



Triton

Industrial CT for
Production

User Manual



Triton User Manual

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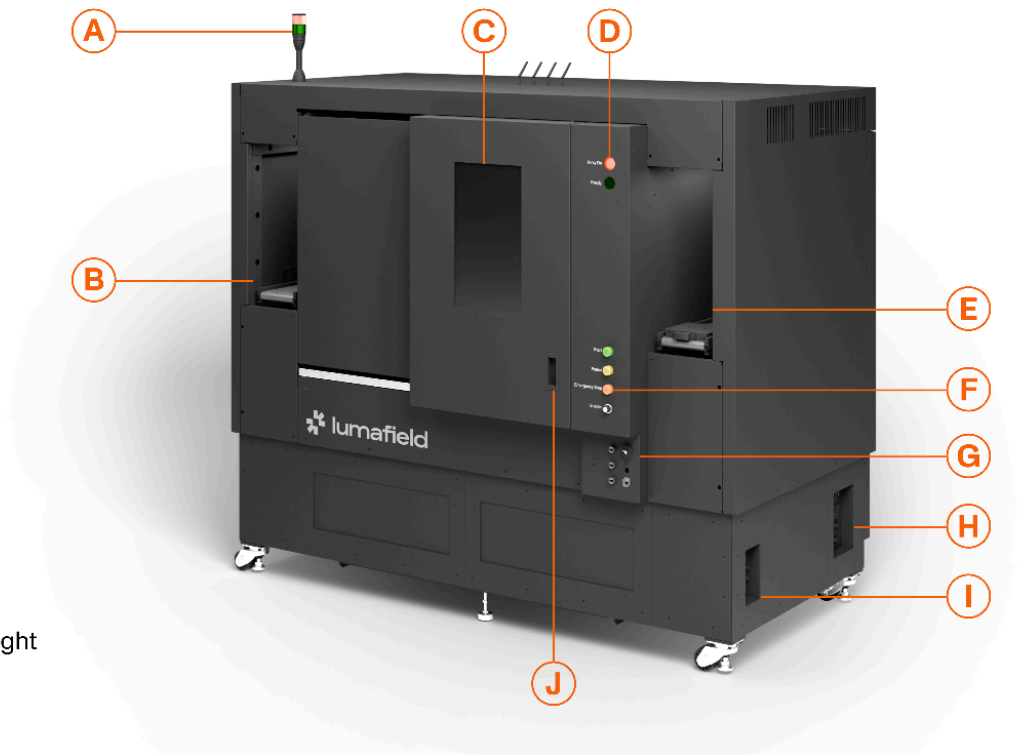
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Preface

