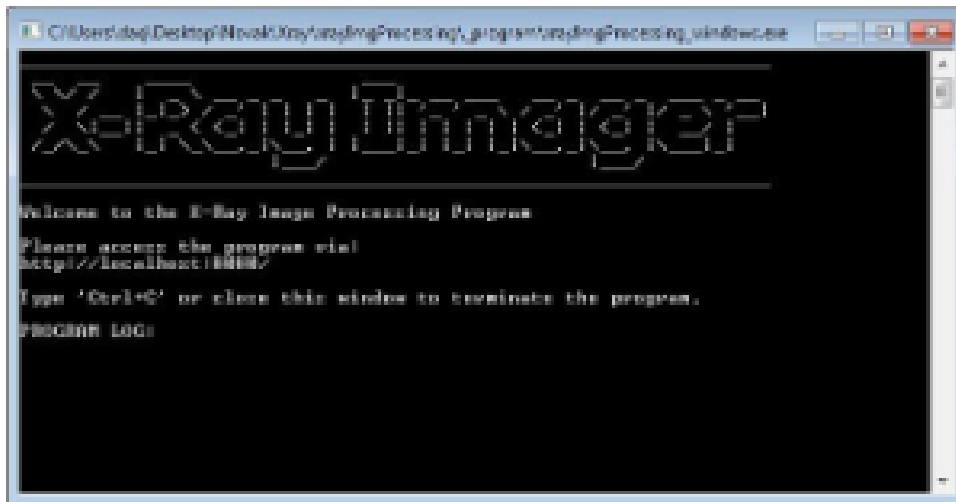


Figure 36. IODP processing X-ray Imager software command window



2. Open an internet browser window and enter/copy the local host address, <http://localhost:8080/>, from the X-ray imager command window
  - a. The X-ray image processing window should open (*Figure 37*).

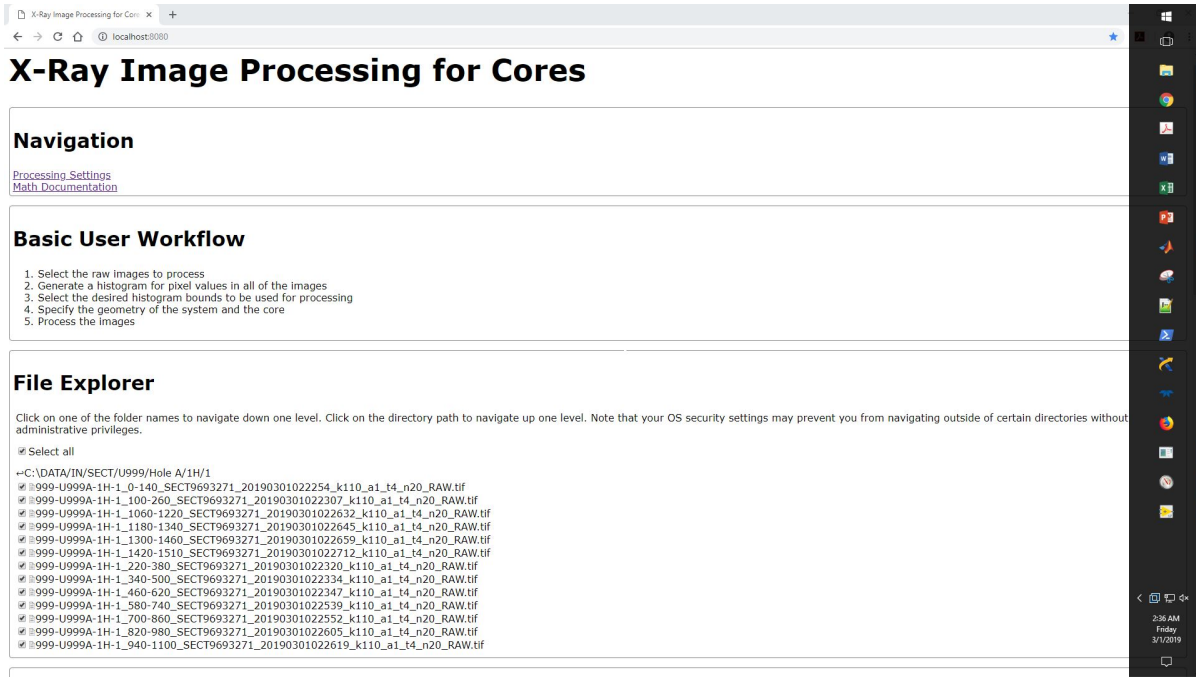


Figure 37. IODP X-ray imager processing window

3. Select the **Processing Settings** link under the Navigation heading. This step is only necessary when first configuring the program or when changing file types.
  - a. The settings window will open (*Figure 38*).

# Processing Settings

## Navigation

[Main Page](#)  
[Math Documentation](#)

## Settings

### Instrument Geometry

Source height above detector (cm)

65

Core height above detector (cm)

0.4

Motion of core between images (cm)

12.5

### Detector Settings

Pixel height of detector

1550

Pixel width of detector

1032

Size of each pixel (cm)

0.0099

Number of bits used to store raw data (may be less than bit size of image)

14

Figure 38. Processing Settings Window

4. Set Instrument Geometry values (*Figure 38*):
  - a. **Source height:** 65 cm, value will only change if source height is changed physically
  - b. **Core height above detector:** 0.4 cm, value will only change if detector position is changed physically
  - c. **Motion of core between images:** 12 cm, value will only change if software is manually changed
5. Set Detector Settings (*Figure 38*):
  - a. If processing IMS raw images:
    - i. **Pixel Height of detector:** 1549
    - ii. **Number of bits used to store raw data:** 16
  - b. If processing Sherlock raw images:
    - i. **Pixel Height of detector:** 1550
    - ii. **Number of bits used to store raw data:** 14
  - c. For IMS and Sherlock raw images:
    - i. **Pixel Width of Detector:** 1032, value will change if a different detector is installed
    - ii. **Size of each pixel:** 0.0099, value will change if a different detector is installed
6. Set Histogram and Core Axis settings (Optional!)
  - a. See *Figure 39* for default values

- b. User can adjust these values, but these settings should not need to be altered in normal operation.

## Histogram Settings

Pixel height of histogram image  
600

Pixel width of histogram image  
800

Number of bins used for histogram  
256

Red value in RGB color of histogram bars  
66

Green value in RGB color of histogram bars  
134

Blue value in RGB color of histogram bars  
244

## Core Axis Settings

Fraction of maximum pixel value that defines the presence of core (core if  $I_{raw} < \text{Fraction} * I_{max}$ )  
0.9

Minimum fraction of core diameter used for edge detection  
0.7

Maximum multiplier of core diameter used for edge detection  
1.2

Polynomial coefficient used to weight pixel intensities for center of mass  
1

Number of times data is filtered during core axis regression  
3

Maximum core angle that automatic detection can calculate (°)  
5

Figure 39. Histogram and Core Axis settings default values

### 7. Adjust Thickness Compensation settings and scale bar settings (Optional!)

a. See Figure 40 for default values

b. Thickness **compensation**:

i. **Minimum Core Thickness Used for Compensation**: Set at 0.5 as default. Adjust these values to change how the software corrects for core thickness. XCB and RCB cores are narrower and may require different compensation values than APC and HLAPC cores. Larger values exclude more of the image from the correction (Figure 41).

ii. **Maximum Core Thickness Used to Define the Edges**: Adjust this value to change the thickness of the black bars indicating the edges of core diameter. Set to zero to remove these lines from the processed images.

c. **Scale Bar Settings**: Adjust these settings to change how the scale bar is projected on the processed image.

## Thickness Compensation Settings

Minimum core thickness used for compensation (values below this will not be adjusted)

0.5

Maximum core thickness used to define the edges ( $0 < \text{edge} < T_{\text{edge}}$ )

0.5

## Scale Bar Settings

Width of ruler prior to projection (cm)

0.2

Width of ROI bar prior to projection (cm)

