

Chanoramas – Advanced image processing techniques for in-core inspection videos

Dr Graeme West

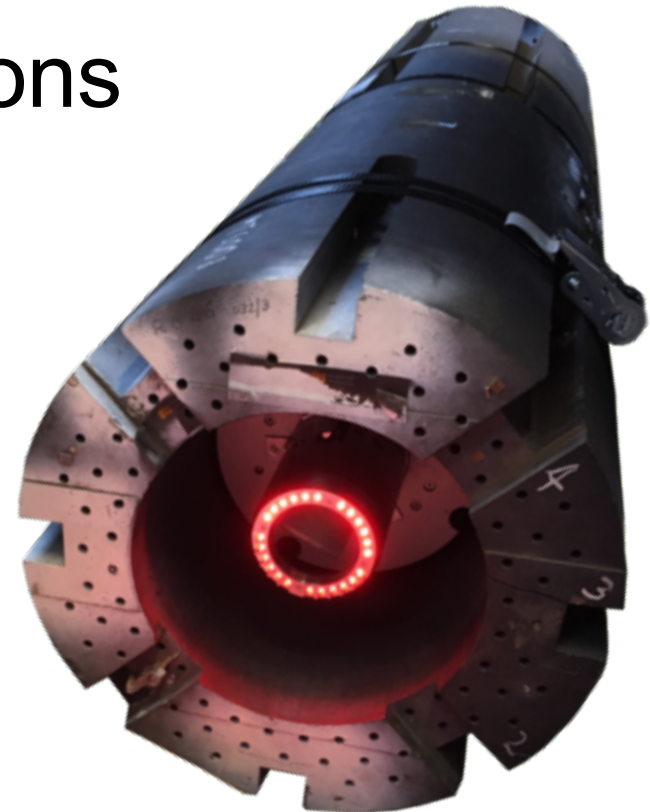
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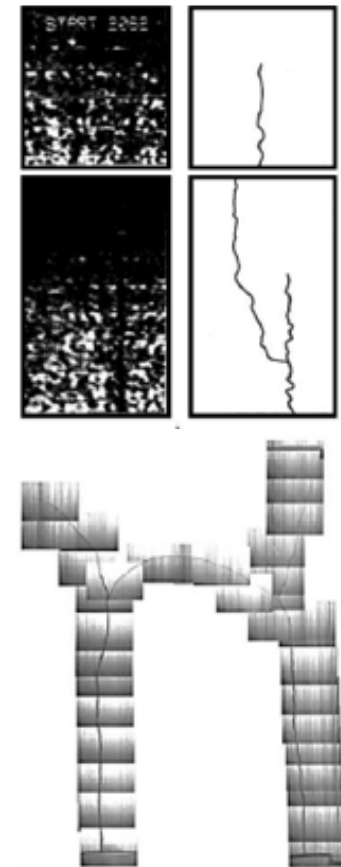
Outline of presentation

- Background
- Supporting visual inspections
- Results
- Route to impact
- Current research
- Conclusions

