

TRACE

FROM INVESTIGATION TO ANALYSIS

NON-INTRUSIVE BRIDGE ANALYSIS USING GPR
AND iCMM: MOVING BEYOND DEFECT SPOTTING
TO STRUCTURAL UNDERSTANDING



Structural Intelligence
Redefined

NON-INTRUSIVE BRIDGE ANALYSIS USING GPR AND iCAMP: MOVING BEYOND DEFECT SPOTTING TO STRUCTURAL UNDERSTANDING

Andy Kitson

Trace Structural Investigations Ltd, 99 Weyhill, Haslemere, Surrey, GU27 1HT, United Kingdom

Note: internal project examples and figure sources have been anonymised within the paper body.

ABSTRACT

Bridge investigations still rely too heavily on surface observation, tap testing and isolated point measurements. Those methods remain useful, but they do not explain how a bridge is built, they do not cover enough of the structure efficiently, and they rarely provide the spatially coherent information needed for targeted repair design. The result is familiar across the sector: high access cost, limited certainty and intrusive follow-on work that are broader than they need to be. This paper argues that non-intrusive analysis (NIA) provides a better route for bridge defect investigation. NIA is not a single test method. It is an analysis-led workflow that combines non-destructive techniques, structured processing, calibration, simulation and engineering interpretation to answer practical questions on construction and condition. Within reinforced and post-tensioned concrete bridge assets, Ground Penetrating Radar (GPR) is particularly effective for defining as-built construction, reinforcement, tendon routes, hidden steel, delamination, void-like responses and zones of elevated attenuation associated with moisture or chloride ingress. Where direct assessment of the ferrous element is required, the Infrastructure Condition Assessment Magnetic Method (iCAMP) can be added to map relative corrosion intensity and, where calibration exists, practical section-loss bands. The paper focuses on what this combined workflow delivers in practice rather than presenting isolated case studies. Evidence is drawn from anonymised bridge and dam investigations undertaken by TRACE, including bridge soffit deterioration mapping, post-tensioned bridge investigations and large-area spillway assessment. Attention is given to velocity calibration, intrusive reference points, simulation-supported interpretation and the need to review full radargrams rather than rely on plan-view exports alone. The central argument is simple: bridge investigation should not stop at locating visible defects. It should define the hidden structure, explain the mechanism of deterioration and provide decision-ready outputs that reduce uncertainty before repair or strengthening work begins.

Keywords: bridge inspection; non-intrusive analysis; GPR; iCAMP; corrosion mapping; delamination; post-tensioned bridges

INTRODUCTION

Principal inspections remain necessary, but on their own they are no longer enough for many bridge assets. They are led by what can be seen at the surface, what can be reached safely and what can be inferred from visible distress. That remains important, but it is a poor basis for understanding how a structure is assembled or for locating hidden deterioration with confidence. The engineer may know that cracking, staining, water ingress or spalling is present, yet still have limited information on the layer involved, the depth of the defect, the reinforcement arrangement behind it or the extent to which a deterioration mechanism continues away from the visible symptom.

Traditional follow-on methods help only in part. Tap testing is fast, but it is subjective, binary and weak in geospatial accuracy. Cover meters provide valuable local checks, but they do not reconstruct the structure over meaningful areas. Half-cell surveys can indicate corrosion probability, but they are slow, operationally demanding and remain a measure of risk rather than a direct measure of steel loss. In practice, bridge investigations often become fragmented: one method identifies a symptom, another checks a small number of points, and the final decision still rests on a large amount of uncertainty.

This is the gap that non-intrusive analysis is intended to close. NIA is built around the view that the value of an investigation lies in the interpretation, not simply in the scan. The aim is not to collect more screenshots. The aim is to answer engineering questions. For bridges, those questions are usually some combination of the following: how is the element built; where are the critical hidden components; what form of deterioration is present; how extensive is it; what is likely to be masked by attenuation or geometry; and where should intrusive works be targeted if they are still required.

That shift in emphasis matters. Most bridge surveys are governed far more by access, possessions, traffic management and safety constraints than by the cost of the instrument itself. Once that access is in place, the cheapest part of the project is often the collection of richer data. The expensive mistake is collecting too little information, opening up the wrong place and then returning to site again.

Table 1. Conventional bridge inspection outputs compared with an NIA workflow.

Approach	Main strength	Main weakness	Typical outcome
Principal inspection	Surface condition review and broad engineering context.	External only; cannot define hidden construction or hidden deterioration with confidence.	Narrative defect record with local judgement on likely severity.
Tap testing	Slow identification of sound change over accessible surfaces.	Subjective, binary and poor at explaining why the response changes.	Approximate zones of hollow or different sounding concrete.
Cover meter / local NDT	Useful spot checks for cover and local reinforcement presence.	Point-based and inefficient for wide-area reconstruction.	Local confirmation only.
Half-cell survey	Useful indication of corrosion probability in the right circumstances.	Slow, environment-sensitive and still indirect.	Risk map rather than direct condition of the steel.
Non-intrusive analysis	Combines wide-area construction and condition information within one workflow.	Requires calibration, experienced interpretation and stated limitations.	Drawings, sections, defect maps and targeted follow-on actions.

CURRENT LIMITATIONS OF BRIDGE INSPECTION

The weakness in much current bridge investigation is not a lack of technology. It is that the workflow remains defect-led and surface-led. Too much emphasis is placed on visible symptoms and too little on the hidden structure that governs those symptoms. In many NDT reports, plan-view exports, depth slices or isolated plots are treated as the result. They are not. They are intermediate products. Without calibration, without full data review and without engineering interpretation, they can mislead just as easily as they can inform.

This matters because bridge repair decisions are expensive. Access, traffic management, possessions, barges, rope access, temporary works and supervision usually dominate cost far more than the scanner itself.

Once that access is in place, collecting better subsurface information is often the most economical part of the exercise. The real waste comes from going back twice, opening up the wrong place, or carrying out repairs on a scope that was defined by incomplete information.

