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IChemE HAZARDS 29

Use of photographic surveys to enhance safety studies and inspection

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Overview – no pun

Use of visual material in safety studies and surveys.

If a picture paints a thousand words – why is it so little used.

- Historical use
- Current – safety studies
- Present – Virtual tours
- Present & near future
- Future – AI tools

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Historical use – investigation

The main use of photographic material is as part of incident recording and investigation

- Record perishable evidence, as soon as possible.
- Overview - cover 360deg around incident site.
- Significant element recording (main element of interest)
- Recording of site inventory - before items are removed.
- Close - up. Multiple angles and some form of scale comparison
- Documentation - those documents for which it may not be possible to remove from the incident site
- Exemplar items if available - such as adjacent sites and identical or similar equipment which is not failed.
- Adequate notes to support the images.

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Historical use – audit

To support audits and asset inspections

- Particular for defect recording
- Helps in identifying where action required (better than word descriptions)
- If date stamped can be used as means for monitoring changes and closing actions

Item	Sub Section	Type of PFEP	Anomaly Severity 1= low, 3 = high	Inspection Observations	Impact ratings (Y/Z) Where Y = Row Z = Severity	Recommendations	Photo (See Apdx A)
Dimlington - ESV001, 36" inlet line from Cleeton and associated piping to pig receiver JF body & Piping = J120, Actuator = J15	36" Inlet pipe from grade to ESV 001	Epoxy PFP	1	Assumed Firetex M90 due piping downstream of HV003 being protected with M90 but topcoat hides the product to prevent factual identification. There is surface cracking/crazing (UV degradation) with some reinforcing mesh near surface, however, the epoxy PFP is likely to provide required fire protection in the short-term. Continued weathering may degrade PFP with potential reduction in fire performance. PFP terminates along the pipe to the pig receiver between the first and second support pillars downstream of ESV001. Epoxy PFP on pipe is likely to meet VCE requirements.	Table C1 (A1/1)	ESV001 and associated piping is identified as critical and requiring PFP – see RAS valve report [3] Recommend application of new topcoat as preventative maintenance at same time as work is undertaken on ESDV001 PFP.	1
	ESV001 Double acting hydraulic, fail closed	Soft Jacket	3	Jacket is old and has continuous lacing. If lacing fails at one point then all lacing comes undone. Incorrect cable-ties used in places. Openings in jacket due to poor re-fitting. Unprotected lifting lugs may lead to hot spots via conduction. Inner insulation exposed around lifting lug. UV degradation of outer fabric – jacket saturated with rainwater – thus potential that inner insulation also saturated. Actuator control & hydraulic lines not protected Jacket will not resist VCE and is unlikely to survive impinging jet fire.	Table C2 (2/3; 4/3; 10/3)	ESV001 and associated piping is identified as critical and requiring PFP – see RAS valve report [3] Remove and replace jacket. Recommend consideration of rigid enclosure such as epoxy PFP, stainless steel enclosure, etc. Consider need for PFP protection of hydraulic lines and control system.	2, 3, 4, 5 and 6

APPENDIX A – SURVEY PHOTOS

Photo 1	Inlet pipe from grade to ESDVmm1. Lightly UV degraded topcoat and mesh near surface of PFP

Photo 2	ESVmmm Jacket PFP

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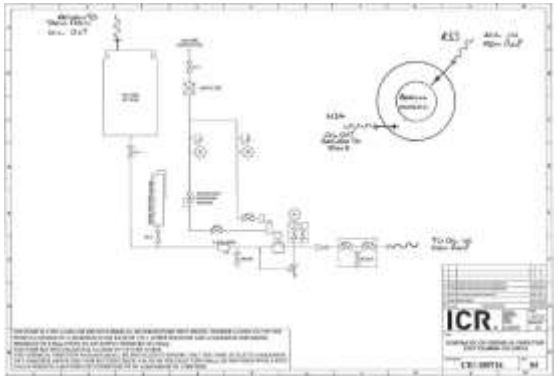
Historical – use in HAZIDs and HAZOP