Triton Overview Front & Back



A X-ray Indicator Stack Light

B Outfeed Portal

C Touchscreen

D X-ray Indicator Lights

E Infeed Portal

F E-stop & Key Switch

G Accessory Ports

H Power, Ethernet & Air

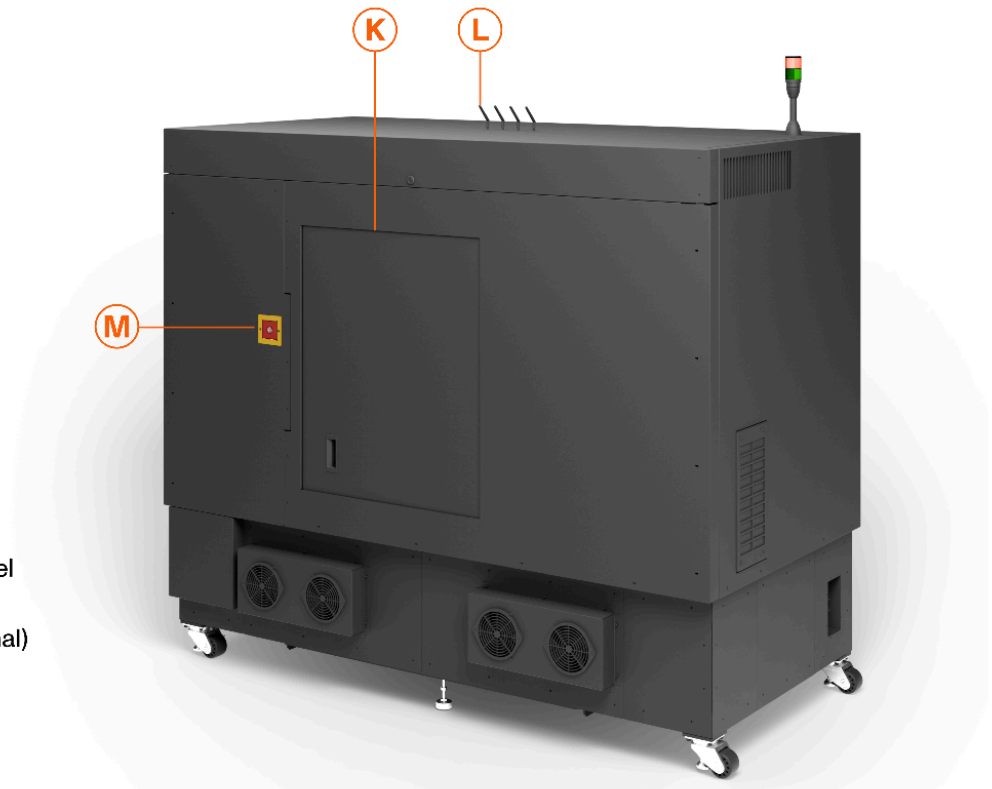
I Conveyor Ports

J Door Handle

K Maintenance Access Panel

L Wireless Antennas (optional)

M Rear E-stop



Quick Start Guide

What is Included

Your Triton scanner comes with the following:

- 1x Triton CT scanning module
- 1x Triton key
- 1x Lockout / Tagout
- 3x Power cable
- Transport pallets & pucks
- Custom part fixturing

Optional conveyor accessories available.

Initialization

If this is the first time starting your Triton, or the first time the scanner has been started in days, there are additional steps that will need to be done before you can start scanning. Triton's embedded software will guide you through the required steps. In general, there are two preliminaries required:

Warming

X-ray sources require a warming or conditioning step. Think of this as preventative maintenance that Triton automates for you. To minimize the wear and tear on a source, if it has not been emitting X-rays for a prolonged period, it will need to ramp up to operation slowly. The warmup time can vary depending on how long the source has been inactive. Lumafield's software will guide you in warming the source for the necessary amount of time based on the model of your scanner, vendor guidance, and our fleet health statistics. NOTE: Maximum time is around one hour.

Homing

Any time the machine has been fully powered down and turned back on, or if the emergency stop button has been pressed, the motion system will require homing. This ensures that the system knows its positions and can provide repeatable execution of part manipulation.

Running a scan

The software will guide you through these steps, but generally scans follow these steps after you've established a Triton scanning routine with a Lumafield partner.

1. Initialize scan program.
2. Continuously infeed parts.
3. Stop the program if necessary.

You can find detailed and up-to-date information for this process and user interface in our application-specific training.

Health and Safety

Safety Notice

It is important to read ALL safety information, instructions, and accompanying documentation before using the system.

Users must take caution and observe all warnings during routine use of the system. Before using the X-ray system, all system operators must have read and understood the safety information and operating instructions. Only personnel who have been properly trained shall operate the system.

Facilities must comply with any relevant local, state, and federal legislation for the possession and use of X-ray generating equipment. Lumafield performs all assembly and installation. Do not modify the system in any way.

Intended use

The Triton CT scanner can be used for inspections of non-living objects. These inspections are performed using X-ray radiation.

Understanding X-ray radiation

X-rays are a form of ionizing radiation that like ultraviolet light, when experienced in high doses, can cause serious injury.

