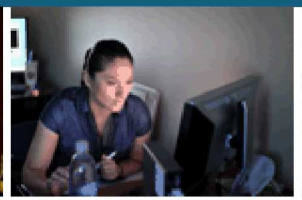
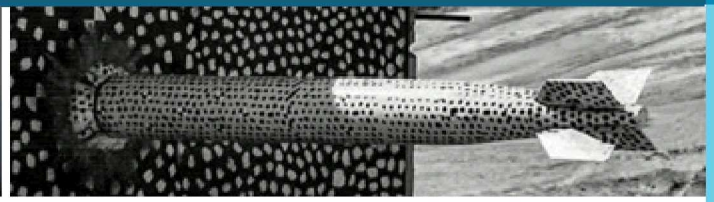
SAND2019-6665C

X-Ray ToolKit (XTK) Update and Review





PRESENTED BY

Sandia National Labs, June 26, 2019

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

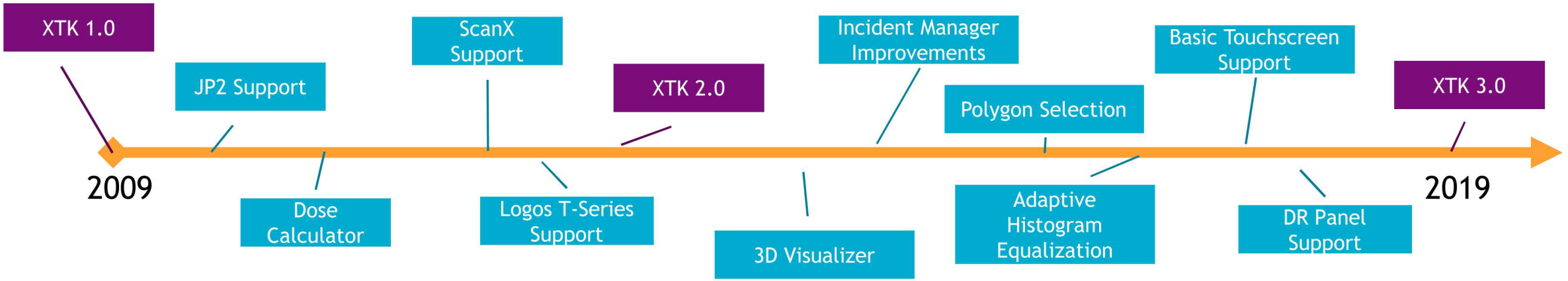
10 Years of XTK

XTK 1.0 was released in 2009, almost 10 years ago!

XTK 3.0 was released in 2019, after ~18 months of development & testing.

Statistics:

- 4000 users
- More than 13,000 estimated installations!



Welcome to XTK 3!

XTK 1.0

XTK 3.0

Why XTK 3?

If XTK is so successful, why would we change it?

Touch screens

- Difficult to adapt existing UI design
- Better to design with touch in mind.

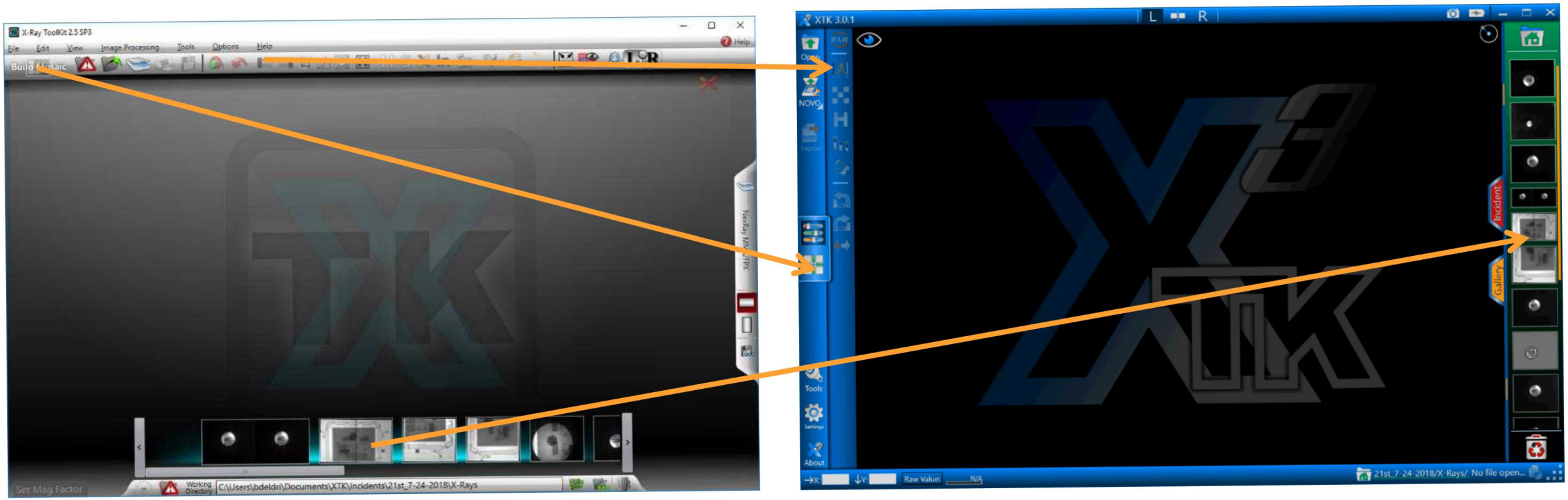
Clean up and simplify.

“Behind the scenes” code cleanup and reorganization to support advanced features.

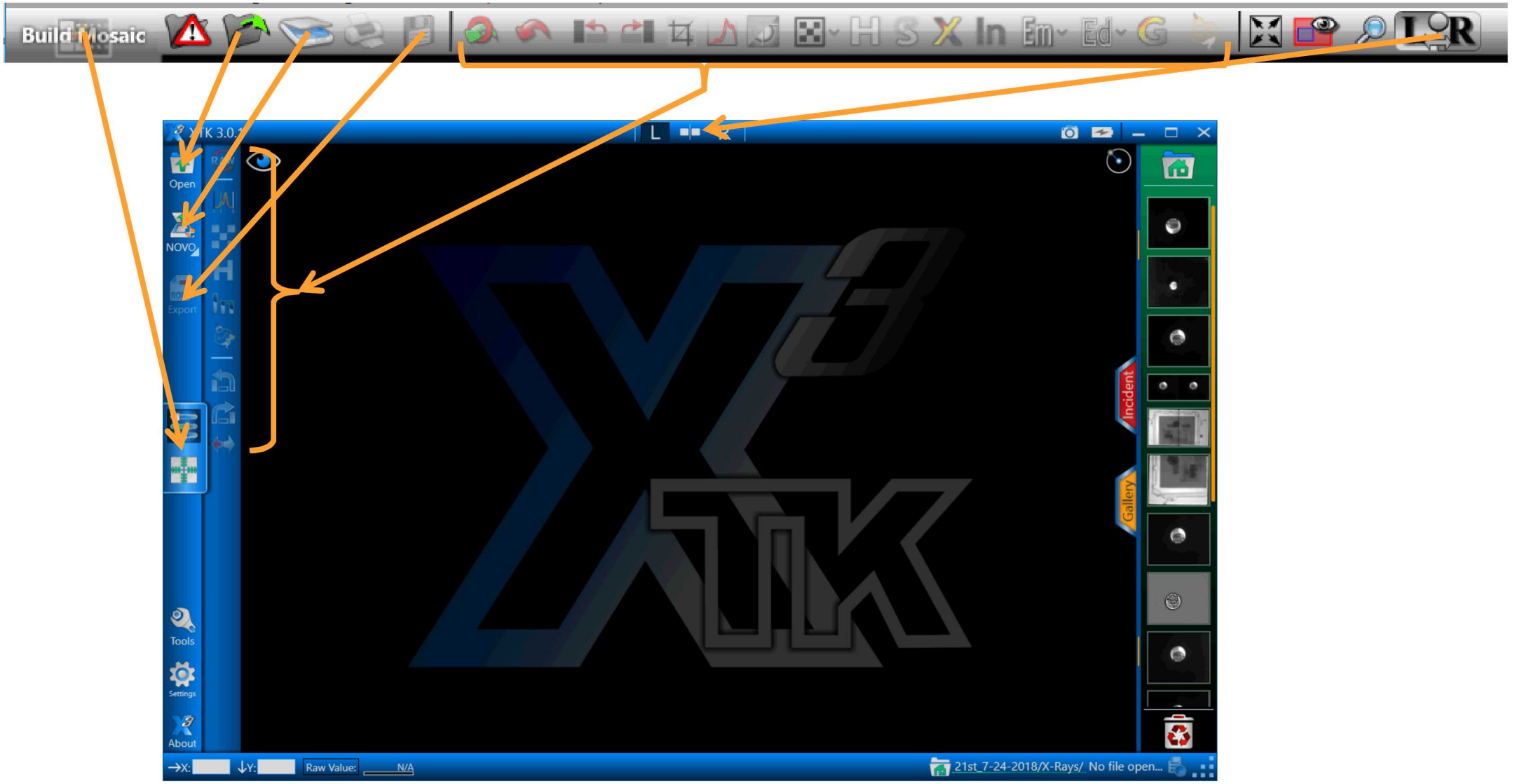
Standardize scanner interface.

Long list of other requested improvements.

What Changed?



What Changed?



Who Moved my Cheese?!

For people who are already familiar with XTK 2:

After some use **it starts to make sense.**

It is easier to understand and use.

All of the tools you are used to are still there, along with some new ones.

Instead of many places to look, we tried to pick one that makes sense.

So it's all cosmetic?

No, other important changes are more behind the scenes.