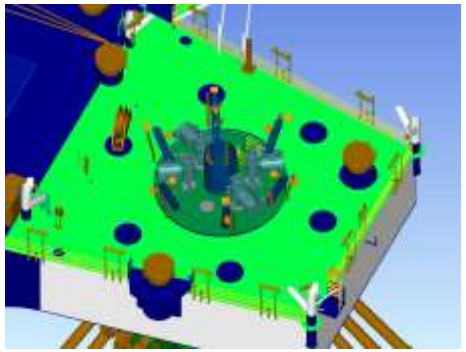
Used to support the study team – particularly for 'novel' and vendor equipment



Best use in Studies – two screens

Guideword/ Deviation	Cause	Hazard	Potential Consequences	Safety	Environmen	Commercial	Non-LoPA	Safeguard -IPL	Safeguard - modifying factors	Likelihood	Recommendations/ Observations	#

On Screen one



On Screen two

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Present - Virtual tours

An “interactive” element
An “immersive” or Virtual reality element

Use of ‘virtual tours’ – Benefits

- Provision of easy to access ‘as built’ information remote from the installation
- Means to confirm site information for difficult to access sites.
- Remotely familiarise personnel and contract staff
- Improves requests to site personnel for site information

- Context is easier to establish, compared to ‘2D’ photos

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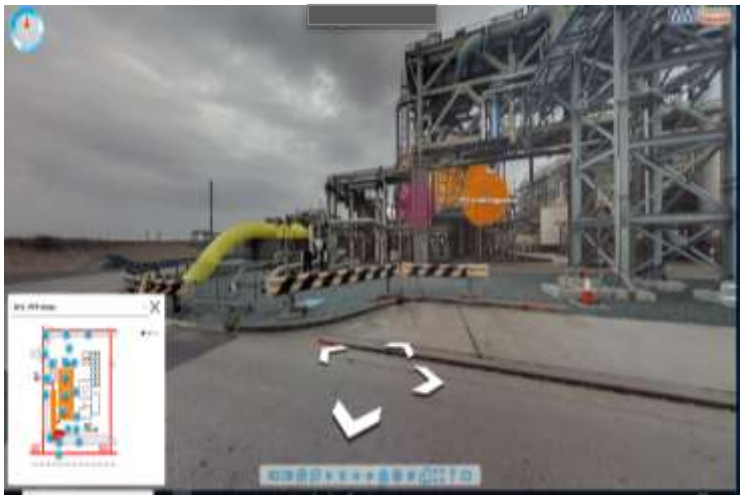
Example – review of fire measures

Virtual tours – embedded material

Another use, improved presentation - embedded material
- Hotspots overlaid – opens supporting information



Benefits from Virtual tours:

- Easy to access
- Multiple perspectives
- Reduce site exposure (for information reviews)
- Presentation tool

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Present and near future – laser scans

Benefits of laser scanning

- Collect data accurately in a short time.
- Accuracy 1/16th of an inch down to 1/32nd of an inch
- Collect data that would be difficult to acquire. Laser scanning using drones is being applied