0.1

Pixel width of border around scale bars

2

## Update Settings

Save

Figure 40. Thickness Compensation and Scale Bar Settings Default values

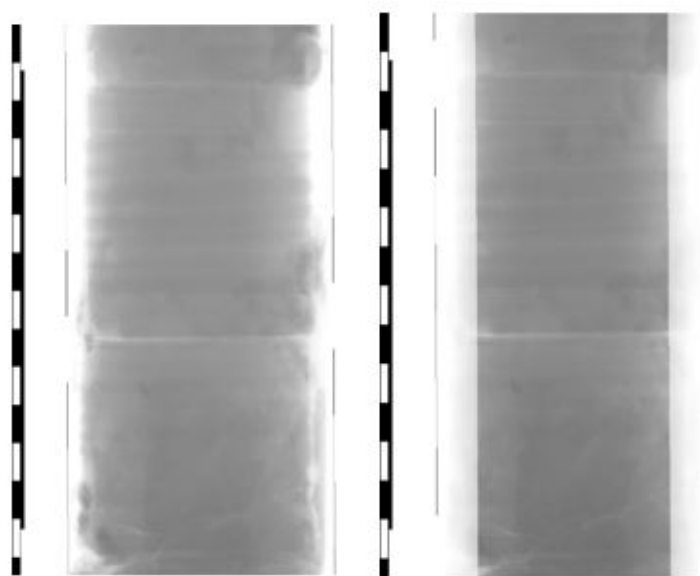
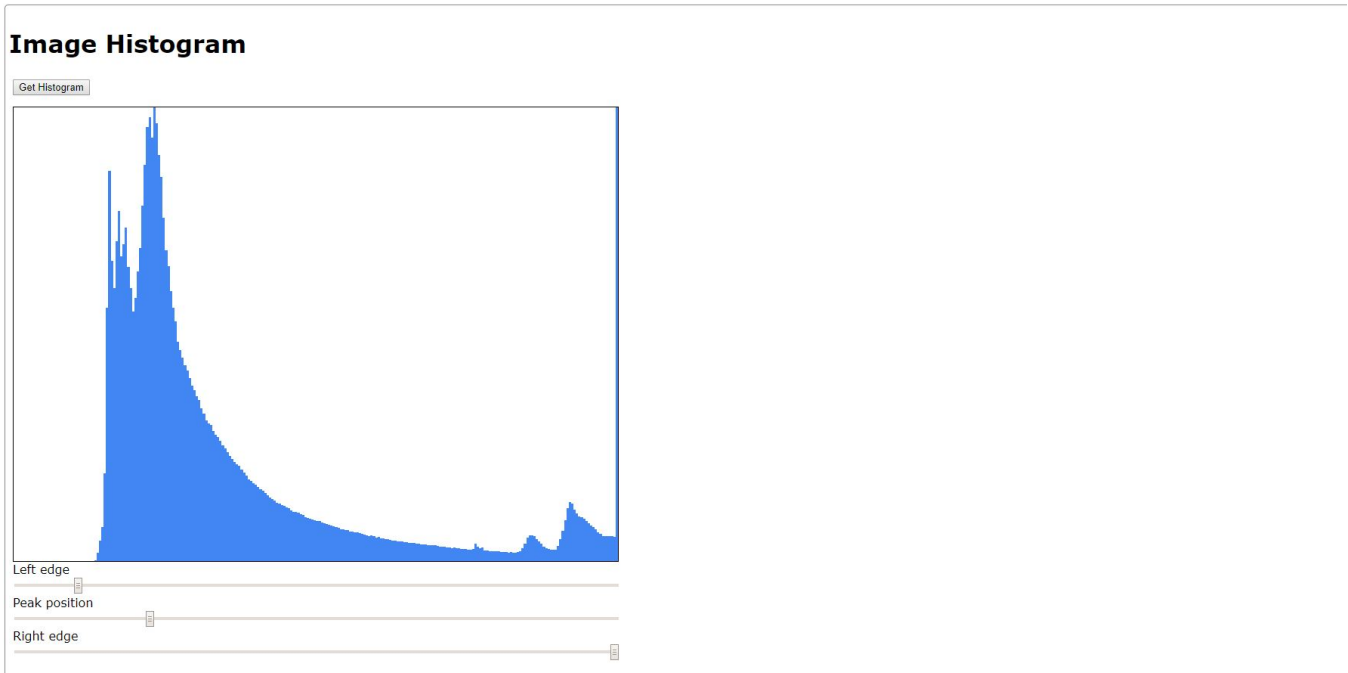


Figure 41. Minimum Core Thickness Compensation Example images. The compensation values for these images are 0.5 cm (left) and 5 cm (right). Notice the narrowed corrected image on the right.

8. Scroll to the bottom of the page and select **SAVE** under the update settings header (Figure 40).
9. Return to the top of the page and select the **Main Page** link. This will return you to the main image processing window (Figure 38).
10. Under the File Explorer heading, navigate to the location of your files (Figure 37).
  - a. The initial address displayed will be the location of the executable file used to open the command window. If you place the `xrayImgProcessing_windows_1.0.1.exe` and associated files (Figure 356) in **C:\Data**, you will only be able to navigate to files that are also stored in the Data folder.
  - b. Use single clicks when selecting a folder
  - c. Use the arrow at the left side of the screen next to the address to go back a folder.
11. Select the raw **.tif** files you wish to process
  - a. Use the **Select All** check box if you wish to process everything within the folder

12. Select **Get Histogram** below the Image Histogram header (*Figure 42*).
  - a. See Troubleshooting section of manual if the histogram appears abnormal (small, bars far apart, etc.)
13. Use the sliders below the histogram to adjust how the image will be processed.
  - a. The left edge slider will make the image darker the further you go to the right. Place this near or at the left edge of the histogram
  - b. Place the Peak Position slider under the main peak of the histogram.
  - c. The right edge slider does not need to be adjusted, but it may help image quality
  - d. This process may need to be done multiple times to find the best settings.



*Figure 42. Image Histogram from x-ray image processing software*

14. Adjust the settings under the Process Images header to match with the image setup (*Figure 43*).
  - a. **Core Dimensions:** Select if the images are for a section half or whole round core
  - b. **Diameter of the Core:** This setting determines how wide of an area of the image is used in the corrections. If this is too wide (includes blank detector) or too narrow (excludes parts of core) the corrections will not work appropriately.
    - i. Set to 7.0 cm for APC cores that fill the liner
    - ii. Use values as close to the core diameter as possible, this may take some experimenting.
    - iii. If wide core (7.0 cm) and narrow core (4.0 cm) are in the same image, the processing will need to be done twice, possibly with the images separated into narrow vs wide batches (*Figure 44*).
  - c. **Axis Determination:** Used to correct for core not being centered over the detector or not being parallel with the sides of the detector when imaged.
    - i. Use the default **Auto Detect Core Axis** in most cases
    - ii. If Auto Detect does not produce satisfactory images, use the **Set Core Axis** option and experiment with settings.

# Process Images

## Core Dimensions

- Whole round
- Half round

Diameter of core (cm)

## Axis Determination

- Auto-detect core axis
- Set core axis

Angle of core axis, counter-clockwise (°)

Core axis offset from center of image (cm)

## File Names

Name of output folder

String to append at the end of the file name

## Process

Figure 43. X-ray image processing screen. Adjust the core settings and folder name before processing images

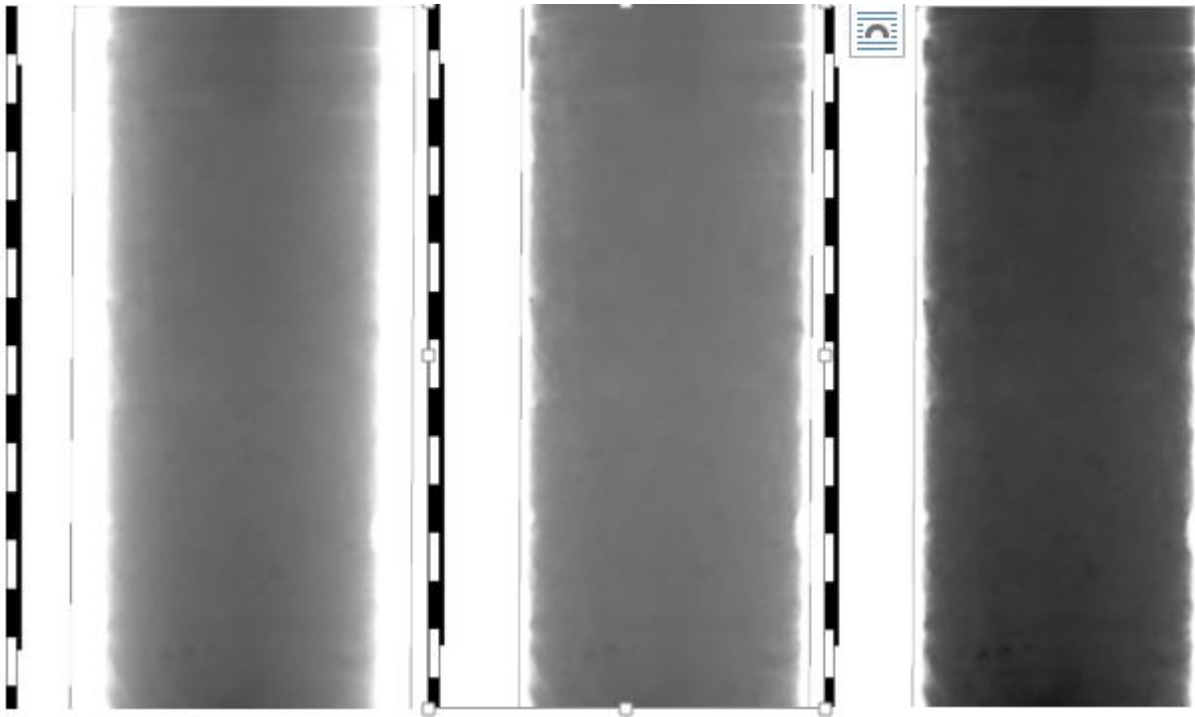


Figure 44. Core diameter adjustment example images. This section of core contained full liner with narrowed sediments in between. The left and middle image were processed with the entire section, whereas the image on the right was processed individually. The diameter of the core is set at 7.0 cm in the left image and is set to 6.0 cm in the middle image and right image. Note that in the individually processed image, some smaller clasts are visible.

15. Under the File Name header:

- a. Input the Name of the output folder. Recommended name is **processed\_core# core type-section #**, ie processed 2H 2
  - i. The folder will be placed in the same location as the raw files
- b. Optional: Enter a string to append to the end of each processed file

16. Select **Process Files** under the Process header.

17. Navigate to the location of the processed files and review the images.

- a. If the images are not satisfactory, return to the histogram and make adjustments. Simply select Process Files and the original processed files will be overwritten in the folder.

Troubleshooting:

1. Image edges are dark after manual processing (Figure 45): The value entered for core diameter is too narrow. Increase the core diameter value and reprocess the images.

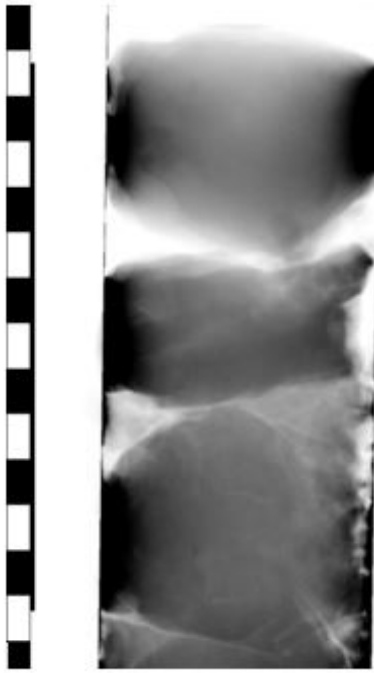


Figure 45. Example of manual processing when the core diameter is set too narrow.

2. No images appear after selecting Process Images: The bit size or pixel length are not set correctly. Check the command window for error messages and check the settings in the processing settings window.

### e) XMSL: View Last Images Utility

**View Last Images** utility can be found under *Instruments > XMSL: View Last Images* (Figure 45B). This utility is useful review the characteristics of the selected images.