Lumafield X-ray systems have been designed, built, and certified to comply with standards for cabinet X-ray systems (21 CFR 1020.40).

Triton CT Scanners are certified to emit less than 1.0 microsievert per hour (1.0 $\mu\text{Sv/h}$) five centimeters (5 cm) from all external surfaces of the cabinet. Under normal operating conditions, there is no significant X-ray radiation risk to users.

If the CT scanner has taken damage or safety features are overridden, this does not constitute normal use. Do not use the system if damaged or malfunctioning, and contact Lumafield immediately.

Safety features and precautions

The Lumafield Triton is a Certified Cabinet X-ray System, and adheres to the regulations that guide the design and operation of such systems.

X-ray radiation safety features

Surveying

The Triton CT scanner undergoes a radiation emission survey both at the time of manufacture as well as at the time of installation. Annual surveys will be performed by Lumafield or a third party authorized by Lumafield. A copy of the survey results will be provided for facility recordkeeping and reporting purposes.

Shielding

The Triton CT scanner utilizes enclosed lead shielding built into the cabinet. This limits the exposure to radiation to the area outside of the cabinet.

Indicators

The user interface has indicators for when the system is ready for X-rays to turn on (green), as well as when X-rays have turned on (red).

Emergency Stop

There is a red emergency stop button accessible from the front of the machine and the rear of the machine near the access portal. This will immediately cut power to the X-ray source and motion systems.

Access Control

The ability to power the X-ray system requires an access key.

Inspection Tunnels

Do not insert any part of the body into the entry or exit ports when the system is energized. Turn off x-rays before reaching into the ports to adjust parts or fix a jam.

Cabinet safety and precautions

Pinch Hazards

Be aware and avoid pinch hazards around moving components.

Crash Event

The machine will attempt to alert the user to unload the machine in the event of movements that could cause a crash. Nevertheless, users should be aware during operation of the potential to crash the motion system, causing damage to the machine or their sample.

Maintenance

The Triton CT scanner is maintained by Lumafield or third parties authorized by Lumafield. In the event of any malfunction, contact Lumafield for assistance at support@lumafield.com.

NOTE:

Do not alter or modify your machine.

Parameter	Value or Range	Value or Range	Value or Range
Marketing Name	Triton CT Scanner	Triton CT Scanner	Triton CT Scanner
Model	Model 97	Model 97	Model 97
Type	Type 130	Type 160	Type 200
Range of kVp adjustment	40 – 130 kV	80 - 160 kV	100 – 200 kV
Range of mA adjustment	0 – 0.30 mA	0 - 0.63 mA	0 – 0.75 mA
Duty cycle	Up to 100%	Up to 100%	Up to 100%

X-ray generation equipment specifications

Triton User Manual

Introduction

The Triton scanner family

The Triton family is a collection of industrial CT scanners designed by Lumafield to simplify X-ray computed tomography. By starting from the ground up, the Triton is more affordable than traditional options and easier to use.

Lumafield designed Triton to plug into your workspace with ease. It is at home on the manufacturing floor. It comes with wheels to easily maneuver through office doors and plugs into standard wall outlets.

Different options are available in the Triton family to meet customers' inspection needs. While the specifics of the family may evolve, each model focuses on certain benefits. Some models may have a higher power source that better penetrates heavy metals, while others may have a configuration that provides higher resolution.

All of these options share the same Triton hardware platform, and all connect to Lumafield's browser-based Voyager analysis software that can be run in the cloud or using Voyager on-prem. This means that your scans require no manual data manipulation. Once you hit Scan, Lumafield's automated pipeline handles the rest.

User interface and interactions

User interface

The main point of user interaction is with the touchscreen. The user interface provides access to the embedded control system and means that no additional hardware is required to operate your system.

The software constantly evolves as Lumafield adds new features and improvements to Triton. While the specifics may change, there are core actions that a user can complete with this interface.

