NEWTON

An Introduction to Newton Labs

NEWTON

Newton specializes in
the combination of
machine vision and robotics,
designing and manufacturing
machines that can see
and make decisions

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From its Beginnings

- At the Massachusetts Institute of Technology (MIT):

Click image to begin video

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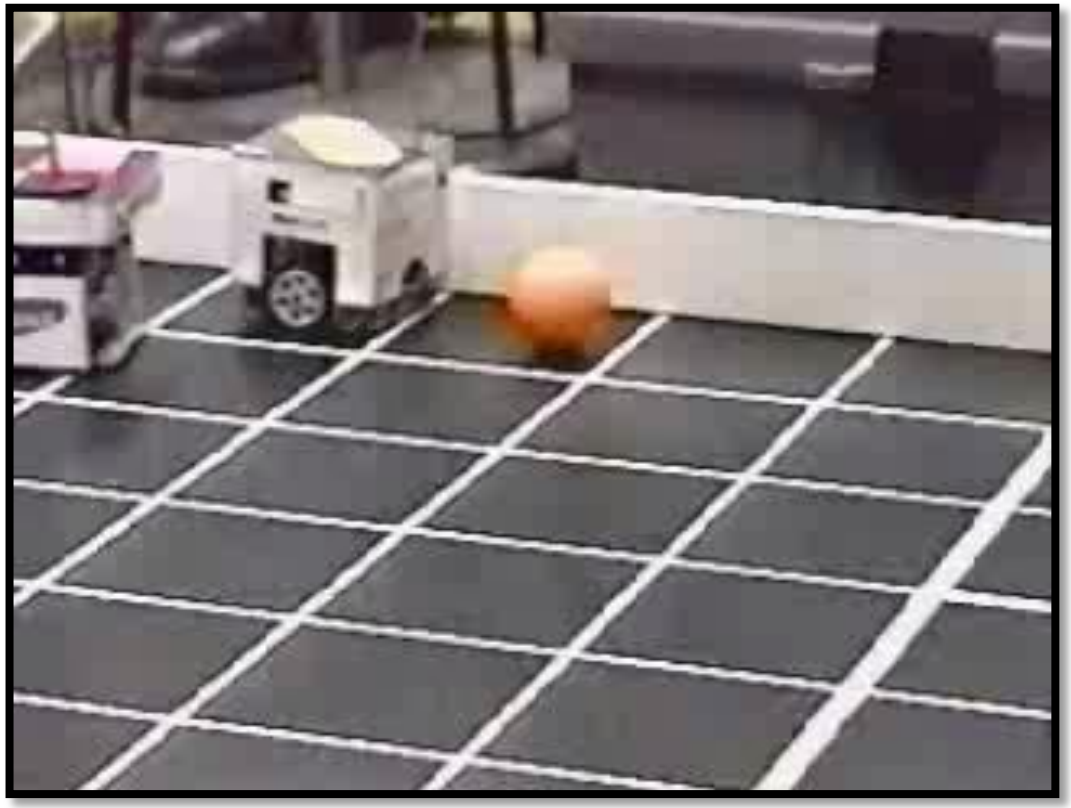
The Newton Advantage

- Newton specializes in the combination of machine vision and robotics, designing and manufacturing machines that can see and make decisions.
- Newton led the field over 20 years ago designing autonomous robots capable of playing soccer without human control
- Technology has advanced and been leveraged into industrial applications.



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History of Newton Labs

- Established in Cambridge, Massachusetts in 1990 as an offshoot of MIT; moved to Seattle in 1995.
- Specializes in machine vision and robotics with an emphasis on automation combining machine vision with mechanics and electronics.
- Services a wide variety of industries, focusing on applications where the introduction of machine vision to robots and automation can provide powerful new functionalities not previously available. Many of Newton's projects are the first of a kind in the world.
- Designs and manufactures all of its own machine vision and robotics software and virtually all of its own hardware, including controllers, cameras, lighting, electronics, machine control and mechanics.
- More than 20,000 Newton systems are deployed worldwide.

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Newton Today

NEWTON

Underwater Laser Scanning Technology and Process

Nuclear Industry TIP Award 2012

This technology enabled Exelon Nuclear to win a Nuclear Energy Institute 2012 Top Industry Practice (TIP) Award for *"Laser Scanning Within a BWR Vessel."*

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Newton Labs develops and manufactures laser scanning systems that are specifically designed to operate underwater and deliver precise measurements.

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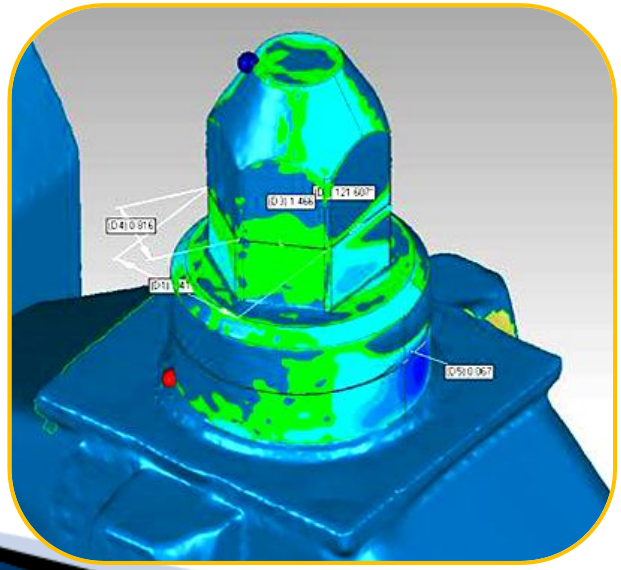
Newton Underwater Laser Scanning

- Underwater laser scanner technology by Newton Labs captures as-built measurements with sub-millimeter precision, as well as being able to quantify rust, wear, fissures, corrosion, cracks, welds, pitting and other deformities.
- Laser scanning produces a point cloud so dense that when utilized with industry standard 3D software, a fully measurable CAD model of a scanned area can be generated.



This fully dimensional CAD model of an underwater jet pump bracket bolt was rendered in 3D software by combining point clouds from consecutive scans at different positions. Areas of greenish coloration indicate corrosion.

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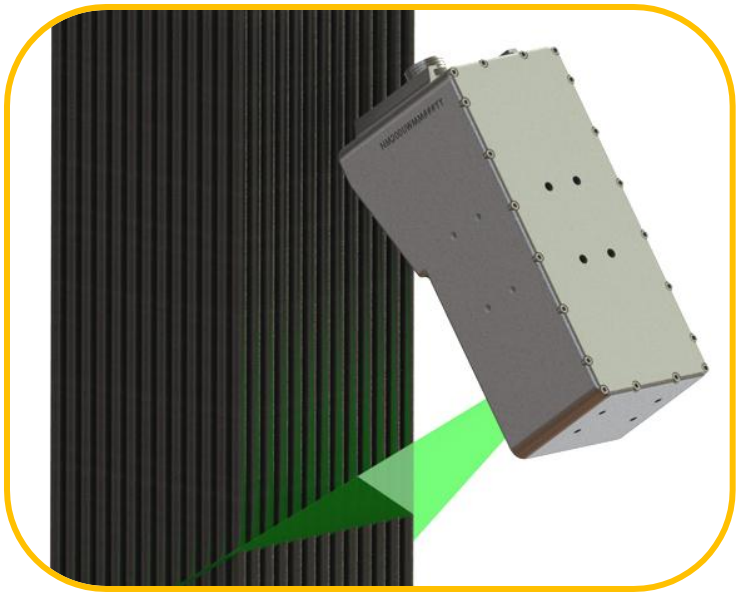
Newton Scanning Technology

- Newton laser scanning is based on projecting a controlled beam of light onto a surface and determine geometrically how the light is reflected light back, both in air or underwater.

- Newton typically employs lasers as the light source and CCD cameras for the sensor. This has been a reliable and powerful solution for many industrial and nuclear customers needing 3D data.