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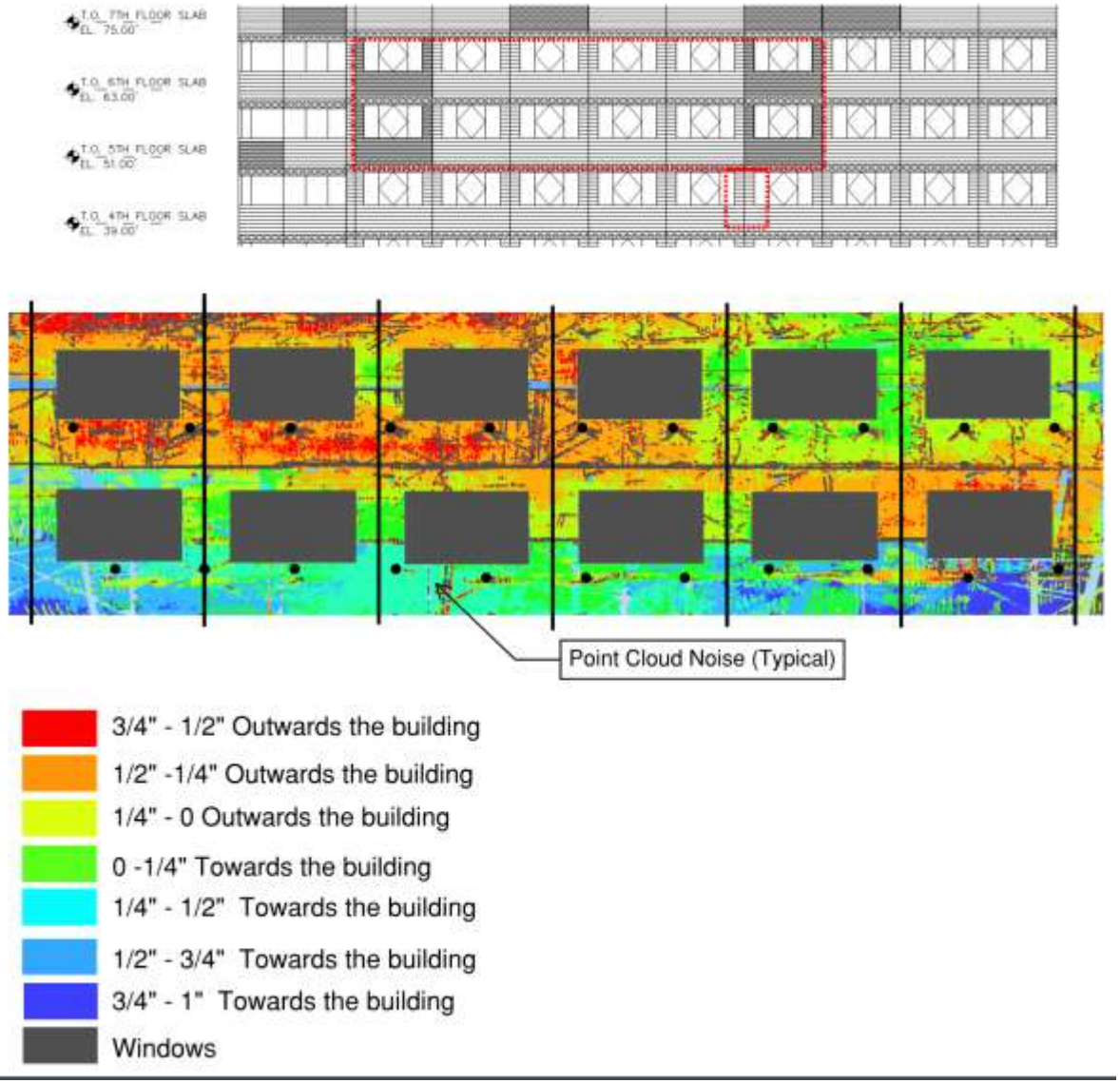
Laser Scans - Forensics

To date – mainly used for investigation – Forensic, where accuracy is significant tool



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Laser Scans – Forensics – and virtual tour replacement

Integrated Camera

The scanner also has an integrated camera that allows photographs to be superimposed on the point cloud, if desired. This imagery is used by the system to associate color with the scanned points.