- Turn X-rays on/off
- Run inspection routines
- Configure and manage routines

Conveyor system

Triton is designed to run batches of scans in an automated fashion, and as such is equipped with a configurable infeed / outfeed conveyor system. During application development, the specifics of this system will be adjusted.

Access key

A user must first enable a safety circuit with an access key in order to turn on X-rays. A user can activate other parts of Triton without this, such as the motion stages or the user interface. When the key switch is on, the system is enabled. When the system is enabled, the key may not be removed. When the key is removed, the system is not able to produce X-rays.

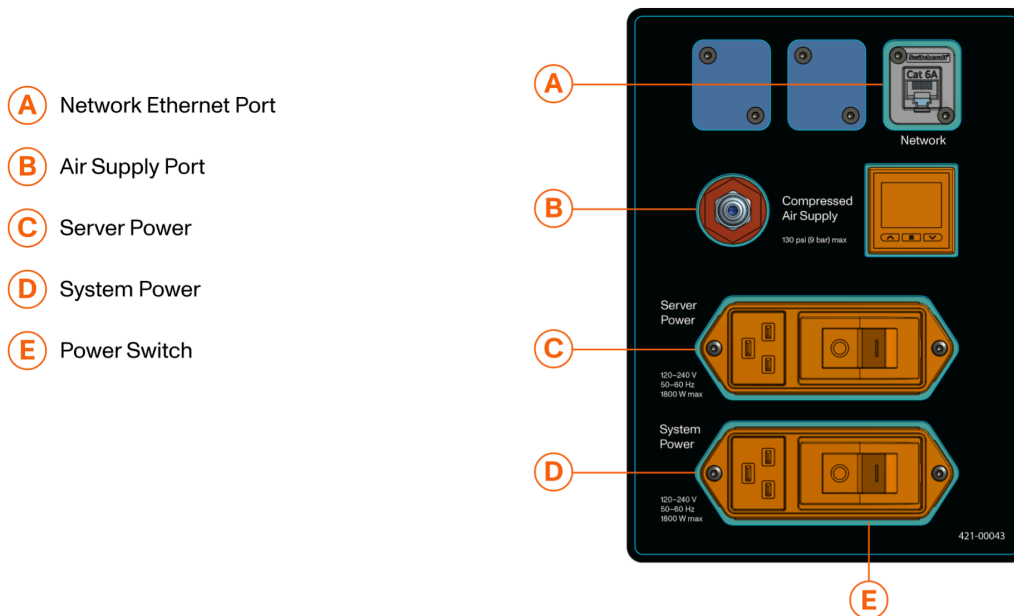
Status lights

The stack light mounted on top of the Triton indicates the machine state. The states are as follows:

1. No lights
 - a. The user cannot activate the X-ray source in this machine state.
2. Green light labeled "READY"
 - a. The user can activate the X-ray source.
3. Red light labeled "X-RAYS ON"
 - a. The X-ray source is active.