A model NM200UW Nuclear Underwater Laser Scanner

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Newton Scanning Technology

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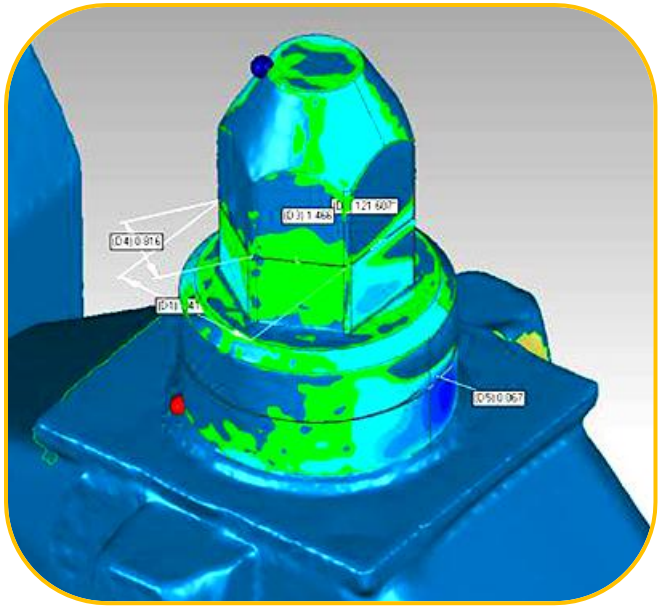

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The In-Vessel Environment

- The NM200UW delivers precise measurements of as-built components located in-vessel and in the cooling pond so that plant operators may:
  - Determine current condition
  - Track cycle-to-cycle degradation in these areas
  - Achieve a correct fit for fabricated replacement parts

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The In-Vessel Environment

- The NM200UW is a landmark technology developed by Newton Labs in partnership with a major U.S. nuclear utility.
- The NM200UW Nuclear Underwater Laser Scanner delivers precise dimensional measurements in the underwater radiation environments found in BWR and PWR vessels
- NM200UW software compensates for water turbulence, heat and radiation to produce a point cloud of great detail and density
- The scanner head is designed and built to tolerate radiation and has performed well in the presence of Gamma radiation levels of 5kR

A model NM200UW scanning within a BWR annulus

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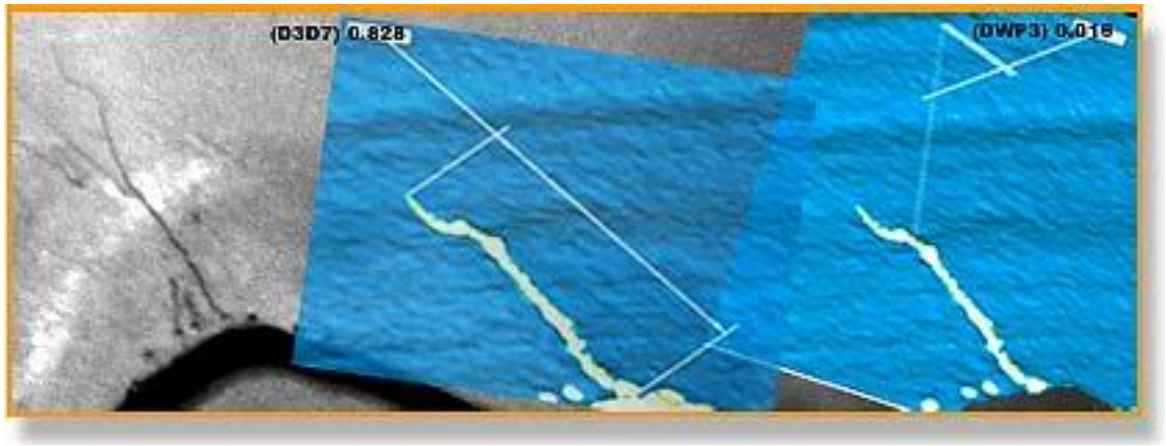
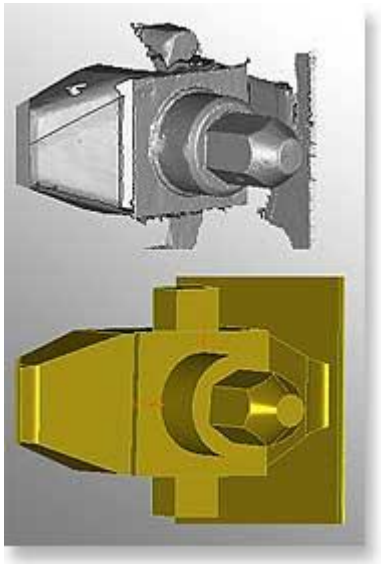
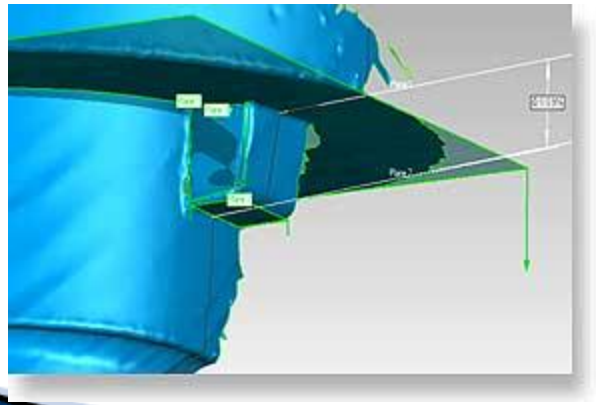
Examples of NM200UW In-Vessel Measurement



(Left) A standard IVVI video shows a crack in a BWR steam dryer door.
(Center-Right) The NM200UW scan can be measured anywhere along length or width.**



Top - An underwater scan of a bolt assembly
Bottom - Same bolt as a fully-measurable CAD file



The point cloud from a scanned BWR main wedge enabled the rendering of a precise, measurable CAD file.**

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Marine and Offshore

- Hardware, piping and structures underwater begin to change over time which can affect their function and integrity.
- Obtaining precise underwater measurements to track changes and degradation is generally difficult and in some cases, dangerous.

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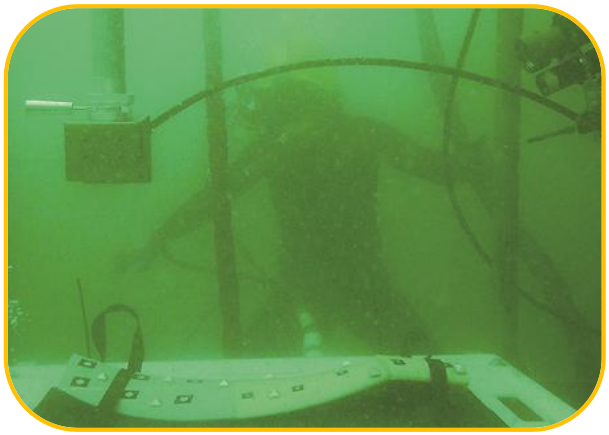
Tuned to the Marine Environment

- Laser light color is maximized for water penetration. The specific wavelength of the laser allows for highest possible efficiency underwater transmission.
- The scanner camera only accepts the specific color produced by its own laser and LED lights
- In the visual observation mode, the LED ring array in the head illuminates the target area and the camera transmits a high-resolution monochrome image to the control console screen to assist the operator for optimum positioning and on-site analysis.
- U.S. Navy divers have deployed Newton underwater laser scanning technology in the waters of Puget Sound



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Adaptive Containment

- Depending on the working depth requirements, the hardware and electronics of the measuring head can be adapted to a range of state-of-the-art marine packaging, as long as the adaptive casing conforms to the required angle and distance between the laser and the video camera.

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Deployment

- The measuring heads of Newton laser scanner are designed to adapt to several methods of deployment.
- The pressure-resistant casing of the measurement head is configured with alternate mounting points on most faces. This enables the unit to be firmly attached to a bracket or pole or arm.
- As with photography, the most accurate laser scanning results are achieved if the measurement head is stable.
  - We recommend that the scanner head be deployed on a larger ROV with station-keeping capability, or at least one that can rest upon, or attach to, a surface or structure.
  - A diver-deployed scanner head should be stabilized with a third-party clamping bracket or pole, a magnetic bracket, or a tripod.

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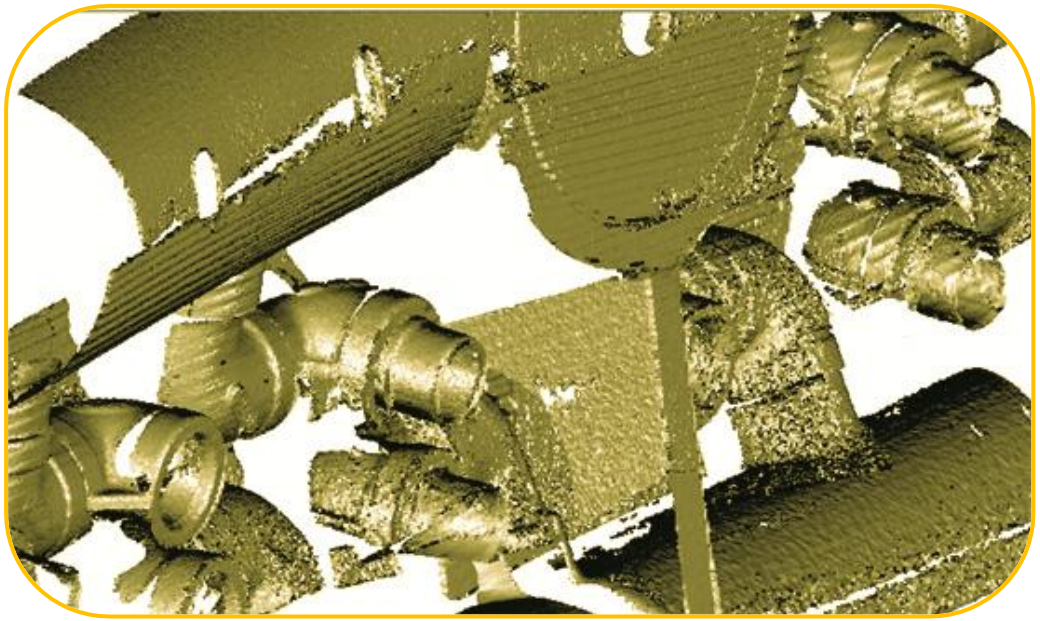
Accurate CAD Models

- Measurable CAD models can be developed from large underwater areas or surfaces by combining the point clouds of several scans.