The same issue applies to deterioration assessment. Principal inspection may identify where concrete sounds different or where staining is visible, but it does not provide a spatially coherent understanding of delamination depth, construction interfaces, reinforcement density, tendon routes or ferrous condition. The engineer is left with a surface symptom and a large amount of uncertainty behind it. NIA shifts the investigation away from that position. It aims to define the structure first and then place the defect within that structure.

NON-INTRUSIVE ANALYSIS

NIA is not a new gadget, and it is not a single sensor. It is a way of carrying out structural investigation. In practical terms it is an integrated workflow that combines multiple non-destructive methods with structured processing, calibration, simulation and expert interpretation to produce engineering-ready information on both construction and condition. The emphasis is analysis-led rather than equipment-led. The method is chosen to suit the question, not the other way round.

For bridge work, GPR is usually the primary wide-area method because it can reconstruct what is present within the accessible concrete volume at speed. It can identify reinforcement layout, cover trends, slab and deck build-up, hidden steel, tendon routes, anchorage zones, probable delamination horizons, void-like responses and zones of elevated attenuation associated with moisture or chlorides. That construction context materially improves every subsequent decision. Without it, a spall, crack or low-amplitude zone cannot be located properly within the structural build-up, and intrusive verification risks being targeted at the wrong feature or depth.

Where direct information on ferrous deterioration is required, iCMM can then be added within the same overall workflow. iCMM is a passive magnetic method in which the stray magnetic field from ferromagnetic reinforcement is sampled from the concrete surface and processed to detect changes associated with corrosion, cracking and other stress-related defects (Mosharafi et al., 2020a; Mosharafi et al., 2020d). Because the method does not require active magnetisation, it is simpler to deploy than active magnetic alternatives and is not materially affected by water, salt or temperature during inspection (Mosharafi et al., 2020b).

The important point is that neither method should be treated as a black box. NIA depends on disciplined processing, stated limitations and a final output that the engineer can actually use extracted construction drawings, sections, CAD mark-ups, defect maps, corrosion-risk drawings, targeted follow-on testing zones and a narrative that explains what the anomalies most likely represent.

Table 2. Typical method roles within an NIA bridge investigation workflow.

Method	Primary question answered	Typical outputs	Principal limitation if used alone
GPR	What is there and where is it?	Reinforcement layout, cover/depth trends, interfaces, steel beams, duct and tendon routes, delamination and attenuation anomalies.	Corrosion outputs are indirect; congestion, moisture and geometry can mask or distort responses.
iCamm	What has happened to the ferrous element?	Relative corrosion intensity, defect zones and calibrated section-loss bands where field calibration exists.	Affected by nearby ferrous interference and requires careful interpretation.
Ultrasonic pulse echo (UPE)/Ultrasonic tomography (UT)	Is there a void, debond or major change in the concrete or duct zone?	Tomographic reflection patterns, void or debond indications and confirmation of selected anomalies.	Slower and normally used over targeted areas rather than full coverage.
Ultrasonic pulse velocity (UPV)	Is the material continuity changing?	Velocity trends, comparative line-scan outputs and targeted assessment of continuity or cold-joint type questions.	Indirect and best used as part of a wider evidence set.
Intrusive reference points	What needs to be ground-truthed?	Calibration points, exposed reinforcement, cores, drill-hole thickness checks and material samples.	Local only, but essential where confidence or quantification needs to be improved.

WHY GPR AND ICAMM MATTER

GPR is uniquely valuable because it answers the question that sits behind most other bridge defects: what is actually there? On reinforced concrete bridges it can define bar layers, spacing, cover, slab thickness and build-up, changes in reinforcement density, hidden beams, local repairs, construction joints, ducts and anchorage zones. On post-tensioned bridge assets, it can often resolve tendon routes directly and, where direct imaging is restricted by geometry or congestion, it still provides the surrounding context needed to interpret why a tendon or anchorage may be masked.

GPR also provides condition indicators. Delamination, debonding, honeycombing, void-like anomalies and zones of elevated attenuation can all be inferred from the radar response when the data are properly calibrated and interpreted. Corrosion-risk mapping through amplitude and attenuation analysis remains indirect, but it is highly valuable because it identifies where the concrete environment is likely to be aggressive and where deeper features may be obscured. Used properly, this is not simply a heat map. It is part of the engineering interpretation of what the concrete and the embedded steel are likely doing.

iCAMP addresses the obvious limitation in that approach. GPR does not directly assess the ferrous element itself. iCAMP does. For bridge investigations, that matters because the ferrous condition is often the critical engineering question once the structural arrangement has been established. The practical value is that the magnetic response can be read against the known build-up from GPR rather than being treated in isolation. The engineer is no longer looking at a corrosion output alone; they are looking at corrosion in the context of cover, bar density, construction detail, moisture-related attenuation and observed defects.

The strongest bridge workflow is therefore not GPR or iCAMP in isolation. It is the combination. GPR establishes the hidden structure and the surrounding concrete condition. iCAMP then interrogates the ferrous response in the relevant zones. That produces an information set that is materially stronger than principal inspection, tap testing, half-cell or point cover readings used separately.