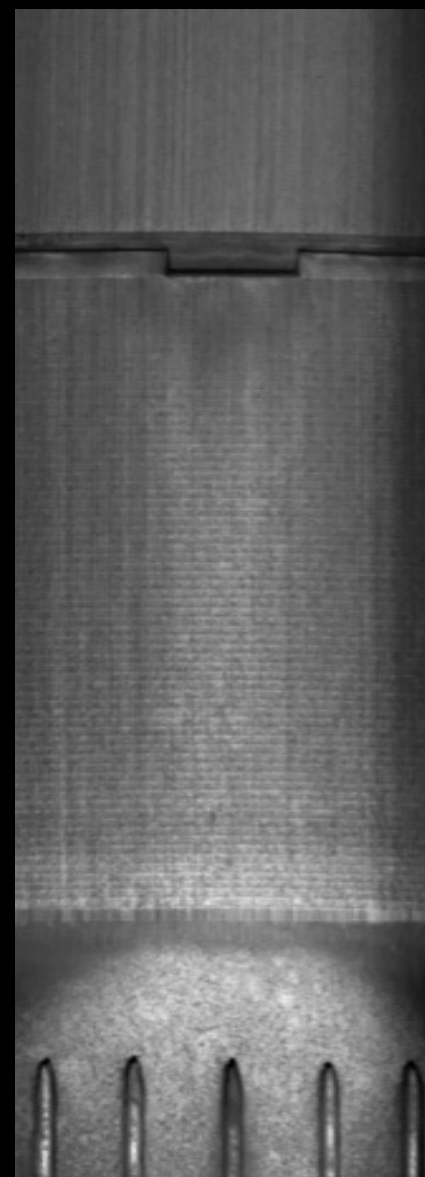
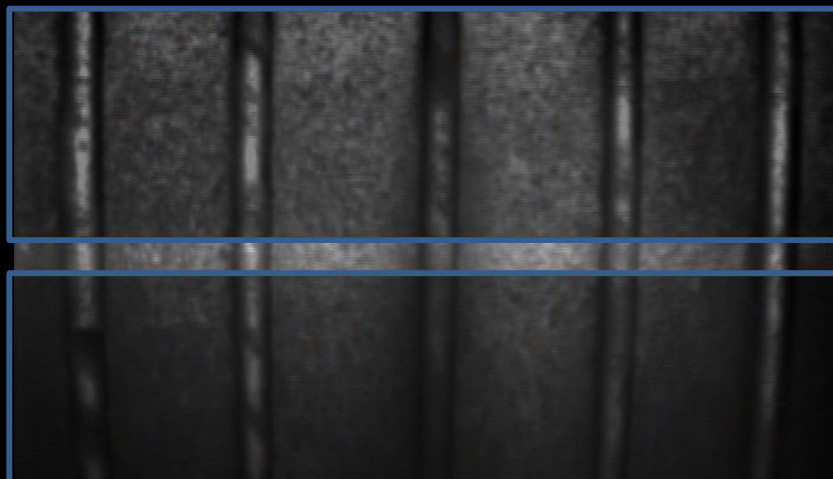


Background – AGR Inspection

- Selected fuel channels undergo remote visual inspection during outages
- Montages of regions of interest are produced to allow them to be studied, quantified, classified and reported before returning the reactor to service
- This activity is a manually intensive process on the **critical path**



Can advanced image & video processing techniques be applied to make better use of the data?





cha·no·ra·ma

/'CHan,'ramə,-'rämə/

noun

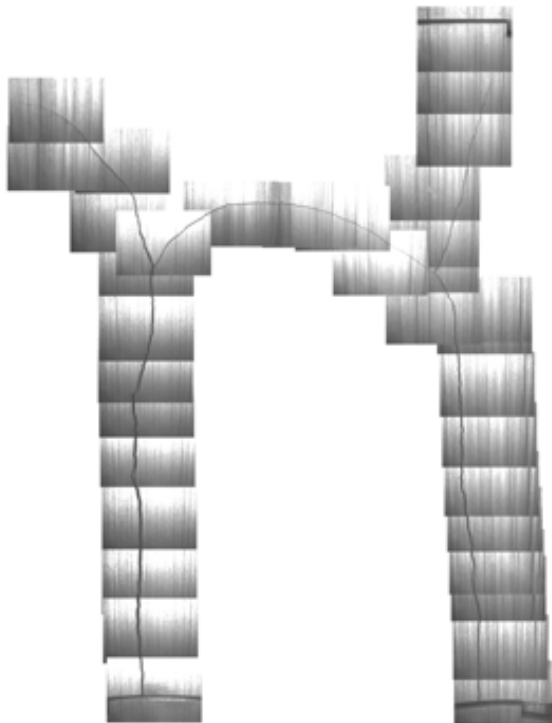
noun: **chanorama**; plural noun: **chanoramas**

1. a 360° image of the inside surface of an AGR fuel channel created from in-core TV inspection devices such as CBIU or NICIE2 and generated using the Automated Software Image Stitching Tool (ASIST) developed by the University of Strathclyde.

“ASIST was used to generate a chanorama for each channel inspected during the recent HNB outage”