Image File Handling

Image Enhancement

Grid Aim

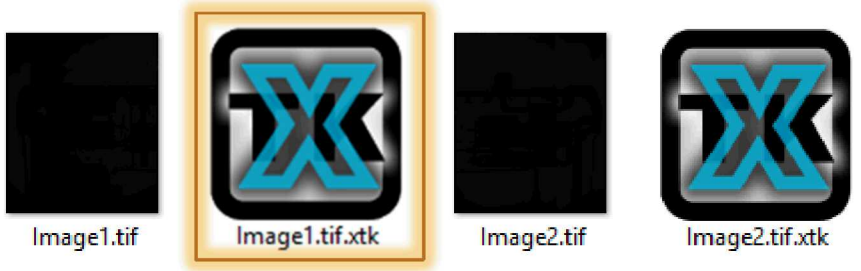
XTK as an Analysis Platform

Image File Handling

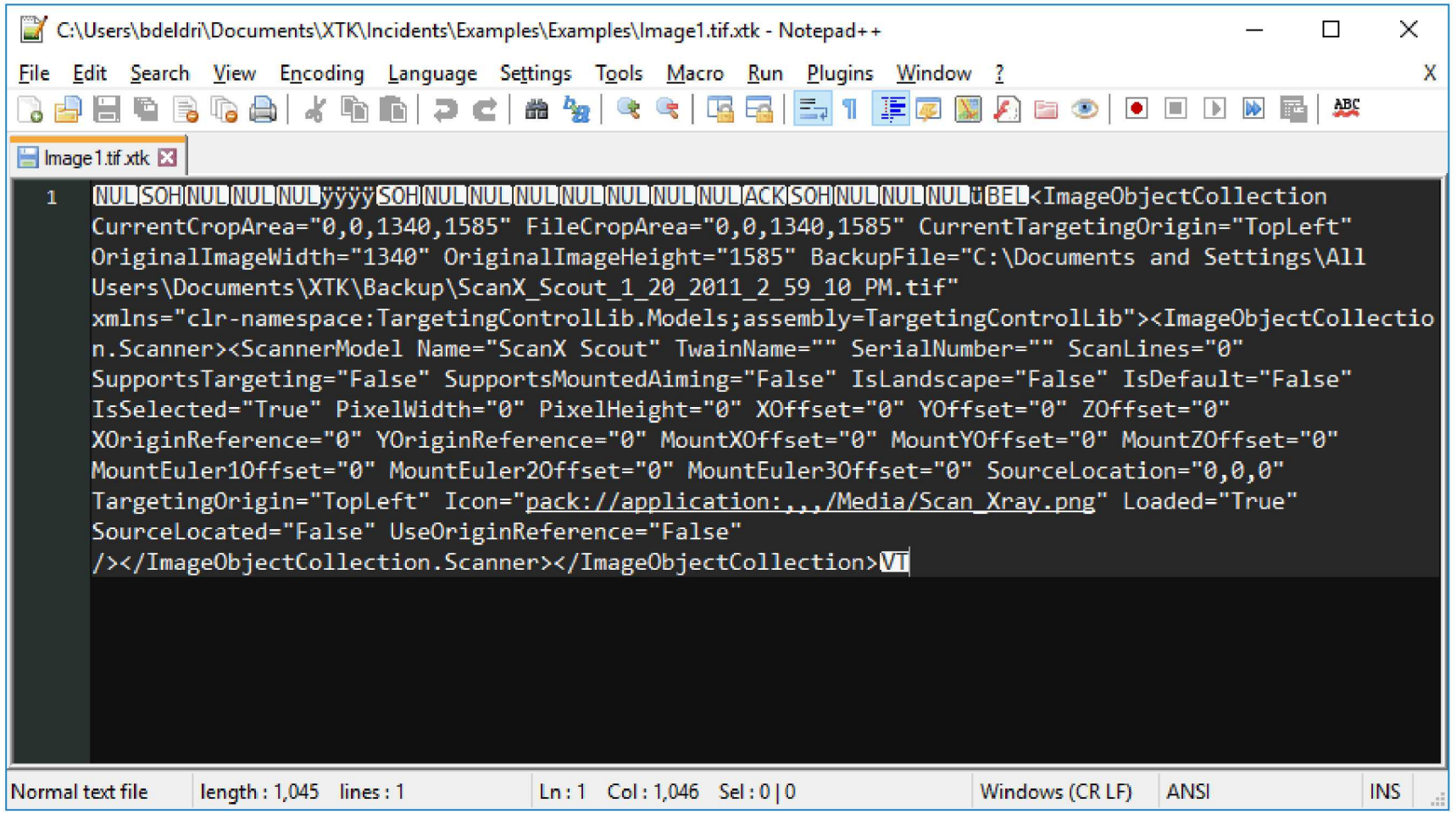
Images often have associated “meta data”, including things like

- Annotations
- Mag Factor
- Acquisition information
  - Date/time of acquisition
  - Exposure information (for some systems)

In XTK 2, this sort of information was stored in a separate “.xtk” file



What's inside a .xtk file?



Issues with this approach

Another file to carry around.

Easy for image and metadata to get separated.

Not very easy for other programs (or humans) to read.

What about the image data itself?

In XTK 2, the enhanced image data was saved back out to the file.

- This means you could "step on" your original raw image data

1. Scan a new image
2. Apply an enhancement
3. Click Save.
4. Oh no! The original file is gone!

XTK 3 Image File Handling

In XTK 3, several important changes were made to how image files are handled.

Change #1: The metadata is stored as part of the image header.

Change #2: The raw image data is never overwritten.

- Only enhancement parameters are saved.
- You cannot lose your raw image data by accident,
- You can undo any and all enhancements made on the image.

Your work is **more portable and less likely to be overwritten or lost.**

Auto Save

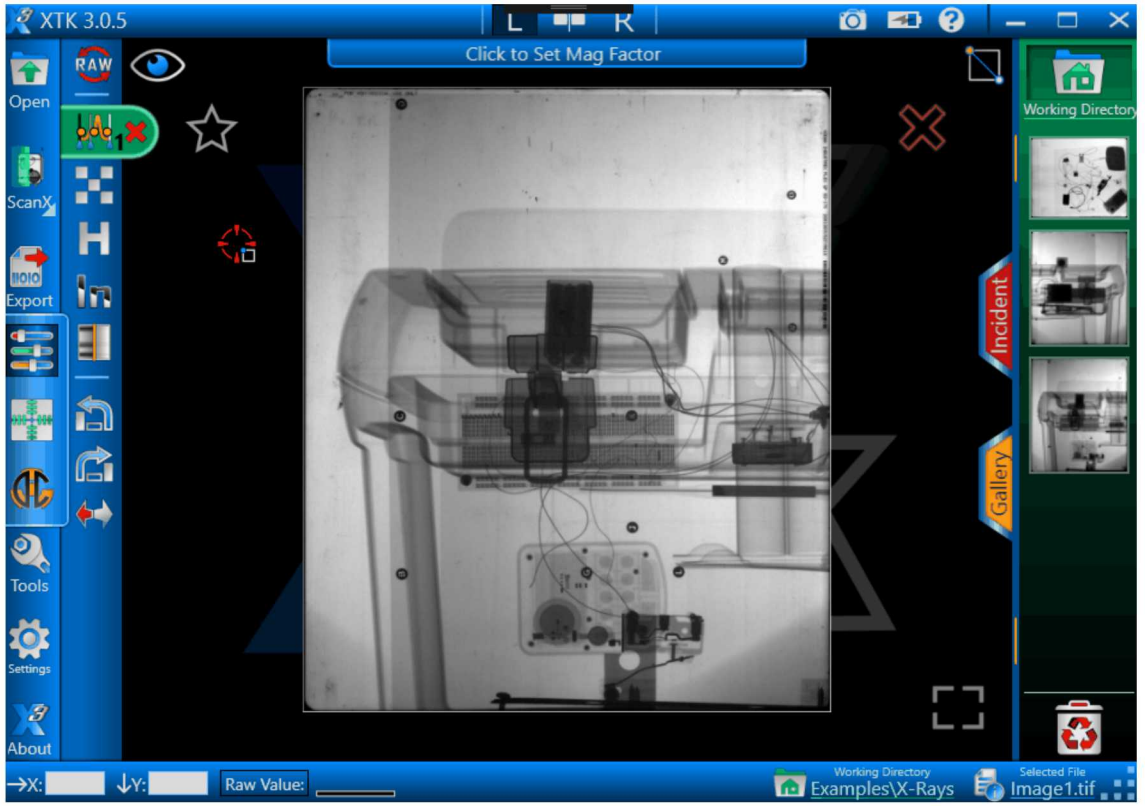
XTK 3 automatically saves your work as you go.

If XTK crashes everything you have done up to that point has already been saved.

Image Enhancements

Many improvements and changes have been made to the image enhancement system.

- Enhancements are like “filters”, you just turn them on and off
- No more undo
- Live preview when adjusting



Grid Aim Changes

Grid Aim has been around for a long time and works well.

Our goal was to make it faster and more consistent.

- Improve the speed at which the operator can obtain an aiming solution
- Reduce the sensitivity to variations between operators.

