UK National Aerospace NDT Board

Midsummer House, Riverside Way
Bedford Road, Northampton
NN5 5NX
United Kingdom

Tel: +44 (0)1604-438251
E-mail: nandtb@bindt.org

NANDTB/29 – UK NANDTB POLICY ON REMOTE NDT

1. Status.

Initial issue, approved for publication at the 28th February 2022 meeting of the UK NANDTB.

2. Scope.

This document sets out the UK NANDTB policy for Remote NDT (RNDT). It is intended to regulate and provide recommendations & guidance for NDT tasks that are carried out collaboratively by personnel at different locations.

The use of RNDT is not mandatory, but where organisations choose to implement it, they must comply with this policy in such a manner that does not contradict or circumvent higher-level regulation and standards (eg EN4179, CAP 747, other NAndtB policy documents, etc).

This document applies only to EN4179 common and emerging NDT methods, plus the 'material evaluation' and 'direct readout' methods & techniques that are set out in NAndtB/18. It does not apply to any other form of aircraft maintenance or support.

This document does not cover any form of remote training for NDT. This is set out in the broader context of aerospace engineering training in CAA CAP 1933 – Guidance for use of Web based training, Distance Learning, Simulation and Virtual Reality.

Given the constantly evolving diversity & complexity of NDT, this enabling policy is intended to be as neutral as possible regarding specific methods, techniques and technologies.

3. Introduction.

The concept of Remote NDT has been widely applied in radiography since the 1970s. A Level 1 may take a radiographic exposure, process the film, check the image quality, then send the radiograph to a Level 2 who interprets it and sentences the part. With the advent of digital radiography, the physical transfer of film is replaced with the electronic transfer of image data, speeding up the process, but still involving a delay. The introduction of web-enabled digital detector arrays to capture and share radiograph data in real time allows image quality to be assessed as it is generated, by a Level 2, possibly on the other side of the world. Where corrections are needed to optimise the image, the exposure can be suspended and instructions fed back to the Level 1 (eg to adjust shot angle, source distance or exposure time). Such an approach is now established practice in medical radiology (diagnostic imaging), where radiographers and radiologists at different locations work together as a team.

With the increasing connectivity of people, devices and data, opportunities are emerging in other aerospace NDT methods, particularly where a “live stream” of data and two-way communication enables collaboration between deployed Operators and Inspectors back at base. In situations where direct, real-time, remote supervision can be achieved, this may allow for a lower level of certification for Operators and more efficient use of Inspectors.

Most of the technical, logistical, and procedural challenges with RNDT are a result of physical separation between the Operator and Inspector. This policy introduces the concept of ‘Verification’ to bridge this gap by assuring integrity of the test data, both for the test conditions and the test results (see Figure 1 below).