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Software is the Key

- The key to the revolutionary the non-contact underwater laser measurement technology is the sophisticated, Newton-developed software working in concert with a laser scanner and a high-resolution video camera.
- The software compensates for refraction, turbidity and suspended particles, resulting in the generation of a dense point cloud of the scanned area that, when processed by industry standard 3-D software, results in a fully measurable CAD file.

A rack mounted PC runs the software in the control console for all Newton underwater laser scanners. The airline-transportable case houses the LCD screen and the keyboard with trackball.

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Newton Scanning Technology

- All Newton underwater scanner models operate by laser triangulation.
- The projected laser line sweeps the target surface and the high resolution camera captures and records any deformation of the line as a point cloud enabling ultimate 3-D computation.
- Scanners are designed to scan and capture much larger target areas, by combining several point clouds together to form larger composites.

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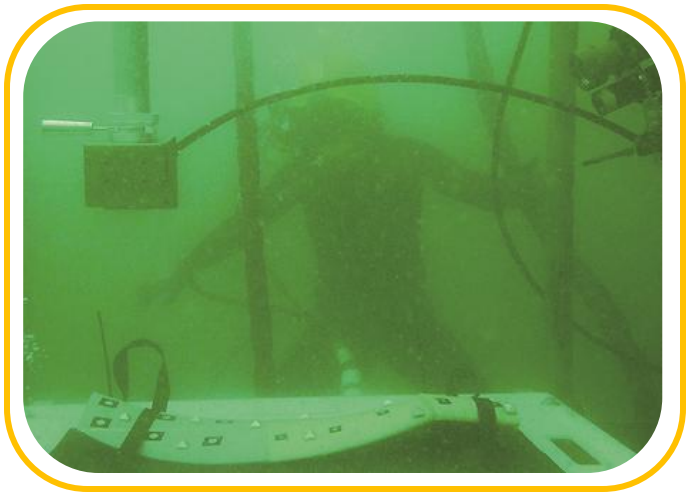
Newton Scanning Technology

- Laser light color is maximized for water penetration. The specific wavelength of the laser allows for highest possible efficiency underwater transmission

- The scanner camera only accepts the specific color produced by its own laser and LED lights, greatly reducing any contamination from stray light in the scanning environment.



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Newton Scanning Technology

- In the visual observation mode, the LED array on the head illuminates the area and the camera transmits a monochrome image to the control console screen to assist the operator for optimum positioning and on-site analysis.
- The control console powers and communicates with the scanner through the cable via low-voltage DC power and signals with pictures and scan data transmitted via Gigabit Ethernet.
- The scanner head can be deployed by a variety of methods, including pole mounting, an articulated arm, an ROV or other robots.
- All data is permanently stored for later analysis and study.

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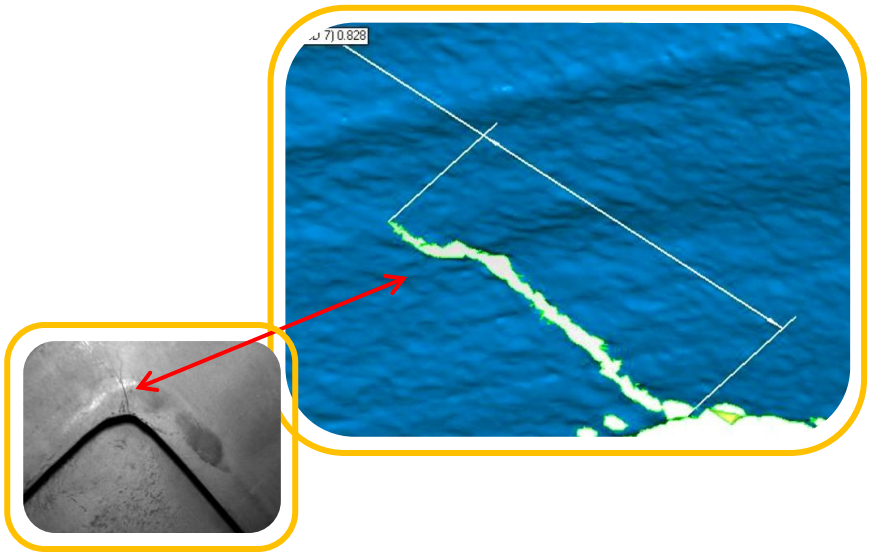
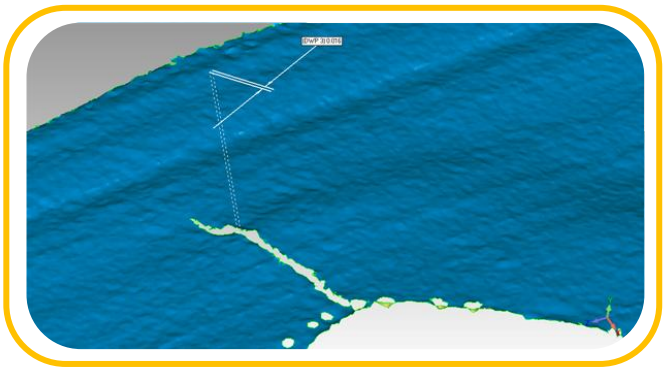
Newton Scanning Software – The Key to Results

- In-air laser scanners have existed for several years
- Precise underwater laser scanning is much more challenging due to the marine environment
- Newton-developed software makes underwater laser scanning possible



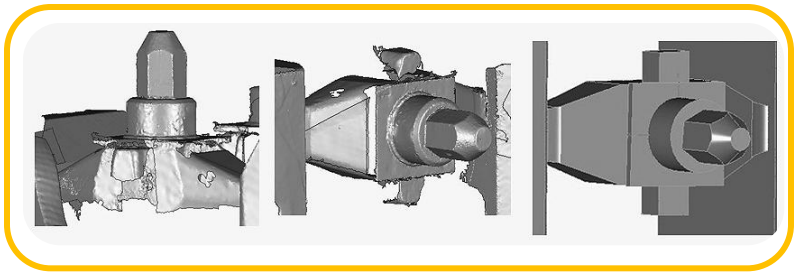


CAD model of a BWR steam dryer door indicating both precise crack length, width and surface condition.

Newton Scanning Software – The Key to Results

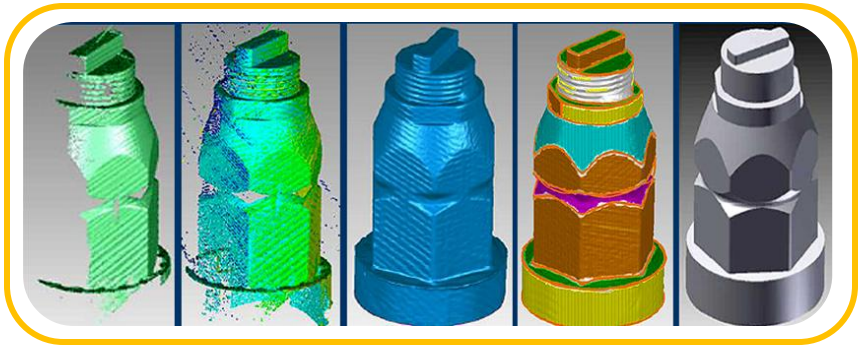
- Newton's software compensates for water turbulence, heat and radiation to produce a point cloud of great detail and density

- The point cloud, when processed by industry-standard 3-D software, produces CAD files with dimensions that correspond precisely to the original target object



Beam bolt scan-side | Beam bolt scan-front | Beam bolt CAD file

The two images on the left are initial point clouds from scans of target from different angles. Processing stages by 3-D software results in the final CAD model (far right).