Results

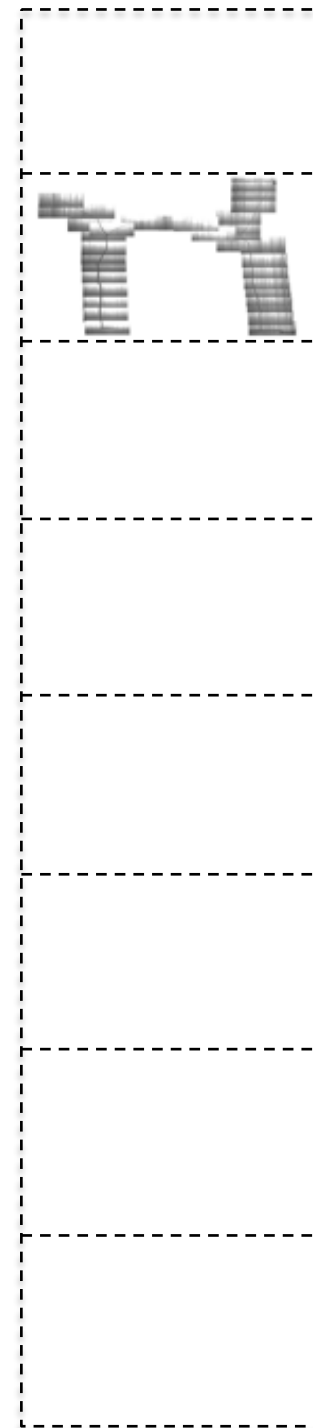
- ASIST Software automatically creates **CHANORAMA** images from inspection videos
- Used for every fuel channel inspection at all 7 stations
- Benefits (per outage)
 - 12 hours saved on critical outage path
 - 120 man hours saved during outage
 - ~£340k saved



Manual



Automated

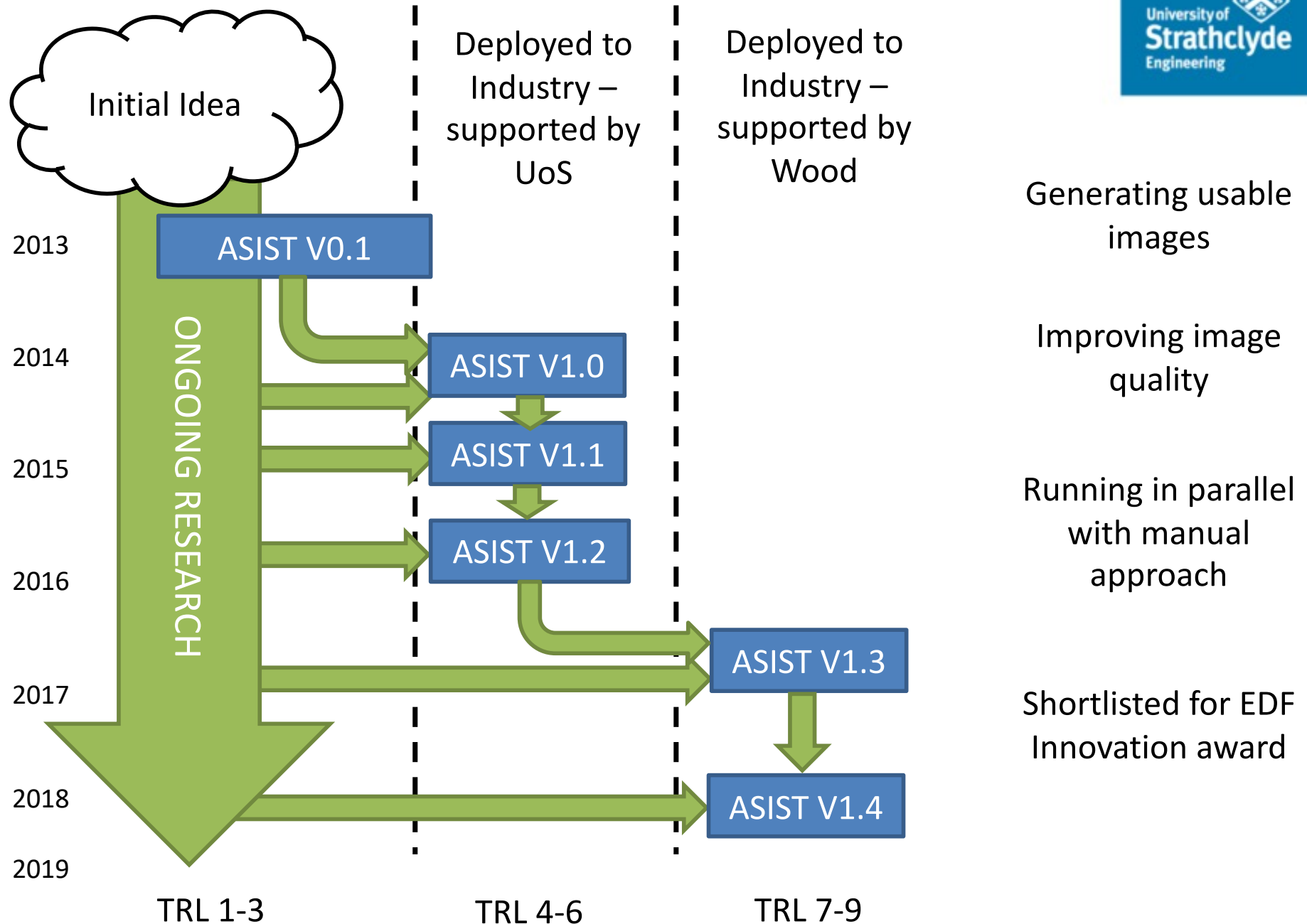


Manual



Automated

Route to Impact



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Hunterston B nuclear reactor to restart after 'cracks' closure