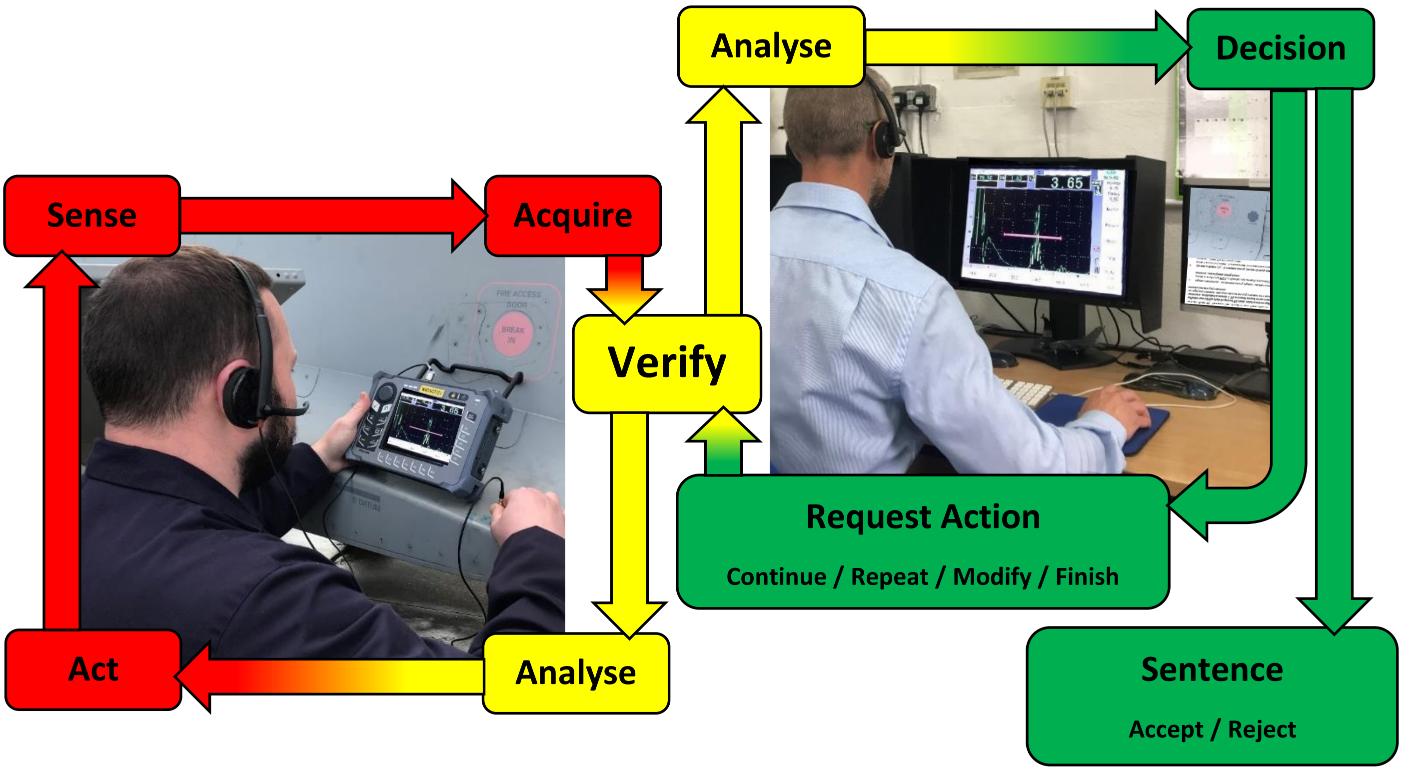


Figure 1: Remote NDT schematic, showing two interlocking process loops for Operator (left) and Inspector (right), with verified test data and feedback flowing between them.

Risk, operational demands, technical obstacles, and financial costs mean that Remote NDT may not be suitable for all NDT methods, techniques, and tasks. For example, with PT or MT, it may be difficult and/or expensive to capture, transfer and store a video record of transient indications with all the nuances of in-person viewing (eg angle, focus, illumination, tracking speed, image size & resolution, etc). Similar issues may be encountered for methods & techniques that rely on subtle skill-of-hand or sensory feedback (eg tap hammer audible/tactile response, UT probe manual handling for position, pressure, coupling, skew angle, surface texture, curvature, etc). However, for situations where objective, quantitative data can be captured, transferred, and stored, Remote NDT is generally more straightforward to implement (eg digital radiographs, UT C-scan data, ET instrument displays, etc).

Whilst there will always be a place for ‘traditional’ NDT carried out by a single certified individual, it is inevitable that organisations will aim to develop RNDT solutions to make inspections more collaborative, effective, versatile, economical, and globally deployable.

4. Basic Concepts and Terminology.

a. Remote Non-Destructive Testing (RNDT). This is the complete, end-to-end process involving personnel, at more than one location, collaborating on a Non-Destructive Testing task. The process typically includes, but is not limited to, the physical set-up, data capture, data transfer, data verification, communication, supervision, interpretation, sentencing of results and certification of the task. The method of data transfer largely dictates whether an RNDT procedure can be:

i. Synchronous. This is where the Inspector and Operator interact at the same time (ie in real-time). This usually requires the live transfer of digital test data (eg live video streaming, two-way audio, screen-sharing of instrument displays, etc). For the purposes of this definition, the time needed for data transfer and processing is deemed to be negligible, providing live interaction is unhindered.

ii. Asynchronous. This is where the Inspector and Operator do not interact at the same time during the task. Reliance on the movement of physical media or large electronic files can delay or prevent effective communication and feedback (eg transfer of radiographic film / samples / removable media, lengthy upload/download times). Due to the lack of live supervision, there is generally more onus on the Operator. Additional training may be needed, due to a greater risk of human error, and therefore a higher possibility of process failure and consequential rework.

NOTE. (i) and (ii) are based on definitions in CAP 1933.

b. Roles / Responsibilities.

NOTE. To avoid the potential confusion of each party regarding the other as ‘remote’, the convention is applied such that the Operator is ‘deployed’ and the Inspector is ‘at base’.

i. Operator. A RNDT certified person at a deployed location, responsible for:

- setting up & calibrating equipment.
- carrying out physical aspects of the test (eg manipulating probes, applying test media, performing scans).
- responding to direction/supervision from Inspector (eg to modify area of interest, recalibrate settings).
- responding to verification feedback (eg adjust, correct, or repeat parts of test that fail verification).
- acquiring & transmitting test data (test conditions and test results).
- certifying the above.

NOTE. It is assumed that the Operator will not usually require certification above Level 1, as this would typically negate the benefits of RNDT.

ii. Verifier. A RNDT certified person, or persons, or automated system, responsible for:

- assuring the integrity of test data.
- providing corrective feedback to resolve shortcomings with the test conditions or test results.
- certifying the above.

iii. Inspector. A RNDT certified person at base, responsible for:

- receiving, formatting, contextualising & interpreting test data.
- providing direction & supervision to Operator (eg specify area of interest, optimise settings, etc).
- sentencing indications.
- producing test report.