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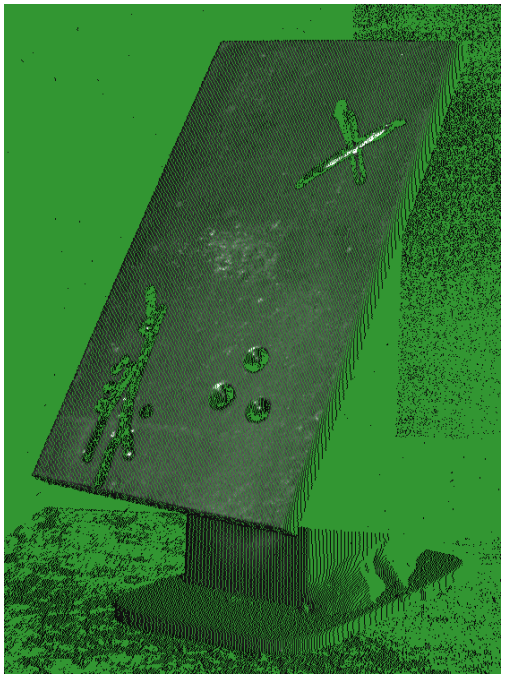
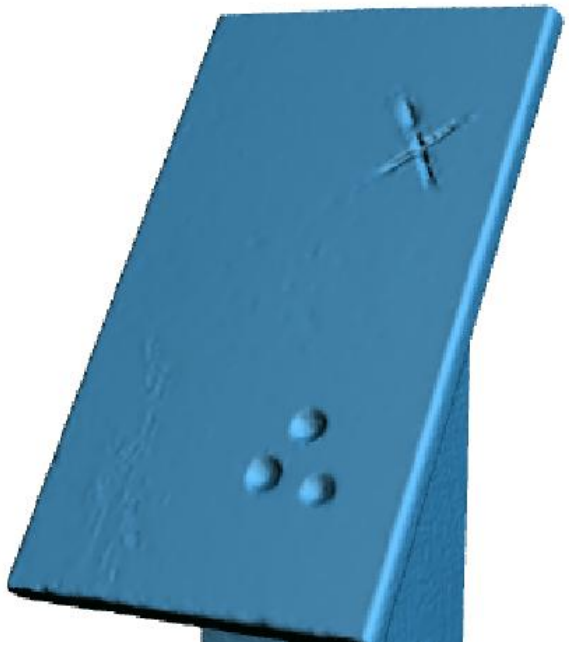
Detect and Measure Surface Distortions and Dimensions

Scanner photograph of object before scan. Bottom left corner shows surface abrasion, bottom right shows divots and the top right simulates a crack



Scan Data of same object



CAD model generated in GeoMagic using scanned data

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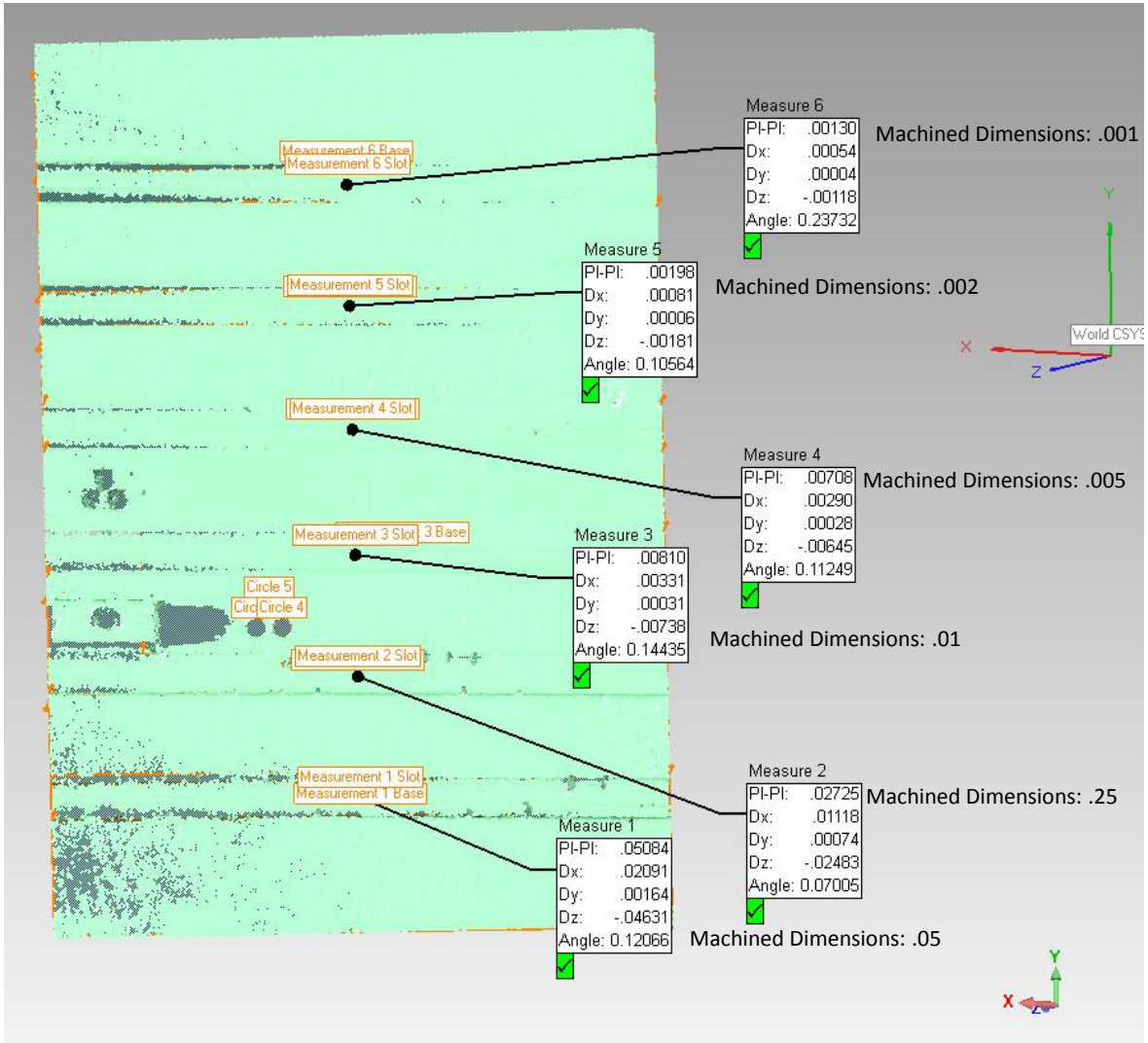
Detect and Measure Surface Distortions and Dimensions

- The image to the right shows measurements taken of a scanned plate with precisely cut grooves ranging from .001 inches (top) to .05 inches (bottom)
- The value of P1-P1 at the right dimensions the scanned depth of the ridge.
- The Newton NM200UW Scanner accurately measured the top groove (.001 depth) to within .0003 inches.
- Measurements are calculated using GeoMagic.



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System Hardware

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Scanner System Console

- All Newton underwater laser scanner models use the same control console although onboard software may vary..
- All scanner models are equipped with software enabling them to operate with the same functionality and accuracy in either air or water.

Specifications	
Height	14.75 in. (374.65 mm)
Width	26.75 in. (679.45 mm)
Length	27.50 in. (698.5 mm)
Weight	84.5 lbs. (38.3 kg)
Construction	Metal electronics rack suspended on eight shock absorbers within a molded, high-impact, airline-transportable case
Output ports	Ethernet, USB, DVI & HDMI
Operating temperature	40° to 110° F (5° to 43° C)
Power input voltage	100 to 240 VAC 50 to 60 cycle
Data storage	Internal solid state & USB stick
Output format	.ply point cloud file
Data file size	Approximately 100 MB per scan
Shipping	Both console & head cases are airline-transportable

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M210UW Medium Range Underwater Scanner

Item	Measurement Head
Height	4.0 in. (101.6 mm)
Width	4.60 in. (117.4 mm)
Length	9.126 in. (232.8 mm)
Weight (in air)	8 lbs. (3.6 kg)
Weight (in water)	2 lbs. (1 k) (plus cable weight)
Construction	Machined from solid billet of 6061T6 aluminum stock
Laser power	40 mW
Video camera	High resolution monochrome
LED ring array	2,320 lumens
Fittings & retainers	300 series stainless steel
Windows	Fused silica or optical glass
Mounting attachments	Four grouped 1/4-20 UNC threaded mounting holes on four sides of case (Metric threads available)
Operating temperature	110° F (43.3° C) in water - 100% duty cycle
Storage temperature	0° to 160° F (- 18° to 71° C)
Power input voltage	Powered by control unit
Maximum scanner-to-target distance	36.0 in. (900mm)
Minimum scanner-to-target distance	6.0 in. (150mm)
Maximum Resolution accuracy (after processing with 3D software)	+/-0.001 in. (0.025mm)**
Scan range	6.0 in. (150 mm) to 36 in. (900 mm)
Watertight depth rating	320 ft. (100 m)

** All M210UW accuracy is related to the field of view, distance from the object to be measured and can vary by the parameters of the object.

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M310UW Extended Range Underwater Scanner

All M310UW accuracy is related to the field of view, distance from the object to be measured and can vary by the parameters of the object.