20 August 2019

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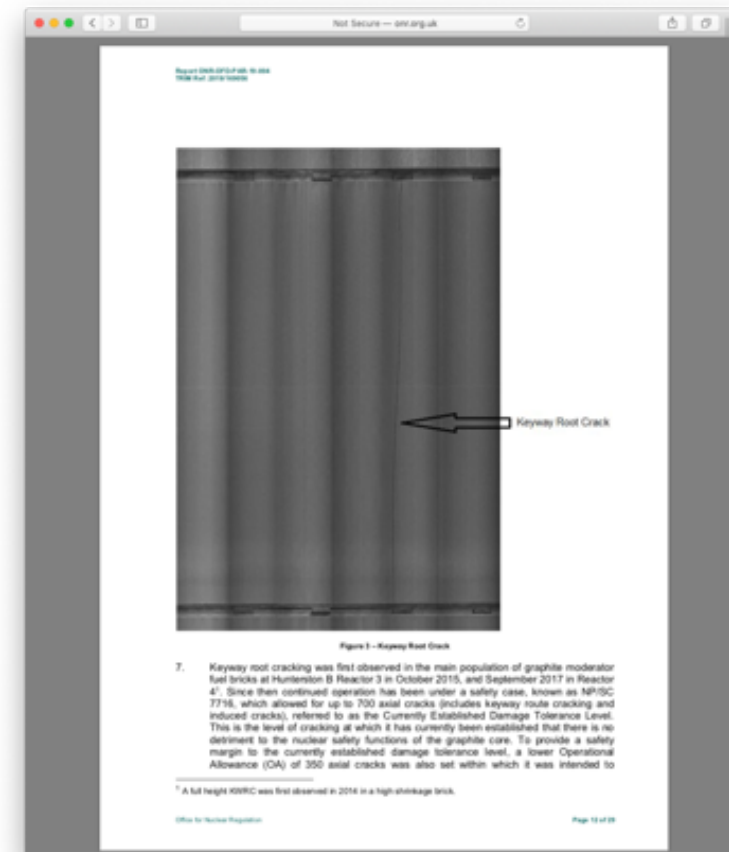


GETTY IMAGES

One of two nuclear reactors at the Hunterston B power plant which were shut down last year has been given permission to return to service.

Hundreds of cracks were found in the graphite bricks within the reactor cores at the North Ayrshire plant.

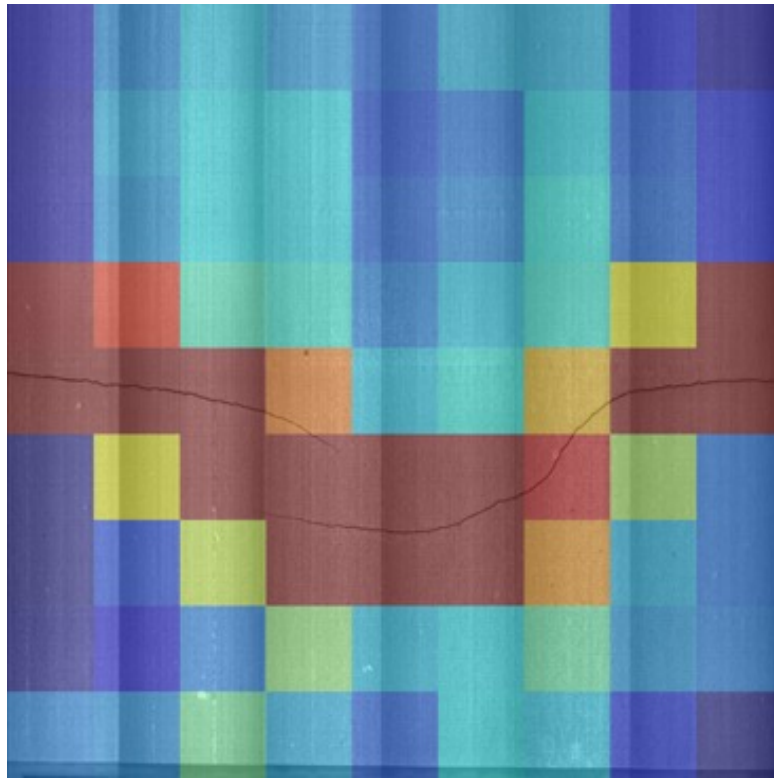
The Office for Nuclear Regulation (ONR) has now agreed that it is safe for operator EDF to restart one of the reactors for a four-month period.