How to do Grid Aim in XTK 2

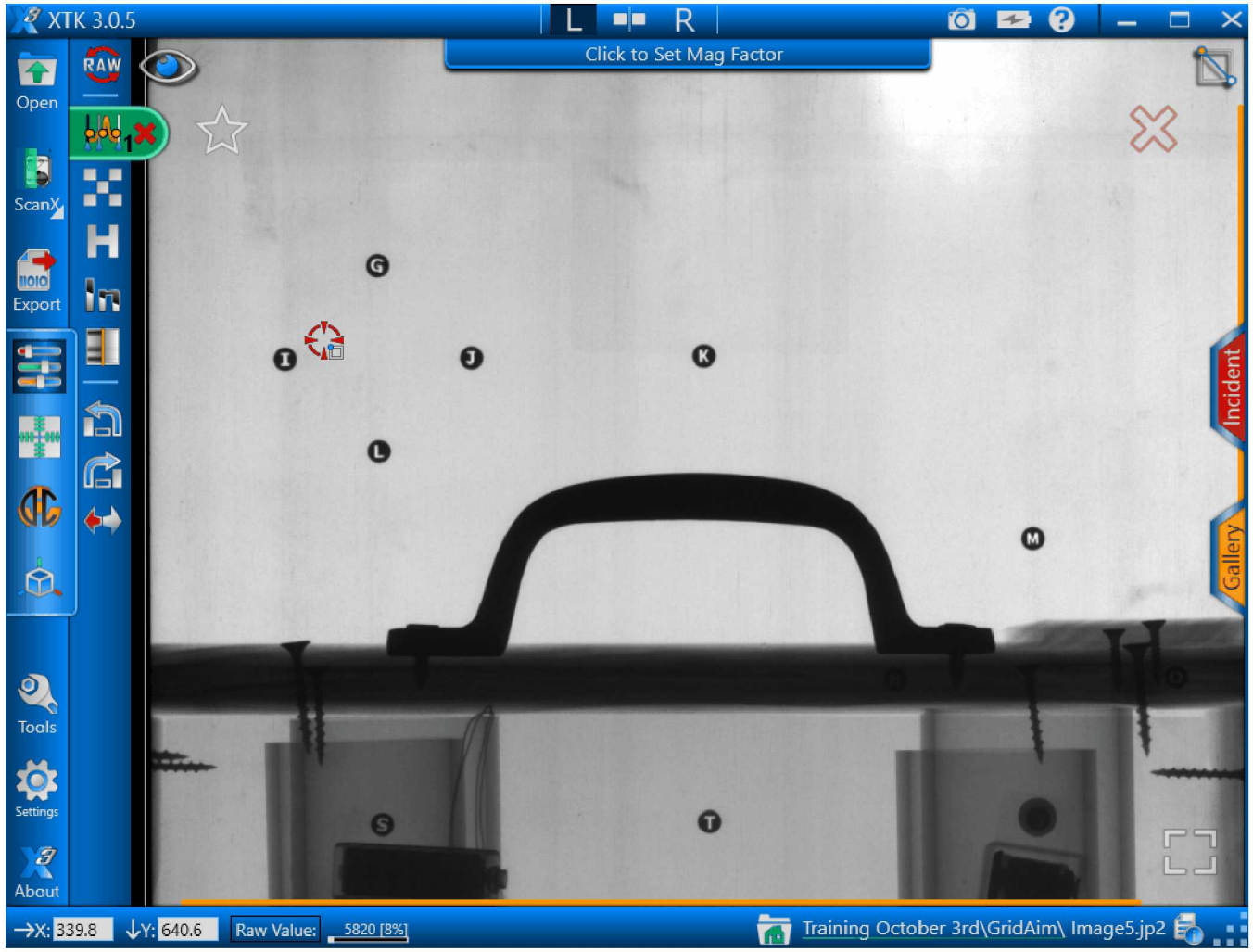
Current procedure:

1) Acquire an image with the Grid Aim fiducials
2) Zoom in on four separate dots and select them
3) Choose the correct letter for each dot
4) Choose your target
5) Look at the solution to aim your tool

Grid Aim in XTK 3

In XTK 3, the software can

- Help you locate the dots
- Identify the letters

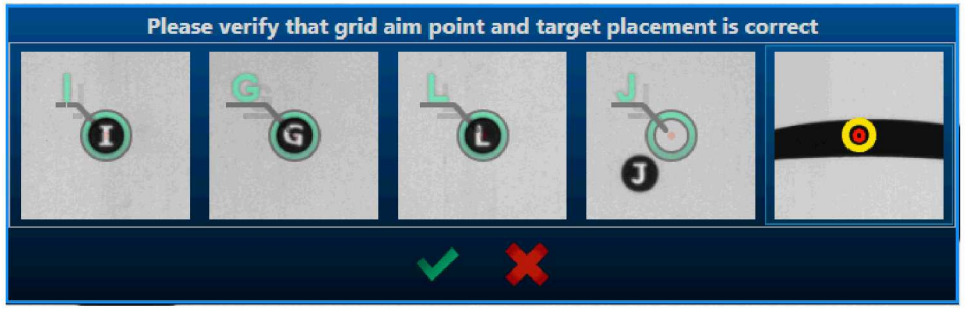


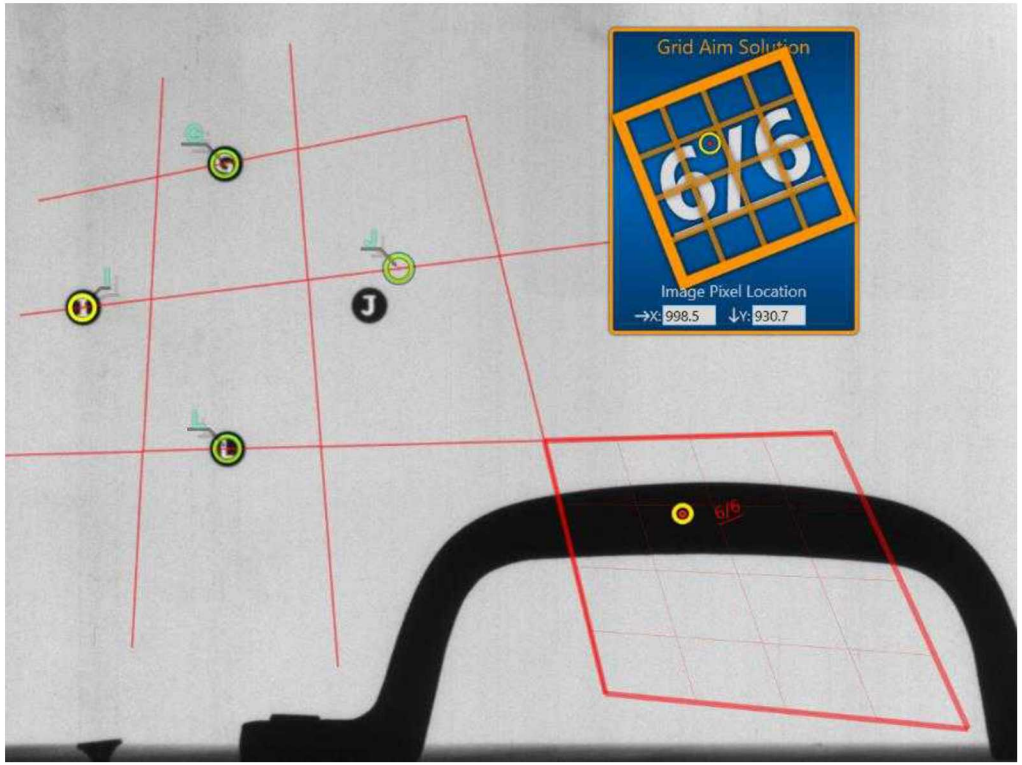
Immediate Visual Feedback

What if something is wrong with my Grid Aim solution?

The verification step helps me catch errors, and

I can immediately tell that the grid isn't lined up.





XTK as an Analysis Platform

Primary use of XTK is to acquire images from a variety of x-ray hardware.

- We try to make this as simple and fast as possible.

Secondary use is to **analyze** your radiography data or measurements with **other tools and processes.**

XTK 3 has been designed to be **open and extensible.**

This makes XTK 3 more than just an image acquisition program, it can become a **radiography analysis platform.**

It can bring together all of your radiography tools, **both hardware and software**, in one place.

Analysis Tools

Things you might want to know:

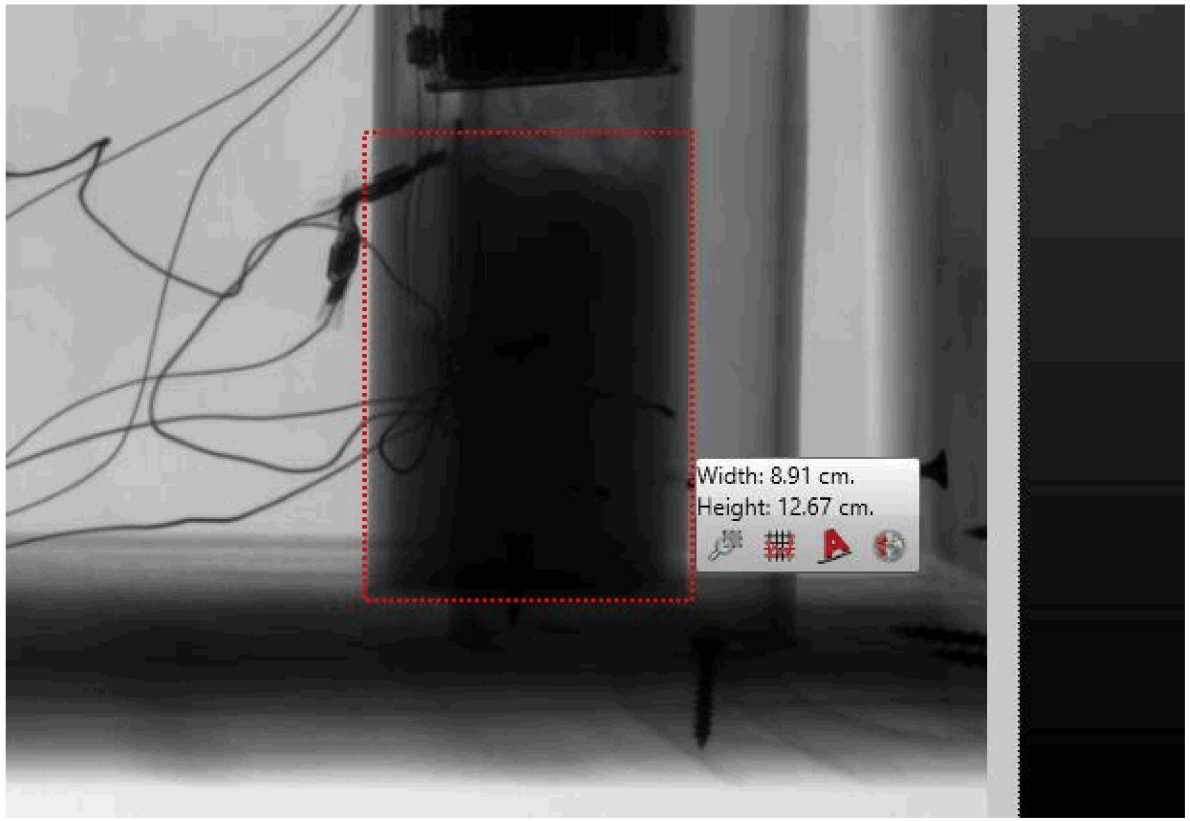
- How much explosive is present?
- Where do the wires go?
- What components can I see?
- What is connected to what?