Item	Measurement Head
Height	14.5 in. (368.3 mm)
Width	5.25 in. (133.35 mm)
Length	5.0 in. (127 mm)
Weight (in air)	17 lbs. (7.71 kg)
Weight (in water)	11 lbs. (5 kg) (plus cable weight)
Construction	Machined from solid billet of 6061-T6 aluminum stock
Video camera	High resolution monochrome
Laser power	35 mW
LED arrays	3,336 lumens
Mounting attachments	Grouped 1/4-20 UNC threaded mounting holes on four sides of case (Metric threads available)
Operating temperature	110° F (43.3° C) in water - 100% duty cycle
Storage temperature	0° to 160° F (- 18° to 71° C)
Power input voltage	Powered by control unit
Maximum scanner-to-target distance	10 feet (3 m)
Minimum scanner-to-target distance	1.5 feet (0.46 m)
Scan area	9 ft. X 7 ft. (2.7 m X 2.13 m)
Watertight depth rating	320 ft. (100 m) *(deeper depth-rated models available)*

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NM200UW Nuclear Underwater Scanner

** All NM200UW accuracy is related to the field of view, distance from the object to be measured and can vary by the parameters of the object.

Item	Measurement Head
Height	4.0 in. (102 mm)
Width	4.60 in. (117 mm)
Length	9.126 in. (233 mm)
Weight (in air)	8 lbs. (4 kg)
Weight (in water)	2 lbs. (1 kg) (plus cable weight)
Construction	Machined from solid billet of 6061T6 aluminum stock
Laser power	40 mW
Video camera	High resolution monochrome
LED ring array	2,320 lumens
Fittings & retainers	300 series stainless steel
Windows	Fused silica or optical glass
Mounting attachments	4ea. 1/4-20 UNC threaded mounting holes on four sides of case (Metric available)
Operating temperature	110° F (43.3° C) in water
Storage temperature	0° to 160° F (- 18° to 71° C)
Power input voltage/current	Powered by control unit
Max. scanner-to-target distance	36.0 in. (900mm)
Minimum scanner-to-target distance	6.0 in. (150mm)
Maximum Resolution accuracy (after processing with 3D software)	+/-0.0004 in. (0.01mm) **
Scan range	6.0 in. to 36 in. (150 mm to 900 mm)
Watertight depth rating	150 ft. (46 m)

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Pan-Tilt Deployment

- The Newton PT200UW Pan-Tilt Arm is specifically designed to mount the Newton family of laser scanners
- The Pan-Tilt Arm enables precise and rapid positioning of a scanner and greater control in tight locations
- The operation range at the "elbow" is 185° and the "wrist" has infinite rotation
- All cables are internal, there is nothing to snag
- Arm motion and speed are controlled with a joy-stick and rheostat located on the front of the laser scanner control console

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Inspector Robot

For Underwater or Dry Inspection of Water Filled Tanks

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Inspector Robot

- Vertical Masts holds LED lights which are used to track the exact location of the robot to within 3.25 millimeters (1/8”). The height of the mast is to maintain the tracking system above any turbulence or particles on the tank bottom
- The tank bottom is then mapped with defects shown on either a global map, plate map or both
- Software can then create a surface map with damaged areas highlighted
- The Inspector can then precisely return to the location of the damaged are for further inspection.

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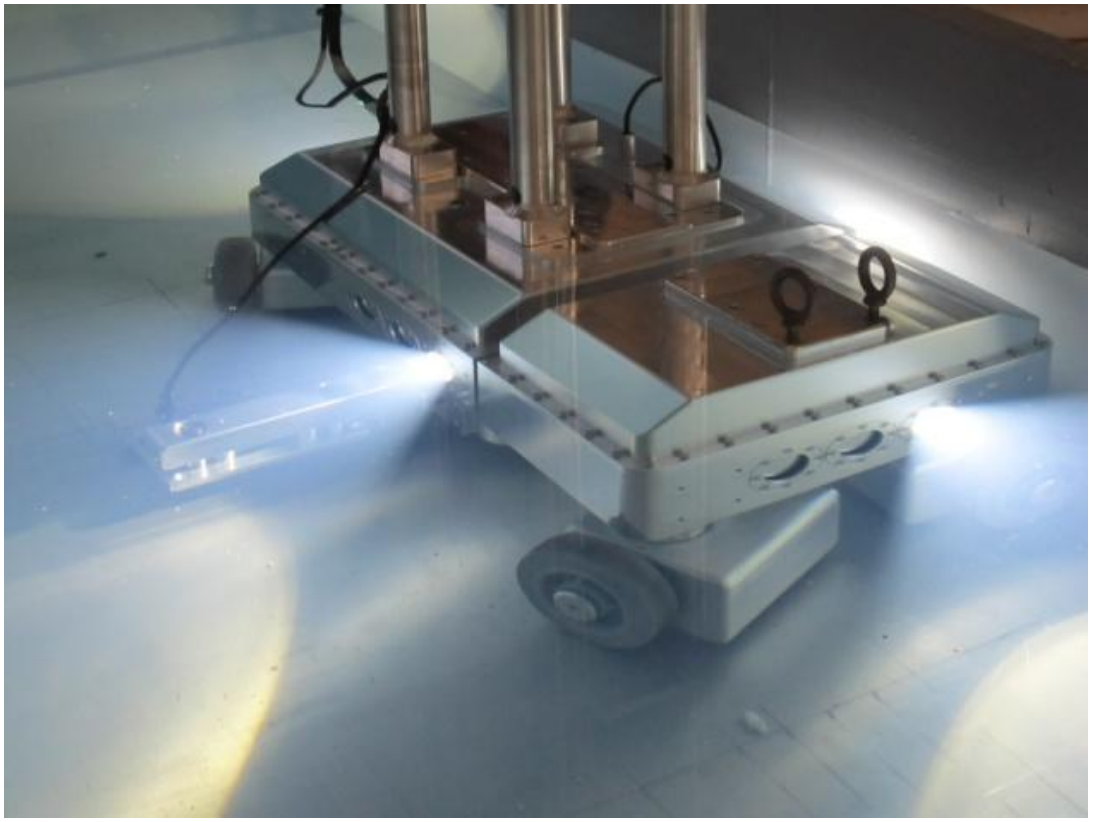
Inspector Robot

Underwater robotic platform onto which operators can attach, convey and precisely position on a variety of measuring instruments or repair tools that are used in the evaluation and maintenance of liquid storage tanks.



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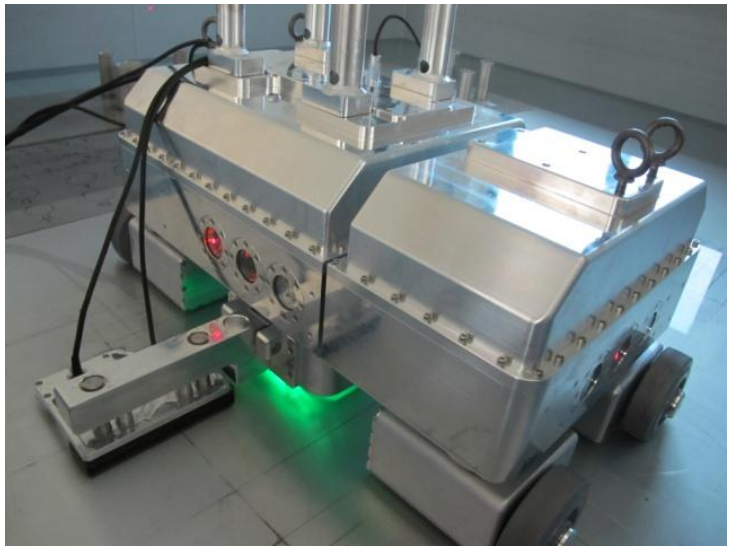
Inspector Robot

- Combines multiple inspection technologies
  - Optical
  - Eddy Current
  - Ultrasonic
  - Laser Scanning
- Precision Navigation-Locates damaged areas and returns to that location within 3.25 mm (1/8”) with overhead precision navigation system
- Maps all damaged areas to either a tank wide map, a plate wide map or both
- Highly maneuverable four-wheel steering
- Four wheel independent drive motor system
- On-board downward-facing 3D laser scanner
- Split chassis design provides constant all-wheel contact
- Laser range finders on all four side for precise positioning