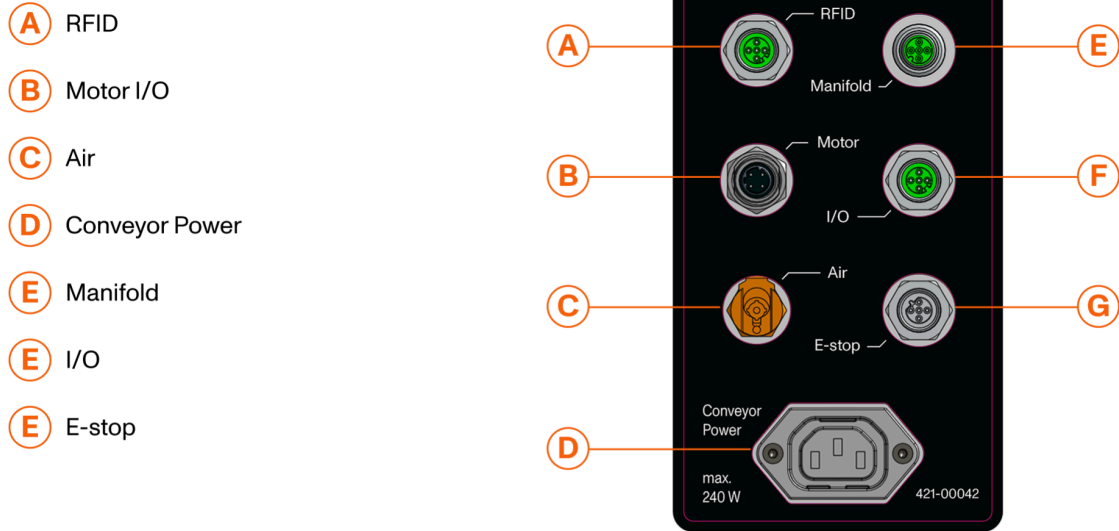
Power switch and IO panel

The right side (when looking at the front) of the machine has a panel for plugging into a power outlet as well as a port for internet connection via Ethernet. It also includes a switch to power the device on or off.



Front IO Panels

The front sides of the machine have two panels for connecting conveyor accessories as well as peripherals such as a barcode scanner.



Emergency Stop

There are two emergency stops (E-stops) on the body of the Triton. The front E-stop is located near the HMI alongside other physical controls. The rear E-stop is located to the left of the rear access portal. In case of an unexpected issue, such as a crash of the motion system, a user can press this button to cease all scanner actions including cutting power to the X-ray source. Additional E-stops may be located on the accessory conveyors.

Running a CT scan

Checking machine status

At a glance, you will be able to understand if your scanner is ready for operation, is currently scanning, or if user interactions are required. Check the touch screen and the status lights to understand if your machine is ready for operation.

Assessing your part

It's important to understand your part's composition and structure in order to produce the best scan.

There are two main factors to consider for how your part absorbs X-rays. X-ray absorption depends on how much material the X-rays must penetrate and the composition of that material. The denser or thicker the material, the more X-rays will be absorbed. In general, the thicker or denser the part, the longer the scan will need to be.

Another factor to consider is the makeup of the part, whether it is mono-material (i.e., all aluminum) or multi-material (i.e., aluminum with steel screws).

Fixturing your part

Developing precise and repeatable fixturing is critical for a successful Triton routine. Key aspects of fixturing are as follows:

Isolate the object

Isolate the object you are scanning from things you do not want to see (such as the turntable).

Prevent unwanted motion

Prevent unwanted motion of the part by securing it firmly in the fixturing material. Any motion other than the intentional rotation of the part by the stage is unwanted.

Center the part

Minimize artifacts by centering the part as well as possible.

Fixturing materials

Consider the density of the material you are scanning when determining the materials to fixture with. Floral foam is ultra-low density, allowing you to easily separate even lower-density plastics from the foam in the resulting scan. However, if scanning denser

materials such as aluminum, 3D-printed plastics may provide the required contrast and provide much more rigidity for repeatable scanning on a Triton.

Fixturing angle

Oftentimes it is best practice to mount your part to avoid flat surfaces perpendicular to the axis of rotation. These flat surfaces can introduce artifacts.

Positioning your part

The Triton offers options to optimize your part positioning. Typically, the primary goal of positioning is to ensure the relevant parts of your object will stay in the field of view during a full scan. Positioning on the Triton is something you can develop with your Lumafield Solutions Engineer.

Magnification

By moving the part closer to the source, you gain more magnification of the part. This results in higher-resolution scans, but reduces the field of view and resulting scan volume.

Understanding key settings

Beam energy

The beam energy or voltage (kV) of an X-ray system is directly related to the system's ability to penetrate materials. The higher the kV, the better the system will be able to penetrate dense materials.

