



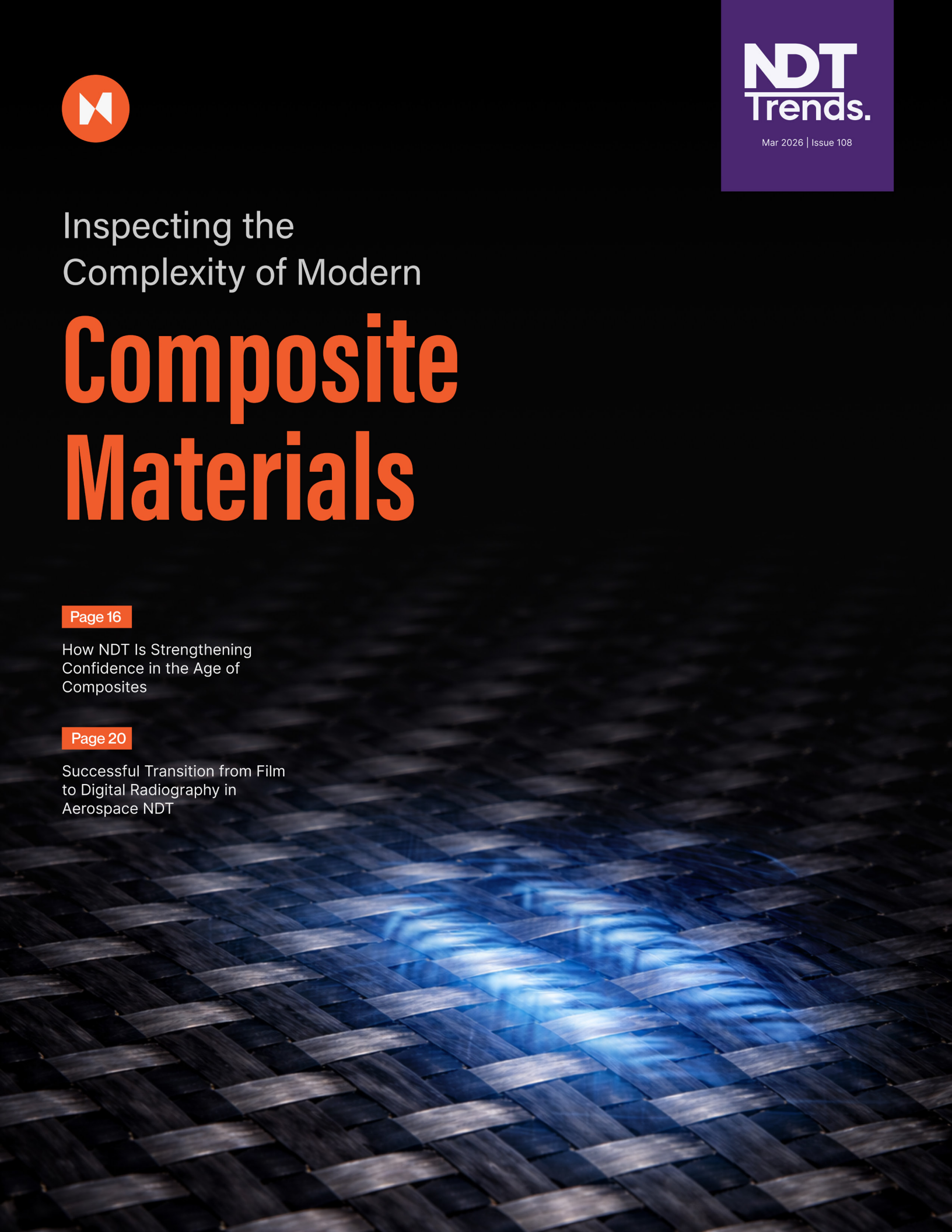
Inspecting the Complexity of Modern Composite Materials

Page 16

How NDT Is Strengthening
Confidence in the Age of
Composites

Page 20

Successful Transition from Film
to Digital Radiography in
Aerospace NDT



A Heartful Thank's to all the Contributors

**Business &
Communications**
Editor in Chief
Santosh Gavankar

Business Head
Govind Walavalkar

Marketing
Marketing Director
Ravindra Warang

Marketing Head/Editor
Kadambari Bendre

Marketing Specialist
Prathmesh Kamat
Himanshu Mishra
Rushil Gupta

Copy
Copy Writing
Abhishek Sawant

Design
Creative Lead
Pratik Satpute

Design Lead
Bhavesht Sawnat

Graphics
Komal Vishe
Priyanka Patra
Mrunmai Patil

Technical Content
Abhishek Chaurasia

Special Thanks to our Contributors

Lennart Schulenburg
Paul Scheel
Telops an Exosens
Pengfei Zhu
Dr. Pankaj Kumar Dash Sharma
Hai Zhang
Stefano Sfarra
Fabrizio Sarasini
Rubén Usamentiaga
Gunther Steenackers
Clemente Ibarra-Castanedo
Xavier Maldague
VisiConsult X-ray Systems & Solutions GmbH

12GRIDS[✓]

WE ARE THE ONE
YOU ARE

LOOKING FOR

A 360° CUSTOMER EXPERIENCE—LED
MARKETING AGENCY



SCAN TO KNOW MORE



Editorial

Inspecting the Materials of Tomorrow

There was a time when inspection followed familiarity. Metals behaved predictably. Failure modes were understood. Experience guided decisions as much as instrumentation did.

Today, that comfort zone is gone.

Composites and advanced materials are no longer future-facing concepts — they are present-day realities shaping aerospace, renewable energy, mobility, marine, and infrastructure sectors. Lighter, stronger, and more efficient structures are redefining what engineering can achieve. But with that progress comes a new layer of complexity.

Unlike traditional materials, composites do not always reveal their weaknesses at the surface. Internal bonding, fibre orientation, curing precision, and layered architecture all influence performance. Damage may develop quietly. Subtle variations can affect long-term reliability. In this environment, assumptions are no longer enough.

Non-destructive testing has therefore taken on a deeper responsibility. Inspection today is not just about detecting defects; it is about understanding structural behavior. It supports certification decisions, production quality, lifecycle planning, and regulatory confidence. As materials evolve, inspection must evolve with equal precision and clarity.

In this edition, we explore how advanced NDT technologies and analytical approaches are adapting to the demands of modern materials. From digital imaging to multi-sensor strategies, the focus is shifting toward insight, traceability, and long-term assurance.

Because in the age of engineered performance, innovation must be matched by integrity — and integrity begins with inspection.

Santosh Gavankar
Editor-in-chief

10

Top Story

Bellows Systems Enhances its NDT Capabilities with Advanced Digital Radiography by DÜRR NDT
Bellows Systems Inc. has taken a significant...

16

Cover Story

How NDT Is Strengthening Confidence in the Age of Composites
Composites did not replace metals because they were easier to manage...

20

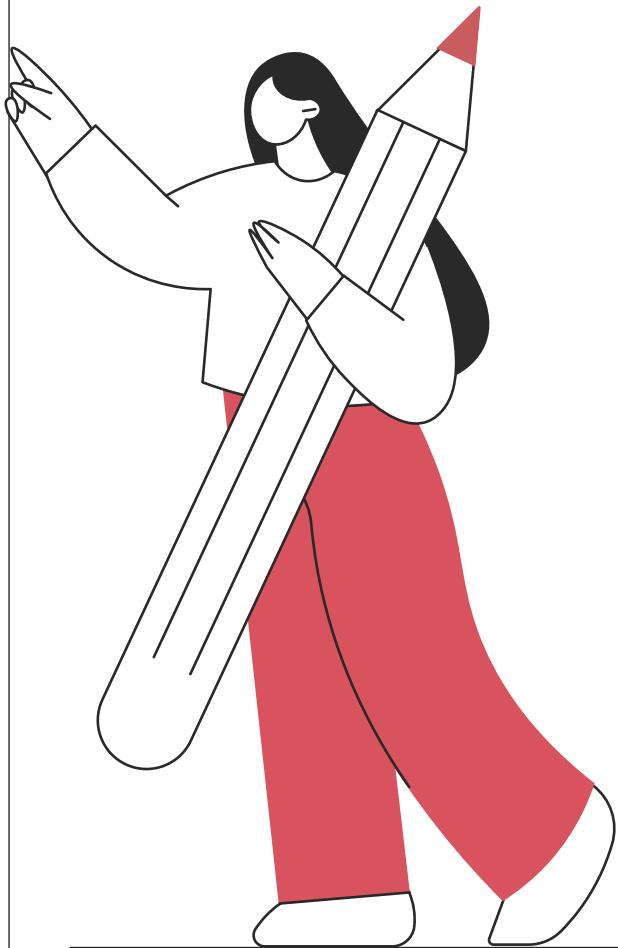
Expert Article

Successful Transition from Film to Digital Radiography in Aerospace NDT
Production is running. The components are ready. Inspection can begin...

26

Expert Talk

Three Decades of Radiation Safety Leadership: A Conversation with Dr. Pankaj Kumar Dash Sharma
With over three decades of distinguished experience spanning research, regulation...



30

Product Spotlight

Beyond the Image: Radiometric Precision in NDT
In Non-Destructive Testing (NDT), “seeing” a defect is no longer synonymous with understanding it. For decades, the industry relied on qualitative thermal..

38

Research Paper

A comprehensive evaluation of the low-velocity impact behaviour of intraply hybrid flax/basalt composites using infrared thermography and terahertz time-domain spectroscopy techniques
Low-velocity impacts severely jeopardize the structural..

OUR NEW
TRANSDUCER CATALOGUE
HAS LANDED.