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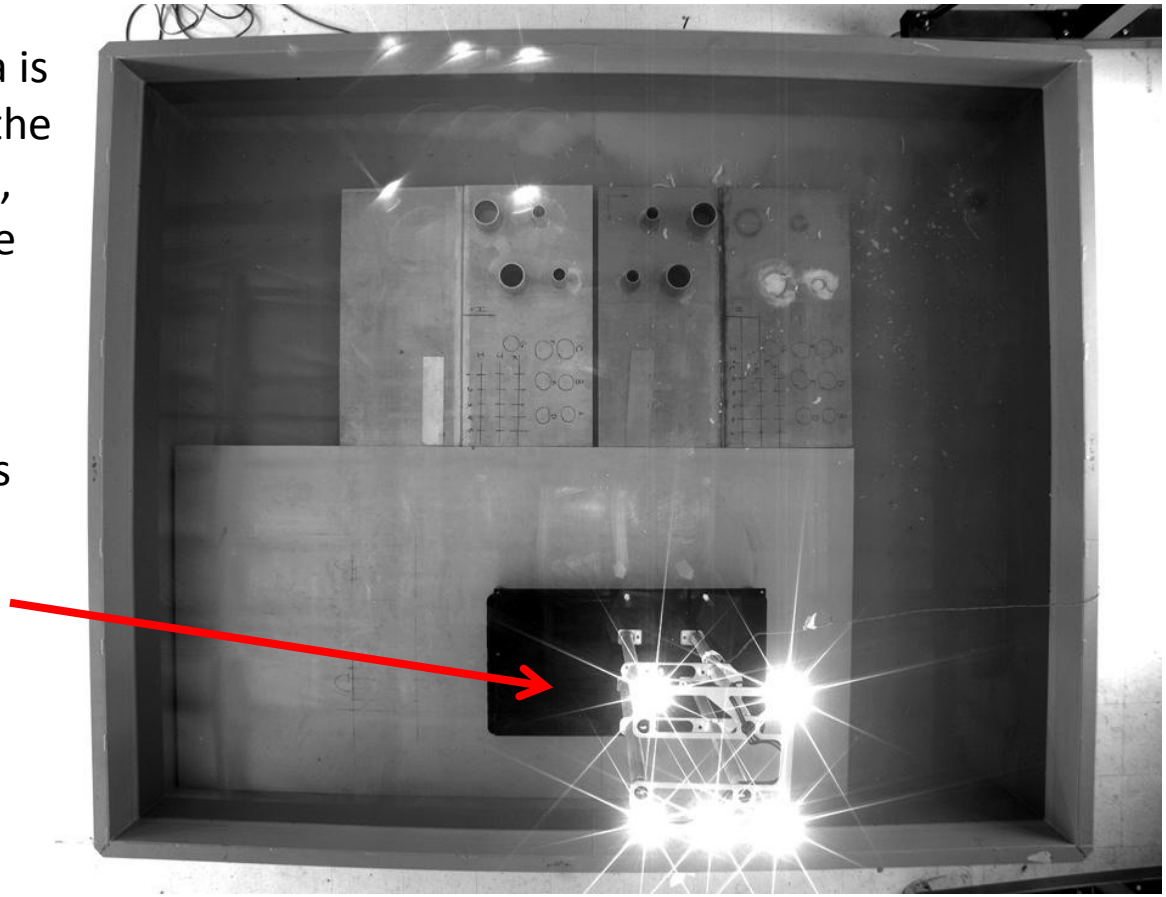
Inspector Robot Precision Navigation System

- The “god’s eye” camera is pole mounted through the hatch, facing downward, and is calibrated into the system software.
- The camera tracks the robot by following the illuminated LED beacons as shown on the right.



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Fuel Rod Scanner

(in Conjunction with EPRI)

to measure the S Clip Wear
or other small defects in a single fuel rod

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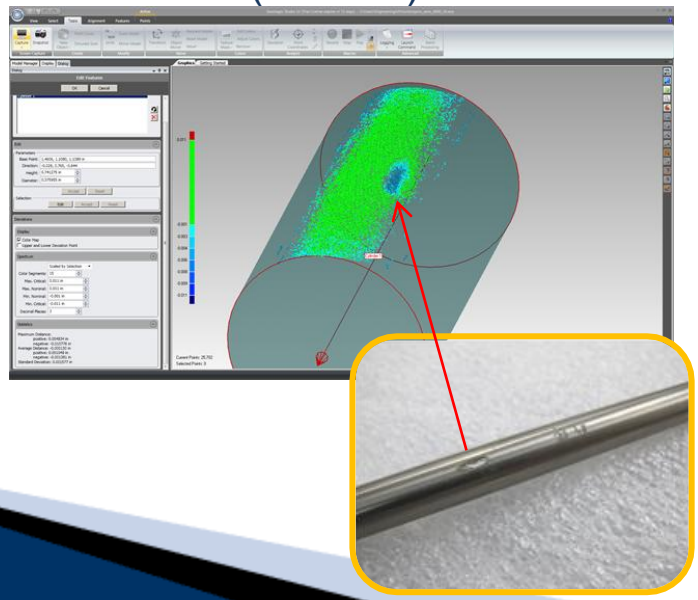
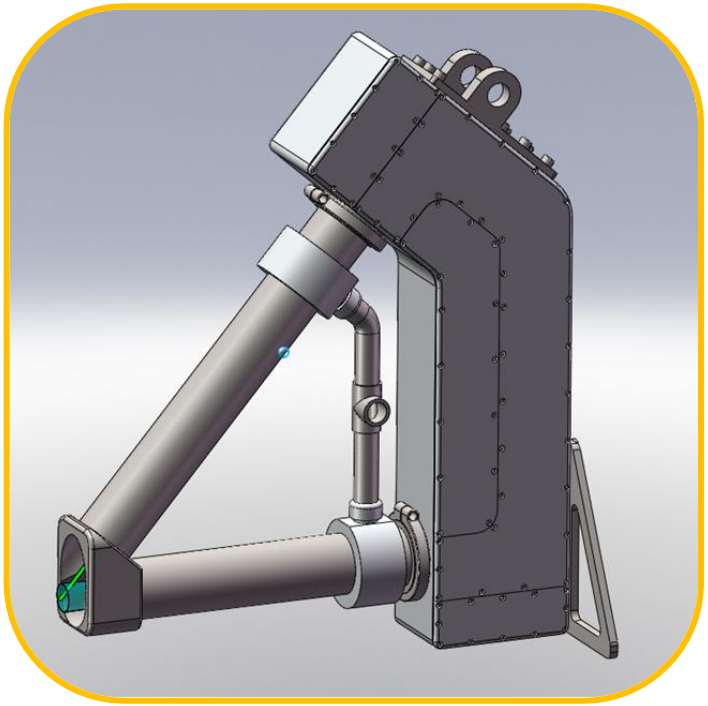
The NM600FR

- A highly-specialized underwater 3D laser scanner for the inspection and measurement of the PWR fuel tube fretting phenomena

- The heavily shielded unit is designed to produce extreme 3D resolution in a small field of view with a point cloud accuracy of +/-.0005“ (0.01mm) over a 1“ (25mm) area at a distance of 24“ (600mm).





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Fuel Assembly Scanner
(In Conjunction with EPRI)

CAD Models of the used fuel assemblies

Performed in the Spent Fuel Pool

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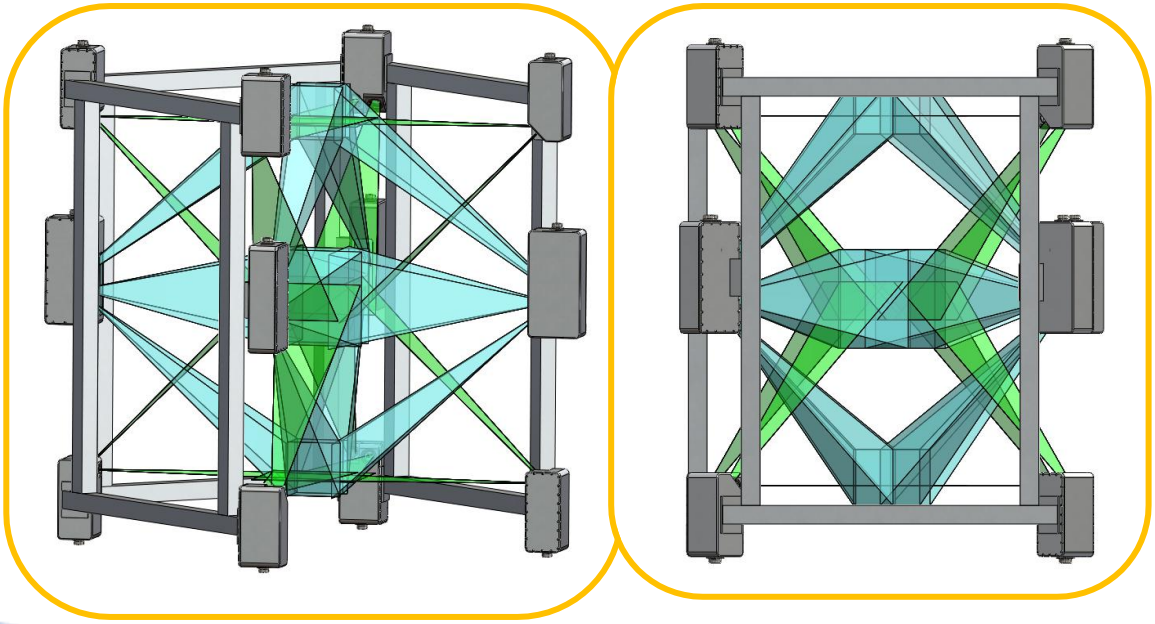
BWR Fuel Assembly Profiling