Agreement to NP/SC 7785 Hunterston B Power Station - Return to service safety case for Reactor 4 following core inspection results in 2018

Automated Crack Detection

(Brick crack likelihood heatmap)



		Actual	
Prediction		Positive (Cracked)	Negative (Uncracked)
	Positive (Cracked)	TP = 39	FP = 41
	Negative (Uncracked)	FN = 4	TN = 458

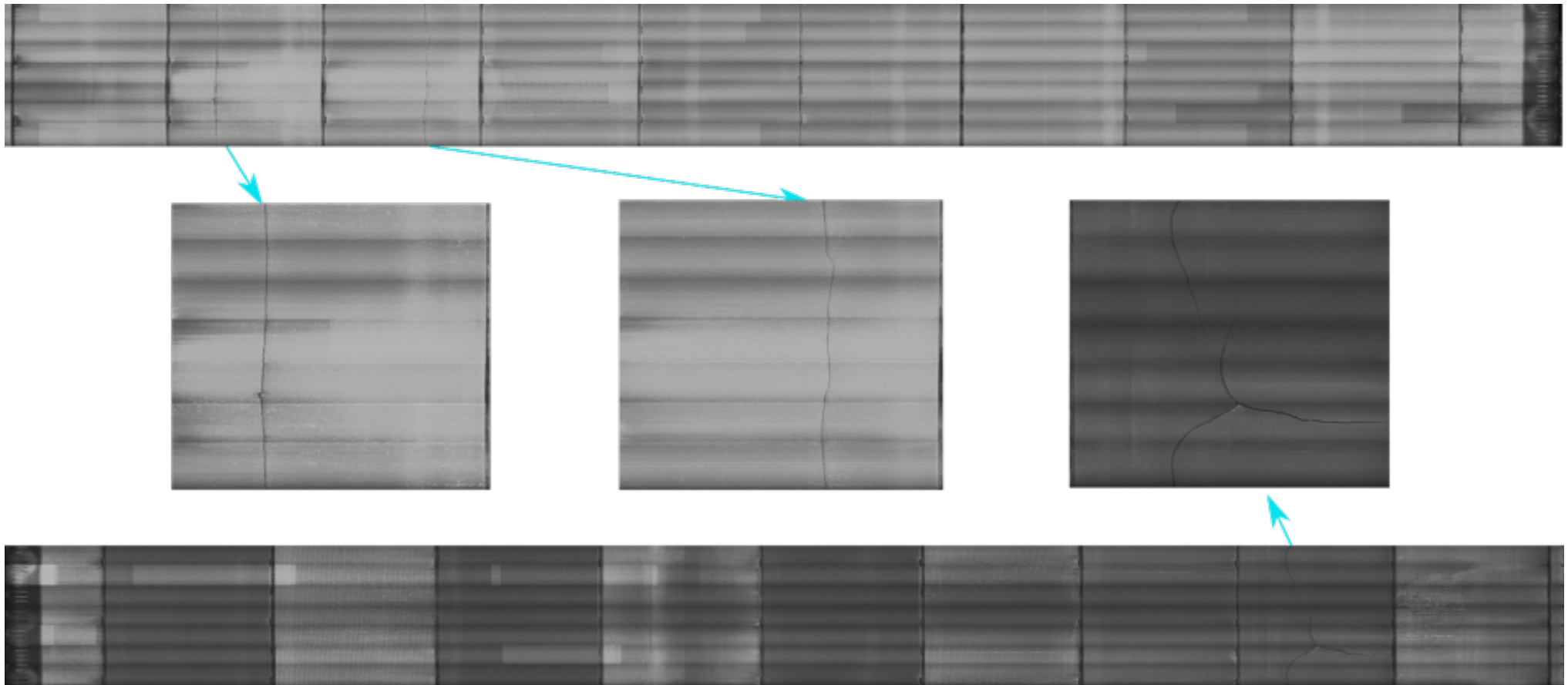
Results of Full Brick Layers
labelled as cracked/uncracked

Bag of Visual Words (BoVW) to classify overlapping image tiles

- Algorithm evaluated on a dataset of 83 Chanoramas with a total of 43 cracked bricks.
- 39 cracked bricks were correctly identified with 4 cracked bricks missed and 41 false positives.
- 458 uncracked bricks were also correctly identified out of 499 uncracked bricks in total.