Time

One of the biggest relationships to understand is the tradeoff between time and scan quality. As a general rule, longer scans will have better quality. However, there are diminishing returns after a certain point depending on the combination of the system and the object being scanned.

Filter

The X-ray source emits X-rays of varying wavelengths. Metal filters (such as copper) can be used to reduce the contribution of weaker X-ray wavelengths (and the artifacts they may create) at the expense of longer exposure times. When scanning multi-material parts (parts with a wide range of densities), adding filters to the beam can improve the contrast of scans.

Online documentation for latest software updates

The Lumafield Triton is a product that continuously evolves. Lumafield is always updating its software, user interface, and features. As such, you can reference support.lumafield.com for the most up-to-date documentation on the user interface, software features, and troubleshooting. Contact your support engineer for any Triton system update inquiries.

Analyzing a CT scan

Introducing Voyager

Voyager is Lumafield's browser-based web application and CT scan analysis software. Voyager serves as your persistent repository of data, your inspection studio, and your collaboration environment.

You can access Voyager anytime at voyager.lumafield.com if you are using Voyager Cloud, or at a custom internal URL if you are using Voyager On-Prem. It is free to sign up for an account, and it also includes access to a living library of public demonstration datasets.

With your Triton scanner comes a managed Organization to securely upload and store your scan data. When members are added to an Organization (via workspace), they get access to paid-for features and software modules, as well as access to any data generated with their Organization's Triton (that is within the workspaces they are added to). Using workspaces allows you to segment your team to access only the data they need to.

Core data types

Images / 2D data

Voyager works with several types of 2D data. For example, radiographs are 2D X-ray images that the scanner generates as part of every full scan. Use Voyager to scroll through a full rotation of your part after your scan is complete.

3D voxel data

Reconstructions are 3D volumes of your scans that the Voyager platform generates from 2D radiographs. Reconstructions are made up of voxels, which are roughly equivalent to cubic 3D pixels. Each voxel has an attenuation value, which is a measure of the relative density of that voxel normalized across the entire volume.

3D surface / CAD data

A mesh is a surface representation made of polygons. In Voyager, meshes are used to represent the surface within your scan (also known as a boundary or segmentation). Voyager is also capable of representing design files input by the user.

Analysis data

Several tools in Voyager empower users to create analyses of defects in their scans. For example, in comparative workflows such as CAD Comparison and Scan to Scan Comparison, a user can run a geometric comparison between two scans and get the resulting deviation field. Another example would be the output of a Porosity Analysis, which would highlight the voids found within a part and visualize them with the rangemapper.

Example analysis workflow

Voyager allows you to explore your data with analysis, visualization, and measurement tools. Below is an example of a common workflow that would allow you to assess whether an injection-molded part is manufactured to specification:

- Step 1: Create a Region of Interest (ROI) for your part.
- Step 2: Create a mesh of the surface of the material of the part in question.
- Step 3: Upload the CAD file of the corresponding surface of the part.
- Step 4: Align the CAD file with the mesh using the Auto Alignment feature.
- Step 5: Submit a comparison to Voyager for analysis.
- Step 6: Inspect the comparison results, and create useful bookmarks.

This workflow can be automated with Recipes. Work with your Solutions Engineer to understand opportunities for automation.

Collaborating

Your CT scans can help you and your team make actionable data-driven decisions about your manufacturing process. Lumafield products support a growing number of collaborative workflows that let you provision both viewing and editing access to different groups of scans.

Online documentation for latest software features

Lumafield's products are constantly evolving. Visit support.lumafield.com to access our ever-growing knowledge base. Documentation, case studies, tutorials, and more are all available.

Applications

Giving an engineering team X-ray CT is like giving them a superpower. The day any engineer receives the first part they designed is filled with wonder and anticipation. But without seeing inside, engineers can never completely understand what they hold in their hands. X-ray CT is the final step to close the loop on manufactured goods.