So what can you do in XTK 2?

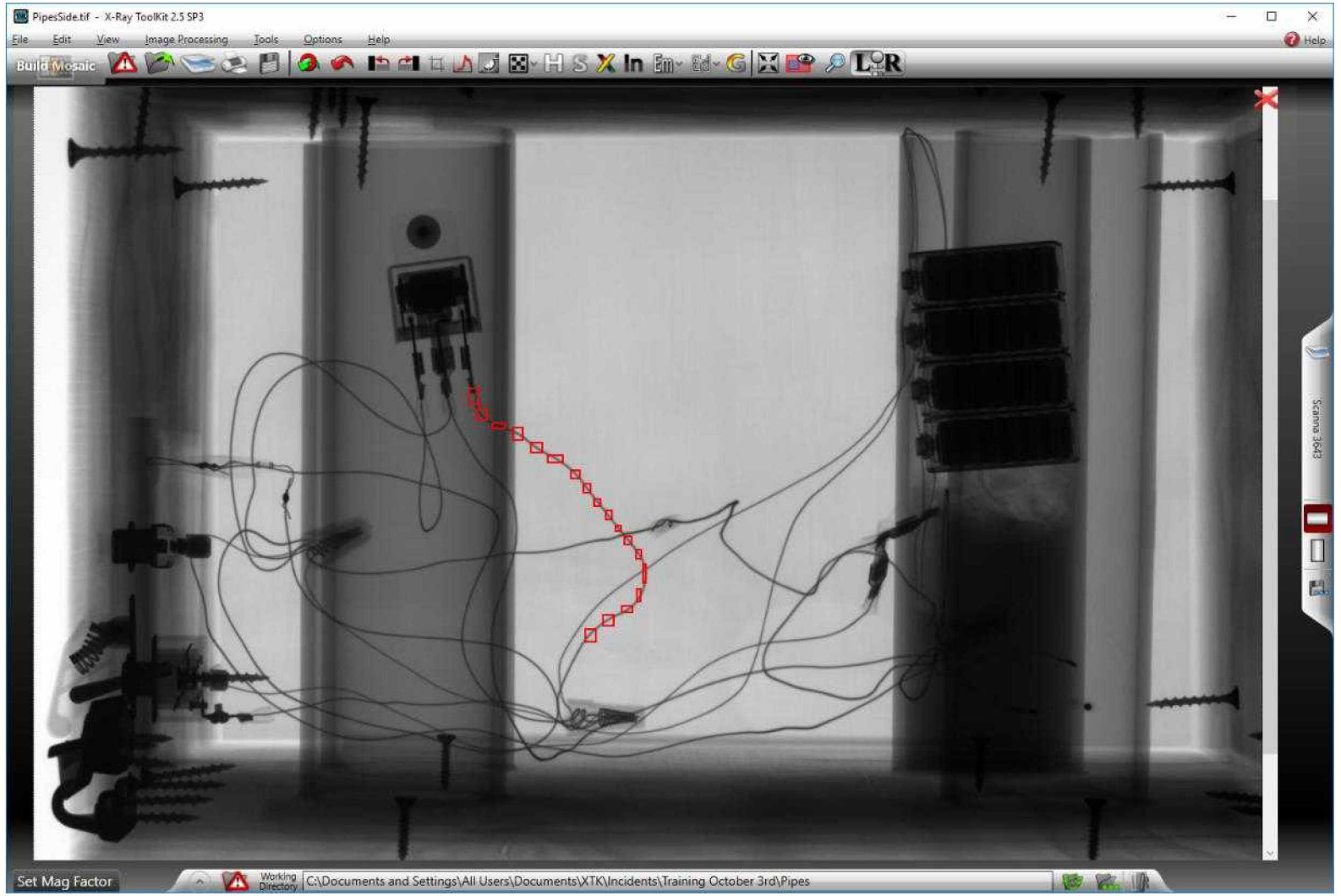
Estimate Explosive Weight?

Sort of, need to do a lot of the math by hand.

- Does everyone remember the formula for the volume of a cylinder?

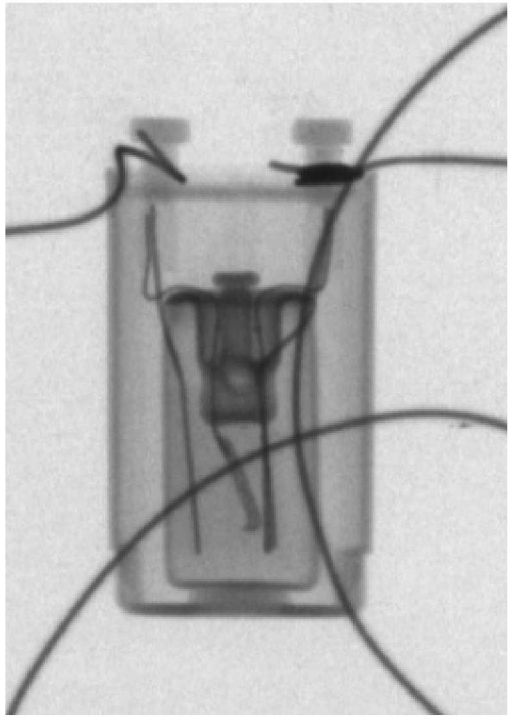


Trace Wires? Sort of…



Identify Components?

Only as good as the operator's knowledge.



???

Analysis Tools in XTK 3

What has been added to XTK 3 to help me with these analysis tasks?

Explosive Weight Calculator

Wire Tracing

Component ID

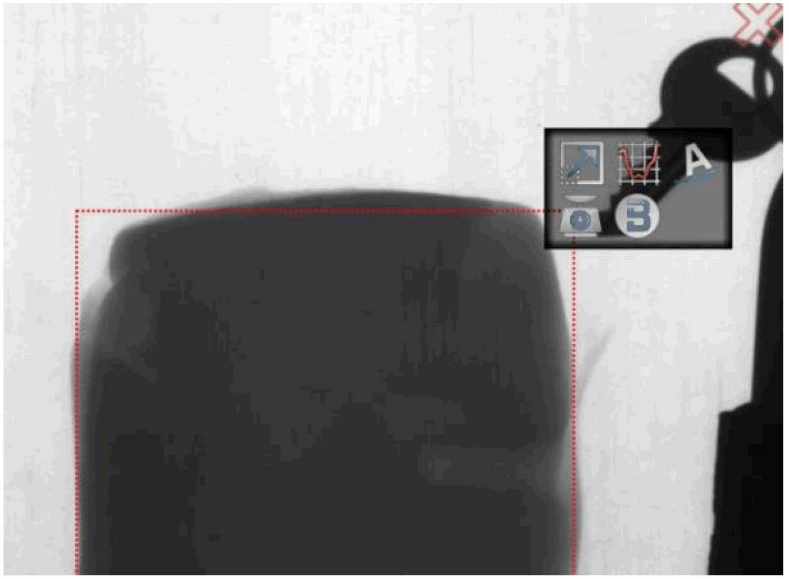
Circuit Graph

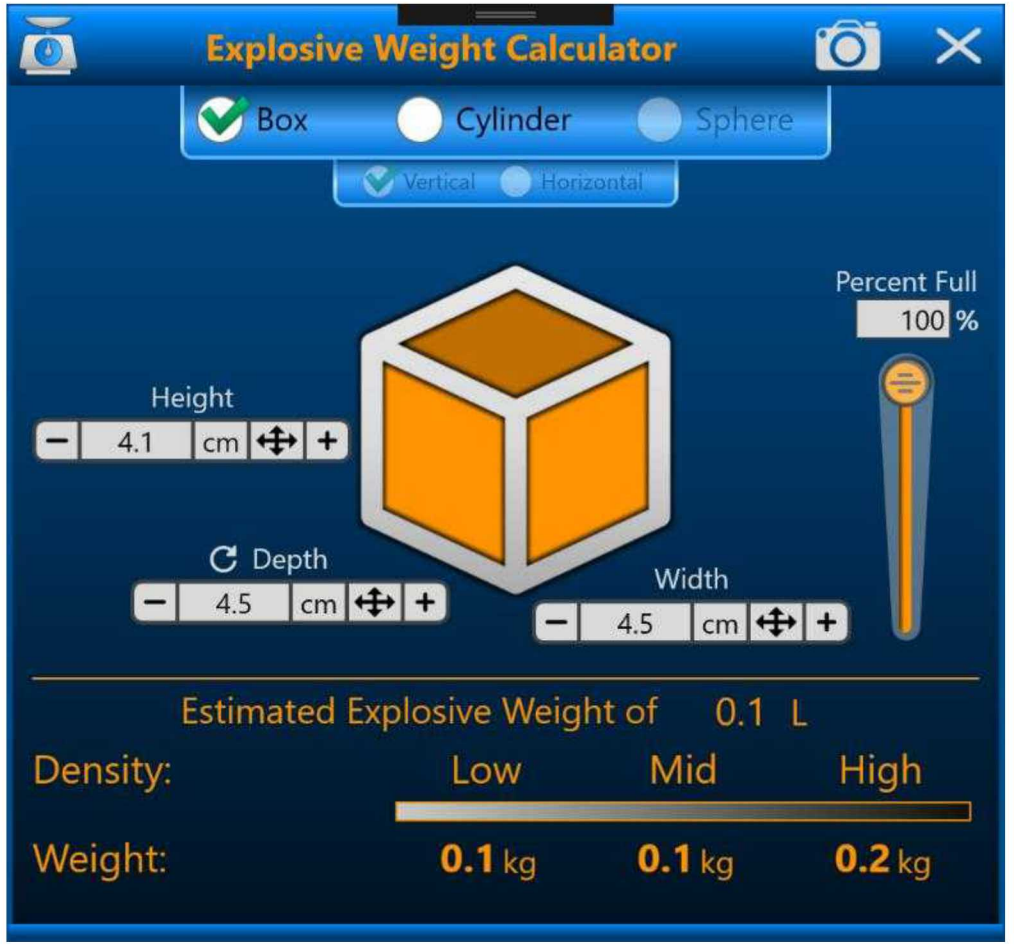
Weight Calculator

Create more accurate estimates.