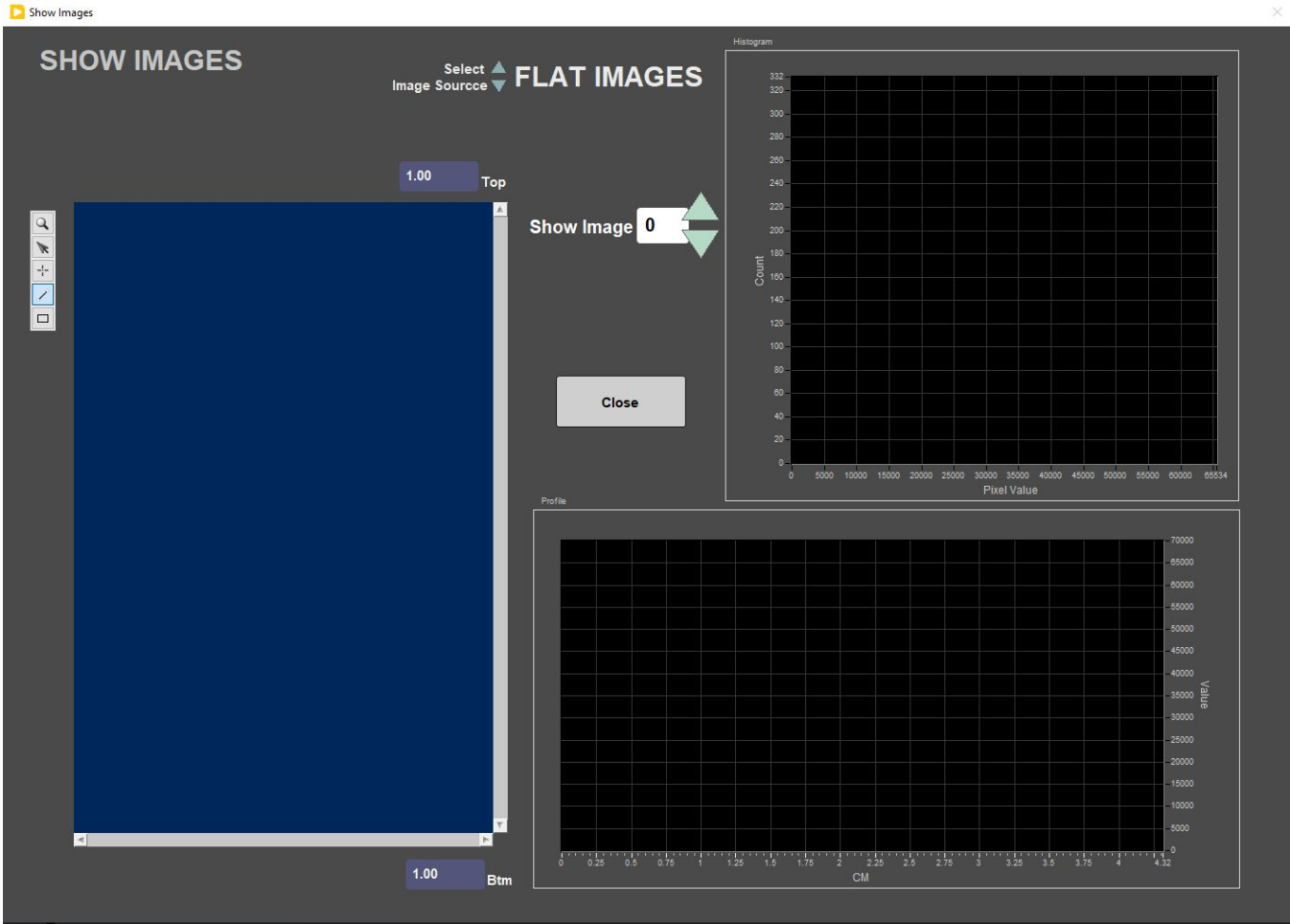


Figure 45B. View Last Images utility

### III. Transferring Images to Data 1

#### A. Data Upload Procedure

Images are transferred to **Data 1** via a script on the XMSL host PC. The script copies the output from the **XMSL** to **data1** automatically and is executed via a task scheduler every 30 minutes.

The script:

- Connects to **Data:\Data1\7.3 Petrophysics\_XRAY** directory
- Mirrors the **Data** and **AUX\_DATA** directories on the host PC (currently XMSL is PC53236) to a "Mirror" directory via an Xray eDirectory user-account

**IMPORTANT:** This is a "one-way" mirror operation. Whatever changes are made to **DATA** and **AUX\_DATA** directories on the host PC will be mirrored in the location in **Data1**. To make the files permanent in the **Data1** folder, copy the mirror contents to the base folder periodically. To make the script more efficient it is also recommended to remove the already copied files from the **Data** and **AUX\_Data** folders so they are not copied multiple times.

The script will hang if a user logs into the file servers while the script runs. No one should log in to the servers on this computer unless absolutely necessary. Task scheduler will kill the task if the script attempts to run for more than an hour and half.

#### Data File Formats

IMS automatically outputs the raw and processed images. Both file types are .tif images.

**Raw file name:** 379-U1533A-1H-1\_0-140\_SECT9762671\_20190225104523\_k110\_a1\_t3\_n20\_RAW.tif

**Raw file location (section halves):** C:\Data\In\SHLF\Site\Hole\Core\Section

**Raw file location (whole rounds):** C:\Data\In\SECT\Site\Hole\Core\Section

**Processed file name:**

379-U1533A-1H-1\_0-140\_SECT9762671\_20190225104523\_k110\_a1\_t3\_n20\_RAW\_processed.tif

**Processed file location (section halves):** C:\Aux\_Data\FIat Images\SHLF\Site\Hole\Core\Section

**Processed file location (whole rounds):** C:\Aux\_Data\FIat Images\SECT\Site\Hole\Core\Section

**Calibration Images (Dark and Light):** C:\IMS-10\CONFIG\_XMSL\XIMG CALB

DARK and WHITE image files are stored in the I\_PI\_GOSCAN.ini configuration file.

A unique time stamp is appended to each image.

## B. View and Verify Data

Data can be verify in real time on the XMSL PC, or with a delay of 30 min, on **Data1**.

## C. Retrieve Data from Data1

Images can be copied directly from Data1.

# IV. Important Notes

## Safety Systems

The x-ray imager has multiple safety systems in place to ensure a user does not operate the system in an unsafe configuration. **Never attempt to operate the x-ray source without the proper shielding in place!** The safety systems include:

- 1) Visual Light Indications
- 2) Door Switches
- 3) Active Area Monitor
- 4) Emergency Stop Switch

These switches and monitors are wired into one fail safe circuit.

### [Failsafe Circuit](#)

In order to generate x-rays, a series of safety switches must be closed to complete the circuit between the CP160's ground (pin 2) and x-ray trigger (pin 4) of the 6-pin external connector.

In addition, the following CP160 parameters must be set using the menu keyboard on the CP160:

- Settings = SafeySys.Mode
- Trigger = Security

Figure 46 shows the failsafe circuit and the safety switches involved. All switches must be closed before the command from the software to generate x-rays will be performed.

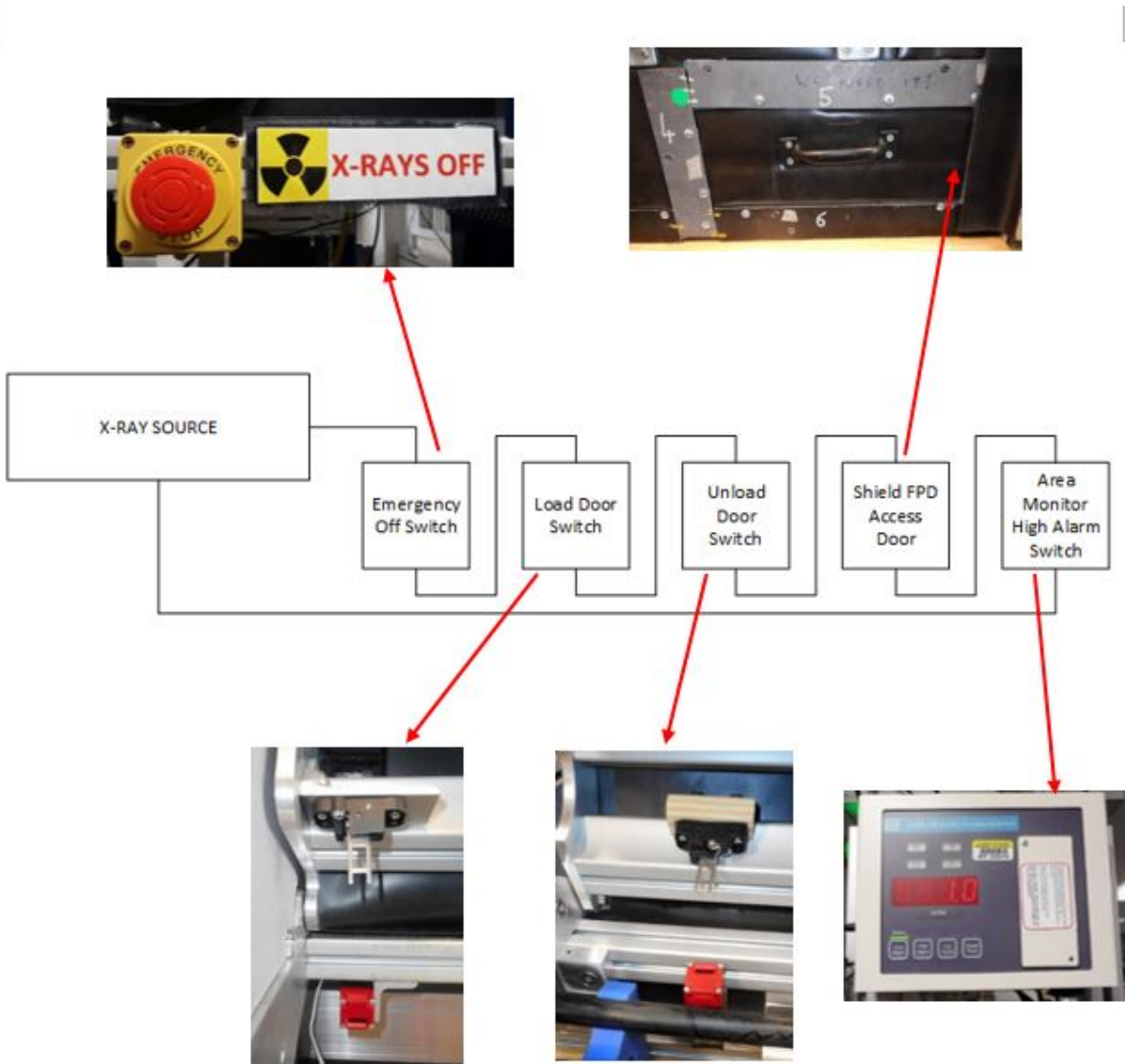


Figure 46. Fail safe circuit diagram.