- Leaky packaging
 - Identify leak paths in complex assemblies without destructive measures.
- Damaged housings
 - Use CT to uncover hiding sources of failure, such as unexpected inclusions.
- Electronics failures
 - Identify hidden sources of failure such as solder shorts or lifted pads.
- Assembly failure
 - Identify and count components, check orientation and validation positions.
- Design validation
 - Use CAD Comparison to visualize the as-manufactured state versus the design intent.
- Assembly process design
 - Use CT to power studies, for example the impacts of screw torques on components.
- Wear testing
 - Scan components throughout lifecycle testing to monitor performance and degradation.
- First Article Inspection
 - Scan batches to spot variation between cavities, incoming lots, or suppliers.
- Assembly interactions
 - Virtual slices let you inspect complex assemblies non-destructively.
- Supplier qualification
 - Porosity Analysis helps quantify molding defects hiding below the surface.
- Quantify hidden defects
 - Identify differences when dealing with complex supply chains.
- Process development
 - Spot defects such as trapped powder when qualifying additive manufacturing.

Routine Maintenance

Maintenance by Lumafield

Surveying

Lumafield performs a radiation emissions survey at the time of installation. Surveys will be conducted annually by Lumafield, unless local regulations mandate a higher frequency.

Interlock testing

Lumafield will perform interlock testing to ensure the safety of the system annually, unless local regulations mandate a higher frequency.

Maintenance by user

General cleaning - Quarterly

During the use of the machine, dust and debris may accumulate inside of the cabinet enclosure and on the conveyor system. Periodically clean or vacuum to remove any debris. Check the air filter below the detector for cleanliness.

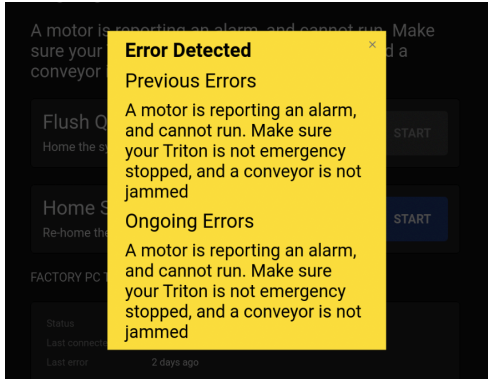
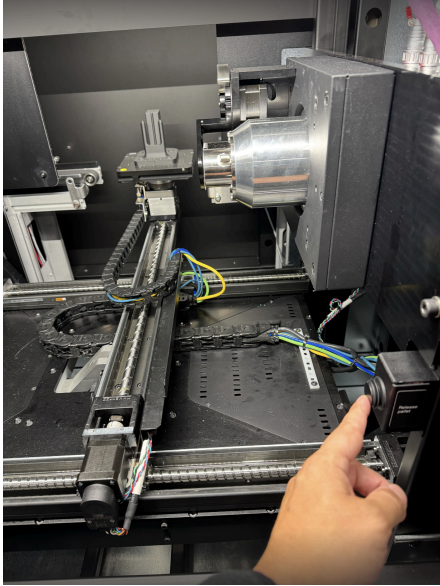
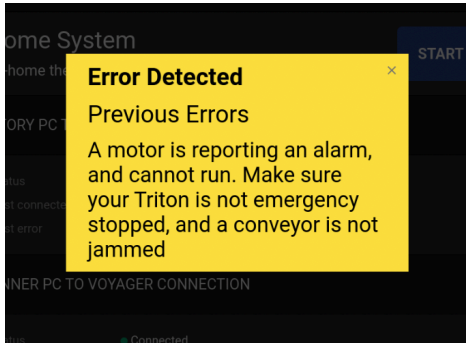
Survey of safety features - Monthly

Check to ensure that the following safety features remain in working order:

- Emergency Stop
- Access key switch
- Indicator lights
- Conveyor system
- Interlock functional test