Save screenshots to document your work.

Use as an input to other calculators and tools.

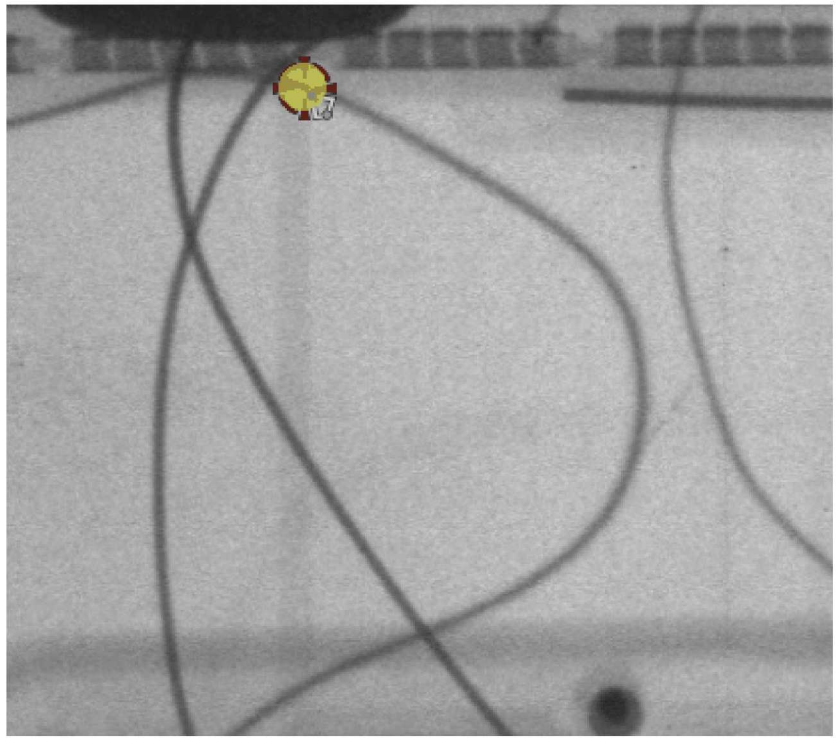




Wire Tracing

Freehand draw a line on the image, convert it to a wire annotation.

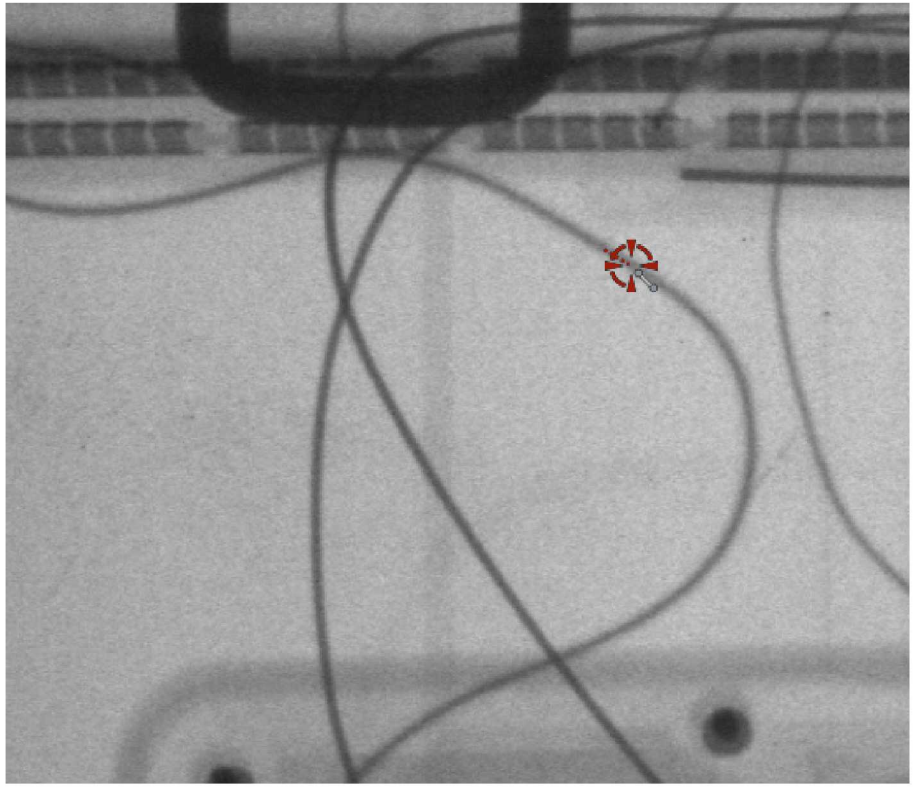
- This works especially well on touch screen computers.



Auto-Trace Wire

From starting position, trace as far as possible.

Needs operator assistance when it encounters clutter.

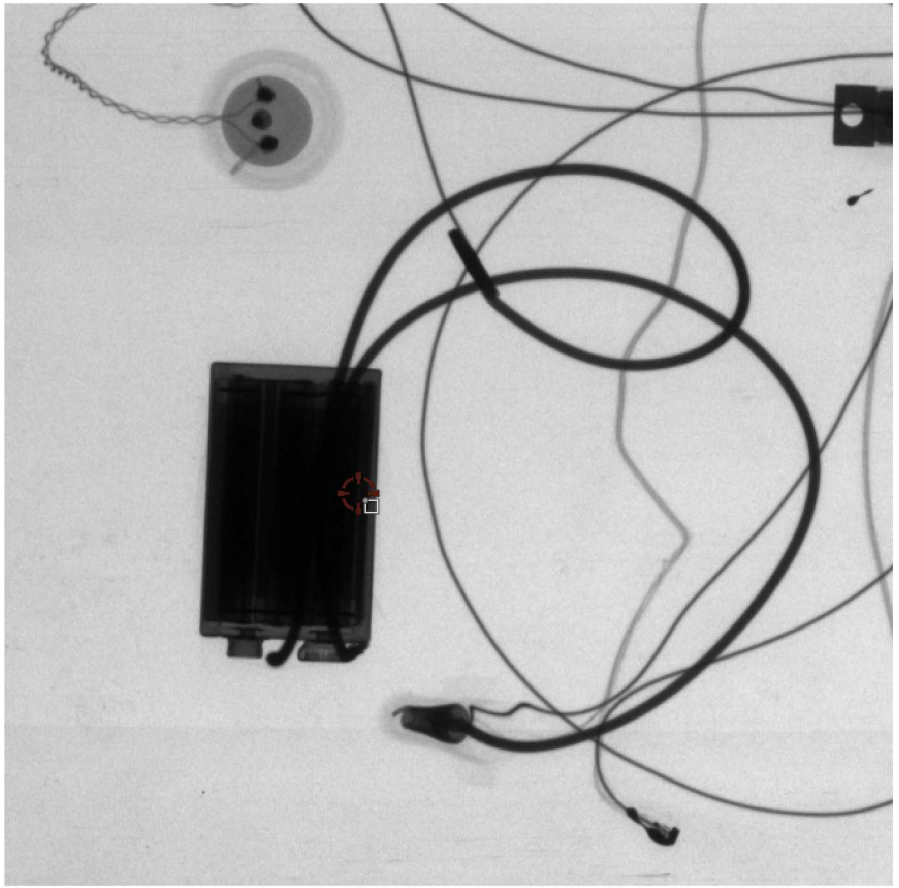


Component ID (in development)

Machine Learning based approach.

1. Highlight Component of Interest

2. View top 3 results, choose correct label or enter your own.



Component ID - RECON Website

https://xtk-recon.sandia.gov

Funded by CTTSO/TSWG

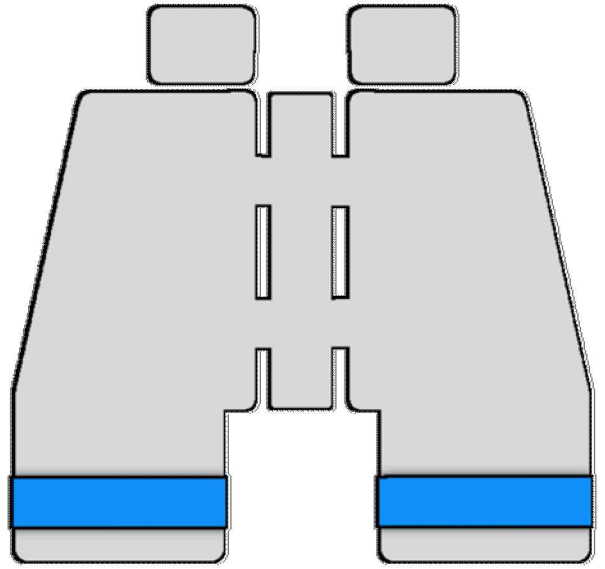
Stores image database used to train Component ID algorithm.