UT
Transducers

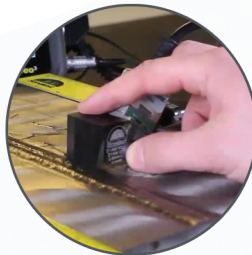
Phased Array
Transducers

ToFD & HTHA
Transducers

Wheelprobes

Calibration
Blocks

Get yours today



Simplicity | Capabilities | Reliability

Inspect with
confidence
sonatest.com

Top Stories

Insights in Focus

*Top Stories Shaping
the NDT Industry*



Bellows Systems Enhances its NDT Capabilities with Advanced Digital Radiography by DÜRR NDT

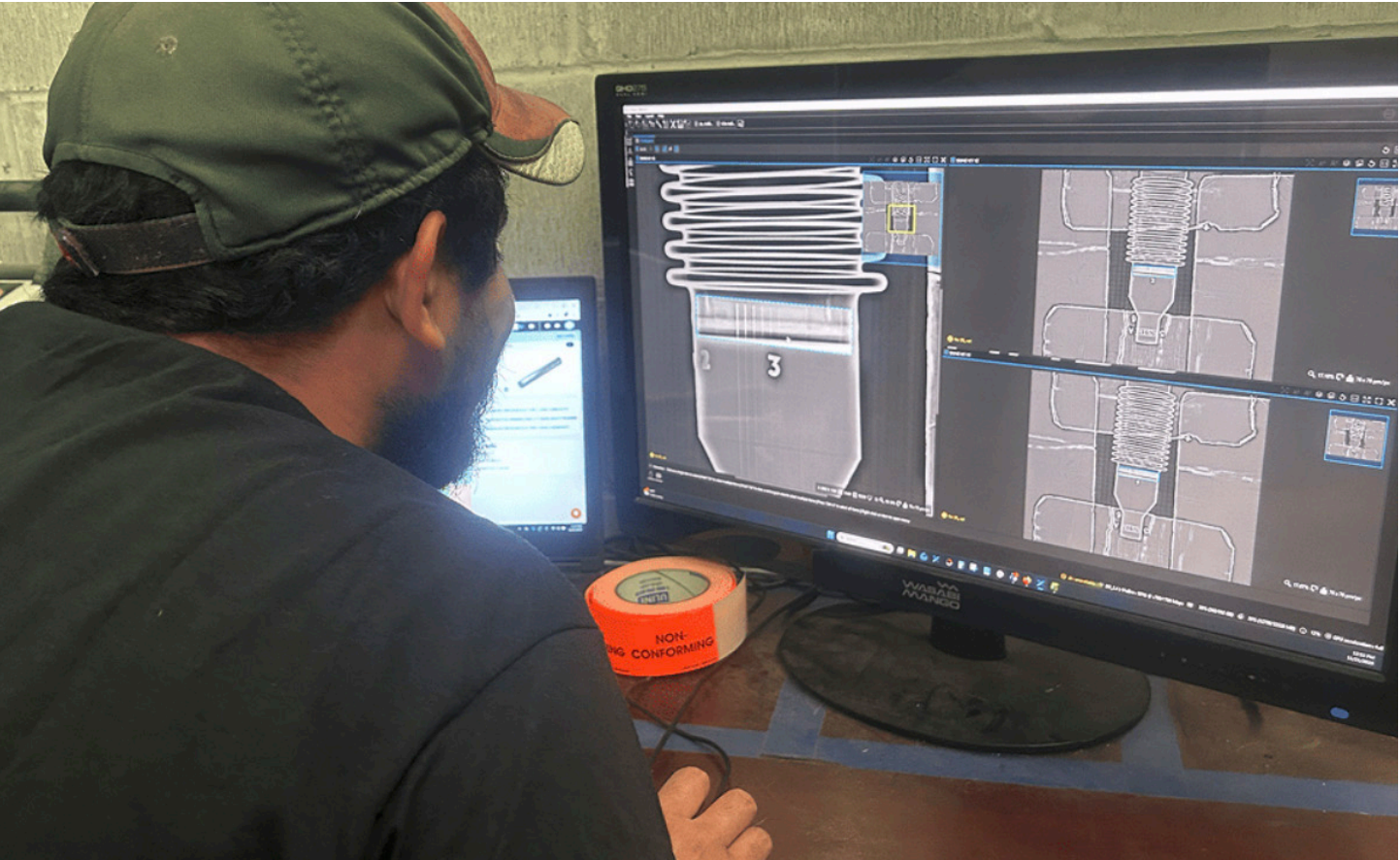


Image Source - @DÜRR_NDT

Bellows Systems Inc. has taken a significant step forward in its commitment to quality and innovation by introducing advanced digital radiography (DR) into its Non-Destructive Testing (NDT) portfolio. This upgrade marks a major milestone in their ability to deliver precision, speed, and reliability for critical components across industries.

Bellows Systems is committed to better serving its customers by continuously enhancing its capabilities in their core competencies. Specifically, to serve its aerospace customers, Bellows Systems has NADCAP special process certification for welding. AWS D17.1 and D17.2 are critical specifications for aerospace welding, requiring stringent inspection methods

to ensure weld integrity. Radiographic Testing (RT) is one of the primary methods mandated for verifying internal weld quality in these standards. Traditionally, this meant film based radiography, which is time-consuming and less efficient.

By adopting state-of-the-art digital radiography technology from DÜRR NDT and Lake X-Ray of Michigan, Bellows Systems meets and exceeds these requirements while delivering additional benefits. For example, compliance assurance, as the DR process aligns with AWS D17.1 and D17.2 for weld inspection, ensuring full adherence to aerospace quality standards. The DRC 2430 digital detector from DÜRR NDT and the D-Tect X software ensure improved

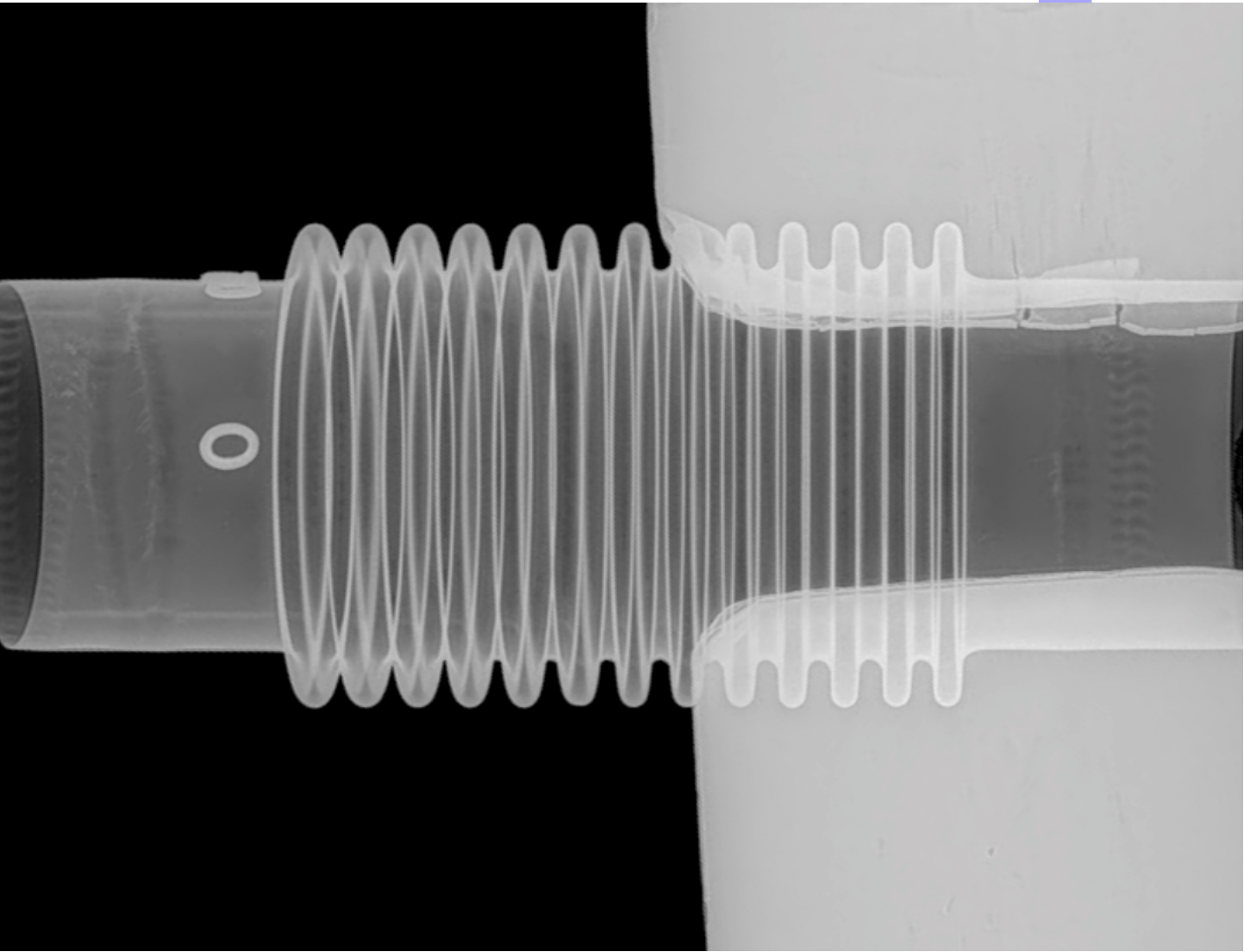
accuracy by providing superior image resolution, enabling precise evaluation of weld discontinuities as required by AWS specifications. Real-time imaging accelerates inspection and reporting, reducing turnaround for critical aerospace components to achieve faster certification.

“At Bellows Systems, we believe that investing in advanced technologies is essential to delivering the highest quality products to our clients,” said Alpha Mahatvaraj, CEO of Bellows Systems. “Our new digital radiography capability reinforces that commitment.”

Bellows Systems is a leading manufacturer of metal bellows, expansion joints and assemblies for critical applications in energy, aerospace, and industrial sectors. With a strong focus on quality and innovation, Bellows Systems is continuously expanding its capabilities to meet the evolving needs of their

customers. Bellows Systems specializes in providing custom engineered solutions and offers integrated systems and assemblies to help clients meet their specific needs. Their focus is on delivering high-quality products and providing best-in-class customer service.

Bellows Systems works with top tier organizations in the space and aerospace industry including SpaceX, Blue Origin, Rocket Lab, Boeing, Honeywell, Aerojet Rocketdyne and Northrup Grumman.



FARO CREAFORM and InnovMetric Strengthen Partnership with New and Complete Integration of FARO CREAFORM 3D Scanner Data Acquisition into PolyWorks | Inspector



Image Source - @creaform

FARO CREAFORM, a business of AMETEK, Inc. and global provider of 3D scanning and portable CMM solutions, in collaboration with InnovMetric, the independent software development company that empowers manufacturers of every size to digitally transform their 3D measurement processes, announced today that data acquisition from FARO CREAFORM's auto-referencing multi-line 3D scanners is now

fully integrated into PolyWorks | Inspector. This means that users can now benefit from real-time data visualization and complete dimensional analysis and quality control toolbox during acquisition.