- archiving test data that requires retention.
- ensuring all Operator & Verifier responsibilities have been certified.
- certifying the above.

c. Test Data. In this context, test data is all the information needed to carry out and record a RNDT task correctly. It includes both:

i. Test conditions. This is information that relates to the process and its participants (eg identification of personnel, equipment set-up, sensitivity calibration, physical actions, adherence to procedure, communication logs, certification of work, etc). This usually takes the form of objectively measurable acceptance criteria and corresponding evidence of compliance.

ii. Test results. This is information that relates to the component / part under test (eg C-Scan data files, instrument displays, photo / video of visual indications, radiographs, NDT fault reports, etc). In most cases, the test results of an RNDT task will provide the same (or greater) detail as its non-remote equivalent.

d. Verification. This is the process of assuring the integrity of test data and providing corrective feedback to resolve shortcomings with the test conditions or test results.

e. Verification Model (VM). These models outline how verification responsibilities should be assigned. There are six basic VMs; details are set out below and minimum certification requirements are tabulated at Appendix 1. VMs are broadly grouped into two models that use single-party verification, three models that use two-party verification and a standalone model that uses third-party verification.

i. Inspector Verification (IV). All verification done by Inspector. Generally suitable for complex or synchronous RNDT, or where test data can easily be acquired, transferred, and stored. Lowest Operator training burden.

ii. Operator Verification (OV). All verification done by Operator. Generally suitable for simple or asynchronous RNDT, or where test data cannot easily be acquired, transferred, and stored. Highest Operator training burden.

iii. Dual Verification (DV). All verification responsibilities are held (in full) by Inspector and Operator. Suitable for high risk (critical) RNDT. All verification is duplicated at each location. Highest overall training burden.

iv. Joint Verification (JV). Some verification responsibilities are duplicated, and the remainder divided between Operator and Inspector, as appropriate. Suitable for moderate risk RNDT, or where vital aspects of verification must be duplicated.

v. Hybrid Verification (HV). Verification responsibilities do not overlap; some are assigned to Operator and the remainder to Inspector. Suitable for low risk RNDT, or where verification need only be done once, by the most appropriate party.

vi. External Verification (XV). Verification is done entirely by an independent third party or automated system. Procedurally and technically demanding, but potentially offers the lowest overall training burden. NOTE. XV should not be confused with Automatic Defect Recognition (ADR) or other machine-assisted fault-finding technologies. All sentencing decisions remain the responsibility of the Inspector.

5. Regulatory Requirements. Organisations implementing Remote NDT shall:

a. Ensure their RNDT policy in the Written Practice and/or Exposition complies with this document and is approved by the Responsible Level 3 and respective NAA.

b. Ensure Operators, Inspectors and Verifiers are appropriately trained, qualified, and certified to carry out Remote NDT.

   i. For each RNDT task, establish the appropriate Verification Model and comply with the minimum certification levels:

      a. Inspector Verification (IV): Operator - Level 1 Ltd. Inspector – Level 2.

      b. Operator Verification (OV): Operator - Level 1. Inspector – Level 2 Ltd.

      c. Dual Verification (DV): Operator - Level 1. Inspector – Level 2.

      d. Joint Verification (JV): Operator - Level 1. Inspector – Level 2 Ltd.

      e. Hybrid Verification (HV): Operator - Level 1. Inspector – Level 2 Ltd.

      f. External Verification (XV): Operator - Level 1 Ltd. Verifier (if not automated) - Level 1. Inspector – Level 2 Ltd.

   ii. If the NAA, NANDTB, Responsible Level 3 or customer requires a higher certification level than given in 5b(i) above, this shall take precedence.

   iii. The employment of trainees on live RNDT tasks is prohibited unless it is for the express purpose of RNDT training or experience. In such situations, adequate safeguards and on-site supervision shall be put in place.

c. Carry out a suitable risk assessment of each RNDT task. This is to include case-by-case confirmation that:

   i. Inspection sensitivity, reliability and repeatability are not compromised by being done remotely, or if there is a variation, why it is tolerable.

   ii. All technical, logistical, procedural, resource and certification requirements are identified and met.

   iii. There is no security threat or vulnerability to fraud, bias, or conflict of interest.

   iv. Certification of the inspection meets applicable NAA requirements and that the security and authenticity of any electronic signatures is assured (eg for certification and release of a Form 1 from a deployed location).

   v. All parties to the RNDT task operate under the Quality Management System (QMS) of the certifying organisation. The use of contractors or sub-contractors as Operators, Verifiers or Inspectors outside the certifying organisation's QMS is not permitted.