Provides component ID training back to participants.

Integrates directly with XTK 3

- Run Component ID from within XTK 3
- Upload images to RECON from within XTK 3

Hosted on a Sandia-owned, secure server.



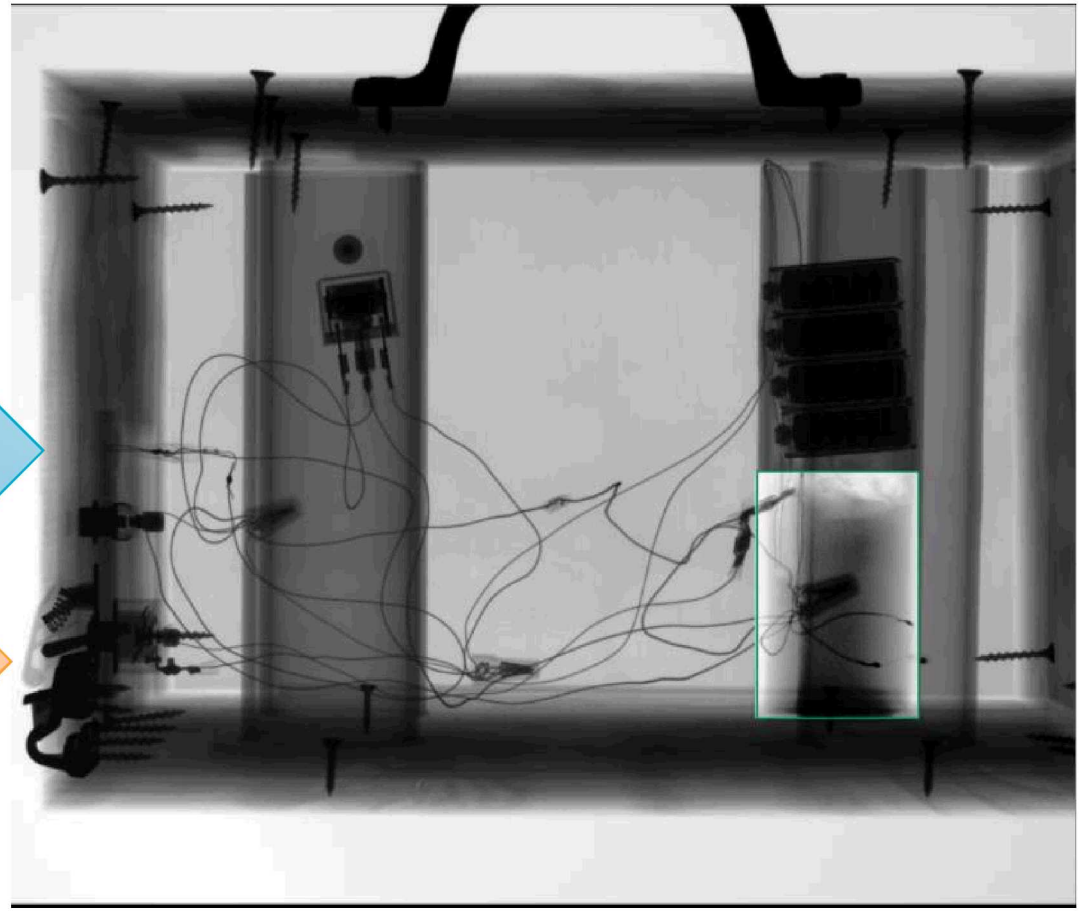
What now?

So we have wire tracing and component identification tools.

What can we do with both together?

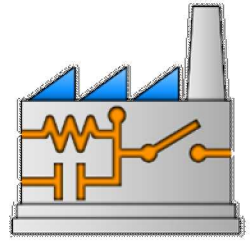
Circuit Graph

Help evaluate circuit function based on known or unknown components and connections.

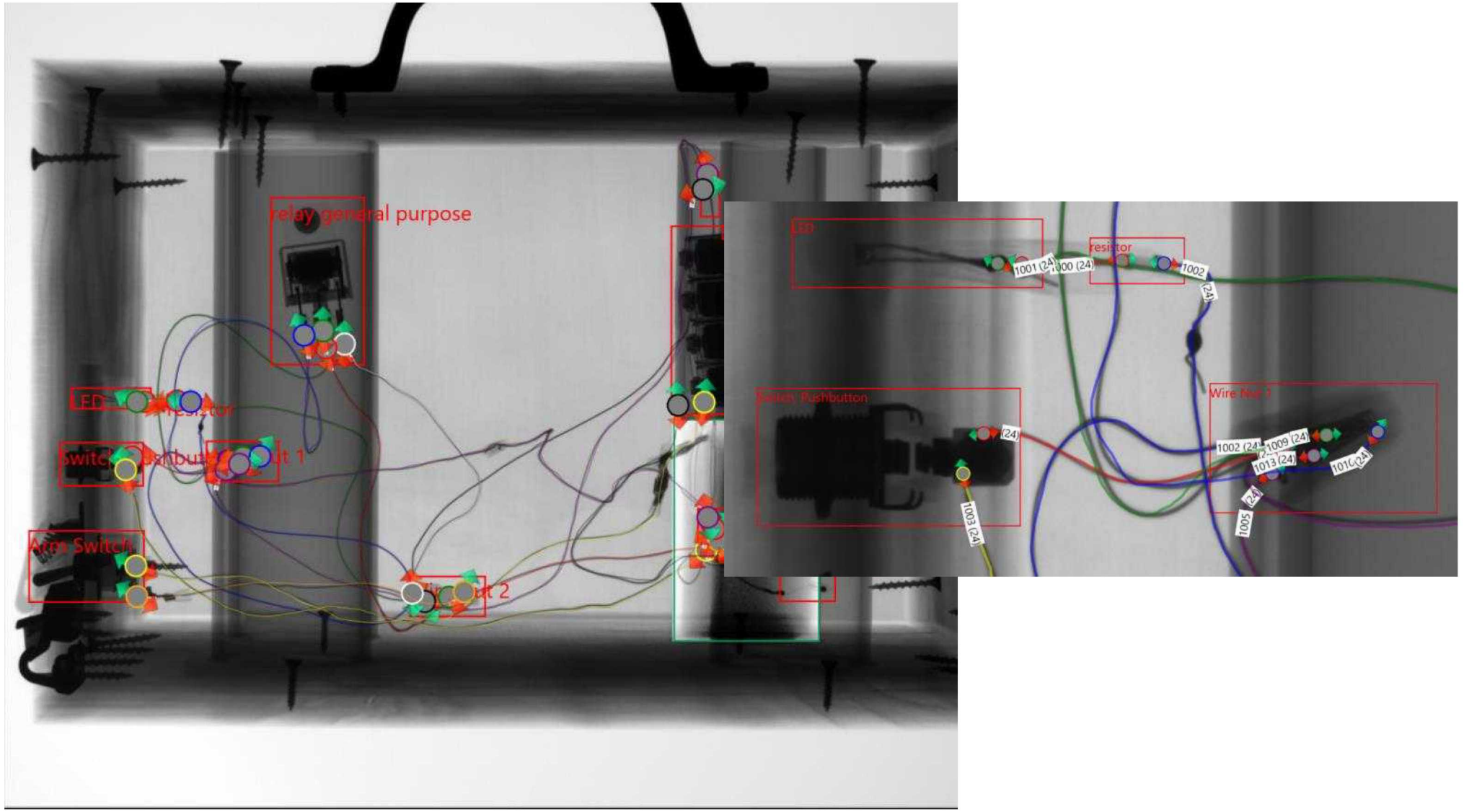


What does this LED indicate?

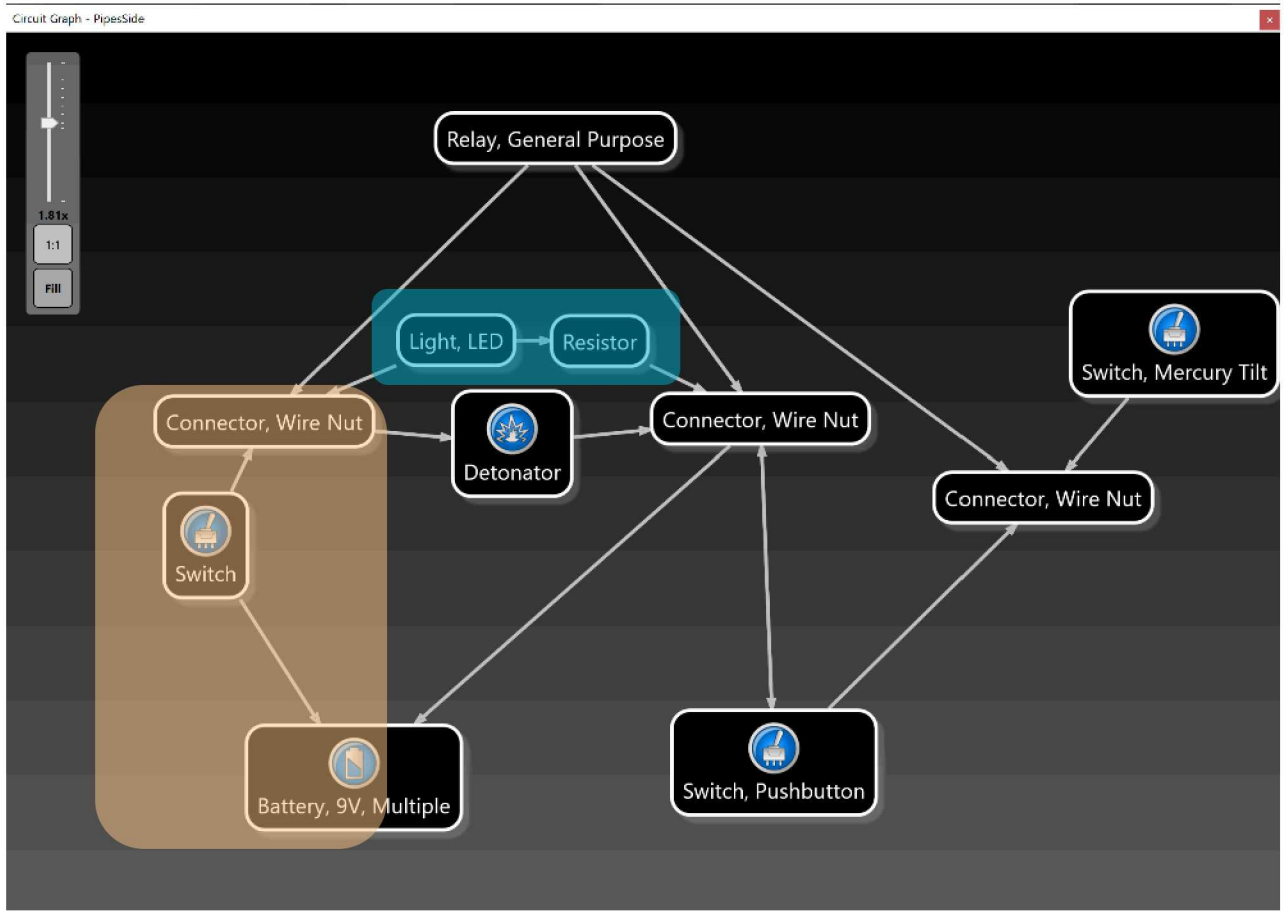
What does this switch do?