- Newton Labs has demonstrated a prototype unit to detect and measure BWR fuel assembly physical deformation caused by thermal and radiation processes.
- Cameras and lasers are attached to a U-shaped space frame that moves vertically on a track in order to image an entire fuel assembly that is placed and held in position.
- First deployment of the prototype system is anticipated for early 2014

-Blue beams represent the camera field of view

- Green beams represent the laser projection



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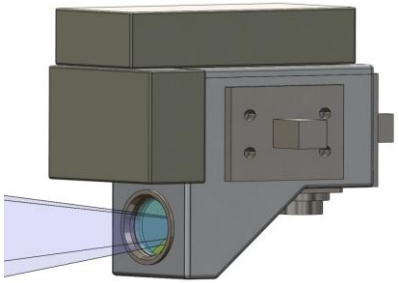
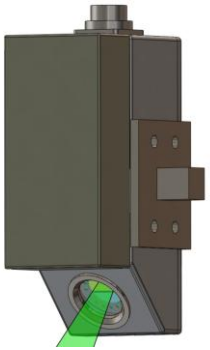
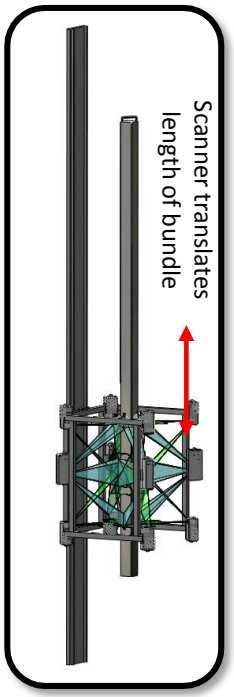
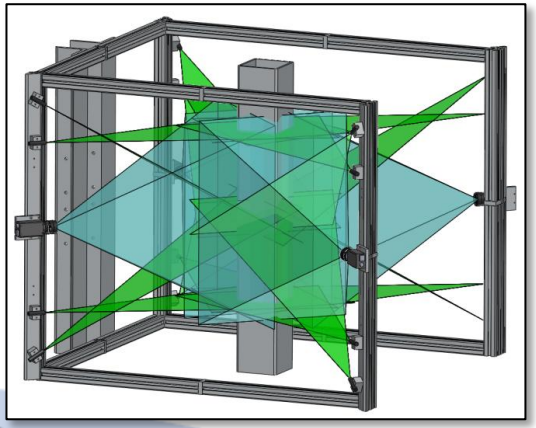
Spent Fuel Bundle Scanner

- Fuel bundle inspection
  - NRL Scanner NM400QUAD
  - Arrays of lasers and cameras with overlapping fields of view
  - 1 m^3 scanner footprint
    - Stand-off ≈ 0.6 m, with shielding and mirrors
  - Complete 3D representation of bundle is generated
  - Installed on spent fuel pool wall in low radiation field location





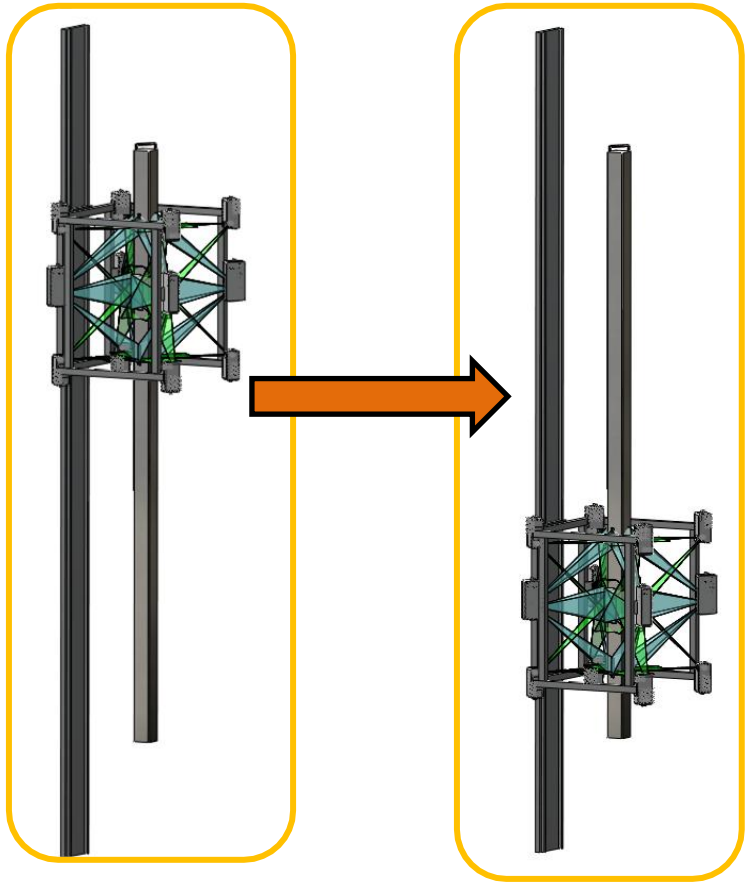




NEWTON

BWR Fuel Assembly Profiling

- The scanning system guide track rigidly mounts to the fuel pool sidewall
- The crane or mast which handles the fuel lowers a fuel assembly into a dock at the base, while remaining attached to the top.
- This docking removes any unwanted motion during the scan pass.



RPV Measuring Robot

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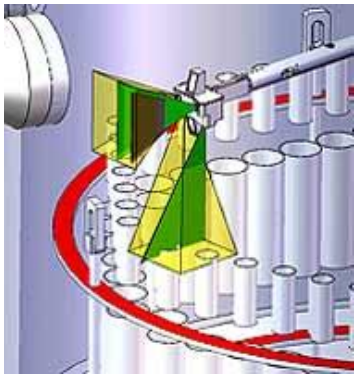
Reactor Pressure Vessel (RPV) Measuring Robot

- Uses Laser Scanning heads to precisely scan, image and measure the sidewall and outer periphery horizontal areas of a BWR above the steam separator during an outage, after the steam dryer has been removed.



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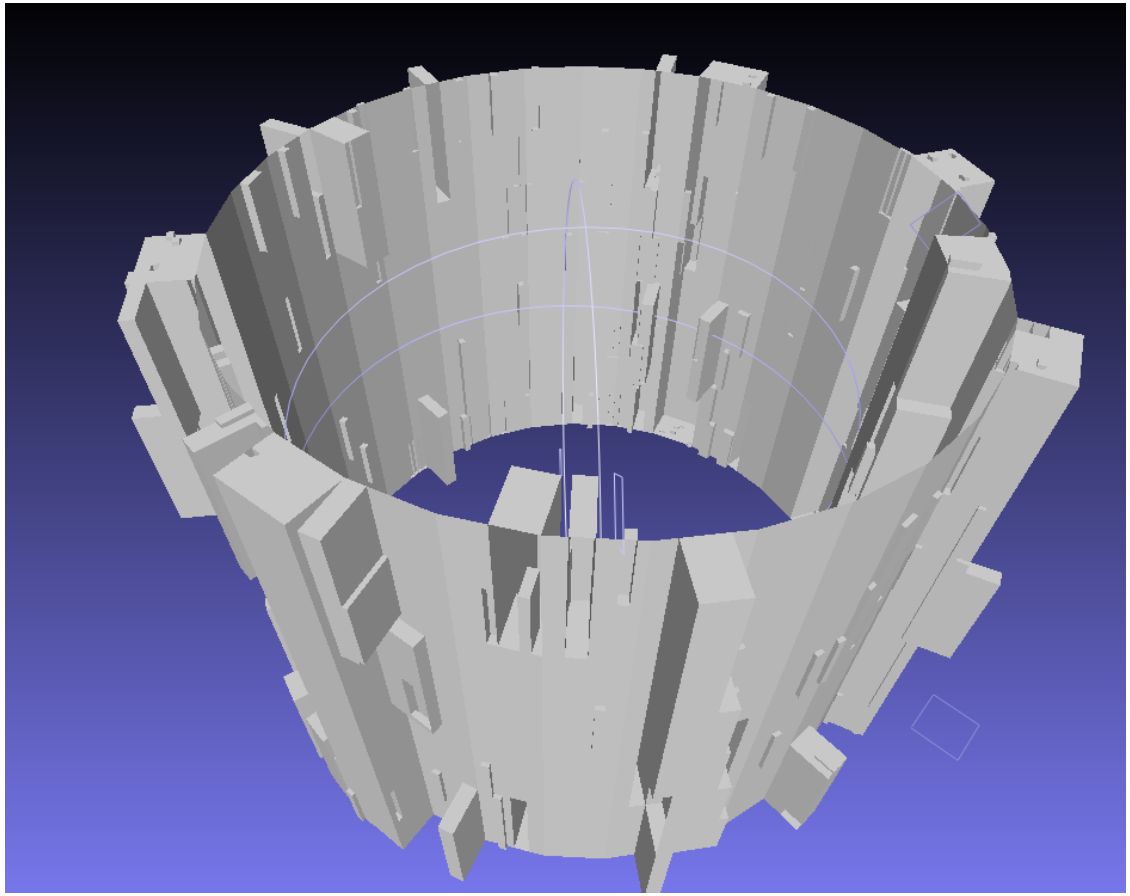
Surface Mapping

• A Newton designed User Interface map data taken by the Underwater Laser Scanners, Phased Array Ultrasonic probes and Eddy Current

•Customer will see overall percentage of surface loss and be able to further inspect data of specific areas as desired.