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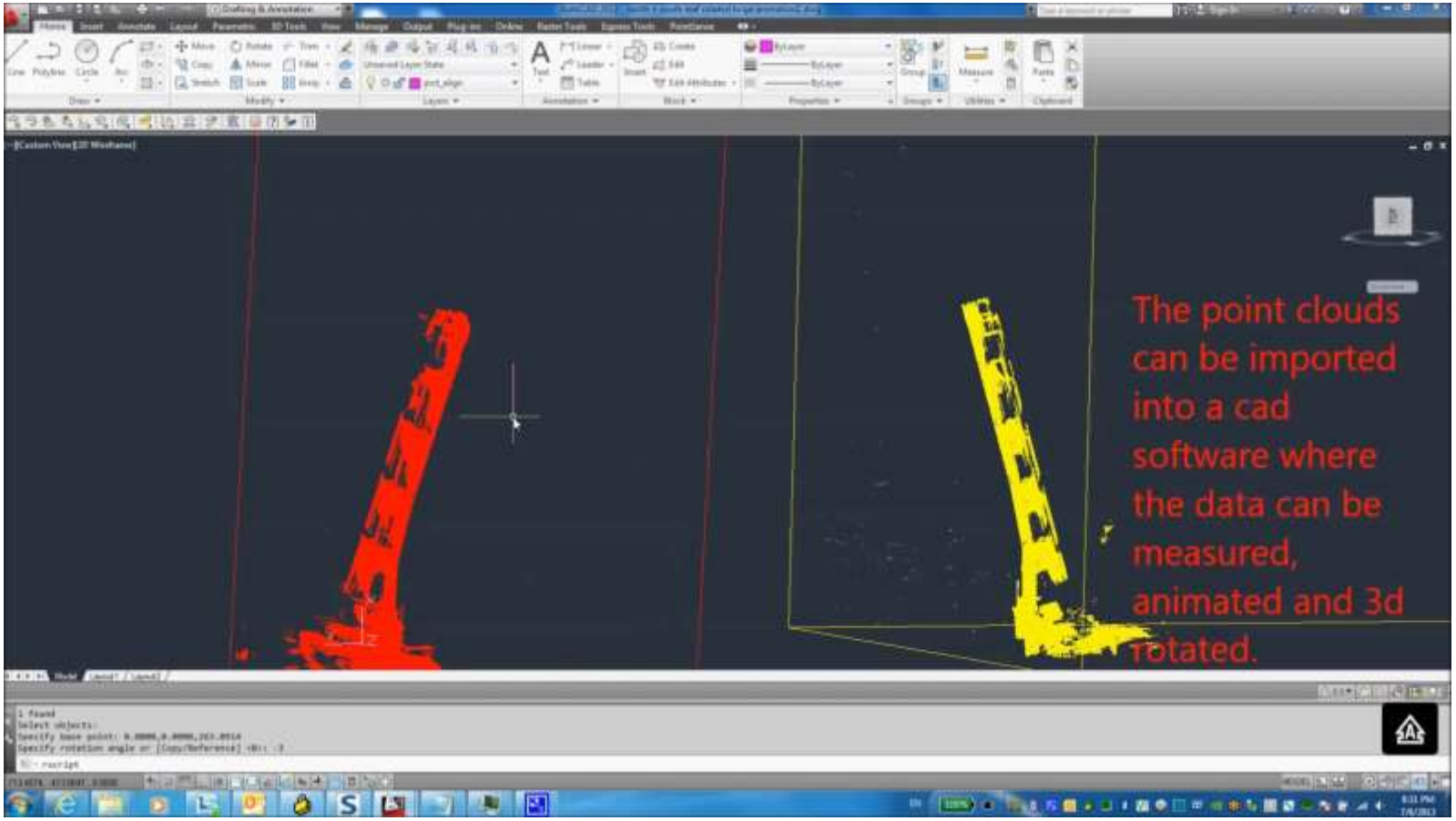
Laser Scan – Forensic Investigation: Animation



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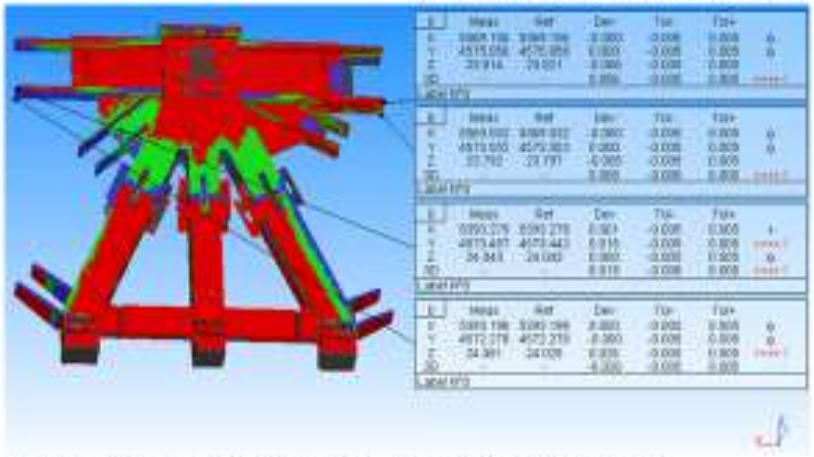
Laser Scan – build check