Circuit Graph – Step 1 – Labeling & Tracing



Circuit Graph – Step 2 – View and Interpret Component Function



The switch appears to be an arm switch, connecting the battery to the rest of the circuit.

The LED likely indicates the status of the detonator.

And now for something completely different…

Bug Reporting Process

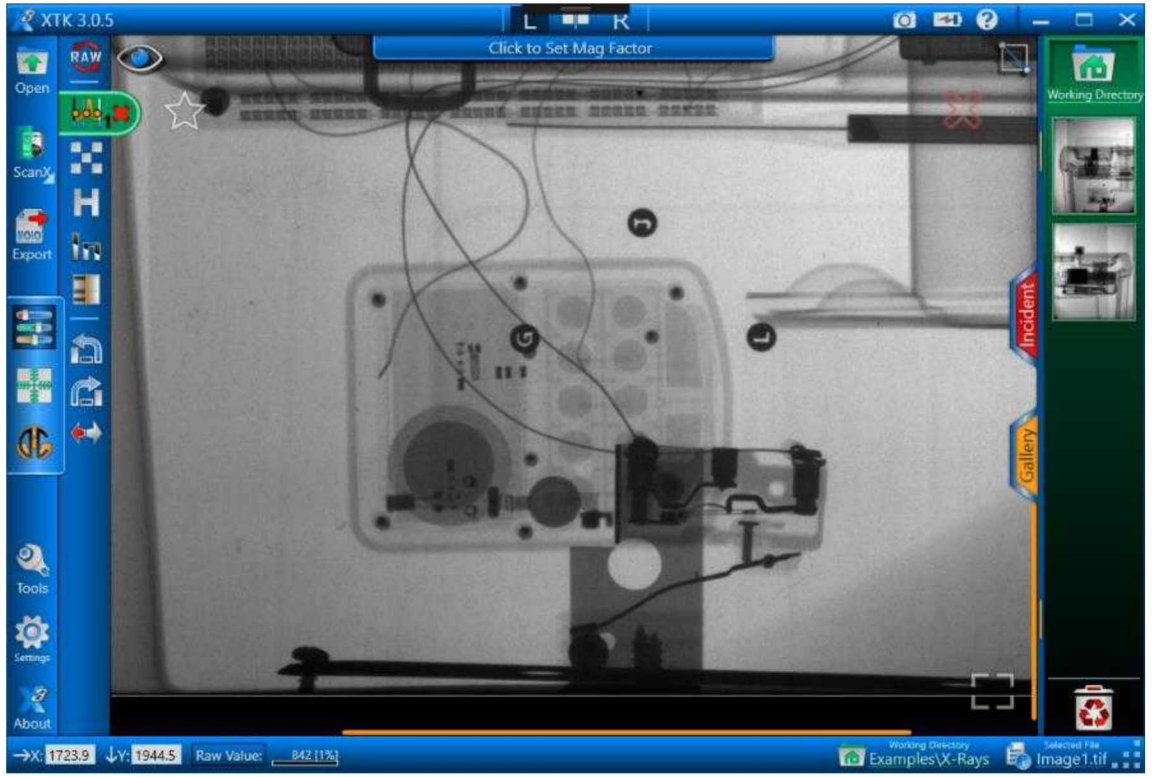
One of the improvements made in XTK 3 is our logging and bug reporting capability.

So what really happens when you submit a bug to us?

End User

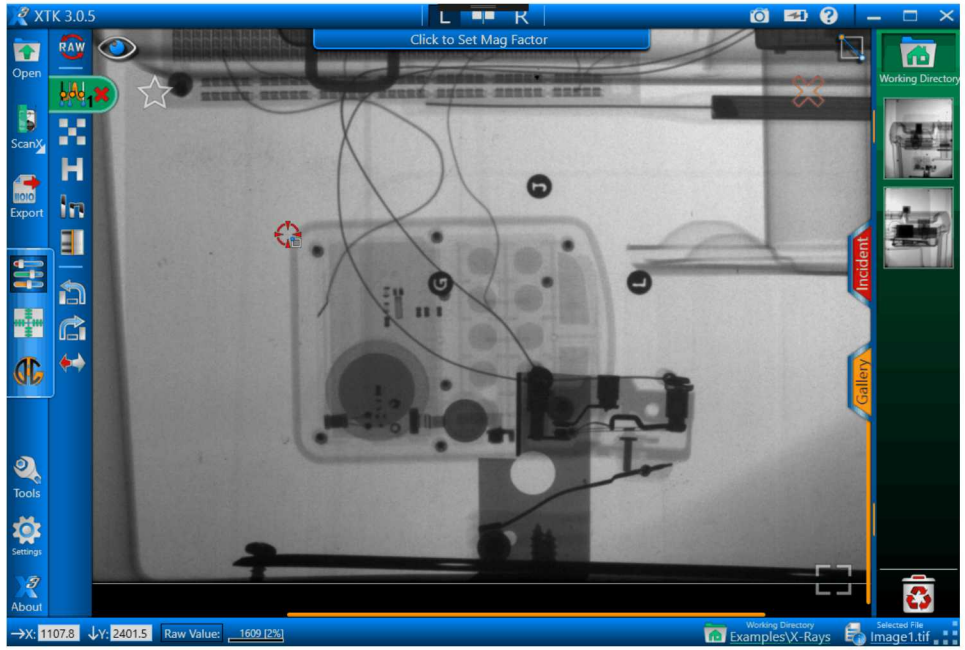
I open XTK, maybe I'll make some annotations.

Open up an image, look around, so far so good.



Something Goes Wrong

Ok, now I'll make anannotation. Click and drag….



The image closed??! What happened?

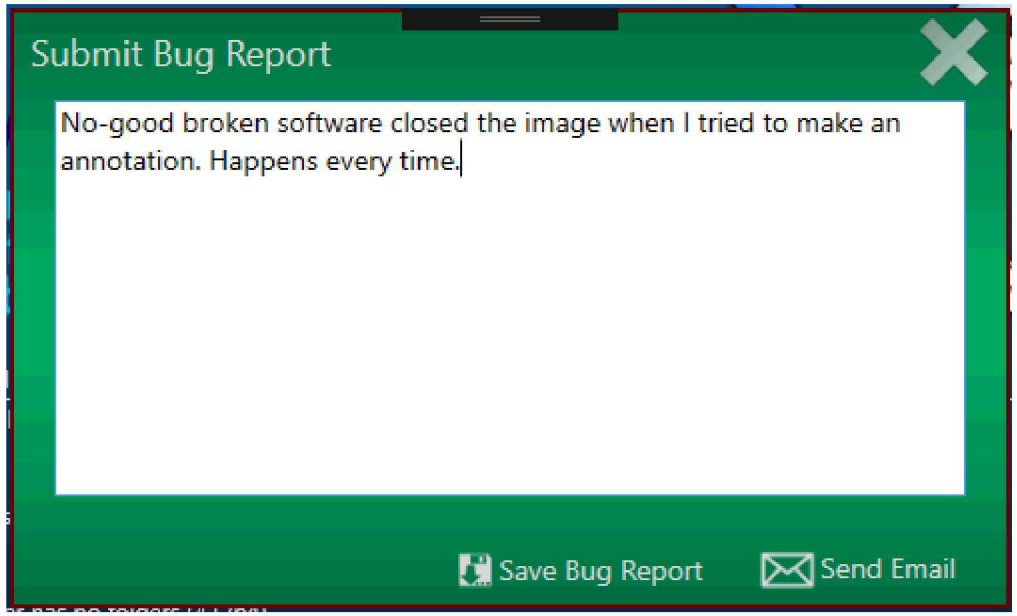
Maybe it was a fluke, restart XTK and try again.

Nope, same thing. Ok, this seems like a bug, I'll **submit a bug report**.