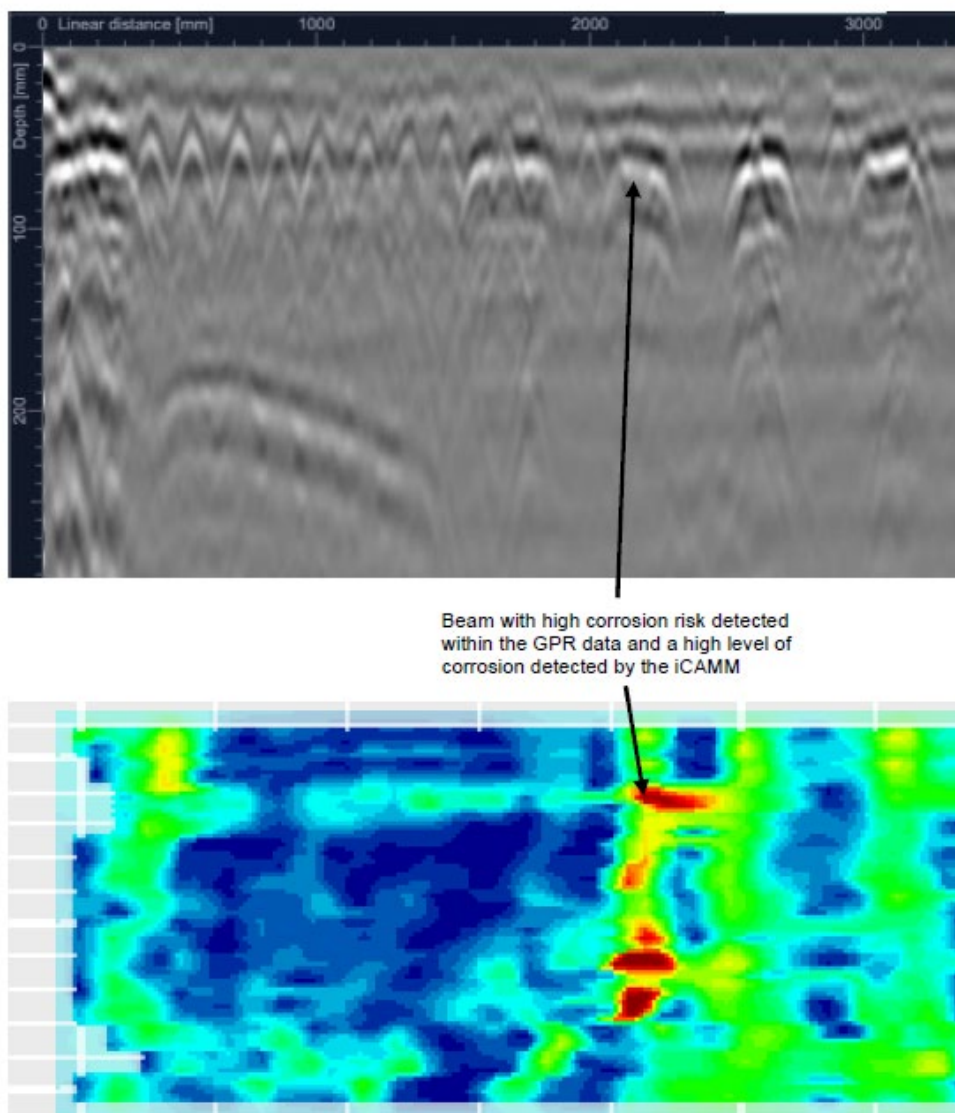


Figure 1: Showing correlation between the iCAMP beam corrosion results and the area of increased signal attenuation indicative of corrosion risk.

VELOCITY CALIBRATION, GROUND TRUTHING AND SIMULATION

The credibility of any GPR-based bridge investigation depends heavily on calibration. Velocity cannot be treated as a generic number applied to every asset. It must be checked against the actual structure. In practice this normally involves a combination of known cover, intrusive reference points, cores, drill-hole measurements, exposed reinforcement, measured slab thicknesses, hyperbola fitting and comparison with other calibrated methods. Different parts of the same asset may require different working velocities where concrete quality, moisture condition or member geometry change materially.

This is one of the areas where NIA differs most clearly from standard scan-and-export work. The objective is not to generate a picture quickly; it is to produce depth estimates and interpretations that are traceable. Across TRACE projects this has included calibrated bridge soffit work where the GPR response for delamination and corrosion risk could be correlated against intrusive observations and iCAMP results, as well as large-area dam work where drill-hole measurements and hyperbola matching were used to derive a working velocity before issuing mapped outputs for possible voiding and attenuation.

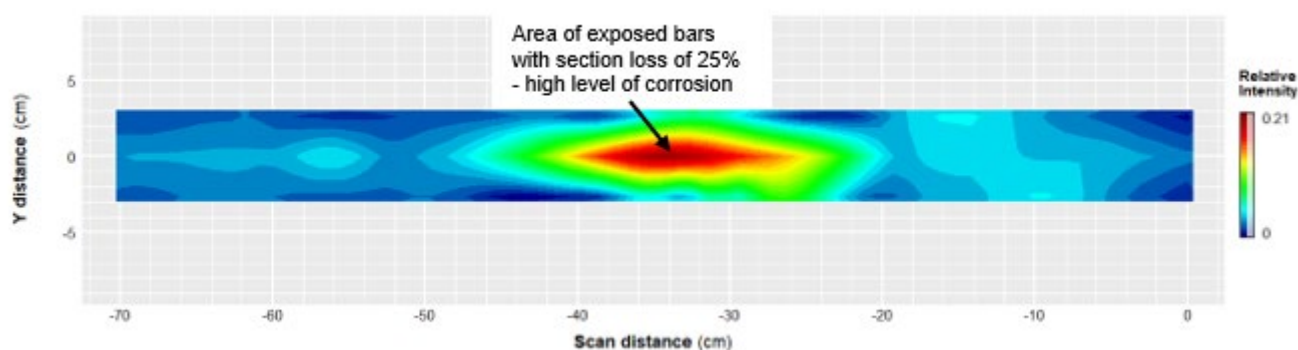


Figure 2: Showing field calibration of iCAMP response against exposed corroded reinforcement and the resulting correlation with GPR corrosion-risk mapping

Simulation is equally important, particularly on complex bridge structures. Modelled radar responses help distinguish true defects from geometry-driven effects caused by reinforcement congestion, slab interfaces, anchor cages, steelwork or previous repairs. This is especially valuable where the first impression from a plan-view output is misleading. A strong plan anomaly may be nothing more than a benign geometric response, while a serious defect may sit in a high-attenuation area where the plan view is weak. The answer sits in the B-scan, the calibration and the known construction context.