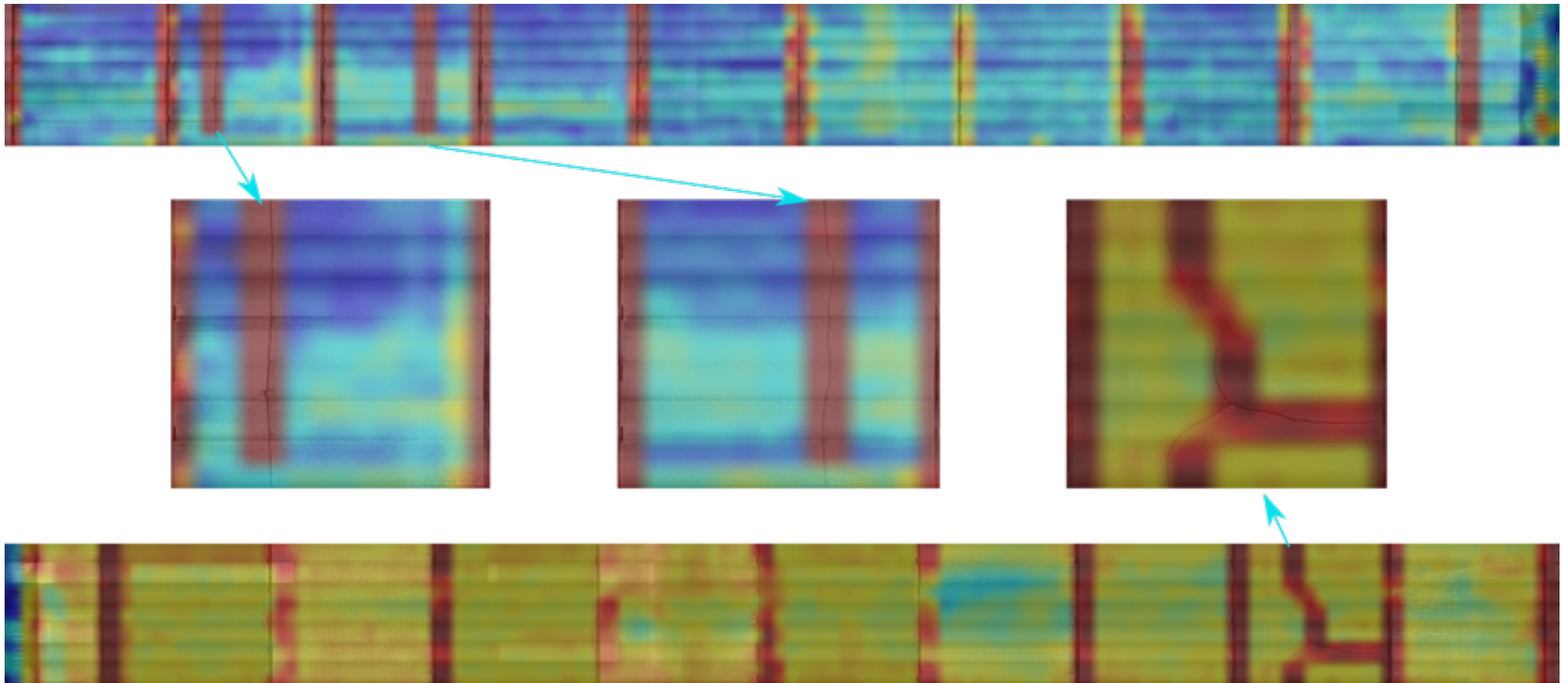
Automated Crack Detection

(Two Chanorama with Cracked Bricks)