This integration was developed in direct response to customer feedback. Many industrial OEMs, already standardized on PolyWorks | Inspector for dimensional

inspection, have emphasized the importance of maintaining established workflows and minimizing disruptions. By enabling direct data acquisition in PolyWorks | Inspector, FARO CREAFORM and InnovMetric ensure that InnovMetric customers can keep leveraging the complete suite of tools and functionalities they trust while benefiting from advanced scanning capabilities.

This latest example of synergy between the two companies also means that organizations can now upgrade their in-line metrology measurement devices, while maintaining procedural compliance and continuity.



- This seamless integration offers significant advantages:**
- Reduced learning curve: Operators no longer need to switch between different software platforms or adapt to new interfaces, cutting training time and accelerating onboarding.
 - Faster time to production: By leveraging operator expertise, established processes, and metrology-grade handheld 3D scanners, manufacturers can reach operational efficiency faster.
 - Full compatibility: FARO CREAFORM offers auto-referencing multi-line 3D scanner data acquisition fully compatible with PolyWorks | Inspector functionalities, including automatic scan-to-CAD alignment, surface and feature scanning guidance, mixed reality measurement workflows, and automation macro scripts.

“Global OEMs often rely on PolyWorks 3D measurement templates to enforce compliance across multiple plants. This integration allows FARO CREAFORM 3D scanners to plug into those templates without requiring custom scripts or additional configuration. It simplifies deployment at scale, ensuring consistent inspection logic and reporting across diverse production environments,” said Marco St-Pierre, DVP Innovation, 3D scanners at FARO CREAFORM. “As a worldwide reseller of PolyWorks® solutions, we were ideally positioned

to create a handheld metrology-grade 3D scanner that fully and seamlessly integrates with the platform and deliver a unified solution that streamlines quality control across worldwide operations.”

“This integration demonstrates our dedication to customer satisfaction and our ability to respond to industry needs. The joint workflow supports hybrid inspection strategies, where portable scanners complement CMMs in a single environment. By enabling direct data acquisition from FARO CREAFORM 3D scanners, we extend the acquisition stage of the PolyWorks digital thread, ensuring that measurement data flows seamlessly from capture to analysis without breaking connectivity,” added Éric Roberge, Vice President of Products and Innovation for the Metrology Suite, at InnovMetric.

This milestone strengthens the long-standing partnership between the two companies and underscores their shared commitment to delivering solutions tailored to their customers’ priorities: maintaining their preferred software tools and procedures, while benefiting from the latest advancements in 3D scanning and inspection.

BDI Appoints NDT Industry Veteran Ricky Morgan as Steel NDT Program Manager

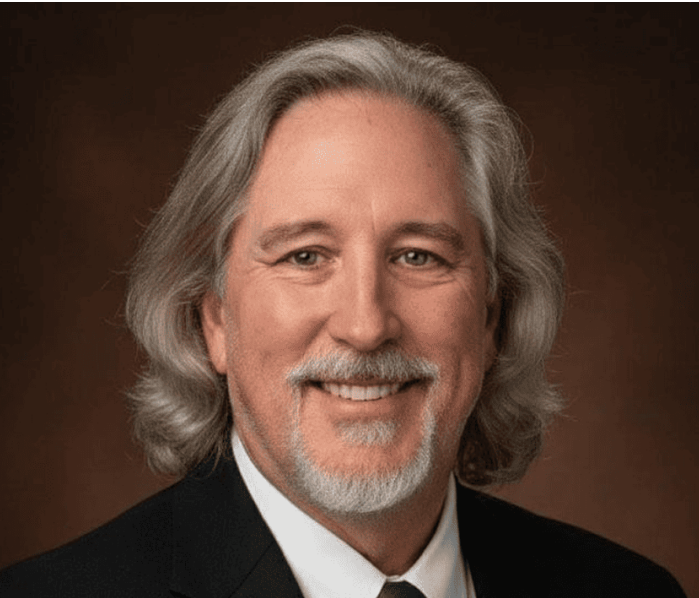


Image Source - @bditest

BDI has announced that nondestructive testing (NDT) industry veteran Ricky Morgan has joined the company as its Steel NDT Program Manager.

Morgan brings nearly four decades of experience in nondestructive testing, structural inspection, and infrastructure safety across transportation, construction, and public-safety sectors. A former President of the American Society for Nondestructive Testing (ASNT), he is widely recognized across the global NDT community for his leadership in advancing inspection practices, workforce development, and the application of emerging technologies in critical infrastructure.

Throughout his career, Morgan has contributed to several high-profile infrastructure and construction projects, including SoFi Stadium, Hudson Yards, and the San Francisco–Oakland Bay Bridge. His work has also supported structural systems in major theme park attractions such as Millennium Falcon: Smugglers Run and Jurassic Park attractions. His professional experience spans bridges, seismic structures, fabrication facilities, marine assets, and large public venues, with a strong focus on life-safety and infrastructure reliability.

Over the course of his career, Morgan has held executive and technical leadership roles across consulting firms, training organizations, and inspection service providers. He has overseen large teams of inspectors working on multi-billion-dollar construction projects and contributed to the introduction of advanced ultrasonic testing methods into structural welding codes. His work also included the development of post-seismic inspection techniques following the Northridge earthquake. In addition, Morgan served as the technical editor for the ASNT Ultrasonic Testing Handbook.

Beyond his technical achievements, Morgan is a U.S. Army veteran and a strong advocate for workforce development within the NDT profession. He has supported technician training initiatives, contributed to the development of certification preparation tools, and mentored many professionals entering the field. He has also been featured on the television series Jobs of Tomorrow.

“Ricky’s career reflects the exact blend of field expertise, industry leadership, and commitment to safety that defines BDI,” said Darwin Nelson, Chief Executive Officer of BDI. “His experience across infrastructure, codes, and emerging inspection technologies will strengthen our ability to support asset owners facing increasingly complex challenges with the quality work they’ve come to expect from BDI.”

Morgan has received several industry honors, including the ASNT Fellow Award, the Philip D. Johnson Honorary Member Award, and multiple mentoring and technician-recognition awards for his contributions to the NDT profession.

“I’ve always believed inspection is about protecting people first,” Morgan said. “BDI’s mission aligns perfectly with that philosophy — applying the right technology at the right time to make informed decisions about critical structures. I’m excited to be part of the team and return more to my structural inspection roots.”

The appointment highlights BDI’s continued focus on strengthening its leadership and technical capabilities to support infrastructure owners in making data-driven decisions related to safety, maintenance, and long-term asset performance.

manufacturing
indaba



MANUFACTURING THE FUTURE:
**INNOVATION
INTEGRATION
INCLUSION**

14 – 15
JULY
2026

SANDTON CONVENTION CENTRE, JOHANNESBURG

www.manufacturingindaba.co.za



Cover Story

How NDT Is Strengthening Confidence in the Age of Composites

Ensuring reliability in complex composite structures

Cover Story

A Different Kind of Structural Risk

Composites did not replace metals because they were easier to manage. They replaced them because they offered performance advantages that traditional materials simply could not match. Lighter airframes, longer wind turbine blades, corrosion-resistant marine structures, and hybrid automotive platforms all reflect a deliberate move toward engineered materials designed for efficiency and strength. But with that evolution came a different kind of structural risk one that is often less visible and more complex to interpret.

Unlike metals, composites do not behave in uniform ways. Their strength depends on fibre orientation, resin bonding, layer sequencing, and manufacturing consistency. Damage mechanisms are not always obvious. A structure may appear intact on the surface while internal layers have separated. A low-velocity impact during handling may leave only a minor mark, yet create delamination beneath the outer ply. A slight variation in curing parameters may alter resin distribution in ways that influence long-term performance. These are not dramatic failures. They are subtle deviations. And in advanced materials, subtle deviations matter.

When “Looks Fine” Isn’t Enough

For decades, inspection decisions in many industries relied heavily on visible indicators and straightforward flaw detection. If a crack was present, it was sized. If corrosion was detected, it was measured. Composite materials challenge that mindset. Surface confirmation alone no longer provides meaningful assurance. What matters is what lies beneath the outer layer and how that internal condition will behave under operational loads.

In aerospace, internal delamination can affect load transfer even when the exterior panel appears undamaged. In wind energy, blade defects that go unnoticed during early stages may expand under cyclic stress and lead to costly downtime. In automotive applications, hybrid composite structures must meet strict crash-performance standards where material integrity directly influences safety outcomes. In each of these sectors, inspection is not simply about detecting anomalies; it is about determining whether

the structure will continue to perform as designed.

This is where non-destructive testing has steadily moved from being a verification tool to becoming a decision-support system.

From Detection to Interpretation

Traditional ultrasonic testing, radiography, and thermography remain central to composite inspection, but the expectations placed on them have changed. It is no longer sufficient to identify the presence of a defect. Engineers want to understand its dimensions, orientation, depth, and likely progression. They want to know whether it is stable or evolving. They want to assess whether it affects structural margins or remains within acceptable limits.

Advancements in phased-array ultrasonics now provide volumetric imaging rather than isolated signal responses, allowing inspectors to visualize internal features more clearly. Time-of-flight diffraction enhances crack sizing accuracy where small differences influence service decisions. Digital radiography offers improved dynamic range and faster data acquisition in layered materials where density variations complicate interpretation. Quantitative thermography provides thermal behavior analysis rather than simple contrast detection, supporting more reliable evaluation of bonding integrity and subsurface damage. Emerging techniques such as terahertz inspection add further visibility in applications where deeper penetration or material characterization is required.

These developments reflect a broader industry transition from pass-or-fail inspection toward informed integrity assessment.

Scaling Inspection with Production

The expansion of composites across industries has introduced another challenge: speed. Aircraft production rates are increasing. Wind turbine components are larger and more complex. Automotive manufacturing relies on repeatable quality control at high volumes. Inspection processes must therefore be both accurate and efficient.

Automation and digital integration are increasingly part of this solution. Robotic scanning systems reduce variability and improve coverage. Automated ultrasonic platforms enable consistent data acquisition across large surfaces. Digital archiving ensures traceability and supports regulatory documentation. Data can now be reviewed, compared, and analyzed beyond the immediate inspection event, allowing trends to be identified over time.

Inspection is no longer confined to a single checkpoint. It is embedded within manufacturing and lifecycle

strategies, supporting decisions that balance performance, safety, and cost.