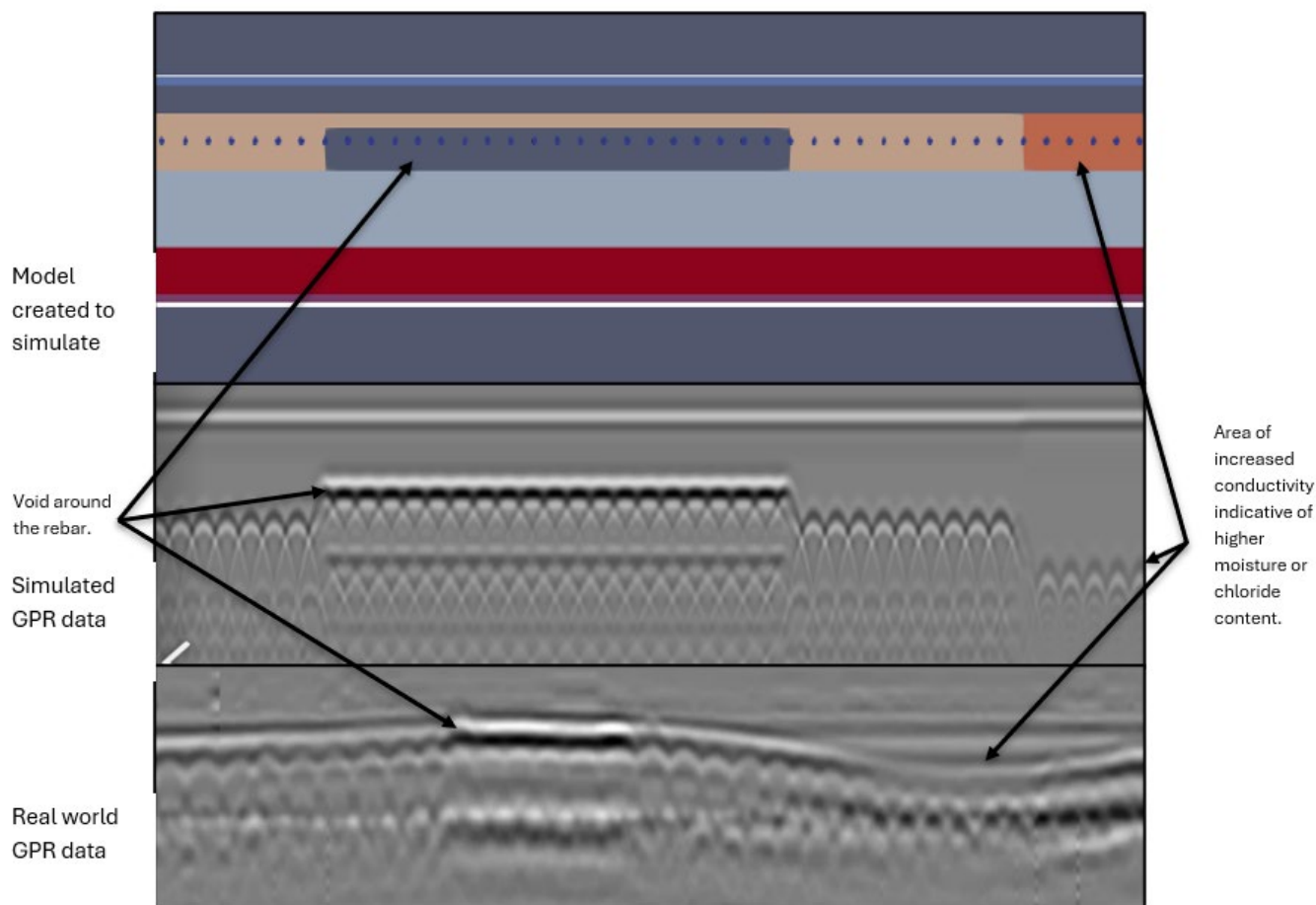


Figure 3: Simulation figure(s) showing how processed synthetic models were used to support interpretation of delamination and corrosion risk responses.

The dam investigation is a good example of why these matters. Earlier outputs had presented broad C-scan style anomalies as if they were the result. Under an NIA review, those data were re-processed, calibrated and checked against simulation and intrusive evidence. The outcome was not simply a different picture. It was a different engineering conclusion: probable voids could be separated from attenuation-related masking and from areas where no significant anomaly was present. The same principle applies directly to bridge decks and bridge soffits. Depth slices and C-scans are communication products. They are not the interpretation.