Comparison between as built and construction drawings (New Structures)

Point Cloud

3D Model from Construction Drawings



Color Contour (Point Cloud Overlaid to the 3D Model

Future - Using Artificial Intelligence to improve inspection efficiency

T2D2: Thornton Tomasetti Damage Detector

T2D2 automatically detects visible concrete damage (cracks, spalls, corrosion etc.) in various types of structures.

How does it work?

T2D2 uses the Artificial Intelligence, specifically deep learning for computer vision, to detect and localize damage from inspection images.

It has been trained on labeled datasets consisting of innumerous images collected from years of manual inspections on various structures with different damage classes.

How does one use T2D2?

T2D2 can be used manually as a mobile app to capture images and detect damage (and localize via GPS) in real-time as the inspector walks around a site.

The same underlying technology can be deployed on a drone for image capture at scale or to reach inaccessible spaces without special equipment or scaffolds.

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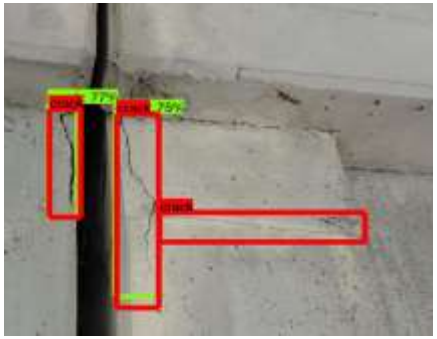
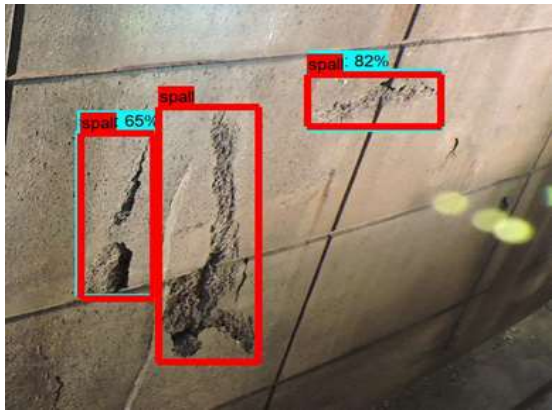
Future - Detection learning

Machine learning - Ground Truth vs Inference

crack



spall



rebar

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Future - Deployment

T2D2 Deployment on Android

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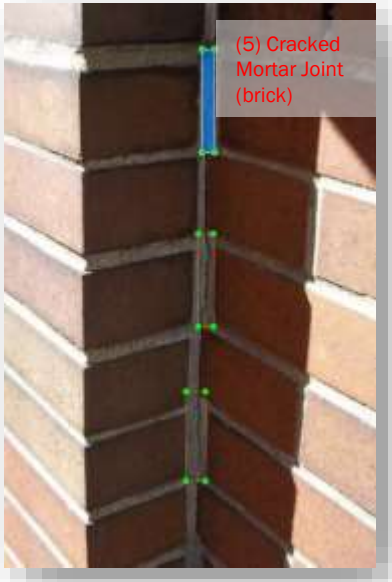
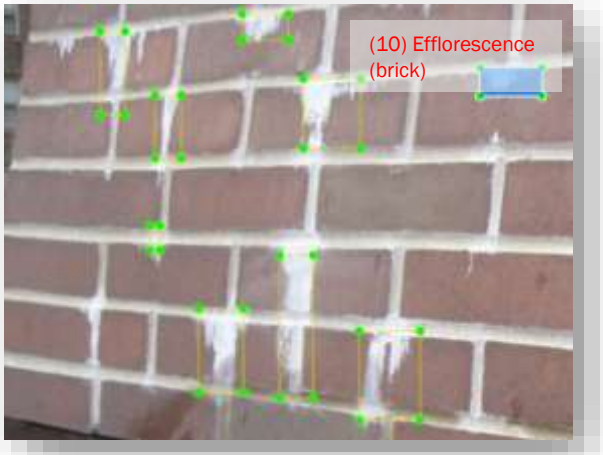
Future - Further AI Training