**Visual Indicators**

A tri-color tower light (Figure 47) mounted on the lead shielded x-ray box acts as a visual indicator of the x-ray source status.

- Amber light is lit when the x-ray source is connected to power.



- Green light is lit when the load and unload doors are closed, FPD access door is closed, and the emergency shut off switch is **not** engaged. (*amber must be lit before the green is illuminated*)



- Red light is lit when x-rays are generated. The light will blink quickly as it powers on and then slowly once the kV and mA are stable.



- When both the amber and green lights are lit, the system is powered and ready to generate x-rays.



- When all three lights are lit, X-rays are on!



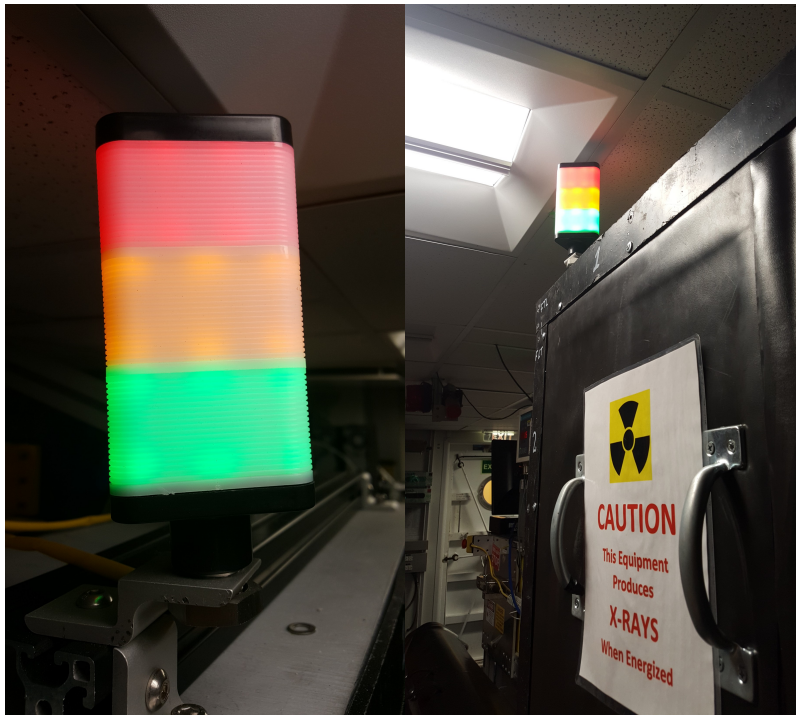


Figure 47. Tri-color tower light mounted on the lead shielded x-ray box. This light acts as a visual indicator of the x-ray source status

#### **Door Switches**

Mechanical door switches have been installed on both the port and starboard doors, as well as on the small hatch in the lead lined box (Figure 48). If any of these switches are open, the communications with the source will be interrupted and the source will not be able to generate x-rays.

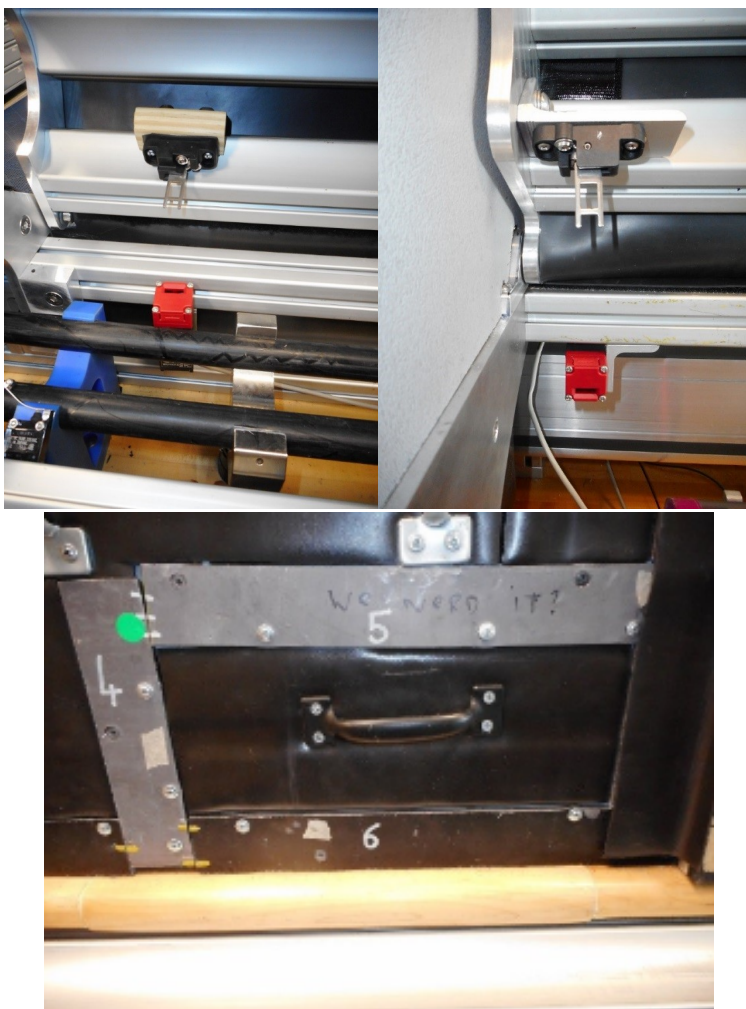


Figure 48. Safety switch inside the port door (left), starboard door (middle), and the hatch where the third mechanical switch is located (right).

**Active Area Monitor**

The purpose of the Active Area Monitor is to provide an independent means of insuring the system's overall safety. The monitor consist of two scintillators mounted at either end of the track so that they view the shielding except for the top and bottom (Figure 49).

Two alarms levels can be set. The low-level alarm will sound a warning beep while the high-level will trigger the strobe light and shut down the x-rays as part of the failsafe circuit. The alarm levels are set as follows:

Low-level: 1-kcps (1000-cps) above background

High-level: 1.2-kcps (1200-cps) above background

*Background radiation levels will change with latitude!*

The goal is to set the alarms high enough so that it does not go off during normal operations with shielding in place; but low enough to immediately sound if the shielding is compromised. The **JR X-Ray Imaging System Safety Inspection and Radiation Survey Forms** provides the procedures for setting and testing the area monitor alarm level.



Figure 49. Active area monitor display (left), high level alarm warning light and port side scintillator (middle), starboard scintillator (right).

### **Emergency Stop Switch**

An emergency stop switch is located over the starboard side shielding (Figure 50). When activated, this switch will interrupt the power to the source and stop the source from generating x-rays as part of the fail safe circuit.



Figure 50. X-ray logger Emergency Shut Off Switch.

## Thermal Management

With continuous running, the CP160 can overheat. The CP160 will shut itself down when the internal tank temperature reaches 55°C. The IMS software continuously monitors the CP160 temperature and displays on the main acquisition screen. If the x-ray source temperature exceeds 45°C the x-rays are shut off and the **Cool Down Wait...** window (Figure 8) is displayed until the temperature drops below 35°C. Once reaching 35°C the X-ray Start command will be given and acquisition will resume. The user may abort at any time by clicking the **ABORT** button.

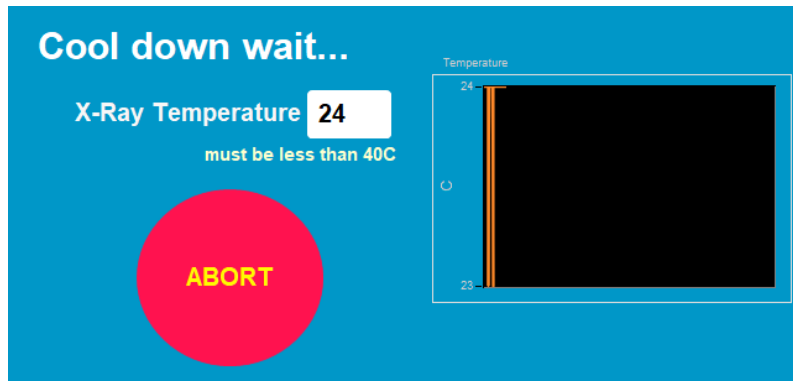


Figure 8- Cool Down Wait window. This window will appear if the IMS software detects an x-ray source temperature of 45 degrees C or higher.

## V. Appendix

### A.1 Health, Safety & Environment

#### Safety

- Keep extraneous items and body parts away from the moving platform, belt, and motor.
- The track system has a well-marked emergency stop button to halt the system if needed.
- Don't insert your hand between the GRA source and the detector
- Do not attempt to work on the system while a measurement is in progress.
- Do not lean over or onto the track.
- Do not stack anything on the track.