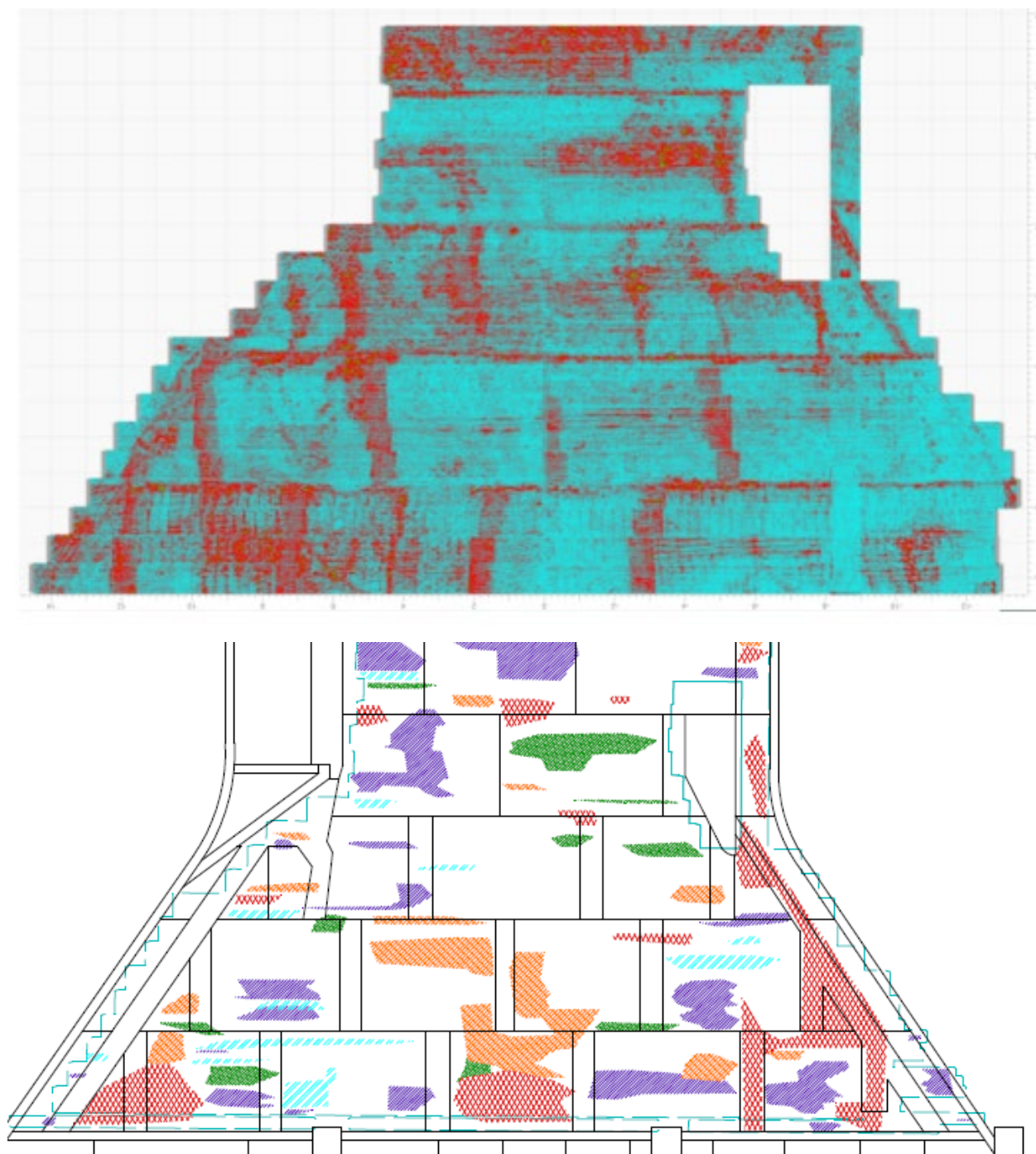


Figure 4: Showing the raw C-scan data (top) and the analysed and categorised results plotted onto a CAD drawing (bottom). This is an example of why interpretation matters: a plan-view export alone can overstate or misclassify anomalies, whereas calibrated NIA review separates probable voiding, attenuation-driven masking and benign zones

FROM DATA TO ENGINEERING INFORMATION

The practical value of NIA is that it produces outputs that can go straight into engineering decisions. The first class of output is as-built construction. For bridge elements this may include slab and soffit build-up, reinforcement arrangement, bar spacing, cover trends, hidden beams, diaphragm details, tendon routes, anchorage zones, bearing plinth reinforcement, local repair extents or interface changes. This matters because assessment and repair design are routinely undermined by uncertainty over what is in the member.

TRACE

TSI R/3

in this case it is not possible to fully resolve it due to the depth of the cage from the scanned surface. If the second cage is present, its position is at suspected anchor option 1 (red rectangle). From the soffit scans the cage dimensions are approximately 300mm in transverse direction (width) and 620mm in longitudinal direction (length). Figure 8 shows radargram with the approximate width of the cage.

- Reflection indicative of tendon of parabolic profile was detected at 300-460mm depth, from the east face; due to the depth of the reflection, it was not possible to conclusively determine whether it comes from a single tendon or two tendons (or two ducts) at very close centres due to its depth and horizontal resolution of the antenna (see Figure 9A). Note that part of this tendon closer to the cage was not detected by GPR, possibly due to its greater depth.
- Possible features were detected within the top part of the east web. The reflection characteristics indicate the presence of a possible cage (detected at 340-350mm depth, from the east face) and tendon (detected at 400-420mm depth, from the east face), however, due to their position and antenna offset, only small part of the reflection is visible, and its exact nature is unknown. It is most likely that these reflections are from the cage and tendon located within the top deck. Level of confidence that these features are indicative of cage and tendon is 60%.

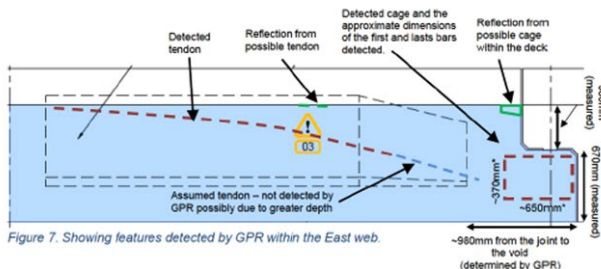


Figure 7. Showing features detected by GPR within the East web.

* the tolerance of the cage dimensions was established as ~50mm.

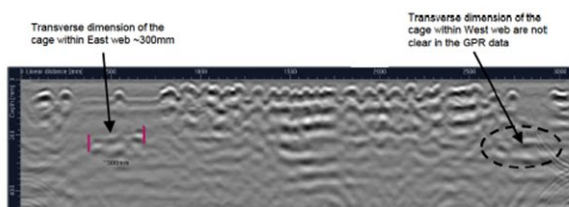


Figure 8. Transverse scan collected on the soffit showing width of the cage within East web.

8

TRACE

TSI R/3

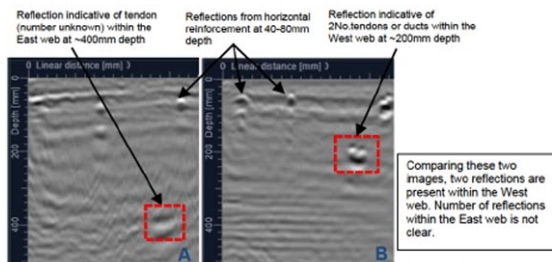


Figure 9. Radargrams showing reflections indicative of tendons - A - East web, B - West web.