   NOTE. Where an existing non-remote NDT WI published by the Type Certificate Holder (TCH) / Original Equipment Manufacturer (OEM) is used as the basis for developing a remote equivalent, the risk assessment shall be done in conjunction with TCH/OEM.

d. Establish a written Work Instruction (WI) for each RNDT inspection procedure. Each RNDT WI shall:

   i. State the required certification levels, responsibilities and procedural steps for the Operator and Inspector (and Verifier, where applicable).

   ii. Be prepared and validated by a RNDT-certified Level 2 Limited, Level 2 or Level 3.

   iii. Be technically approved by a RNDT-certified Level 3.

iv. Be published as a standalone procedure, entirely separate from its non-remote equivalent.

e. Ensure NAA approval is obtained prior to first application of Synchronous RNDT WI. This shall be done by timely submission of the RNDT WI for NAA oversight, along with its corresponding risk assessment, validation, and Level 3 technical approval.

NOTE. This requirement may be waived if the RNDT WI utilises Inspector Verification and is published in the approved OEM data.

f. Ensure an enduring record of each RNDT inspection is retained, such that the test conditions, test data, and WI compliance can be audited and verified at a later date.

NOTE. This requirement applies to both Synchronous and Asynchronous forms of RNDT.

6. Recommendations. The following recommendations are intended to standardise RNDT practices. They are not mandatory, but organizations should follow them where it is practicable to do so.

a. RNDT risk assessment. When assessing RNDT risks, the following should be considered:

i. Fault / defect characterization. Ensure there are clear characteristics for expected faults / defects and their corresponding indications.

ii. Discrimination. Ensure clear distinction between relevant indications and non-relevant indications.

iii. Signal level. Ensure high signal level for good sensitivity of genuine indications.

iv. Noise level. Ensure low noise (eg minimal variation due to material/component structure, equipment performance, skill of hand, A/D & D/A signal conversion, etc).

v. Process reliability. Ensure processes are robust, stable and ‘fail-safe’, with suitable contingency measures and negligible error. In this context, ‘negligible’ means the inspection outcome is not affected.

vi. Environment. Ensure the surroundings do not unduly impact the RNDT task. For example, a RNDT task developed in a controlled, Part 21 manufacturing facility may not be appropriate in the challenging conditions of a Part 145 maintenance environment, especially if carried out ‘on-wing’ by deployed Operators (eg with restricted access, limited cleanliness) or in an austere location (eg inadequate hangarage, lighting or connectivity, etc). Similarly, Inspectors at base may require an adapted environment (eg suitable IT suite with minimum distractions, modified shift patterns to accommodate other time zones).

vii. Human Factors (HF). In comparison to ‘traditional’ NDT or standard maintenance activities, RNDT may create significant, unforeseen, or novel HF issues, such as confirmation bias due to communication ‘slope’ between Operators and Inspectors. It is beyond the scope of this document to list all possible RNDT HF considerations, however general information to support HF management is published in CAA CAP 716 to 719. It is recommended that organizations develop a suitable RNDT HF checklist.

b. Verification Model (VM) selection. To identify the most suitable VM for each RNDT task, organizations should make use of the VM Summary at Appendix 1 and VM Flowchart at Appendix 2. Where doubt exists around which VM to adopt, the most stringent one should be selected. Where circumstances warrant greater knowledge, skill or experience, organizations should consider going above and beyond the VM minimum certification requirements. Conversely, if equipment, skills, and confidence in the RNDT process improve, the task may be re-assessed and, where it is safe to do so, a less demanding VM adopted following NAA re-approval.

c. Remote Non-Destructive Evaluation (RNDE). For Non-EN4179 NDT methods and techniques, which are classed in NAndtB/18 as 'material evaluation' or 'direct readout', it is unlikely that there would be significant benefit in carrying them out remotely. However, should organizations choose to implement RNDE, this shall be done 'in the spirit of EN4179'. This will typically require the Operator and Inspector to undergo appropriate formal training, qualification, and certification for the RNDE method/technique. The principles, risks and regulations stated elsewhere in this policy are equally applicable, and appropriate controls should be put in place.

7. Guidance. The following guidance is intended to enhance or simplify RNDT but is not exhaustive. It is advisory only and may be modified, added to, or omitted to best suit the organization's needs.

a. Data integrity. Compared to 'traditional' NDT, RNDT processes typically require significant amounts of data to be captured, transferred, processed, and stored. Organizations should manage the integrity of test data in a systematic manner. For example, a checklist that has been successfully adopted in other industries, is the 'ALCOA+ Principles of Data Integrity[1]':

i. Attributable. Identify the originator or system that created the data (eg restrict system access to authorized users, and log user IDs and serial numbers of components & equipment).

ii. Legible. Test data should be sufficiently readable and unambiguous (eg verbal feedback must be clear and in a common language, video streams must have adequate size, resolution, etc).

iii. Contemporaneous. Test data should be captured chronologically and include a record of when it was created (eg, capture time critical activities such as PT contact & development durations, video should have timestamps, if operating across time zones establish which is the reference, etc).