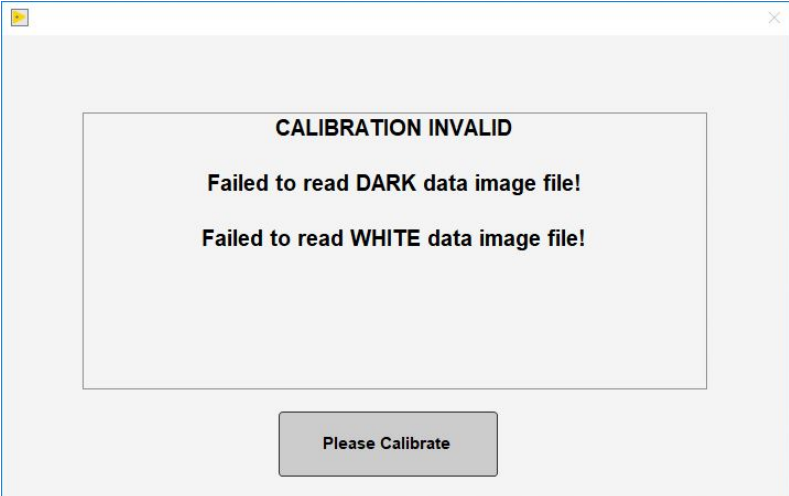
- This analytical system does not require personal protective equipment.

**Pollution Prevention**

This procedure does not generate heat or gases and requires no containment equipment.

## A.2 Maintenance and Troubleshooting

**Trouble Shooting**

Issue	Solution
<p>An error message occurs when the user opens the software indicating an invalid calibration for the dark and white images, but the dark and white images are available on the computer.</p> 	<p>Verify that the .ini files are referring to valid calibration images that exist in the correct locations. If the files exist, then check the USB connections to the computer, particularly the USB for the X-ray source.</p>

## B.1 IMS Program Structure

### a) IMS Program Structure

IMS is a modular program. Individual modules are as follows:

- **Config Files:** Unique for each track. Used for initialize the track and set up default parameters.
- **Documents:** Important Information related with configuration setup.
- **Error:** IMS error file.
- **FRIENDS:** Systems that use IMS but don't use DAQ Engine.
- **IMS Common:** Programs that are used by different instruments.
- **PLUG-INS:** Code for each of the instruments.
- **Projects:** Main IMS libraries.
- **Resources:** Other information and programs needed to run IMS.
- **UI:** User Interface
- **X-CONFIG:** .ini files, specifics for each instrument.
- **MOTION plug-in:** Codes for the motion control system.
- **DAQ Engine:** Code that organizes INST and MOTION plug-ins into a track system.

The IMS Main User Interface (IMS-UI) calls these modules, instructs them to initialize, and provides a user interface to their functionality.

The XMSL system, specifically, is built with one INST module (XMSL), one MOTION module, and one DAQ Engine module.

Each module manages a configuration file that opens the IMS program at the same state it was when previously closed and provides utilities for the user to edit or modify the configuration data and calibration routines.

## **b) Communication and Control Setup**

### **GOSCAN Hardware Setup for IMS**

To use the GOSCAN Flat Panel Detector with IMS it is necessary to make the following hardware configuration in the Window's Device Manger and in NIMAX.

#### **Device Manager**

1. Login as administrator
2. In the window, select the Intel 1350 Gigabit Network Connection (that is the NIC that the GOSCAN is connected to) (*Figure 51*).
3. Right click and select properties.
4. Click advance tab
5. Select Jumbo Packet and set value to 9014 Bytes.
6. Click OK

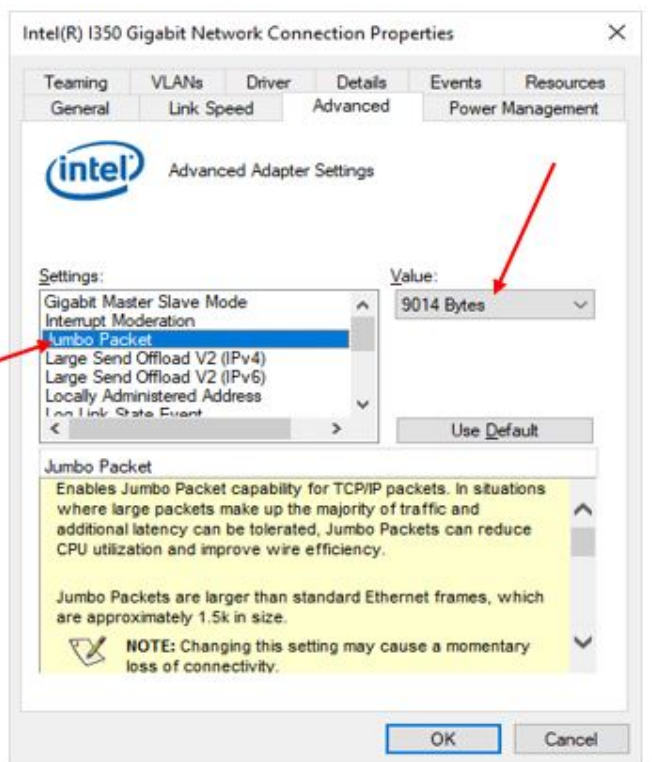
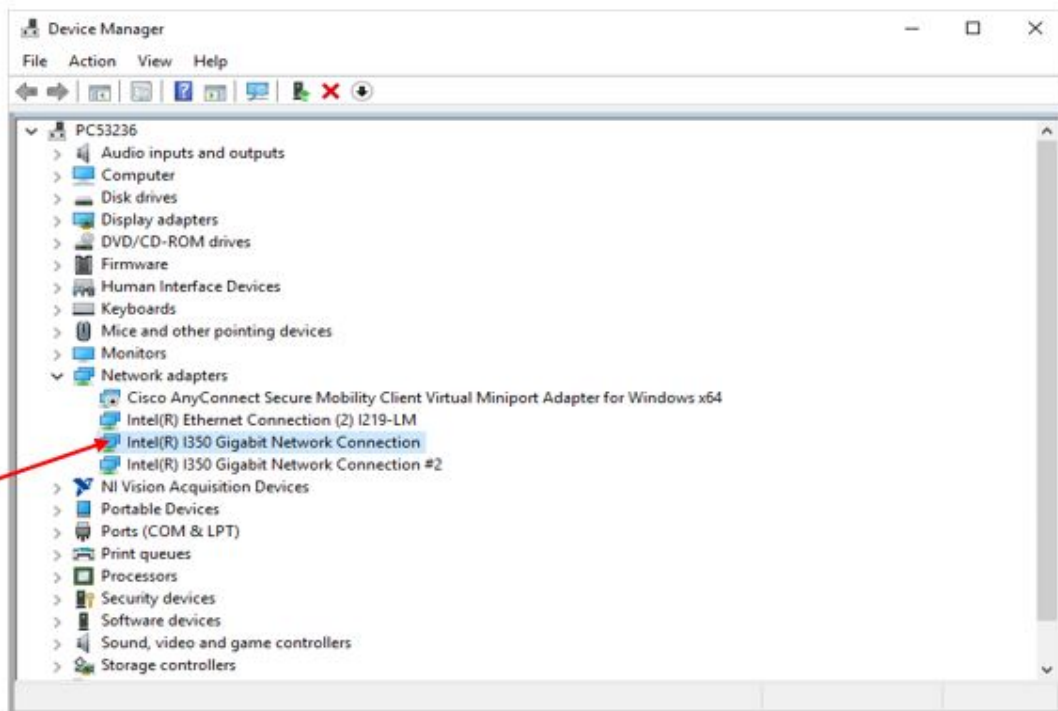


Figure 51. Device Manager window and jumbo packet setup

### NI MAX Configuration

1. Open NIMAX
2. Select **Device and Interfaces>Network Devices> Teledyne DALSA GoScan 1510HR** (Figure 52)
3. Select the Acquisition Attribute tab
4. Set the values as shown in Figure 53.

5. Make sure that Packet Size is **9004**. Should be able to set this value 9014 (Jumbo Packet Size). From experience, this would cause instability in the acquisition.

6. Click Save.

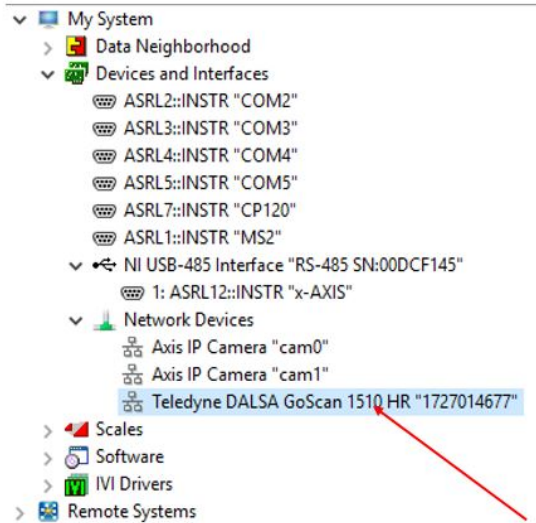


Figure 52. NIMAX device manager

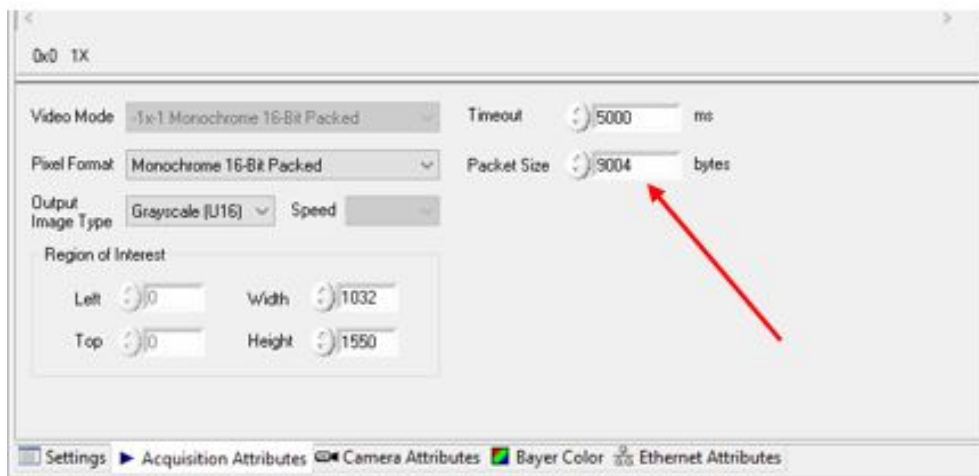


Figure 53. Acquisition Attributes window. Set the packet size to 9004.