WEST WEB

- Reinforcement details:
 - Vertical/transverse bars detected at 90-120mm centres and at 15-40mm depth from the west face and 10-30mm depth from the soffit. Vertical reinforcement start ~750mm from the vertical face of lower rib.
 - 3No. horizontal/longitudinal bars at 30-50mm depth detected within the west face and 4No. longitudinal bars at 40-60mm depth detected within the soffit.
 - additional horizontal/longitudinal bar running diagonally, detected at 40-60mm depth from the west face; the bar starts ~2.2m from the bottom half joint at the top of the west face (shown in blue on Figures 11 and 12).
 - Dovels connecting the cantilever and suspended spans were not resolved.
- Post-tensioned tendons components (see Figures 9B 10 and 11):
 - Reflections indicative of a cage were detected at 50-70mm depth from the west face and 150-200mm depth from the soffit. Based on the data interpretation and the record drawings, the detected cage appears to be in the position of known anchor (black rectangle on Figure 2), analogically to the east web. The approximate size of the cage is 370mm high and 650mm long. It is possible that the reflections are coming from two cages very close to each other (one on top of the other). In this case it was not possible to conclusively resolve it, due to possible proximity of two cages (see Figure 12). If the second cage is present, its position is at suspected anchor option 1 (red rectangle). See notes below Figure 11 for explanation.
 - From the soffit scans the cage dimensions are approximately 620mm in longitudinal direction. The west side cage is not clearly visible in transverse scans due to more reinforcement present on this side, therefore the transverse dimension is not given (see Figure 8).
 - 2No. reflections indicative of tendons or ducts of parabolic profile were detected at 190-220mm depth, from the west face (see Figure 9B).
 - Level of confidence that 2No. reflections are present is 95% (there appear to be one reflection splitting into two ~700mm from the cage). We cannot confirm from the GPR data whether these reflections are from two tendons or two ducts. The GPR cannot distinguish between tendon and duct. No information obtained from the survey would suggest that there is an anchorage to the side; during the meeting with [redacted] it was concluded that, it is possible that the two reflections are coming from 2No. of ducts relating to the same tendon.
 - Possible features were detected within the top part of the west web. The reflection characteristics indicate the presence of a possible cage (detected at 140-150mm depth, from the west face) and tendon (detected at 200-220mm depth, from the west face), however due to their position and antenna offset, only small part of the reflection is visible. It is most likely that these reflections are from the cage and tendon located within the top deck. Level of confidence that these features are indicative of cage and tendon 70%.

9

Figure 5: Showing data analysis and extraction of key details of a bridge half joint, the information is then presented with a series of sketched and drawings, alongside the text.

The second class of output is condition information. Delamination extents and likely depth bands can be mapped. Areas of elevated GPR attenuation can be identified as zones of possible moisture or chloride-related deterioration and as areas where deeper features may be obscured. iCAMP can then be used within the same dataset to identify relative ferrous deterioration and, where suitable calibration exists, translate those responses into practical section-loss bands. Taken together, this gives the engineer a materially stronger basis for deciding whether a defect is superficial, local, extensive or likely to require intrusive confirmation.

Bridge soffit investigations undertaken by TRACE demonstrate this well. A single access-limited zone was used to derive soffit construction, delamination interpretation, GPR corrosion-risk mapping and magnetic ferrous corrosion mapping. That is a materially different outcome from a principal inspection note describing isolated spalls and hollow-sounding areas. The repair engineer can see not only where a defect is likely present, but also what sits behind it, how deep it may be and how it relates to the hidden steel.

The same applies to post-tensioned bridges. In those cases, the value of GPR is not limited to whether a duct is directly visible in every location. Its value is that it reconstructs the deck build-up, identifies likely tendon corridors, explains why certain zones are masked, highlights anchorage positions and allows follow-on UPE, endoscopy or intrusive access to be targeted rationally. This is a better engineering use of limited possessions than broad speculative opening-up.

A wider point follows from this. The output of NIA should not be a collection of plots requiring the client to interpret them. It should be drawings, sections, accurately mapped and categorised defects, and a written explanation that states what the observed anomalies most likely represent, what the limitations are and what should happen next. That is where the value sits.