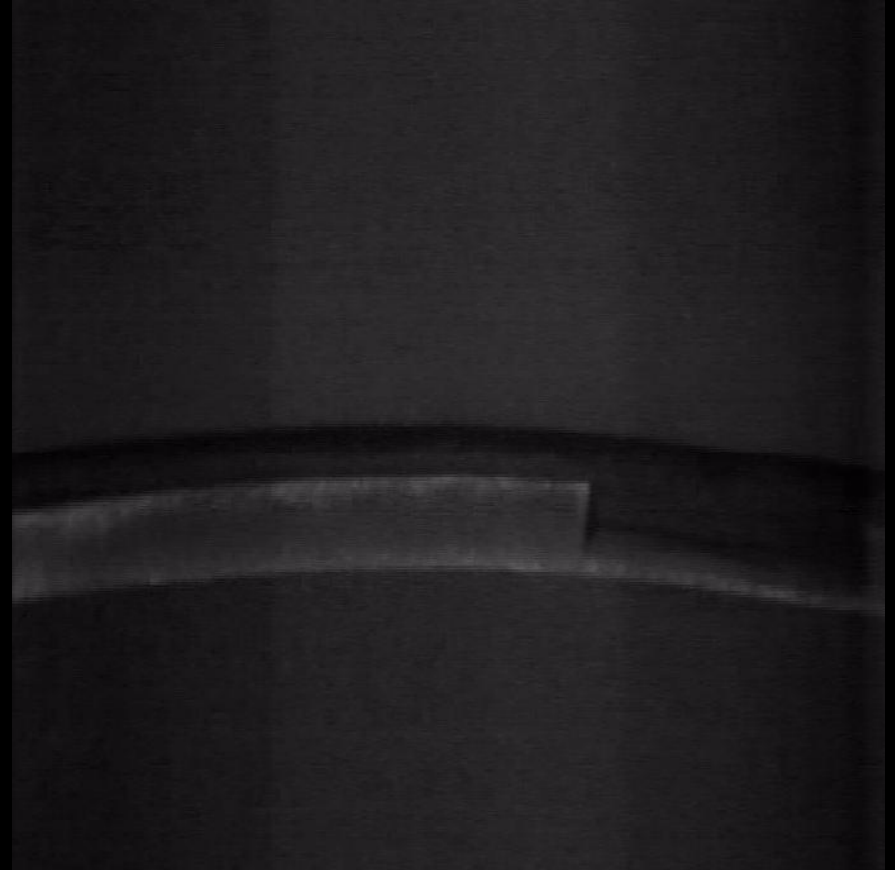


Automated Crack Detection

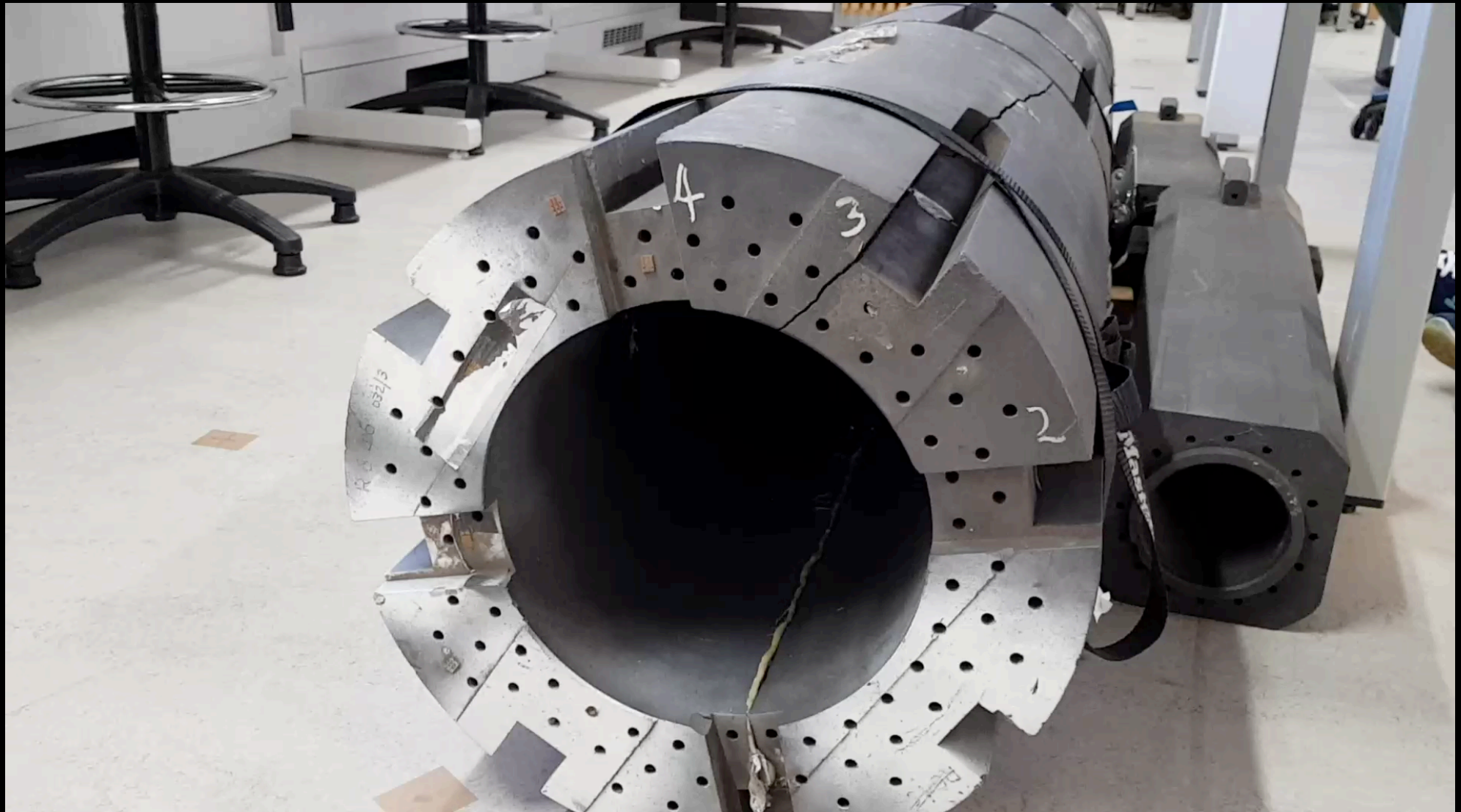
(Chanorama crack likelihood heatmap)