iv. Original. Original (raw) test data should be retained wherever possible and security measures adopted to eliminate fraud (eg authenticate all component serial numbers match test data, use C-Scan data presentations for interpretation (not screenshots), etc).

v. Accurate. Test data should correctly reflect the reality of the test in sufficient detail. Errors and variability must be reduced to negligible levels, so that there is no undue effect on inspection outcomes. (eg ensure equipment compatibility, readings must be taken in the agreed units, etc).

vi. Complete. The capture, transfer, processing, and storage of test data should not delete or conceal vital information (eg adequate system stability & bandwidth to avoid 'dropouts', use of lossless compression algorithms, adoption of checksum and audit procedures).

vii. Consistent. Data should display in the same way, wherever it is accessed. In most cases, this means all parties working from a single data set, rather than working on uncontrolled copies or local versions. (eg screen-sharing of the current (live) instrument displays, ensuring all hardware & software is compatible and current).

viii. Enduring. The customer's requirement for the data retention period should be established and records retained for the entire period they could be subject to audit. All test data must be securely backed-up (eg video-stream data or digital radiographs archived in local and cloud-based storage until superseded).

ix. Available. Test data should be accessible to all authorized users, whenever and wherever it is needed. (eg establish an effective metadata or indexing system with search function, maintain appropriate access controls for users, managers, auditors & customers, etc).

b. Designation of techniques & WIs for Limited certification. Aside from the ‘Film’ and ‘Filmless’ RT techniques set out in EN4179, the designation and boundaries between techniques within a method are defined in each organization’s Written Practice. When introducing RNDT to an organization that uses Limited certifications, the potential impact on certification scope should be addressed.

NOTE. NAndtB/17 currently prohibits the use of Level 2 Limited for RT.

For example, as per NAndtB/17, a Level 2 Limited may only hold one technique. If already qualified in ET(Static), they cannot also have ET(Static-Remote) added to their certification. A typical solution might be to introduce ET(Static: Remote & Non-Remote) designation for those qualified in both, and for those who require just the ‘traditional’ equivalent, ET(Static: Non-Remote).

A similar situation exists for Level 1 Limited, whereby EN4179 permits certification for a maximum of 3 parts, features or WIs. Given the regulatory requirement in Para 5d(iv) for RNDT WIs to be standalone procedures, existing Level 1 Limited certifications with multiple WIs may require some, or all, of the non-remote WIs to be removed so that new RNDT WIs can be introduced.

In summary, organizations should give careful consideration as to how their techniques and WIs are designated and bounded, in order not to breach the terms of Limited certifications.

c. RNDT Reports. Whilst ‘traditional’ NDT reports are often just a summary of fault findings, the reports for RNDT tasks may also warrant the inclusion of some (or all), of the test conditions and test results. Full stakeholder engagement is vital to establishing appropriate reporting requirements.

Signed for the Board

Kevin Pickup

Chairman of the NANDTB

Appendices:

1. Verification Model Summary.

2. Verification Model Flowchart.

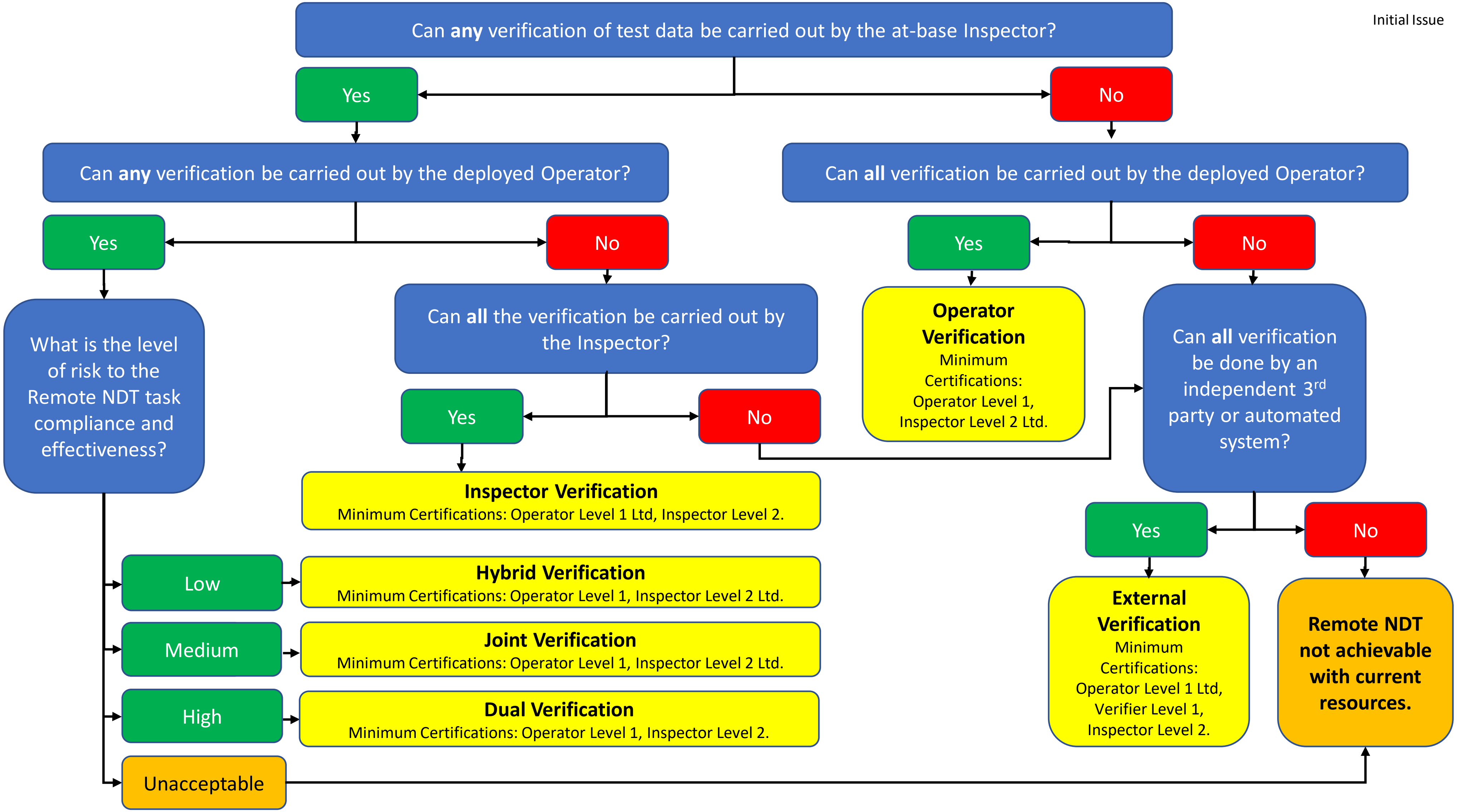
3. Example Scenarios 1, 2 and 3.