Additional Damage Classes: Brick/Limestone/Stone Masonry





Masonry Damage Classes

1. Incipient Crack
2. Crack
3. Spall
4. Spall-after-shard-removal
5. Cracked Mortar Joint
6. Open Mortar Joint
7. Cracked Brick
8. Failed Patch
9. Bio-growth
10. Efflorescence
11. Misc Anchors

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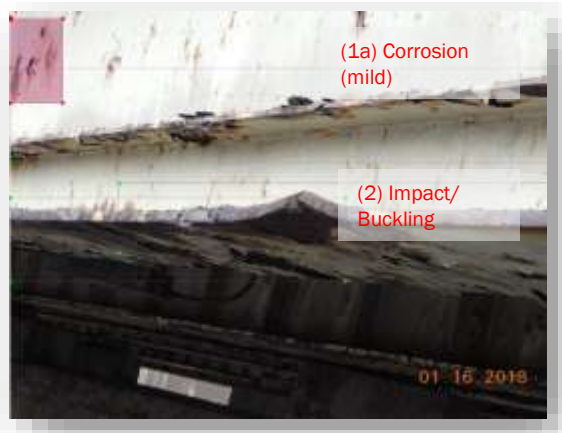
Future – Addition defect identification

Additional Damage Classes: Steel

Steel Damage Classes

1. Corrosion
   a) Mild
   b) Moderate
   c) Severe
   d) Extreme
2. Buckling/Impact Bending
3. Steel-crack/Tearing
4. Pitting/Thinning
5. Missing-bolt
6. Sheared Nut



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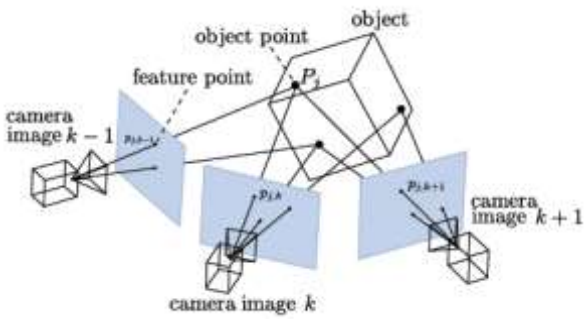
Future – AI tool benefits and other developments

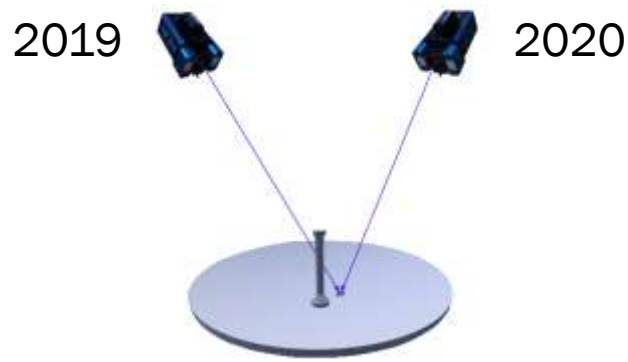
Current tool benefits:

- Scans can be undertaken by inexperienced individuals
- Surveys of areas difficult to access.
- Extension to other types of visually identifiable damage

Future developments :

- Metric – tool to be able to provide quantification of damage extent
- Repeatability and time stamp – potential use as a management tool to monitor damage progression





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Summary

- Historical – Incident and fault/defect recording
- Current support – limited to supporting safety studies (if applying best practice)
- Current – Use of 360^0 'virtual tours
  - Improved support tool
  - Presentation tool
- Current – Laser scanning
  - Improved incident recording and investigation
  - Build check
  - Potential 'virtual' tour replacement and as built record
- Future – AI tools and machine learning
  - Quicker surveys
  - Easier surveys
  - Future potential – asset management tool?
- Where next?
  - AI tools using IR and acoustic source material

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