Pivot Videos



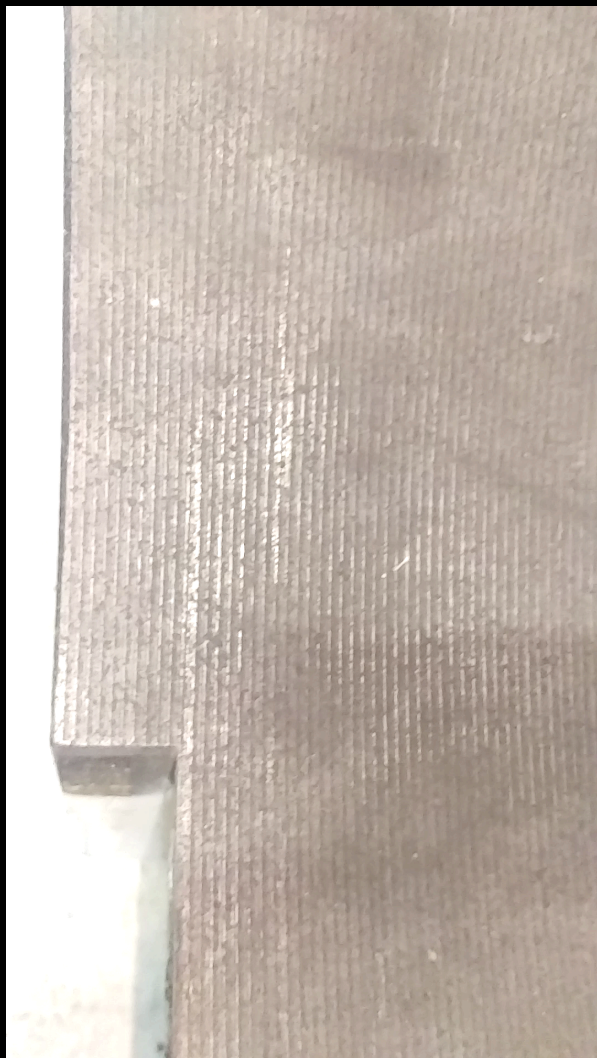
3D Structure from Motion



3D Structure from Motion



Inside the brick...



Summary



- Minimising time between data capture and analysis on the critical path
- Facilitating the return to service of stations without delay
- Freeing-up experienced personnel to analyse data rather than creating it
- Factor of 8 time saving in labour-intensive tasks
- Saving 12 hours of critical path time and saves 120 person hours per outage
- Leverages existing hardware and data
- Step change in the use of inspection data

Address to Nuclear Power

*Fair fa' your honest, sonsie face,
Great chieftain o' the pow'r-race!
Aboon them a' ye tak your place,
Sol'r, wind, or therm' :
Lo' carbon 'leccy ye generate
W'out harm*