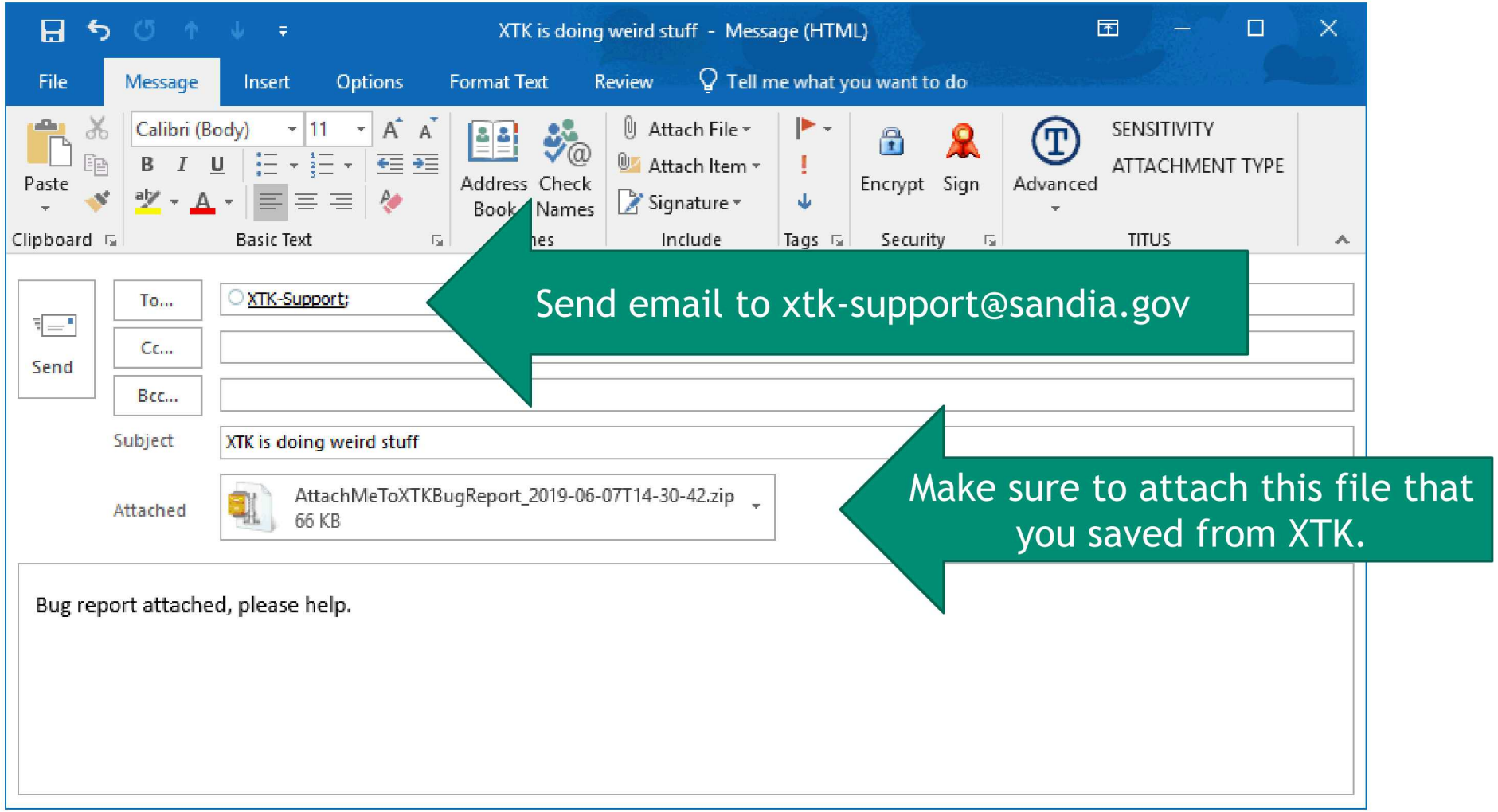
Sending in the Bug Report

First go to About -> Submit Bug Report.

Enter details about what happened, then click “Save Bug Report”.



Sending in the Bug Report



A Day in the Life of an XTK Developer

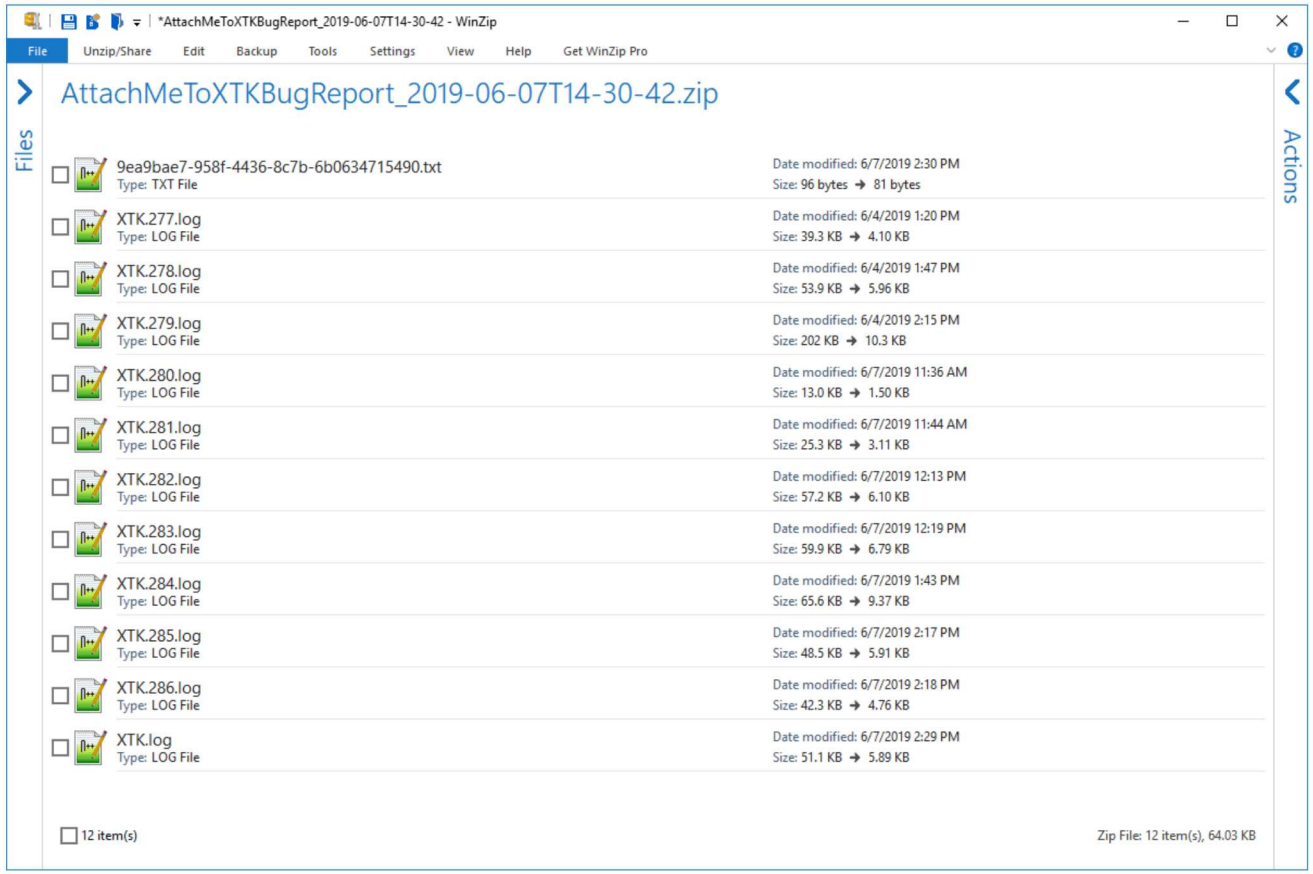
Checking email, drinking coffee, trying to decide what amazing feature to implement next.

Oh look, an email from one of our users, what could it be?

A bug? That's impossible, our software doesn't have bugs! Better check anyway, just in case.

First, lets look inside this bug report.

Bug Report ZIP file



Bug report file contains the logs from the last 10 times you have ran XTK on that computer, plus an extra file with the text you entered in the bug report box.

What is the problem?

So let's look in the logs and see what is happening here.

```
2019-06-07 14:26:37.8586 INFO SelectImageRegionInteraction: mouse down, enabling drag
2019-06-07 14:26:37.9823 INFO SelectImageRegionInteraction: Starting selection drag
2019-06-07 14:26:41.3842 INFO SelectImageRegionInteraction: mouse up, drag complete
2019-06-07 14:26:44.5387 INFO ImageViewModel: Closing Image, removing all overlays
```

Hmmm, so for some reason it is closing the image after the selection is complete. That shouldn't happen, so let's go look at the code.

The Code

After some digging around in the code that is executed when the selection finishes, we find this:

```
/// <summary>
/// This is called on mouse up.
/// </summary>
/// <param name="p_imagePos"></param>
37 references | 0/9 passing | Blayde Jungels, 78 days ago | 1 author, 1 change
public override void FinishShapeSegment(Point p_imagePos)
{
    this.Defining = false;
    base.FinishShapeSegment(p_imagePos);

    Debug.WriteLine($"FinishShapeSegment: {p_imagePos}");

    RaisePropertyChanged(() => SubSelectionStartPoint);
    RaisePropertyChanged(() => SubSelectionEndPoint);

    // Bad behavior added for demonstration purposes only.
    this.ViewTransform.ImageViewModel.CloseCommand.Execute(null);
}
```

Well, that explains it. Somebody added a line to close the current image when the selection is finished.

Why should I submit Bug Reports?

Your bug reports make XTK more stable and reliable.

The more detail you can provide the better.

This helps us in the cycle of continuous improvement for XTK.

The Six Stages of Debugging

1. That can't happen.
2. That doesn't happen on my machine.
3. That shouldn't happen.
4. Why does that happen?
5. Oh, I see.
6. How did that ever work?

What is in the Future for XTK?

More Scanners

We are actively working with anyone who sells x-ray scanning or digital detector equipment.

The scanner interface to XTK is open and standardized.

Everyone has equal access to XTK.

Advanced Features

Dual Energy

HDR

Improved Auto Stitch

Noise Reduction Algorithms

Improved 3D Visualization Tools

More?

User Feedback!

Ultimately XTK belongs to the EOD community, and we will continue to work hard to make sure it meets your needs.

Email us at xtk-support@sandia.gov if you have any comments or suggestions!

Questions?