The Shift Toward Lifecycle Integrity

Perhaps the most important change is philosophical. Advanced materials require long-term thinking. Designers consider inspectability during material selection and structural layout. Manufacturers incorporate in-process monitoring to detect deviations before final assembly. Operators analyze inspection data not only to approve components, but to predict behavior over years of service.

This shift has elevated NDT into a strategic role. Inspection data informs certification processes, maintenance planning, and investment decisions. It supports regulatory compliance and provides defensible evidence when performance margins are questioned. As composite structures age, understanding their internal condition becomes essential to extending service life responsibly.

Advanced materials offer significant benefits, but those

benefits depend on confidence. That confidence is built on measurement, interpretation, and continuous validation.

Holding Innovation Together

Composites and advanced materials have expanded what engineering can achieve. They enable lighter, more efficient, and more durable systems across multiple industries. Yet their complexity demands disciplined oversight. Assumptions based on surface appearance or initial qualification are no longer sufficient.

Non-destructive testing provides the clarity needed in this environment. It transforms internal conditions into actionable knowledge. It bridges the gap between design ambition and operational reliability. As materials continue to evolve, inspection must evolve with them maintaining rigor, embracing technology, and supporting informed decisions.

In the broader narrative of innovation, NDT may not always occupy center stage. But in the world of composites and advanced materials, it remains the steady presence ensuring that performance is not just promised, but sustained.





Expert Article

Successful Transition from Film to Digital Radiography in Aerospace NDT



Lennart Schulenburg
CEO at VisiConsult X-ray Systems & Solutions GmbH



Paul Scheel
Content Marketing Manager
VisiConsult X-ray Systems & Solutions GmbH

Production is running. The components are ready. Inspection can begin.

But in X-ray inspection with analog film, every step takes time. Exposure, development and evaluation limit throughput and flexibility. What should be a smooth production flow is often disrupted by delays in the NDT process.

Many NDT teams are familiar with this situation. The results are reliable, but they are not fast. And while we wait, the backlog of parts waiting for inspection continues to grow.

This situation did not spare established global technology leaders. At Kongsberg Defence & Aerospace (KDA), film-based X-ray inspection had become a visible bottleneck. Additionally, rising prices for film consumables resulted in significantly increasing inspection costs that grows linearly with the production volume.

At the same time, a major production ramp-up was approaching. Continuing with film was not sustainable. The challenge was clear: remove the bottleneck without introducing new risk.

KDA had a strategic decision to make. Replacing film in a safety-critical aerospace environment means touching qualified processes, customer approvals, and audited workflows. A failed transition would slow down production and risk the ability to deliver. Yet doing nothing carried an even greater risk. So KDA made a decision.

Eight years later, Jan Danielsson, Radiation Protection Officer and Responsible Level 3 at KDA, looks back on this moment at the NDT Forum in Prague.

“Introducing digital radiography was one of the most important investments we have made in the last eight years,”

With it, the bottleneck had disappeared. But how was it done? And what advice is there for companies facing the same issues today?

Choosing a partner

Film radiography is still widely used across the aerospace industry. It is fully accepted. However, Standards that have evolved over decades, customer-specific specifications, and established audit processes make change complex. Film radiography is documented and familiar. Auditors, customers and inspectors know exactly what to expect and trust the outcome. Any new method must prove that it reliably detects the same defects. And it must prove that it

delivers stable, reproducible results over the long term.

The planning process, from film to digital X-ray inspection, was about a complete process. KDA needed an end-to-end solution partner.

They therefore defined their requirements very clearly. This is a key recommendation for anyone facing similar challenges. For KDA the system should be able to inspect metals and composite materials for

foreign objects (FOD), defects, and other deviations from quality specifications. It should work manually and automatically. It should reliably detect all relevant such a system. defect types. And above all, it should demonstrably deliver this performance during the test period before going into production. This pre-deployment evaluation saves later effort and cost for everyone who wants to introduce such a system.

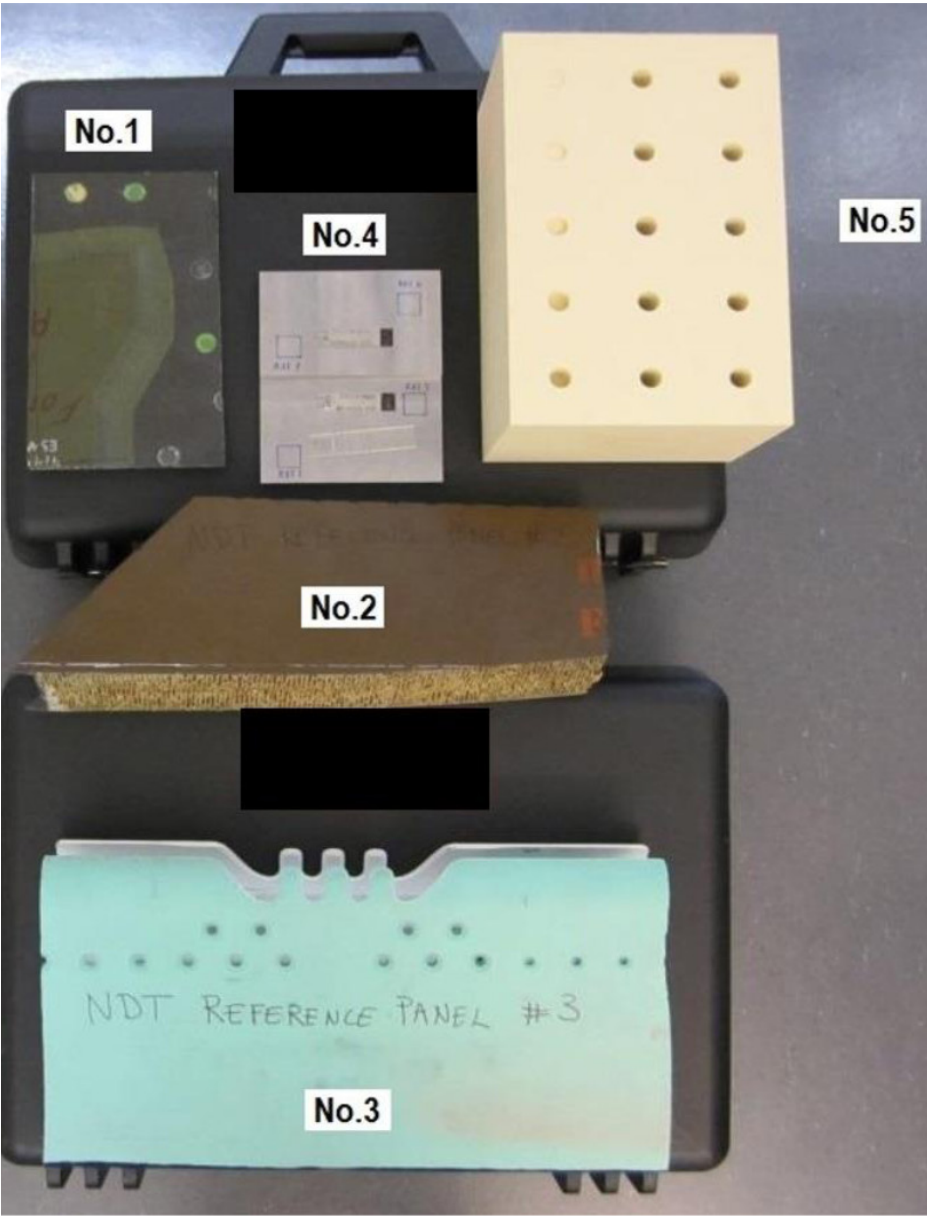


Figure 1 - Various test specimens: 1. Honeycomb Sandwich cut out, 2. VLW cut out, 3. Rudder cut out, 4. ASTM E2737 Duplex Plate Phantom IQI, 5. Reference Quality Phantom IQI © Kongsberg

The five non-negotiables before ordering a DR System

Know exactly what the system must detect

Define materials, geometries, and defect types upfront.

If this is unclear, qualification will fail later.

Prove performance before installation – not after

Verify image quality, sensitivity, and defect detection during FAT and, where possible, through pre-order performance validation.

Do not rely on promises. Rely on evidence.

Treat the detector as the heart of the system

Pixel size, signal-to-noise ratio, and stability define what you can see.

Do not optimize around the detector. Build the system around it.

Standardize processes from day one

Operation, calibration, maintenance, and verification must follow defined procedures. Standards do not slow you down. Missing standards do.

Think beyond inspection: data, traceability, availability

Define data formats, storage (e.g., DICOM), backups, and spare-part strategy early. Qualification is not the finish line. Availability is.

This clear understanding of the requirements shaped the selection of the partner. The search was for a provider who would take responsibility for the entire system. For planning, setup, testing, qualification, and training.

KDA found this partner in VisiConsult X-ray Systems & Solutions from Germany. VisiConsult specializes in customized solutions for the most demanding inspection tasks. Together, they developed an XRHGantry system with seven axes that was precisely tailored to KDA's components and testing requirements.

This end-to-end approach was crucial. It reduced interfaces, simplified communication, and ensured that technical decisions were always made in the context of subsequent approval. For KDA, this was a prerequisite for implementing the system change in a controlled manner and without surprises.

However, the real test was still ahead at this point: testing, qualifying, and accepting the system under real-world conditions. And the crucial question of whether the task could even be accomplished within the set time limit.

Qualification as the Critical Path

In the field of aerospace NDT digitalization fails when the qualification process breaks down. For KDA, it was therefore clear from the outset that digital radiography had to meet existing standards fully, demonstrably, and without exception.

International standards such as ASTM E2737 defined performance and long-term stability requirements for the digital detector array. These were complemented by additional ASTM standards and customer-specific specifications. Above all, Nadcap approval according to AC7114/10 was non-negotiable. Without it, digital radiography would not enter production.