**Programmer's Note:** the value "1727014677" is the alias name used by the LabVIEW code:

**NIMAX summary**

Most values shown are the default values. Those highlight are critical to the IMS acquisition.

## MAX Configuration Report

3/19/2019 6:12:21 PM

## B.2 Motion Control Setup

Motion control should be set during initial setup and further changes should not be necessary. Motion control setup can be accessed by selecting **Motion > Setup** from the IMS panel menu 3). The M-Drive Motion Setup control panel will open (Figure 54).

The user may select between four setup panels from this window.

- Motor and Track Options
- Fixed Positions
- Limit and Home Switches
- Motion Profiles

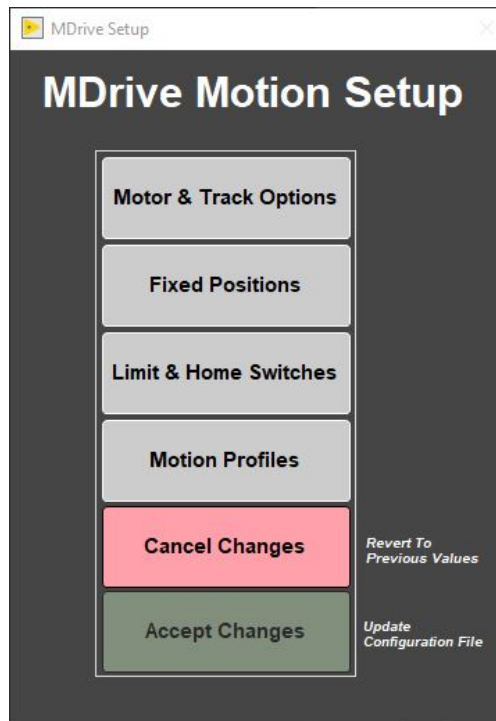


Figure 54. M-Drive Motion Setup

### **Motor and Track Options**

Once these values have been properly set, they should not change. This panel is only for initial setup.

Make sure to use the values shown for the XMSL (Figure 55).

The relationship between motor revolutions and linear motion of the track is defined in this window and is critical to both safe and accurate operation. User should be familiar with the M-Drive motor system prior to adjusting these settings.

- **Select Axis:** In the case of the XMSL it is always X.
- **Encoder Pulses/rev:** Defined by the manufacturer of the M-Drive as 2048.
- **Screw Pitch:** Set to 2.0 (the ratio of 2048 steps per revolution and chain displacement (cm) as a function of the drive gears diameter).
- **Gear Ratio:** Set to 4.0.
- **Direction:** Counter clockwise rotation moves the tray in a positive direction (from home to end of track).
- Click the **Motion Utility** button to open the Motion Utility window (Figure 56) and test the settings. Click **Close** to exit this window.

Click **Accept** to save the values or **Cancel** to return to previous values.

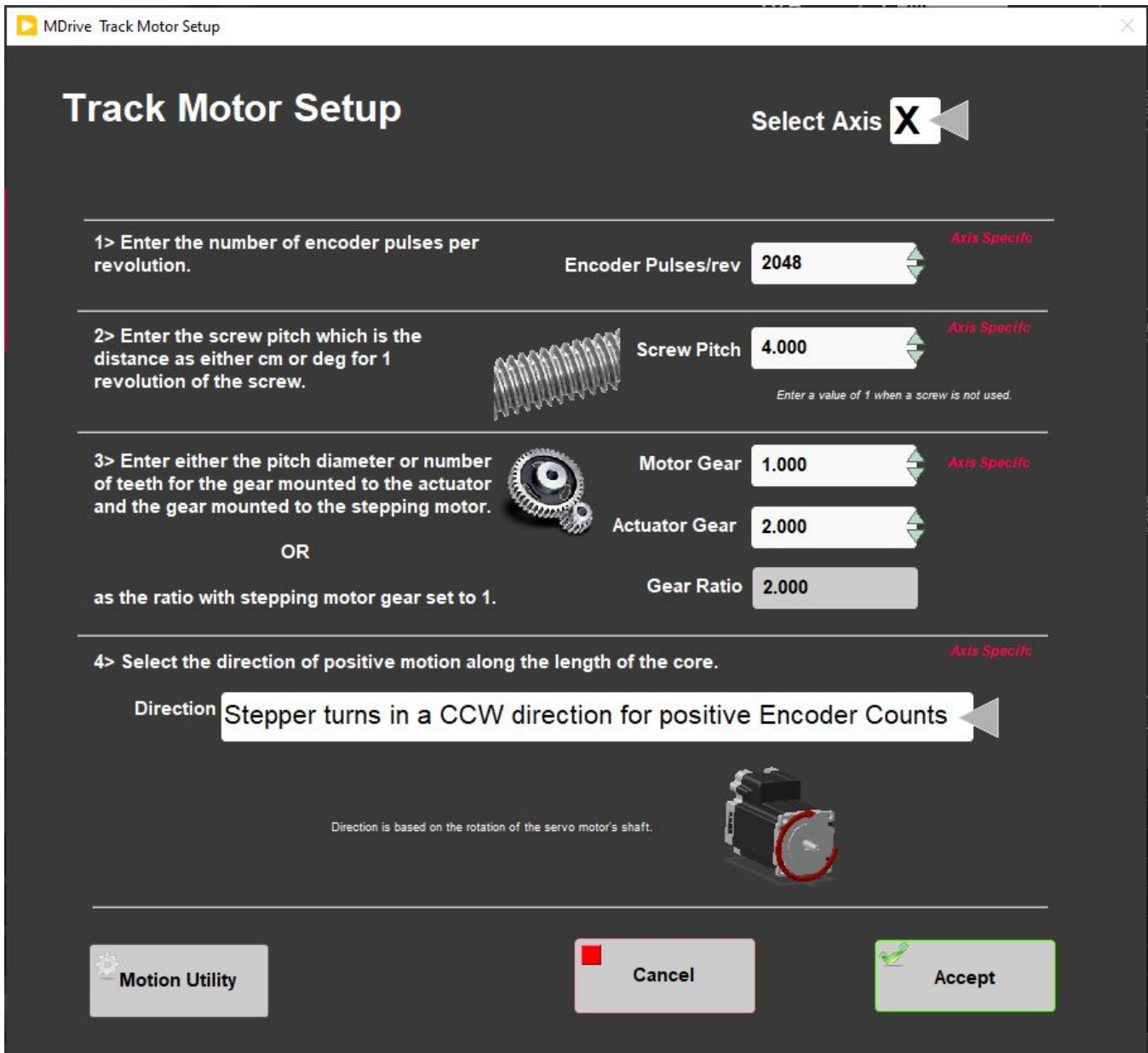


Figure 55. XMSL Motor and Track Options Setup Window



Figure 56. Motion Utility Window

### Fixed Positions

Once these values have been properly set, they should not change. This panel is only for initial setup.

In this window the user may define fixed track locations used by IMS motion control. For the XMSL, make sure to use these value unless there has been a physical change to the system (Figure 57).

- **Select Axis:** In the case of the XMSL it is always X.
- **Max Section Length:** Maximum length of section that can be placed in the track. This value is set to 160 cm.
- **Track Length:** Distance in cm between the limit switches. Use the Motion Utility (Figure) to determine this value by moving from limit switch to limit switch. Currently the value is set at 200 cm.
- **Load and Unload:** For the XMSL set to 0. This will always bring the tray back to the sample load end after a measurement sequence.
- **Top-of-Section Switch?:** ON
- **Top-of-Section Switch Offset:** 158.85
- **Push Past:** 5.
- **Fast Past:** 5
- **Run Out Switch?:** ON.
- Click the **Motion Utility** button to open the Motion Utility window (Figure 57) and test the settings.
- Click **Close** to exit this window.
- Click **Accept** to save the settings. Click **Cancel** to return to previous values.

**Note, these values along with the detector position set in the Camera: General Setup under instruments must be accurate for proper motion control. Take care in setting these values.**