Appendix 1 to NAndtB/29: Verification Model Summary.

Who is involved?	**Operator**	**Verifier**	**Inspector**
What are their responsibilities?	• set up & calibrate equipment • carry out physical aspects of test (eg manipulate probes, apply test media, perform scans) • respond to direction from inspector (eg extend / modify area of interest, recalibrate settings) • respond to verification feedback (eg adjust, correct, or repeat parts of test that fail verification) • acquire & transmit test data (test conditions and test results) • certify the above	• assure integrity of test data • provide corrective feedback if test conditions or test results fail verification • certify the above.	• receive, format, contextualise & interpret test data • provide direction & supervision to operator (eg specify area of interest, optimise settings) • sentence indications • produce test report • archive test data that requires retention • ensure all operator & verifier responsibilities have been certified • certify the above
When does it occur?	In real time	Synchronous or Asynchronous	Synchronous or Asynchronous
Where does it occur?	'Deployed'	*varies*	'At Base'
How significant are the additional training & qualification requirements for RNDT?	See below **Minimum certification level**	See below **Minimum certification level**	See below **Minimum certification level**
Inspector Verification (IV) *All verification done by Inspector. Generally suitable for complex or synchronous RNDT, or where test data can easily be acquired, transferred, and stored. Lowest Operator training burden.*	**Operator** Low **Level 1 Limited**	**Inspector / Verifier** **NOTE:** This is the only VM that does not require NAA oversight of the RNDT procedure.	High **Level 2**
Operator Verification (OV) *All verification done by Operator. Generally suitable for simple or asynchronous RNDT, or where test data cannot easily be acquired, transferred, or stored. Highest Operator training burden.*	**Operator / Verifier** High **Level 1**		**Inspector** Low **Level 2 Limited**
Dual Verification (DV) *All verification responsibilities are held (in full) by Inspector and Operator. Suitable for high risk (critical) RNDT. All verification is duplicated at each location. Highest overall training burden.*	**Operator / Verifier** High **Level 1**	**Inspector / Verifier**	High **Level 2**
Joint Verification (JV) *Some verification responsibilities are duplicated, and the remainder divided between Operator and Inspector, as appropriate. Suitable for moderate risk RNDT, or where vital aspects of verification must be duplicated.*	**Operator / Verifier** Moderate **Level 1**	**Inspector / Verifier** Extent of respective responsibilities must be defined in RNDT procedure.	Moderate **Level 2 Limited**
Hybrid Verification (HV) *Verification responsibilities do not overlap; some are assigned to Operator and the remainder to Inspector. Suitable for low risk RNDT, or where verification need only be done once, by the most appropriate party.*	**Operator / Verifier** Moderate **Level 1**	**Inspector / Verifier** Extent of respective responsibilities must be defined in RNDT procedure.	Moderate **Level 2 Limited**
External Verification (XV) *Verification is done entirely by an independent third party or automated system. Procedurally and technically demanding, but potentially offers the lowest overall training burden.*	**Operator** Low **Level 1 Limited**	XV process is deemed part of the overarching RNDT procedure and as such, requires L3 approval. **Verifier** Variable **Level 1** (if not automated)	**Inspector** Low **Level 2 Limited**

Appendix 2 to NAndtB/29: Verification Model Flowchart.