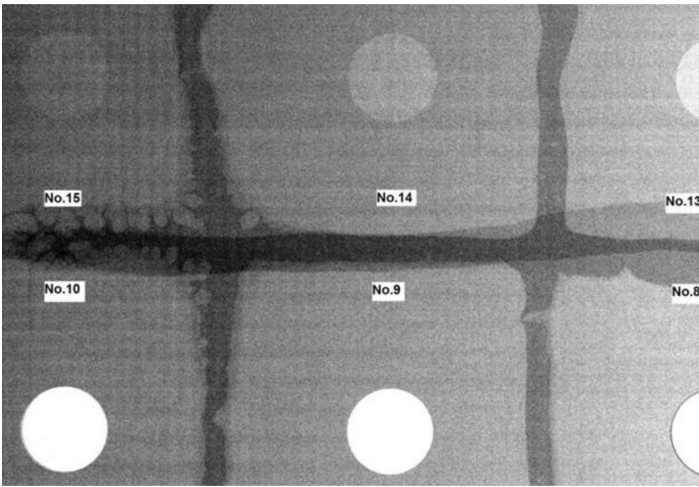


Figure 2 - Tests for Image quality requirements © Kongsberg

Before installation, KDA submitted reference specimens that had already been inspected using film radiography. The digital system had to demonstrate equivalent defect detection with equal clarity and reliability. This requirement made the Factory Acceptance Test a decisive proof point rather than a formal milestone. “Despite the challenging specimens, the first tests were excellent. All defects were clearly visible,” recalls Lennart Schulenburg, CEO of VisiConsult. With these results, confidence in the system increased. Installation could proceed, followed by qualification under production-relevant conditions.

Training, qualification, and approval were executed in parallel. Inspectors were trained according to NAS-410 and EN-4179 while technical verification progressed. Issues were identified early, documentation was prepared in advance, and verification followed a clearly defined structure.

As a result, the system was fully qualified and approved after eight weeks. This was significantly earlier than initially planned.

“I have heard that qualification and approval in only eight weeks is a world record in the aerospace business,”

-Jan Danielsson

The timeline was the consequence of an end-to-end approach that aligned engineering, standards, and training from the start.

Life after the bottleneck

With the approval, everyday life in X-ray inspection at KDA changed fundamentally. Around 90 percent of the previous film work was converted to digital X-ray inspection. The bottleneck disappeared.

Where multiple inspectors were previously required to work in shifts and plans existed to increase the team further, two qualified inspectors are now sufficient to inspect the same number of components. The total inspection effort was reduced by more than 85 percent.

The difference was most visible in the workflow. Digital images became available within seconds. Adjustments could be made immediately. Image enhancement and magnification no longer affected quality. Waiting times caused by film development and re-exposure disappeared.

Automation played a key role. Today, around 95 percent of components are inspected using automated programs. Inspectors focus on evaluation and decision-making rather than repetitive manual steps.

An effect KDA did not fully anticipate was the impact on people. “I have more motivated and engaged inspectors today,” says Danielsson.

Technology was not perceived as a threat, but as support. Instead of slowing production, inspection now moves at its pace.

Detector quality: the make-of-break factor

For KDA digital X-ray inspection had to deliver at least the same image quality as film and ideally exceed it. In practice, this comes down to one component: the detector.

Pixel size, signal-to-noise ratio, and long-term stability determine whether small defects can be reliably detected. For KDA, the detector was therefore treated as the core of the system, not an accessory.

The selected detector technology met all relevant standards and delivered higher sensitivity than film, particularly in complex composite structures and thin-walled areas. And digital image handling has added another advantage. The images can be archived without degradation and retrieved at any time. This is an essential factor for audits. And feedback confirmed the results to Jan Danielsson.

“Customers come back and say: ‘Wow, how can you make such good images?’”

At KDA, film is now used only where component geometry physically limits detector placement. Wherever digital radiography is technically feasible, it has replaced film. For the remaining applications, KDA is currently implementing a computed radiography (CR) scanner with digital software from VisiConsult, continuing its transition toward fully digital X-ray inspection.



Figure 3 - XRHGantry Control Room © Kongsberg

Conclusion – Digital Radiography in Aerospace Practice

The transition to digital radiography at Kongsberg Defence & Aerospace was driven by necessity. Film-based X-ray inspection had become a bottleneck in a production environment that could no longer afford delay. It also alleviated strain caused by rising film and consumables cost. Replacing it meant touching qualified processes, customer approvals, and established workflows. This undertaking carried

real risk.

What made the transition successful was the combination of clearly defined requirements and an end-to-end implementation approach, supported by a partner willing to take responsibility beyond system delivery.

Working closely with VisiConsult, KDA implemented a digital radiography system that was engineered, tested, qualified and trained as a single, integrated solution. This alignment allowed performance to be proven early and qualifications to be completed

without compromising standards or timelines.

Today, X-ray inspection at KDA no longer slows production down. It supports it and keeps pace with manufacturing.

Production is running. The components are ready.

And inspection can begin.

Know More

Three Decades of Radiation Safety Leadership: A Conversation with Dr. Pankaj Kumar Dash Sharma



Former Head, Radiation Applications Safety Division
Atomic Energy Regulatory Board, India



With over three decades of distinguished experience spanning research, regulation, industry, and healthcare, Dr. Pankaj Kumar Dash Sharma has played a pivotal role in strengthening India's radiation safety ecosystem. From his early career at BARC (Bhabha Atomic Research Centre) to leading the Radiation Applications Safety Division (RASD) at AERB (Atomic Energy Regulatory Board), his journey reflects deep scientific rigor, regulatory insight, and an unwavering commitment to safety. In this conversation with OnestopNDT, he shares reflections on his professional journey, regulatory evolution, technological advancements, and guidance for future professionals in radiation safety and NDT.

Q: Dr. Sharma, welcome to OnestopNDT — it's a privilege to have you with us. You bring over three decades of experience across regulatory, industrial, research, and healthcare environments, including leading the Radiation Applications Safety Division at Atomic Energy Regulatory Board (AERB). Could you walk us through this remarkable journey and how your roles have evolved from BARC (Bhabha Atomic Research Centre) to AERB?

A: Thank you for the warm welcome. I would like to sincerely thank OnestopNDT for providing me with an excellent opportunity to share my views with the stakeholders of NDT practice.

My professional journey began at BARC after acquiring experience with an NDT company as a Radiological Safety Officer (RSO) and at a Radiation Therapy Centre as a Medical Physicist/RSO. The experience thus gained helped me immensely during both my Research & Development (R&D) activities at BARC and later during regulatory functions at AERB.

At BARC, I was directly involved in R&D activities, particularly in the field of radiation safety and dosimetry across medical, industrial, and research applications. During the later phase of my tenure at BARC, I was

also engaged in advisory services for radiation facilities.

AERB was established in 1983 as an independent regulatory authority to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to public health or the environment. However, even after its establishment, BARC continued to provide advisory and regulatory services to radiation facilities across the country. It was only in 2001 that a few officers from BARC, including myself, were transferred to AERB to strengthen regulatory oversight.

Over the years, my responsibilities expanded to include policy formulation, development of regulatory documents, safety evaluations, licensing, inspections, incident investigations, and enforcement actions. As Head of the Radiation Applications Safety Division (RASD), I was responsible for overseeing radiation safety across medical, industrial, and research applications nationwide.

This progression enabled me to develop a holistic understanding of radiation risk management—balancing technological advancement with occupational and public safety.

Q: You began your academic journey in physics with an M.Sc. and went on to complete a Dip.R.P. and later a Ph.D. from the University of Mumbai. How did this strong scientific foundation shape your long-term orientation toward radiation safety, compliance, and regulatory oversight?

A: After completing my M.Sc. in Physics from Sambalpur University in 1987, I began my career as a Physics teacher, which was personally fulfilling, as I have always been passionate about teaching.

At that time, access to information was limited compared to today's digital era. When I was selected for the Diploma in Radiological Physics (Dip.R.P.), I joined primarily because

of the association with 'BARC,' without fully understanding the scope of the course. However, the one-year rigorous training in this applied branch of physics completely transformed my professional trajectory.

Although the course content was primarily oriented toward Medical Physics in oncology settings, limited job opportunities led me to begin my career as a Radiological Safety Officer (RSO) in an industrial radiography company. Later, I joined a cancer hospital as a Medical Physicist-cum-RSO. These early experiences provided me with first-hand exposure to both industrial and medical radiation practices before joining BARC in 1992.

I completed my Ph.D. from the University of Mumbai after moving to AERB.

My combined experience in industry, medical institutions, BARC research, and regulatory oversight shaped my professional outlook decisively. The strong scientific foundation helped me



adopt a risk-based regulatory approach rather than a checklist-driven model. It also enabled effective communication with licensees, radiographers, and safety professionals—bridging theory with field realities.

I am pleased to note that this scientific rigor and professional integrity earned me recognition as a strict yet fair regulator among stakeholders. This approach aligns closely with international radiation protection philosophies promoted by agencies such as the IAEA.

Q: Radiation safety intersects both technology and governance. In your early years as a Medical Physicist and later as Scientific Officer at BARC, what foundational lessons did you carry forward that proved critical when transitioning into a regulatory leadership role?

A: Mankind has benefited immensely from the use of radiation sources, including both radioactive materials and radiation-generating equipment such as X-ray systems. However, ionizing radiation is a double-edged sword and must be handled with utmost care, as it can cause significant harm to living beings.

A major challenge is that radiation cannot be detected by human sensory organs.

One foundational lesson from my early career was that radiation incidents are rarely caused solely by equipment failure. More often, they stem from human & organizational factors—fatigue, time pressure, inadequate supervision, or communication breakdowns.

From a regulatory perspective, I repeatedly observed that procedures existed and equipment was certified, yet safety steps were bypassed under commercial pressure. This reinforced my conviction that effective regulation must address safety culture, human factors, and managerial accountability—not merely technical compliance.

Q: As Head of RASD (Radiation Applications Safety Division), you oversaw regulatory inspections, safety documentation, and radiation protection across medical, industrial, and research sectors. From your vantage point, how have India's standards, compliance culture, and regulatory maturity evolved over the last two decades?

A: Over the past two decades, India's radiation regulatory framework has evolved substantially. Licensing processes have become more structured, inspections more systematic, and training requirements clearly defined.

During my tenure, AERB revised all Safety Codes and Guides pertaining to radiation applications, aligning them more closely with international

standards. In December 2025, AERB published a unified Safety Code on Radiation Sources, Equipment, and Installations (AERB/RF/SC), enhancing coherence across sectors. Additionally, five practice-specific Safety Guides—including the Safety Guide on Industrial Radiography (AERB/RF/SG/IR)—were issued.

These guides provide flexibility, allowing end users to adopt alternative compliance approaches with AERB approval, thereby improving practicality without compromising safety.

After 2001, a clear regulatory separation emerged, and AERB strengthened enforcement and awareness initiatives. Through sustained outreach, seriousness toward radiation safety and compliance increased significantly among end users.