•Data can be reviewed in real time – allowing for quick decisions and identifying location of at-risk areas



Surface map shown from Newton's RPV scanning robot – areas of concern can be listed and flagged.

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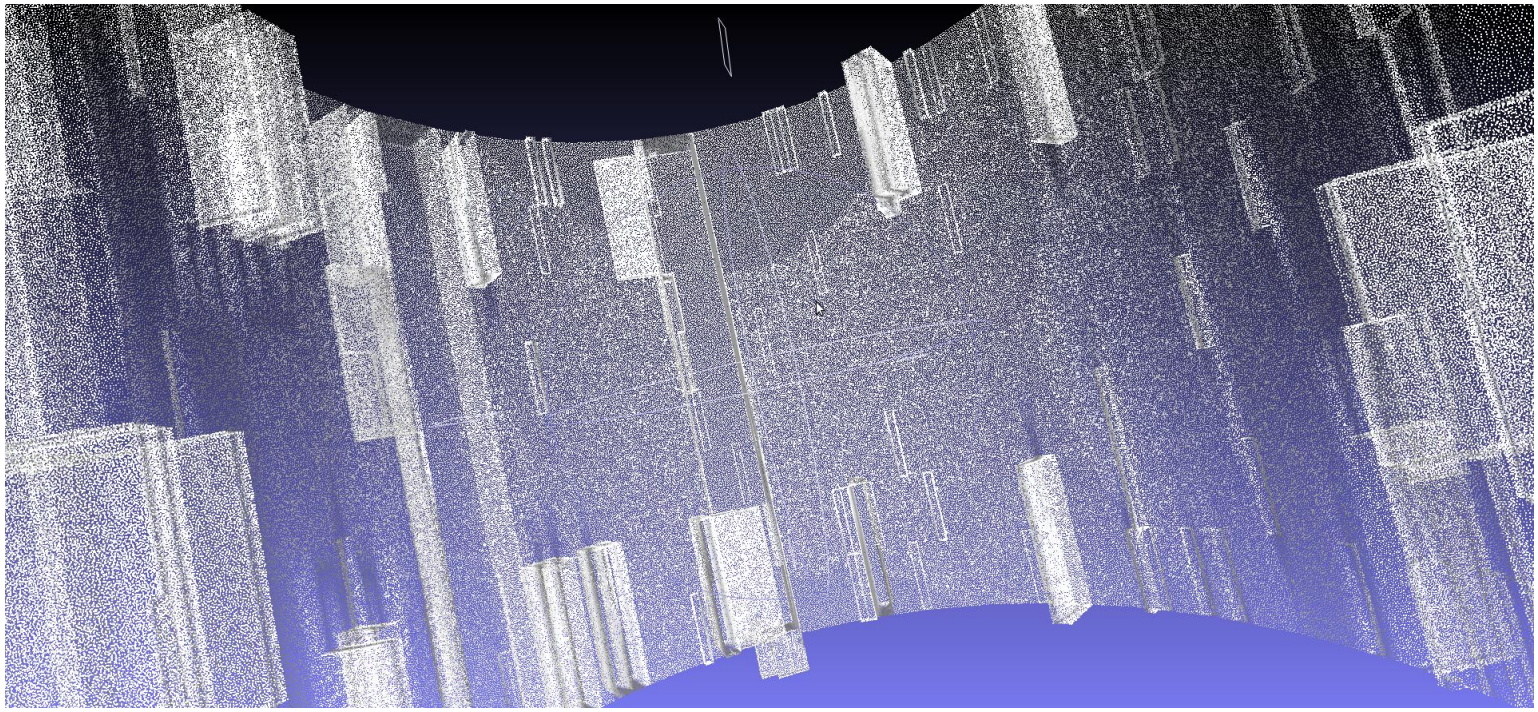
Surface Mapping



Further inspection can be made by investigating scanned points.

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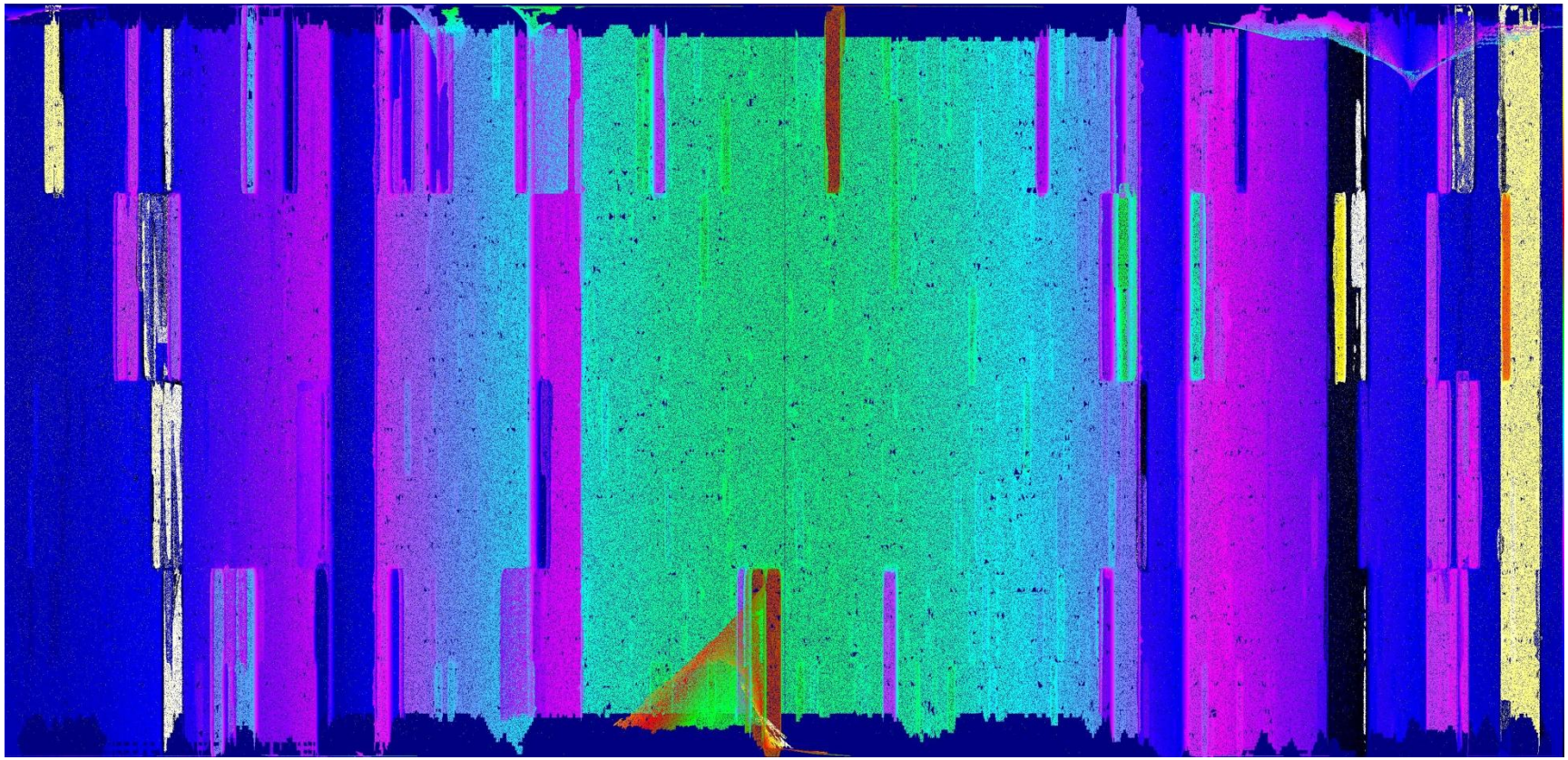
Surface Mapping



3D data view can be converted to 2D flat plane viewing

NEWTON

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Thank You