Initial Issue



Appendix 3 to NAndtB/29: Example Scenarios.

The following scenarios outline basic approaches to implementing a RNDT task. They are intended as illustrations only and should not be used a definitive solution, recommendation, or guide.

Scenario 1 - Synchronous RNDT – Ultrasonic Testing (A-Scan) – In-Service (Part 145).

Background. Company A intends to use RNDT for an on-wing inspection using the UT A-Scan technique. This will involve a long-reach, combined UT/video probe being inserted into an engine (via a borescope port) to test a complete compressor stage for cracking of the blades.

- The inspection is not sensitive to operator manual variation; the probe is profiled to only fit the blade edge in the correct orientation. Correct probe coupling is verifiable by A-Scan backwall response and the current scan position can be verified using a combination of video and A-Scan. These are deemed beyond Level 1 ability to interpret. Fault sentencing requires even more detailed interpretation of backwall & fault responses against defined timebase and amplitude thresholds.
- The Inspector's live video and A-Scan data feeds allow them to fully verify test conditions and test results. The test data can be digitally archived for further interpretation offline, customer review or future audit.
- The Inspector and Operator both work for Company A and secure, two-way, live audio communication in a common language is achievable.

Assessment. The Company assesses the suitability of each VM thus:

- OV – unsuitable due to complex interpretation needed to verify test data.
- IV – suitable, as all verification can be carried out by Inspector and synchronous supervision provided.
- DV – unsuitable due to interpretation demands.
- JV – partially suitable, but only for some test conditions, not test results.
- HV – partially suitable, but only for some test conditions, not test results.
- XV – unsuitable, as automated system not capable of verifying probe position by A-Scan data alone and 3rd party offers no advantage over IV.

The Inspector Verification model is selected as most appropriate. The Company carries out a risk assessment and identifies:

- Potential human error of the compressor being rotated more than one blade and thus missing part of the inspection. This is resolved in the WI by partially withdrawing the video probe, so Inspector can monitor each blade as it passes.
- There is a requirement to agree with NAA, customer and other stakeholders the work certification process, when Operator and Inspector are in different locations and jurisdictions.

The Company Written Practice is updated and RNDT-specific certification put in place for Level 1 Limited Operators (for this specific WI) and Level 2 Inspectors (for UT(A-Scan-Remote)). A standalone WI is prepared by a Level 2, independently validated by another Level 2, and approved by Level 3.

All relevant documentation is submitted to the NAA and approval obtained before first application of the RNDT procedure.

Indicative Outcome: RNDT compliant.

Scenario 2 - Asynchronous RNDT – Penetrant Testing (Fluorescent, Line-based) – Manufacturing (Part 21).

Background. Company J has large quantities of parts cast in aluminium alloy by an approved sub-contractor, Company K, which is in another country. Prior to machining the parts, the Quality Control process requires PT, which requires careful interpretation due to complex geometry. Company J wishes to use its existing certified PT Level 2 personnel to carry out interpretation and remotely supervise Company K personnel, who will operate the penetrant line. The proposed procedure is:

- Company K's Operators will carry out and certify all physical aspects: line process control (eg temperature, penetrant water content, wash spray pressure, UV intensity, etc) and processing of the parts.
- Accompanying each part will be a TAM panel with unique QR code, which enables the Inspector to verify process sequence, timings, overall line performance and video quality.
- The video files for all parts processed during the shift will be timestamped, uniquely named, and uploaded for later analysis by Company J Inspectors.

Assessment. The Company assesses the suitability of each VM thus:

- OV – mostly suitable, providing Operators can monitor the video quality as it is captured.
- IV – unsuitable, as the physical line process control checks are numerous and difficult to digitize.
- DV – unsuitable due to the above.
- JV – partially suitable, providing the critical aspects can be verified by both parties.
- HV – suitable, as there is a clear boundary between Operators verifying the physical aspects and Inspectors verifying the digital aspects.
- XV – unsuitable, as automated systems not capable of verifying complex physical test conditions and 3rd party is an unnecessary contractual complication.