Q: Industrial users—particularly in NDT—operate sealed sources, radiography cameras, X-ray systems, and other radiation-emitting devices. From a regulator's perspective, what factors determine whether user industries are prepared, compliant, and safety-conscious in their operations?

A: Industrial radiography is one of the most challenging radiation applications globally due to mobile worksites, night operations, and demanding working conditions.

Unlike fixed facilities, radiography services are often performed at third-party premises not fully controlled by the radiography company. Since the entry cost is relatively low, intense competition sometimes results in shortcuts.

From a regulatory perspective, preparedness is reflected not in documentation alone but in day-to-day behavior—visible management commitment, empowered Radiation Safety Officers, realistic work scheduling, fatigue management, and strict exposure control.

Incident reviews consistently show that lapses occur when commercial urgency overrides safety discipline. Organizations that embed safety as a core operational value demonstrate superior compliance and fewer incidents.

Q: One of your major contributions was steering the eLORA e-Governance initiative, which transformed licensing, compliance, and inspection workflows. What drove its development, and how significantly has it reshaped regulatory transparency and ease of doing business for radiation users?

A: It became evident that regulating a rapidly growing number of radiation facilities with limited manpower required digital

transformation. Manual systems lacked traceability and efficiency.

The solution was a comprehensive IT-enabled platform—eLORA—which established a centralized database of institutions, sources, equipment, trained manpower, and lifecycle tracking mechanisms.

eLORA modernized regulatory workflows and enabled graded (risk-based) oversight. Low-risk applications could be auto-cleared using embedded business logic. During the COVID era, eLORA ensured uninterrupted regulatory functioning.

The system was recognized as a 'Good Practice' by the IAEA during its review of AERB.

For NDT companies, eLORA simplified licensing, source tracking, and compliance reporting, enhancing transparency and ease of doing business while strengthening oversight.

Q: For organizations deploying radiography or radiation-based NDT, what key factors should guide their procurement decisions—whether it's equipment design, safety interlocks, operator training, lifecycle compliance, or source management?

A: Procurement decisions in industrial radiography are fundamentally safety decisions. Beyond cost and performance, organizations must consider: (i) equipment reliability, (ii) robust safety interlocks, (iii) availability of spares, (iv) training support, and (v) source return and disposal arrangements.

AERB grants Type Approval to sources and equipment after design scrutiny. Users must procure only approved devices.

International experience shows that poorly planned procurement leads to long-term safety and compliance challenges. Lifecycle compliance must therefore be considered at the procurement stage itself.

Q: Technology continues to evolve, with digital radiography, portable X-ray systems, AI-based interpretation, and integrated safety architectures becoming more prevalent. How do regulators view such advancements, and how should industry prepare for the next phase of modernization?

A: Regulators welcome advancements that reduce reliance on high-activity gamma sources. Digital radiography and portable X-ray systems offer substantial risk reduction potential.

Radiation safety combines 'Built-in Safety' and 'Operational Safety.' Open-field gamma radiography relies heavily on operational controls, whereas enclosed radiography and the use of radiation-generating equipment offer better inherent safety.

However, technology alone does not eliminate risk. Regulators expect proper validation, retraining, and updated operational procedures. Human competence must evolve alongside technological advancement.

Q: There is often a narrative gap between regulators, equipment manufacturers, and end users. From your experience, what mechanisms or collaborative forums could help bridge these perspectives and strengthen India's radiation safety ecosystem as a whole?

A: This gap exists globally. Regulators observe repeated non-compliances, while industry perceives rigidity.

Structured engagement—workshops, guidance documents, and shared learning—bridges this divide. AERB regularly organizes platforms such as the National Conference on Regulatory Interface, encouraging dialogue without compromising safety.

Collaboration improves safety outcomes more effectively than enforcement alone.

Q: Midway through our conversation, we want to highlight an important achievement—your recent selection for the prestigious DAE-Homi Sethna Chair, which enables continued contribution to radiation safety frameworks at AERB. Could you share what the focus areas of this three-year tenure will be and what impact you envision?

A: The DAE-Homi Sethna Chair enables experienced retired professionals to continue contributing meaningfully. Though I am yet to formally join, this is a great honor. My focus areas are expected to include stakeholder engagement, simplification of regulatory processes, alignment of regulatory documents under the SHANTI Act, 2025, and providing structured feedback to strengthen compliance without compromising safety.

Q: Training and competency play a central role in radiation protection. Based on your experience, what gaps still remain in awareness, certification, or operator-level responsibility—especially within industrial radiography and NDT segments?

A: Industrial radiography involves high-activity sources and limited built-in safety, making operator competence critical. Given challenging working conditions and limited financial incentives, attracting and retaining skilled manpower remains difficult. Despite certification systems, gaps remain in refresher training, supervision, and accountability. Many near-misses reveal that principles were understood but not applied under operational pressure. Continuous competency development is essential beyond one-time certification.

Q: Given your interactions with hospitals, research facilities, industrial radiography companies, and regulators, how do you see India balancing innovation with safety—particularly when industries demand faster workflows, lower costs, and increased productivity?

A: Advancements in equipment design have improved inherent safety. Earlier shutter-based cameras were more vulnerable to misuse. Modern devices provide improved source security. Newer isotopes, such as Selenium-75-based cameras,



offer shielding advantages for thinner jobs. Indigenous manufacturing initiatives by BRIT are expected to enhance cost-effectiveness and productivity. Globally, shortcuts often result in incidents & reputational damage. Safety must therefore be seen as a productivity enabler rather than a constraint. Balancing innovation with safety is central to modern regulatory thinking worldwide and is essential for sustainable industrial growth.

I have never hesitated to share knowledge fully, believing that collective competence strengthens institutions. Teaching embeds safety institutionally rather than individually. I remain optimistic about stronger academia-industry-regulatory collaboration as technologies and standards evolve.

Q: To conclude, what message would you like to share with young professionals entering radiation safety, regulatory sciences, industrial radiography, and NDT domains—especially at a time when technology, standards, and workforce skills are rapidly evolving? And how do you view the role of platforms like OnestopNDT in bridging knowledge, community learning, and industry-academic-regulatory collaboration going forward?

A: Teaching has always been close to my heart. Nation-building requires knowledge-sharing. My message to young professionals is simple: never

underestimate radiation risk. Familiarity must not breed complacency. Professional competence must always align with ethical responsibility. Platforms like OnestopNDT play a vital role in disseminating best practices, fostering dialogue, and strengthening global NDT collaboration. Thank you once again for this opportunity. Dr. Sharma's journey reflects not only technical excellence but also a profound commitment to safety culture, regulatory integrity, and knowledge-sharing. His insights underscore the importance of balancing innovation with responsibility, enforcement with collaboration, and competence with ethics. As radiation technologies continue to evolve, such leadership perspectives remain invaluable in guiding the next generation of professionals and strengthening India's radiation safety framework.



Reliable Ultrasonic Measurement

Quick, Reliable and Safe UTM for Mines with Coal Dust and Methane Gas



Thanks to the intrinsic safety design of Cygnus 1 Ex Ultrasonic Thickness Gauge

- It is engineered for efficient, reliable thickness measurement through thick coatings or extreme corrosion
- Intrinsically Safe design eliminates the need for Hot Work Permits or plant shutdown
- Live A-scan for visual measurement verification



Order now, **SAVE £200***

DISCOUNT CODE **NDTT25**

*Only valid when ordering directly from Cygnus Instruments Ltd

MADE IN BRITAIN

cygnus-instruments.com

Beyond the Image: Radiometric Precision in NDT

From thermal images to precise measurements, discover how radiometric infrared thermography is redefining accuracy, data integrity, and confidence in modern NDT.



**Telops
Radia M100**

In

Non-Destructive Testing (NDT), “seeing” a defect is no longer synonymous with understanding it. For decades, the industry relied on qualitative thermal imaging—looking for anomalous thermal contrast to identify a potential defect. A hot spot on a breaker, a cold void in a composite. If the operator saw the contrast, the job was done.

But as safety margins in aerospace and energy tighten, “seeing” is often not enough. We are hitting a ceiling where standard uncalibrated sensors fail to provide the necessary confidence. To push past this, the NDT industry is shifting from thermal imaging to quantitative infrared thermography.

This is a metrological distinction. It is the difference between a photograph and a measurement. At Telops, this philosophy drives the Radia family. We designed these instruments to bridge the gap between basic imagers and our ultra-premium scientific systems, serving as the accessible, metrology-grade anchor for modern testing.

The Science of Accuracy

As a scientist by training, I view infrared cameras as analytical instruments, akin to a spectrometer or chromatography system. In analytical chemistry, we would

never accept results from an uncalibrated instrument that drifts with ambient temperature yet in thermal NDT, such drift is often accepted as a limitation of the measurement equipment.

True radiometry—deriving absolute temperature from a detector’s signal—is difficult. It requires highly stable internal electronics that isolate the target’s heat from the camera’s own thermal noise as well as an in-depth understanding of the emissivity properties of the target. While many commercial cameras rely on “scene-based” corrections that essentially guess the baseline to create a pretty image, true radiometry demands precise, real-time compensation to ensure the reading never drifts. For home inspections, this type of approximation works. For characterizing the thermal diffusivity of aerospace composites, it is a liability.

The Radia family is built on permanent radiometric calibration. Utilizing high-performance detectors (cooled MWIR and uncooled LWIR) and proprietary algorithms, these cameras maintain accuracy across shifting environmental conditions. This allows professionals to trust the scientific data behind the pixel: a 5°C delta measured today means exactly the same thing as a 5°C delta measured six months from now.

Radia Architecture: The Smart Alternative

NDT requirements are rarely one-size-fits-all. In the Telops ecosystem, we distinguish between our flagship HDR M700, designed for extreme performance in high-

contrast environments, and the Radia Family, designed for streamlined versatility.

Understanding this distinction is key to ROI. The Flagship HDR line uses a specialized architecture to capture extreme gradients simultaneously (e.g., a molten weld next to cold metal) in a single snapshot. While revolutionary, it is a specialized tool.

The Radia family is the “daily driver” for the majority of NDT applications that require precision without the cost of flagship architecture.