Troubleshooting

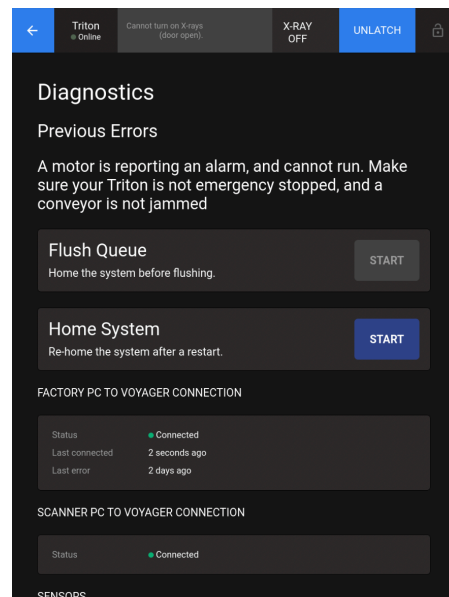
E-Stop Recovery Workflow

<p>Step 1 of 4</p> <p>When an e-stop is engaged on your Triton you will see this message on the HMI.</p>	
<p>Step 2 of 4</p> <p>You will need to release the e-stop. There are 2-4 physical e-stops located on your machine.</p> <p>Open the door to the scan chamber on your Triton. If there is a pallet in the tool holder. Use the release pallet button to release the pallet and remove it from the machine.</p>	
<p>Step 3 of 4</p> <p>Clear the below error by pressing the "X" in the corner.</p>	

Step 4 of 4

After verifying that the scan chamber is empty, home the machine using the button shown here.

It is strongly recommended to flush the machine after an e-stop.



FAQ

Why is my Triton unresponsive?

The Triton UI will remain unresponsive if any of the E-stops are engaged. Depending on your accessories, the Triton may have up to 4x E-stops on the machine. There are 2x located on the body of the Triton, one in the front and one in the back. With our most common infeed and outfeed modules, there are 1x E-stops on the infeed and the outfeed. Additionally, the key needs to be in the on position for the Triton to operate.

Why didn't my scan upload?

The Lumafield Triton CT Scanner is a fully contained device but data must be transferred from the scanner to the on-prem Voyager unit (known as "uploading"). Rebooting the scanner may help restart an upload process. The top bar of the scanner will display if the scanner is Online or Offline.

Why isn't my scan available yet?

Voyager relies on data uploading from the Lumafield Triton scan unit to the on-prem Voyager processing unit. Once the data has been uploaded, reconstructions are typically completed within an hour and much less depending upon your application. If you have confirmed that your scan has uploaded from the Triton, but the reconstruction is taking longer than expected, reach out to support@lumafield.com for assistance.

How do I move my scanner?

You should not attempt to move your scanner without consulting Lumafield. Reach out to your Lumafield Solutions Engineer, Account Executive, or support@lumafield.com.

How do I access the software?

Talk to your system administrator.

How do I fixture this part?

Fixturing should hold your part rigidly in a low-attenuation material to prevent unwanted motion while allowing you to separate the part from the fixture in the CT scan. From there, there are several tricks to tailor fixtures to specific intent. See the Fixturing section (2C.) in this User Manual, or visit support.lumafield.com for more detail. You may also reach out to support@lumafield.com with specific questions.

What is the factory-set password?

The factory password for the Lumafield Triton operator mode is "lookwithin" without the quotes. The factory password for the Lumafield Triton manager mode is "lockedwithout" without the quotes. If this does not work, double check support.lumafield.com for the latest support docs, or reach out to support@lumafield.com for assistance.

Contact support

Your Triton includes on-demand technical and application support for your entire contract. Your Lumafield Solutions Engineer or Account Executive should be your first points of contact. They are always happy to provide guidance and help you get the most out of both your Triton scanner and Lumafield's Voyager analysis software. If you do not know who your Solutions Engineer or Account Executive are, speak with the owner of the equipment at your company. You may also reach out to the email addresses below anytime with questions:

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