The Hybrid Verification model is selected as most appropriate. The Company carries out a risk assessment and identifies:

- Trials show that standard TAM panels are not representative of the complex geometries of actual parts and are only suitable for general verification of the line itself.
- The QR code becomes unreadable once developer is applied and that covering it, even temporarily, means verification of the part ID is not absolute. Alternative solutions, such as RFID chips, are deemed prohibitively expensive.
- The asynchronous nature of the RNDT means live supervision is not possible. Indications cannot be verified after the part is cleaned eg by a 'wipe-off' test. Any process failures identified by Inspectors after the shift result in expensive rework.
- The inspection booth fixed video camera cannot adequately view parts with complex geometries. Hand-held cameras are inferior to in-person viewing, especially when there is no live feedback for the Operator. Headset-mounted cameras are deemed prohibitively expensive.
- The Inspector's standard display monitors do not respond in the same way as the human eye to fluorescent penetrant indications. Specialist hardware or software is needed to make on-screen indications as prominent (vivid) as in-person viewing.
- Given the large volume of parts and the need for lengthy HD video files, the amount of data may be unmanageable with current IT systems.
- There is a requirement to agree with customer and other stakeholders the work certification process, when Operator and Inspector are in different locations and jurisdictions.

The Companies carry out a joint cost/benefit exercise and establish that addressing the above technical issues would be significantly more expensive than additional training, and furthermore, some residual risks with RNDT would remain. It is pointed out that as Company K is a sub-contractor outside the control of Company J's QMS, that Remote NDT would be prohibited under Para 5c(v). The decision is taken to not pursue RNDT in this situation and instead train & certify Company K personnel to PT Level 2, so the task can be done entirely on-site.

Indicative Outcome: RNDT not compliant.

Scenario 3 - Asynchronous RNDT – Radiographic Testing (Computed Tomography) – Manufacturing (Part 21) and Maintenance (Part 145).

Background. Company X manufactures and repairs composite helicopter tail rotor blades. They plan to use RT(CT) on manufactured blades (to check for voids, ply wrinkling, etc) and in-service blades (to assess impact damage and moisture ingress). CT scanning will be available at several regional facilities around the world, with test data being analysed by trained Inspectors at Company X's corporate headquarters. The proposed procedure is:

- Company X Operators will be fully competent with all aspects of radiation safety and the CT system will be equipped with interlocks and fail-safe systems.
- Once certified as Level 1 RT(CT), Operators will be able to carry out and self-supervise all aspects of exposure and test data capture.
- The Operator downloads the WI and CT scanner program for the specific blade type and loads the blade into the CT scanner. The CT scanner program is run and following exposure, the Operator labels the test data file and uploads it to a secure server at Company X's corporate headquarters.
- The Level 2 RT(CT) Inspector accesses the test data, verifies that the correct program was run and carries out image quality checks against defined criteria. If verification fails, the Operator is tasked with repeating the exposure.
- Once test conditions and test results are verified, Inspectors interpret and sentence any indications.
- If more detail is needed by Inspectors (eg to resolve an ambiguous indication), a modified CT scanner program can be developed and approved, so that the Operator can download it and carry out a further exposure.

Assessment. The Company assesses the suitability of each VM thus:

- OV – unsuitable due to complex interpretation needed to verify test results.
- IV – suitable, as CT is a wholly digital process, capturing test conditions and test results for Inspectors to verify against defined criteria.
- DV – unsuitable, for same reasons as OV.
- JV – mostly unsuitable, as it would only offer duplication on aspects that require no interpretation (eg Operator manually verifying position of the blade within the cabinet AND Inspector verifying on the image). Unable to use this VM's lower certification for Inspectors, as Level 2 Limited for RT is prohibited by NANDTB/17.
- HV – mostly unsuitable, for similar reasons as JV.
- XV – unsuitable, as automated system currently not capable of verifying all parameters. 3rd party offers no advantage over IV.

The Inspector Verification model is selected as most appropriate. The Company carries out a risk assessment and identifies:

- There is such precedent for this basic process in Radiography, that it may not be clearly understood as Asynchronous RNDT. A RT(CT-Remote) technique and certification pathway will need to be developed and published in the Written Practice.
- Potential for human error if the wrong blade is scanned or file mislabelled. Resolved by Inspectors being able to view and positively confirm the blade's physical serial number, as it is visible within the CT data file.
- The Inspection Team's viewing suite and IT systems require upgrades.
- Inspectors will be certified as RT(CT-Remote) Level 2. Under the IV model, Operators could conceivably be qualified as Level 1 Limited, however due to radiation safety and complexity of operating the software, Company X's RL3 sets the minimum certification to Level 1.
- There is a requirement to agree with customer and other stakeholders the work certification process, when Operator and Inspector are in different locations and jurisdictions.

Future Development. After several years, Company X has migrated to cloud-based storage & processing and has accrued a large amount of CT data and Inspector experience. This is used to develop an automated verification system (AVS). After each CT scan program is complete, the AVS detects and reads the serial number of the blade and looks up its specification. Key aspects of the blade's test data are compared against acceptance criteria for that blade type and scan program. This enables any verification failures (eg data drop-out, object positioning errors) to be flagged directly to Operator and most rework can be completed without delay. A further advantage is that Inspectors would be used mainly for fault interpretation, rather than for time-consuming test data verification. To realise these benefits, Company X demonstrates the reliability of the new AVS procedures, replaces their old IV model with XV and updates the relevant WI.

Indicative Outcome: RNDT compliant.