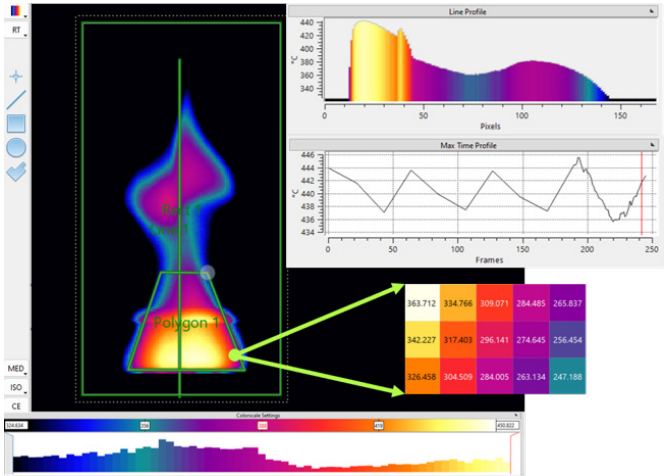


Figure 2. Telops RevealIR software displaying radiometrically-calibrated, quantitative thermal imaging data

The Radia M100: The High-Temp Workhorse

The M100 is designed for speed and dynamic range. It boasts a calibrated dynamic range of 0°C to 850°C using a single open optical path. Furthermore, by equipping the M100 with a single Neutral Density Filter (NDF), the calibrated temperature range expands massively to 15°C to 2500°C.

Crucially, the M100 achieves this through intelligent adaptability. Unlike many sensors valid only at fixed integration times, Telops calibration allows for at-will and continuous adjustment of exposure time without losing radiometric accuracy. This powers the M100’s Automatic Exposure Control (AEC).

AEC reads scene radiance and automatically adjusts integration time in real-time. If a process spikes in temperature, the camera adapts instantly to prevent saturation. This delivers the core radiometric integrity of a Telops camera—stability, calibration, and speed—without the complexity of the Flagship HDR design.

The Radia V60: Compact Versatility

While the M100 handles high speed & heat, the Radia V60 brings metrology-grade accuracy to a compact, uncooled LWIR package. The Radia V60 is a fully radiometrically calibrated system with a complete suite of user-swappable, adjustable focus lenses. This gives NDT professionals the flexibility to move from inspecting large infrastructure materials to analyzing medical imaging on organic tissues without the hassle of recalibration when changing lenses.

Because it is uncooled, the V60 offers a smaller footprint and easier integration into tight spaces, making it an ideal solution for long-term monitoring where the high frame rates of a cooled detector aren’t required, but the data stability is.

The Radia Family: The Engine of Modern Thermography

The applications for quantitative thermography are expanding rapidly. While Active Thermography—exciting a material with flash lamps, induction, or ultrasound—remains a critical driver, we are seeing a surge in Passive and In-Process thermography.

Active Thermography

Historically, Telops provided full turnkey systems for active thermography. However, recognizing that specialized integrators are increasingly building custom rigs for specific airframes or pipelines, we have repositioned the Radia M100 as the engine for these advanced systems.

In active thermography, timing is everything. When a flash lamp fires, the thermal response happens in milliseconds. If the camera cannot synchronize perfectly with the excitation pulse, the data is useless. The Radia M100 features advanced triggering capabilities (microsecond precision) and supports high frame rates through subwindow operation, essential for “freezing” thermal diffusion in high-conductivity materials.

Passive & In-Process Monitoring

Not all NDT requires an external flash. Passive thermography—using natural thermal cycles—is gaining traction for infrastructure monitoring. For example, the daily heating and cooling cycle of a bridge caused by the sun can reveal delamination or voids.

Similarly, in-process thermography is becoming vital in construction and manufacturing. Consider the pouring of concrete for critical infrastructure; the solidification process is an exothermic reaction. By monitoring this heat



Figure 1. Telops Radia V60 (uncooled LWIR, left) and M100 (cooled MWIR, right)

	Radia M100	Radia V60
Detector Type	Cooled HOT MW	Uncooled Microbolometer
Detector Format	640 x 512	640 x 480
Spectral Range	3.6 - 4.15 μm	8.0 - 14.0 μm
Maximum Frame Rate (full window)	180 Hz	60 Hz
Typical NETD	30 mK	45 mK
Data Output Types	RAW, NUC, Radiometric Temperature, In-Band Radiance, In-Band Irradiance	RAW, NUC, Radiometric Temperature, In-Band Radiance, In-Band Irradiance
Data Transfer	USB 3.0	GigE
Lens Options	Standard: 25 mm EFL, 14.6° x 11.7° Wide Angle: 13 mm EFL, 27.7° x 22.3° Telephoto: 50 mm EFL, 7.3° x 5.9°	Standard: 14 mm EFL, 30.7° x 23.2° Wide Angle: 7.5 mm EFL, 54.2° x 41.9° Telephoto: 25 mm EFL, 17.5° x 13.1°
Size	84 x 94 x 96 mm	45 x 45 x 75 mm
Weight	820 g	250 g

generation, engineers can identify internal defects and voids.

For these applications, the Radia V60 shines. Its high sensitivity to ambient temperature fluctuations and stability over long acquisition periods make it perfect for tracking the slow thermal evolution of curing concrete or the diurnal cycle of a composite aircraft wing sitting on the tarmac.

Data Integrity in a Digital World

In today's industrial environment, an inspection is a digital record. If a turbine blade fails years later, manufacturers must prove the part was defect-free at production.

This is where the difference between a JPEG and a radiometric dataset is critical. The Radia family outputs 16-bit radiometric data—saving a temperature/radiance matrix, not just an image. This allows for post-processing and re-analysis indefinitely.

Furthermore, both the RAW and calibrated data are fully accessible via our SDK or our license-free RevealIR software. This allows users to visualize and process data on any computer, facilitating easy sharing of results with colleagues or clients without requiring expensive software

seats. Whether you are developing custom pulse phase thermography algorithms or running custom Principal Component Analysis (PCA), the Radia family provides the data transparency needed for robust processing workflows.

Conclusion: The ROI of Accuracy

Investing in high-end instrumentation is a balance between performance and budget. The Radia family resolves this tension.

For extreme, high-contrast applications, our Flagship HDR line remains the pinnacle. But for core NDT tasks—delamination checks, stress analysis, process monitoring—the Radia Family offers the perfect balance. It brings the rigor of the analytical chemistry lab directly into the hands of an NDT inspector in the field, ensuring that when you say a part is “clear,” you have the data to back it up.

Know More

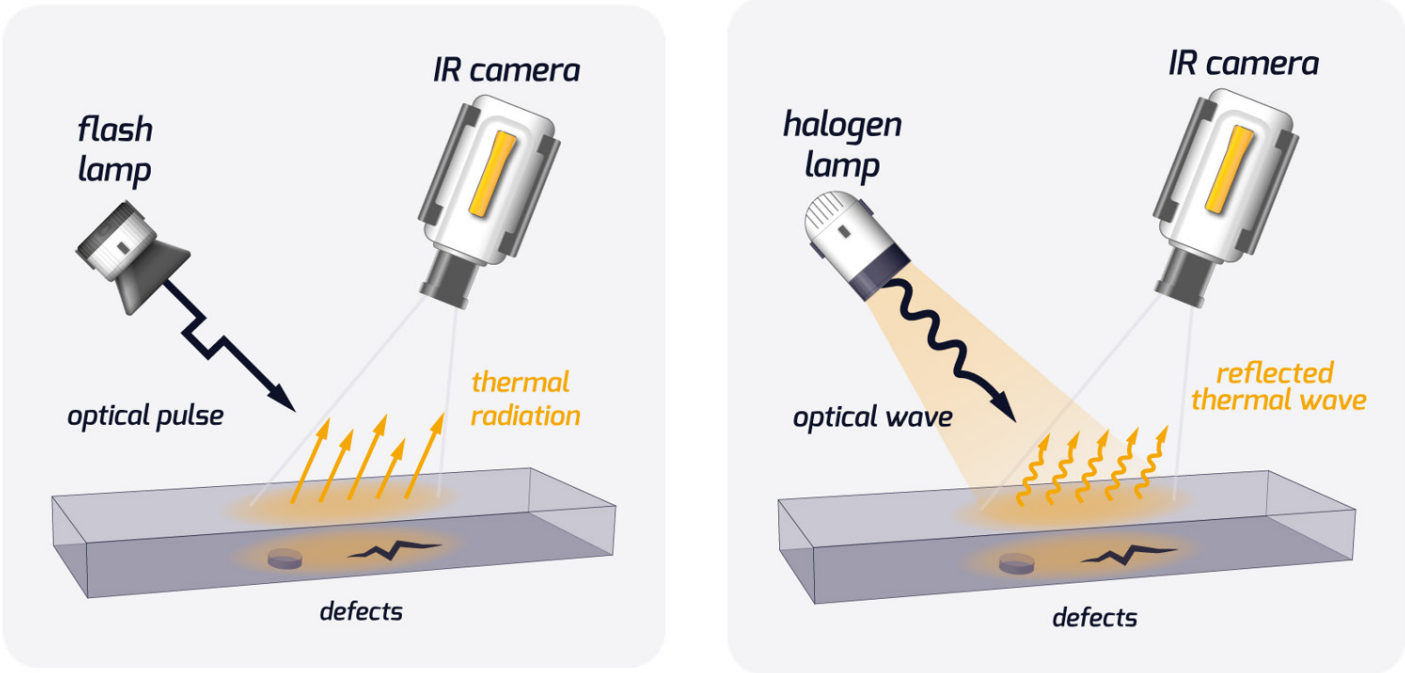


Figure 3. Schematic demonstrating the principles of pulsed phased active thermography (left) and continuous excitation, lock-in active thermography (right)

SOME THINGS IN NDT CAN'T BE ~~Googled.~~

That's why we created NDT Talks — a monthly panel where real experts share insights you won't find online.



A comprehensive evaluation of the low-velocity impact behaviour of intraply hybrid flax/basalt composites using infrared thermography and terahertz time-domain spectroscopy techniques

Pengfei Zhu, Hai Zhang, Stefano Sfarra, Fabrizio Sarasini, Rubén Usamentiaga, Gunther Steenackers, Clemente Ibarra-Castanedo, Xavier Maldaque

Abstract

Low-velocity impacts severely jeopardize the structural reliability of polymer composites. In view of this, a thorough evaluation of the impact damage of the polypropylene (PP) composites reinforced with an eco-friendly intraply flax/basalt hybrid fabric was performed based on infrared thermography (including pulsed thermography, linear scanning thermography) and terahertz time-domain spectroscopy (THz-TDS) techniques. However, the main problem is the lack of multi-source fusion techniques regarding more than two sensors, and the discussions regarding homologous fusion (pulsed thermography and linear scanning thermography), and non-homologous fusion (infrared thermography and THz-TDS). In this work, a comprehensive evaluation of the impact resistance of hybrid polymer composites was conducted, including detecting the uneven resin distribution and exploring a new multi-sources fusion strategy. The experimental results demonstrate the superior capability of multi-source fusion techniques.