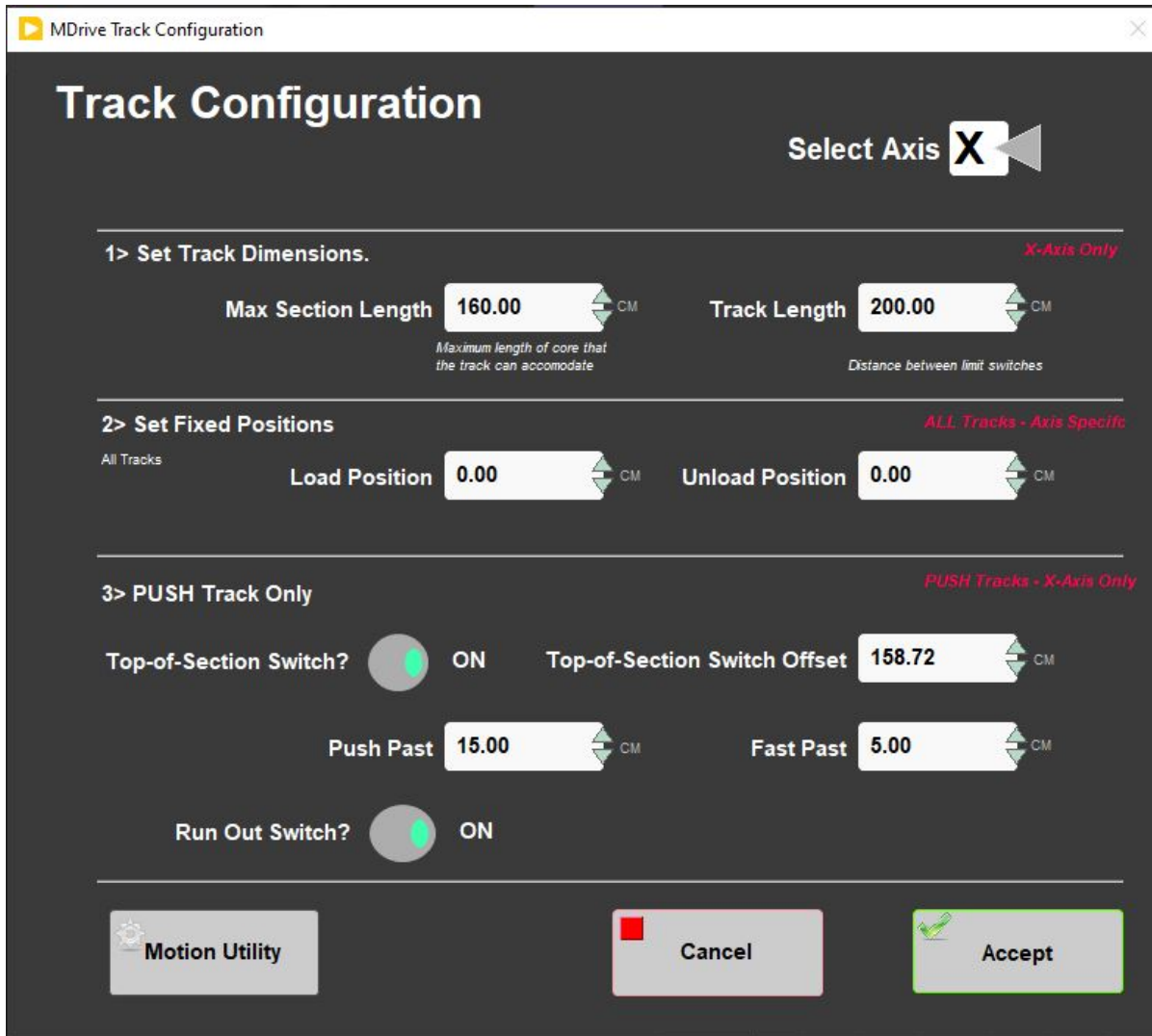


Figure 57. XMSL Fixed Positions Window

### Limit and Home Switches

Once these values have been properly set, they should not change. This panel is only for initial setup.

- This panel is used to define the orientation of the track system, limit switches, and the home switch (Figure 58). The MDrive can be used with either a dedicated Home switch or a limit switch as a home switch. In the case of the XMSL track we use a home switch.
- **Select Axis:** In the case of the XMSL it is always X.
- **Select Track and Home Geometry:** For the XMSL, select CW look @ CCW Edge
- Click the **Motion Utility** button to test the settings.
- Click **Accept** to save the settings. Click **Cancel** to return to previous values.





Figure 58. XMSL Limit and Home Switches Window

### **Motion Profiles**

The motion profiles window can be used to adjust the speed and acceleration profiles used by the track (Figure 59) for various types of movements.

Setting the correct values for the motion profile takes a little experimentation to make the track run efficiently and safely. It is not usually necessary to adjust these values.

- **DAQ Move:** This profile controls moves between measurement positions.
- **Limit Seek:** This profile finds the limit switch location. *Do not exceed 3 cm/sec. Do not use a large acceleration value, but always use a large deceleration value.*
- **Home Final:** This profile finds the final location of the home switch. *Do not exceed 3 cm/sec. Do not use a large acceleration value, but always use a large deceleration value.*
- **Load/Unload:** This profile is used for moving the actuator for general movements and moving out of the XMSL to the final position prior to ending a measurement.
- **Push-Slow:** This profile is used to move to the degauss start position
- **Push-Fast:** This profile is used to move the section/discrete samples from degauss stage position through the in line AF degauss coils for X, Y, and Z.
- **User Defined:** This profile is used for testing only in the **Motion Utilities** (Figure 56) program.

Click the **Motion Utility** button to open the **Motion Utility** (Figure 56) window and test the settings.

Click **Accept** to save the settings. Click **Cancel** to return to previous values.

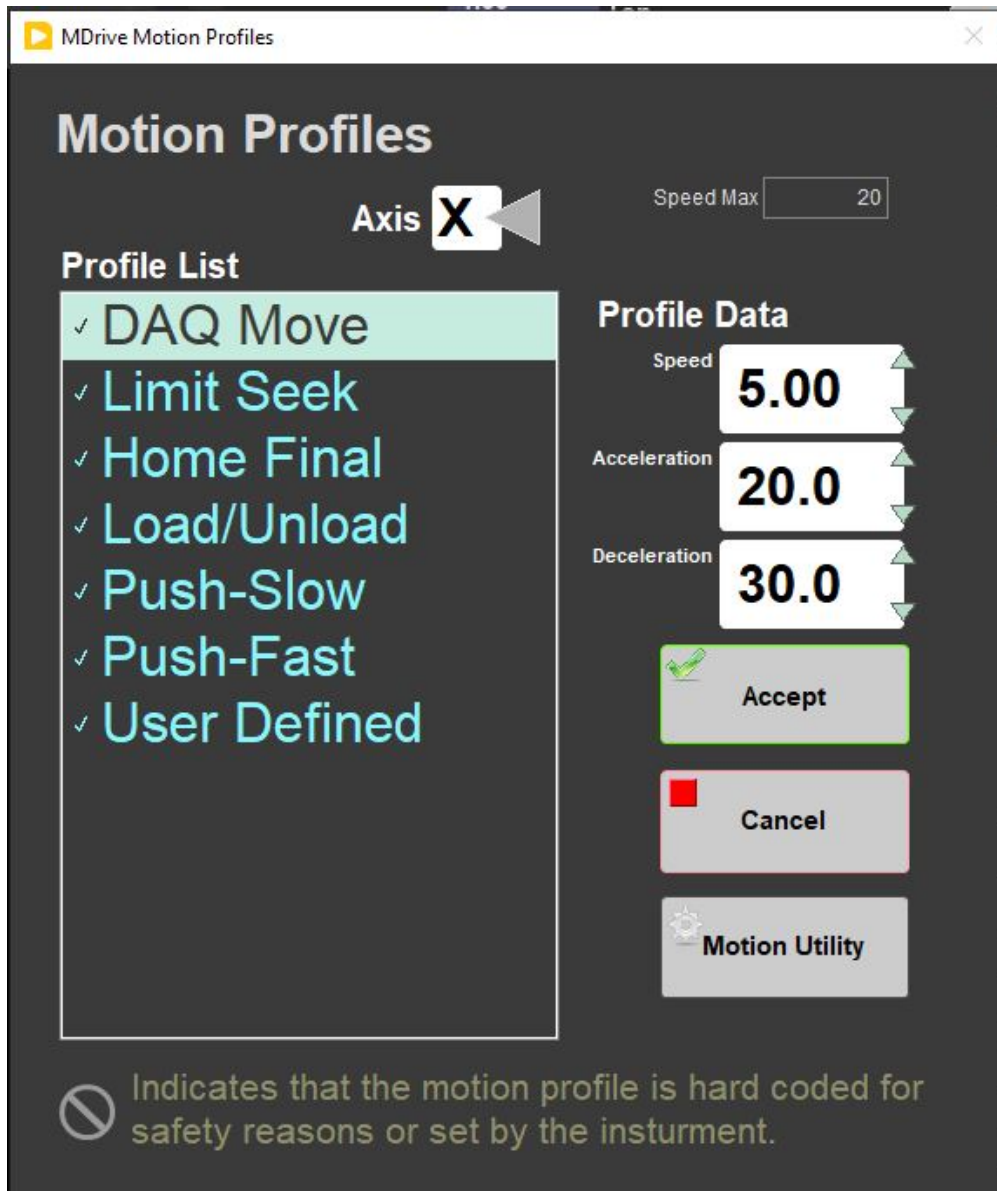


Figure 59. Motion Profiles Window

The following table shows the motion profile settings for the XMSL.

Axis	X-Axis		
	Speed	Accel.	Decel.
DAQ Move	5.0	20.0	30.0
Limit Seek	5.0	1.0	80.0
Home Final	3.0	2.0	80.0
Load/Unload	5.0	5.0	10.0
Push-Slow	5.0	5.0	100.0
Push-Fast	5.0	5.0	50.0
User Defined	5.0	5.0	5.0

## Table: Motion Profile X-Axis for XMSL

## C.1 Hardware

The IODP x-ray system is composed of a 120 kV, 1 mA constant potential x-ray source and a detector unit. The source is a Teledyne ICM CP120B portable x-ray generator with a 0.8 by 0.5 mm focal spot. The beam angle is 50 by 50 degrees generating a directional cone onto the detector, which is distanced 65 cm from the source. The detector is a Go-Scan 1510 HR unit composed of an array of CMOS sensors with an active area of 102 by 153 mm and a resolution of 99 microns.

### **Manual Configuration**

You must manually configure Teledyne ICM CP120B prior to closing the shielding. This needs to be done whenever you replace the source. From the control panel on the source do:

1. Insert Key and turn on power. Wait for system to initialize.
2. Press Menu
3. Press either the plus or minus buttons until you see "Settings"
4. Press Enter and then press the plus key once for each configuration
  - **Auto Config = Manual Mode**
  - **Keep Alive = Disabled**
  - English (don't care)
  - **Fil(iment) Always On = Enable**
  - Bluetooth = some code (ignore)
  - **Trig(ger) = Security Enable**
  - **Com Status = Enable**
  - **Baud Rate = 9600**
  - **Long Time = Enable**
  - Menu Step = Quick (don't care)
  - **Factory = Disabled**
  - Back Light = Enable (don't care)
  - **External Trig = Disabled**
  - **Start Button = Disabled**
  - **Pre-warning = 0 sec**
5. Press Escape

### **Shielding**

The shielding consists of four sections as shown in *Figure 60*. The Source Shield houses the x-ray source and detector. It is constructed with 6-mm of lead with an internal baffle on the unload side of the box. The exterior corners are covered with 6-mm lead strips and lead vinyl (½-mm) covering the sides. The GRA-MS shield section is constructed with 2-mm of lead with an internal baffle on the load side.

The starboard load end of the track and the port unload end of the track are shielded by lead vinyl (½-mm) (*Figure 61*). Take care when handling the load and unload doors, they are heavy. On the load side, we have counterweighted the door to hold it open and to take some of the weight. On the unload door we have mounted magnets to hold it open. Keep in mind that the vinyl lead shielding is held in place with Velcro and can be dislodge compromising the shielding.