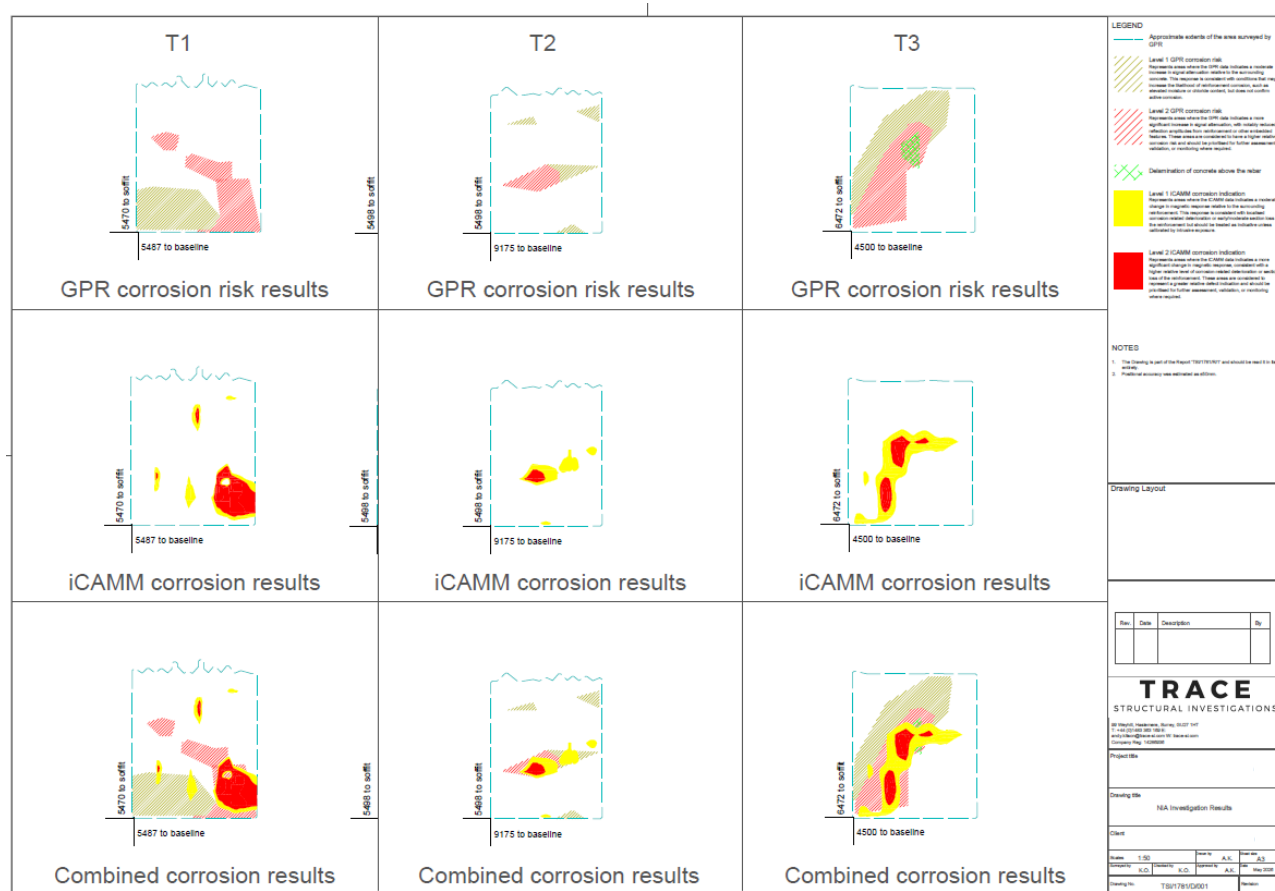


Figure 6: NIA output drawing for bridge soffit: combined mapping of delamination and corrosion risk from GPR and iCAMP showing the sort of engineer-ready drawing that NIA should produce, rather than isolated raw scan exports.

Table 3. Typical decision-ready outputs from NIA and the engineering questions they help answer.

Output	Usually derived from	Engineering value
Extracted construction drawings	GPR, calibration points, record review	Defines member build-up and hidden arrangement for assessment and repair design.
Delamination and void maps with depth bands	GPR, simulation, targeted intrusive checks, local UT where needed	Targets repairs and avoids over-break or blind opening-up.
Corrosion-risk maps	GPR attenuation/amplitude analysis	Identifies aggressive concrete zones and where deeper features may be masked.
Relative ferrous deterioration / section-loss bands	iCAMP tied to GPR context and field calibration	Improves confidence on the condition of hidden steel.
Duct and anchorage mark-out	GPR, UPE/UT, endoscopy and records where relevant	Directs follow-on PT investigation within limited possessions.
Recommended intrusive works	Integrated NIA interpretation	Turns wide-area data into a targeted verification plan.

Legend:

-  Red circle – High confidence voiding. Interpreted as areas showing a strong amplitude reflections, likely to be an indicative of a void within the duct.
-  Green circle – Low confidence voiding. Interpreted as areas with weaker amplitude reflections, suggesting possible void within the duct but may be a result of other features in the data creating the reflection changes.

Black background is an indicative that the duct is fully grouted. Interpreted as areas showing minimal reflection response, well-grouted sections where the ultrasonic signal propagated through the material.

Minor anomalies, likely indicative of data artefacts, which should be ignored for the purpose of this survey.

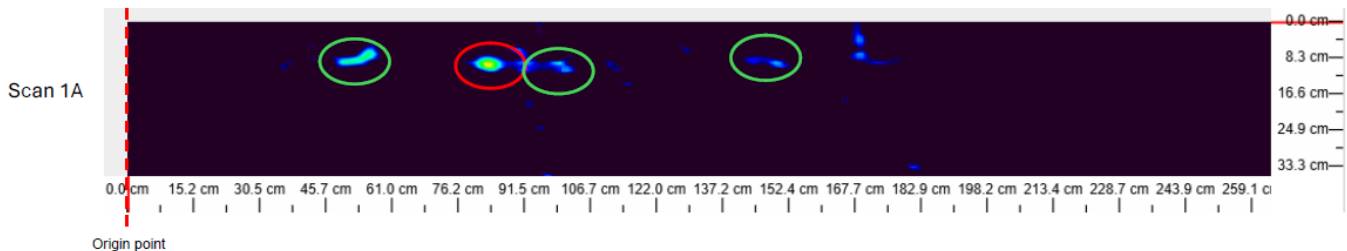


Figure 7: Analysed and categorised UPE data to be plotted onto CAD drawings.

REPEATABILITY AND MONITORING CHANGE OVER TIME

A further opportunity is to use NIA as a baseline for monitoring. A mapped investigation records the construction and condition indicators at a particular point in time. Returning to the same locations could allow the engineer to assess whether an interpreted defect is extending, whether a response is changing or whether the surveyed area remains broadly consistent within the limits of the methods. The value would be a clearer basis for deciding where closer investigation or intervention is needed, and where continued observation may be appropriate.

That depends on repeatability. A second survey is not automatically comparable simply because the same instrument is used. Survey positions need to be tied to a common reference, with consistent coverage, scan direction, sampling and sensor position relative to the surface. Equipment settings, calibration, processing steps and interpretation criteria should be recorded and reproduced where practicable. Retaining the raw data is equally important: if the analysis changes, the baseline and repeat datasets should be reviewed on the same basis. Repeat passes over selected reference areas would help establish the variability of the survey before a difference is interpreted as deterioration.

The comparison must also account for changes in survey conditions. GPR responses can vary with moisture, surface condition and coupling, while magnetic comparisons require control of sensor position and consideration of nearby ferrous objects or changes to the structure. Repairs and other interventions need to be recorded. A stronger anomaly or a different colour on a map is not, on its own, evidence of advancing corrosion. Meaningful change needs to exceed the established measurement variability and be supported by the full data, construction context and, where necessary, targeted verification. Where section-loss bands are used, the comparison must also account for the uncertainty in the calibration.

For asset owners, the potential is to move from a one-off condition map towards an evidence-based record of change. Comparable drawings could show changes in interpreted delamination extent, GPR attenuation or ferrous response, with uncertainty stated alongside the findings. Repeat intervals would be selected to suit the asset risk and the change the survey is capable of resolving. This is a prospective application of the workflow; the project examples in this paper do not yet demonstrate deterioration tracked through successive surveys. Establishing that evidence is an important next step.

TIME, ACCESS AND DELIVERY

The time advantage of NIA is frequently misunderstood. It is not just that a radar array or magnetic scanner may cover area quickly, although that matters. The larger saving comes from the way bridge projects are actually delivered. Most are access-led. Once a lane closure, scaffold, MEWP, rope team, underbridge unit, track possession or over-water access system is in place, the marginal cost of capturing better information is usually small compared with the cost of returning for another phase of exploratory work.

That is why wide-area non-intrusive surveys regularly outperform traditional point-based approaches in real project terms. A principal inspection or local half-cell programme may appear simpler, but it often delivers less useful information for a comparable or only slightly lower access cost. By contrast, an NIA workflow can define the arrangement, indicate condition, identify zones for intrusive confirmation and reduce the amount of speculative opening-up required. The engineer receives more information from the same access window.

There is also a safety dimension. Where the survey can be completed from one face only, by remote access or by robotic deployment, the amount of time spent over water, over traffic or in difficult access positions can be reduced materially. This does not remove the need for access planning. It does mean the access is used more efficiently.

LIMITATIONS AND GOOD PRACTICE

NIA is not a replacement for engineering judgement or for intrusive verification where that is genuinely required. GPR corrosion outputs remain indirect and can be influenced by moisture condition, chlorides, variable concrete properties, reinforcement congestion, scan direction and previous repairs. iCamm can be affected by neighbouring ferrous elements and should be calibrated against known physical conditions if section-loss estimates are to be issued with confidence. Ultrasonic methods remain important where voiding or debonding needs to be checked more directly in selected zones.

Equally, not every bridge question needs the same method mix. Some assets require GPR and iCamm. Some require GPR and UPE. Some need targeted intrusive work to confirm a mechanism or to provide laboratory durability data. NIA is useful precisely because it does not force a single method onto every problem. It allows the investigation to be built around the structural question and the access constraints.

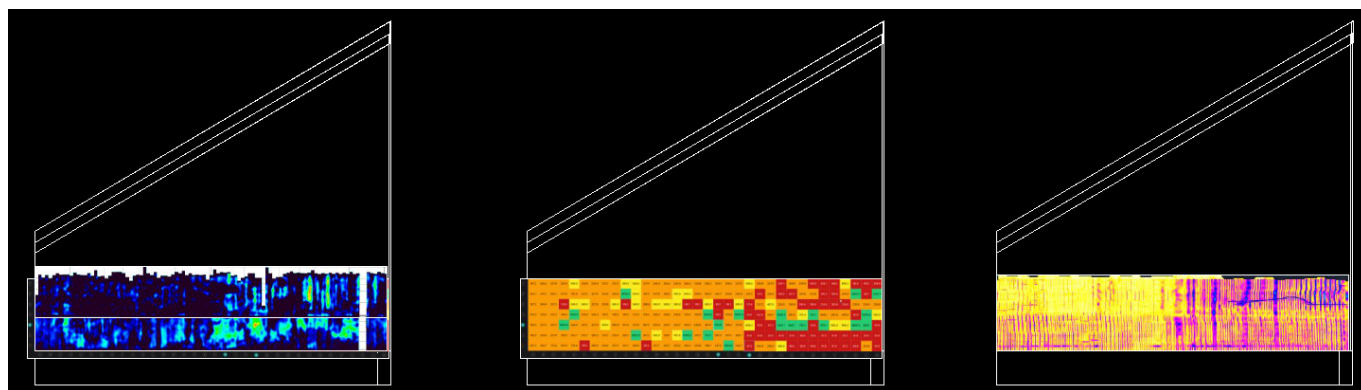


Figure 8: Data samples from a bridge abutment wall, UPE (left) UPV (middle) and GPR (right) showing the value of collecting and cross analysing data to determine defects.

The most important caution is interpretative. Heat maps, depth slices and exports are communication tools, not the analysis itself. The industry has been too willing to treat automated plan outputs as answers. They are not. The answer comes from the radargrams, the calibration, the simulation, the known construction context and the final engineering judgement. Where that discipline is applied, NIA is highly effective. Where it is not, the result is simply more data with the same uncertainty.

CONCLUSIONS

Current bridge inspection practice remains too dependent on surface observation, isolated point testing and defect spotting. That approach is not sufficient for many modern investigation questions, particularly where the engineer needs to understand both as-built construction and hidden deterioration before deciding on repair, strengthening or monitoring.

Non-intrusive analysis offers a better route forward. It is analysis-led rather than equipment-led, and it combines methods to answer practical engineering questions. Within bridge work, GPR is central because it reconstructs the hidden structure and identifies condition indicators over meaningful areas. iCAMP strengthens that workflow by providing direct information on the ferrous response and, where calibrated, practical estimates of relative section loss. Supporting methods such as UPE, UPV, eddy current testing and targeted intrusive works can then be used where they add genuine value.

The project evidence behind this paper shows that the gain is twofold. First, NIA provides materially more engineering information than principal inspection or other traditional point-based methods. Second, it provides that information in a form that is directly useful: drawings, sections, condition maps and targeted follow-on actions. That reduces speculative opening-up, makes better use of access windows and improves the basis for repair decisions.

The broader conclusion is therefore simple. The industry should stop treating raw data exports as results and should stop asking bridge investigations only where a defect might be visible. The better question is what the structure is, how it is built and how it is changing. NIA is a practical way of answering that question.





CONTACT US

info@trace-si.com

01483 363 169

www.trace-si.com