**X-IMAGER Radiation Survey Map  
Starboard-Aft**

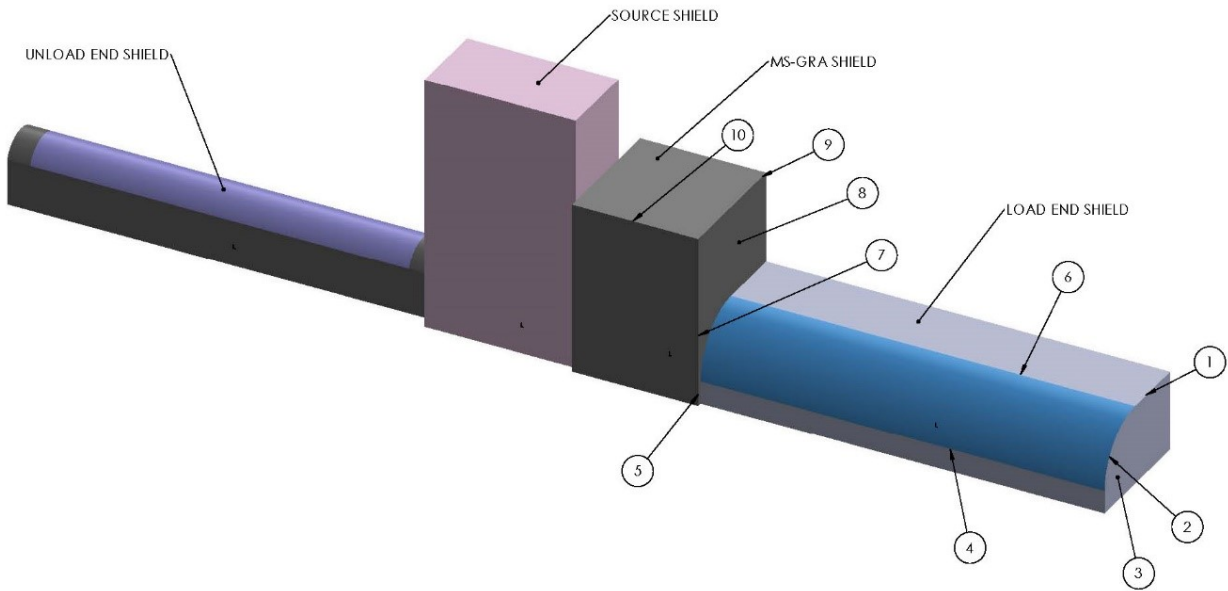


Figure 60. X-ray Image Logger Shielding



Figure 61. X-ray Image Logger from starboard (left) and port (right).

**C.2 System Settings**

**System Settings**

Hostname	PC53236
----------	---------

DNS Name	<a href="http://PC53236.ship.iodp.tamu.edu">PC53236.ship.iodp.tamu.edu</a>
Vendor	HP
Model	HP Z240 SFF Workstation
Serial Number	2UA7121YXV
Firmware Version	N51 Ver. 01.52
Hardware Revision	
Operating System	Microsoft Windows 10 Enterprise
System Start Time	3/4/2019 7:24:09 PM
Description	PC53236 - 64 bit Workstation Image
System Configuration Web Access	Local Only

### System Resources

Total Physical Memory	31.8 GB
Free Physical Memory	26.2 GB
Total Virtual Memory	36.5 GB
Free Virtual Memory	30.7 GB
Primary Disk Capacity	476 GB
Primary Disk Free Space	130 GB
CPU Model	Intel(R) Core(TM) i7-6700 CPU @ 3.40GHz

Teledyne DALSA GoScan 1510 HR "1727014677"

### Settings

Name	1727014677
Hostname	169.254.5.141
Vendor	Teledyne DALSA
Model	Teledyne DALSA GoScan 1510 HR
Serial Number	DC60A1378609

### Attribute Categories

AcquisitionAttributes	
Property	Value
BitsPerPixel	Use hardware value
ImageDecoderCopyMode	Auto
IncompleteBufferMode	Ignore
OutputImageType	Grayscale (U16)
OverwriteMode	Get Newest
<b>PacketSize</b>	<b>9004</b>
ReceiveTimestampMode	System Time
ShiftPixelBits	false
SwapPixelBytes	false

Timeout	5000
---------	------

AcquisitionAttributes AdvancedEthernet BandwidthControl	
Property	Value
ActualPeakBandwidth	1000.00000
DesiredPeakBandwidth	1000.00000

AcquisitionAttributes AdvancedEthernet Controller	
Property	Value
DestinationMode	Unicast
DestinationMulticastAddress	239.192.0.1

AcquisitionAttributes AdvancedEthernet EventParameters	
Property	Value
MaxOutstandingEvents	50

AcquisitionAttributes AdvancedEthernet FirewallTraversal	
Property	Value
Enabled	true
KeepAliveTime	30
Supported	true

AcquisitionAttributes AdvancedEthernet ResendParameters	
Property	Value
MaxResendsPerPacket	25
MemoryWindowSize	1024
MissingPacketTimeout	2
NewPacketTimeout	100
ResendBatchingPercentage	10
ResendResponseTimeout	2
ResendThresholdPercentage	5
ResendTimerResolution	1
ResendsEnabled	true

AcquisitionAttributes AdvancedEthernet TestPacketParameters	
Property	Value
MaxTestPacketRetries	1
TestPacketEnabled	true

TestPacketTimeout	250
-------------------	-----

AcquisitionAttributes		AdvancedGenicam	
Property		Value	
CommandTimeout		100	
EventsEnabled		true	
EventsSupported		true	
IgnoreCameraValidationErrors		false	

AcquisitionAttributes		ChunkDataDecoding	
Property		Value	
ChunkDataDecodingEnabled		true	
MaximumChunkCopySize		64	

CameraAttributes		deviceInformation	
Property		Value	
DeviceVendorName		Teledyne DALSA	
DeviceModelName		GoScan 1510 HR	
DeviceID		1727014677	
DeviceVersion		209.21	
HardwareRevision		IL1.0	
TimingVersion		12.119	
deviceMacAddress		DC:60:A1:37:86:09	
DeviceUserID		1727014677	
UserSetDefaultSelector		Factory Setting	
UserSetSelector		Factory Setting	
UserSetLoad			
UserSetSave			
DeviceTemperature		50.0000000	

CameraAttributes		detectorControl	
Property		Value	
SettingsRevision		2	
Standby		Off	
ReadOutMode		Full Resolution	
ReadOutDirectionY		Bottom to Top	
ReadOutDirectionX		Right to Left	

TriggerMode	Free Running
SoftwareTrigger	
SoftwareTrigIntTime	50000
ExtendedExposure	10000
Offset	1.95%
FullWell	High Full Well
ROIStartH	0
ROIStopH	1031
ROIStartV	0
ROIStopV	1549

CameraAttributes		Diagnose
Property	Value	
ImageSourceSelector	Sensor Data	
SensorDigitalTestPatternValue	0	
TestImageIncrement	1	
PowerCheck3V5DIG	false	
PowerCheck5V4	false	
PowerCheck1V2	false	
PowerCheck1V5	false	
PowerCheck2V5	false	
PowerCheck3V3	false	
PowerCheck3V5ANA	false	
PowerCheck1V8	false	
ResetHighReadbackAbs	3.49500000	
SelectHighReadbackAbs	3.49375000	
VrReadbackAbs	3.19875000	
NWellReadbackAbs	3.49375000	
AdcRefReadbackAbs	2.79875000	
AnaT2ReadbackAbs	0.0387500000	
PSupReadbackAbs	11.4541485	
Opamp5VReadbackAbs	4.99875000	
RefreshDiagnoseBits		
transferQueueCurrentBlockCount	0	

CameraAttributes		ImageFormatControl
Property	Value	
PixelPacking	Mono16	
PixelFormat	Monochrome 16-Bit Packed	
PixelCoding	Mono	



PixelSize	16 Bits/Pixel
Width	1032
Height	1550
Mono12PackedBitSelection	LSB

CameraAttributes		ImageProcessingControl	
Property		Value	
SUMEnable		Off	
SUMNofFrame		1 Frame	

CameraAttributes >> TransportLayerControl	
Property	Value
deviceUPnPDiscoveryMode	Active
GevLinkSpeed	1000
devicePacketResendBufferSize	12.9375000
GevIPConfigurationStatus	DHCP
GevPrimaryApplicationIPAddress	169.254.116.129
deviceCCP	Control Access
GevDiscoveryAckDelay	
GevGVCPHeartbeatDisable	

CameraAttributes >> FileAccessControl	
Property	Value
FileSelector	Firmware
FileOperationSelector	Open
FileOperationExecute	
FileOpenMode	Write
FileAccessOffset	
FileAccessLength	4
FileOperationStatus	Success
FileOperationResult	0
FileSize	0

CameraInformation	
Property	Value
BaseAddress	0x0
BusType	Ethernet
HostIPAddress	169.254.116.129

HostMACAddress	00:0A:CD:2F:13:8C
HostNetworkInterfaceName	{1E2FC758-4010-4217-A057-038CD47B344A}
IPAddress	169.254.5.141
ModelName	GoScan 1510 HR
PrimaryURLString	Local:TeledyneDALSA_CD45M21_02_2457f43f_1CA40.0000.xml;b000;31a8e
SecondaryURLString	<a href="http://www.teledynedalsa.com/public/mv/software/genicam/GenICamFile.xml">http://www.teledynedalsa.com/public/mv/software/genicam/GenICamFile.xml</a>
SerialNumberHigh	0xDC60
SerialNumberLow	0xA1378609
VendorName	Teledyne DALSA

StatusInformation	
Property	Value
AcqInProgress	false
HandledEventCount	0
IncompleteBufferCount	0
LastBufferCount	0
LastBufferNumber	4294967292
LostBufferCount	0
LostEventCount	0
LostPacketCount	0
ReceivedResendPackets	0
RequestedResendPacketCount	0

## VI. Credits

All improvements to the Quick Start Guides and User Guides are a communal effort, with honorable mention to the group of LOs, ALOs, and technicians who have helped.

## VII. Archived Versions

[X-Ray Image Logger UG - 25022020](#)

[X-Ray Image Logger User Guide 2021 .pdf](#)