1. Introduction

Low-velocity impacts (LVI) can severely jeopardize the structural reliability of polymer composites. In an attempt to increase the low-velocity impact response of natural fibre composites, fibre hybridization was introduced and

offers a comprehensive set of possibilities leading to synergetic effects or to properties not exhibited by the single constituents [1–3].

Among the different combinations available, the use of flax fibres with natural fibres of mineral origin, such as basalt fibres, has been widely investigated in literature with promising results [4]. Hybridization led to better impact performance compared to pure basalt and flax composites in terms of peak force and penetration energy along with a much lower delaminated area. This behaviour was due to the energy absorption ability of flax layers through a non-elastic mode and to the deflection of the impact damage progression [5].

Polymer composites are able to absorb the impact energy due to the presence of polymeric matrix that distributes the energy in the material [6]. However, due to their laminar microstructure, composites are prone to severe damage even under low velocity impacts, often resulting in delamination between layers. This concealed delamination disrupts visual inspection procedures and poses the potential for catastrophic failure over the operational lifespan of the material. With respect to the impact damage evaluation, the scientific community is increasingly focused on non-destructive testing (NDT) techniques including infrared thermography (IRT), X-ray computed tomography, and ultrasonic testing, shearography, etc [7–10]. Ultrasonic

testing is effective for detecting deep defects but suffers from low scanning efficiency and sensitivity to material anisotropy. In contrast, optical shearography is sensitive to surface stress changes but limited in detecting deep defects and requires stringent control of environment vibrations and surface quality.

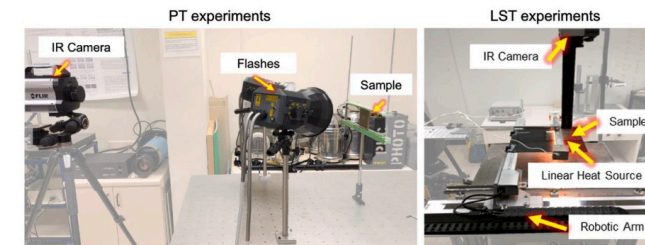


Fig. 1. Experimental setups of pulsed thermography (PT) and linear scanning thermography (LST).

An ideal NDT technique should be effective in detecting buried slight delamination, while also being fast, reliable, and simple to use [11]. In this regard, infrared thermography techniques such as pulsed thermography (PT) and linear scanning thermography (LST) have gained increasing attention in the recent years due to their fast inspection rate, contactless nature, high spatial resolution, acquisition rate [12,13] and versatility of application in various research fields. Important examples confirming the latter point are illustrated in Refs. [14–18]. However, for composites testing, the noise caused by the weaving pattern including uneven surface emissivity and anisotropic thermal diffusivity significantly affects the damage recognition. Pulsed phase thermography (PPT) technique was proposed in 1996 and validated as an effective method for reducing the surface emissivity effect and increasing the defect contrast [19]. Subsequent study has been constructing quantitative defect features such as the relationship between phase and defect depth [20,21]. For anisotropic thermal diffusivity, there is no effective solution.

Limited detection depth (~4 mm) significantly affects the applications of IRT. In this case, an emerging technique, i.e. terahertz time-domain spectroscopy (THz-TDS), was introduced [22,23]. THz bridges the gap between microwave electronics and infrared photonics. THz spectrum can determine the low-frequency vibrational modes of molecules, which are related to intermolecular interactions in chemical compounds, such as hydrogen bonds and van der Waals interactions between molecules. Therefore, it has the potential to detect the uneven resin distribution, which significantly affects the mechanical properties of materials. THz-TDS is attracting more attention as a new NDT method

due to its human-safe (nonionizing) and deeper penetration capabilities. THz-TDS technique has deeper penetration capability (~10 mm) comparing with infrared thermography. Similar to infrared thermography, THz-TDS does not require any contact with the sample surface. It is possible to combine these two techniques to achieve a better detection effect. However, information from different NDT systems can be conflicting, incomplete or vague if looked at as discrete data [24–26]. The concept of data fusion can be used to combine information from multiple NDT systems and help in decision-making to reduce human error interpretation [27]. Existing fusion technologies were focused on the data from two sensors [28–30], and there is a lack of research on data fusion from more than two sensors. This is due to the increase in time and operating costs that come with the addition of sensors.

Here, two types of intraply hybrid flax/basalt composites subjected to low-velocity impact (LVI) were tested by three contactless and non-destructive techniques, including pulsed thermography (PT), linear scanning thermography (LST) and terahertz time-domain spectroscopy (THz-TDS). In addition, a novel data fusion technique is proposed for providing more details regarding different damage modes, including delamination and cracks. This technique is based on pixel-level data fusion, which increases knowledge about the location and characteristics of defects and reduces ambiguity.

The rest of this paper has been organised as follows. Firstly, specimens, experimental setups and main contributions are introduced in Section 2. The resin characterization method and multi-source fusion technique are provided in Section 3. The experimental results and discussions are provided in Section 4. Finally, our conclusion is outlined in Section 5.

2. Experiments

2.1. Materials

PP-based composites were manufactured through hot compression moulding, by using the film-stacking technique with alternating layers of PP films (75–80 μm thick) and flax/basalt hybrid fabrics. A hybrid woven fabric supplied by Depestele Group under trade name of LINCORE® HFT2 360 was used as the reinforcement material. This fabric displays a twill 2/2 weave pattern, comprising 50 wt% flax and 50 wt% basalt, with an areal density of 360 g/m². The matrix was a polypropylene (PP) provided by Borealis AG under the commercial name of Bormod HF955MO. A 2 wt% maleic anhydride grafted polypropylene (MA-g-PP),

Polybond 3000 by Chemtura, was used as coupling agent to increase fibre/matrix interfacial adhesion. The modified PP formulation (PPC) was manufactured by using a co-rotating twin-screw extruder Teach-Line ZK25T by Collin GmbH with a temperature profile of 180-190-205-195-185 °C from the hopper to the die. The screw operated at a speed of 60 rpm. PP and PPC films were produced using a flat head extruder Teach-Line E 20-T, which was equipped with a CR 72T calendar by Collin GmbH. The process involved a temperature profile of 180–190–200-190-185 °C and a screw speed of 55 rpm. The laminates with a 4 mm thickness and an overall fibre volume fraction of 0.4 were hot compressed in a P400E press by Collin GmbH by alternating eight hybrid fabric layers with nine PP (or PPC) films.

Specimens measuring 100 mm × 100 mm × 4 mm were subjected to low velocity impact tests at four different impact energy levels, i.e., 5 J, 10 J, 20 J and 30 J by using an instrumented drop-weight impact testing machine (CEAST/ Instron 9340) equipped with a 12.7 mm hemispherical tip and a total weight of 8.055 kg. Test coupons were pneumatically clamped between two steel plates leaving a circular unsupported area with a diameter of 40 mm.

2.2. Experimental setups

In this study, the multi-source systems are divided into three parts, including pulsed thermography (PT), linear scanning thermography (LST), and terahertz time-domain spectroscopy (THz-TDS) [31–33]. Fig. 1 shows the PT experimental setup in the reflection mode. A cooled infrared camera (FLIR X8501sc, 3–5 µm, InSb, NEdT <20 mK, 1280 × 1024 pixels) and two xenon flashes (Balcar, 6.4 kJ for each, 2 ms) are used.

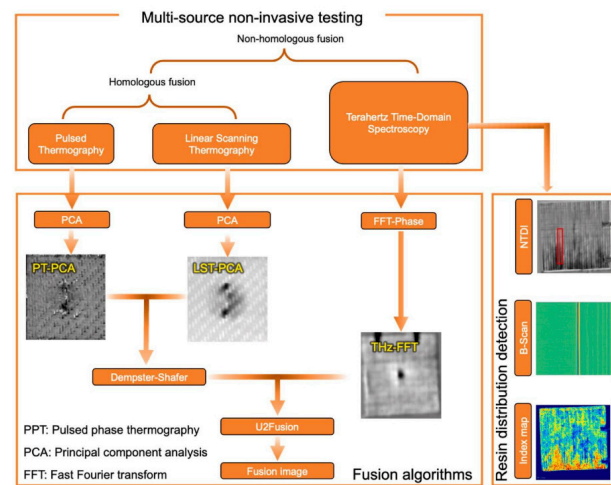


Fig. 2. The main contributions in this work: resin distribution detection and multi-source fusion.

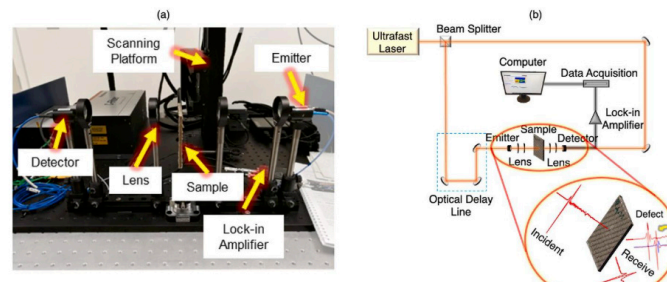


Fig. 3. The photograph (a) and schematic image (b) of THz-TDS systems.

The LST experimental setup contains a cooled infrared camera (FLIR Phoenix, 3–5 µm, InSb, NEdT <20 mK, 640 × 512 pixels) and a linear heat source with a power of 500 W (Visioimage inc. industrial line scan). Additionally, a robotic arm is used to move the samples at a speed of 10 mm/s. The scanning speed has an impact on the amount of energy that is delivered to the samples and hence on the maximum depth at which a defect can be detected [34]. It was determined that the optimal scanning speed is around 10 mm/s in this specific case. At scanning speeds much slower or faster than this, defects appear with lesser contrast.

The THz-TDS system, Menlo Systems GmbH (Munich, Germany), comprises THz spectrometer (compact spectrometer with integrated laser, ADC unit, control computer), THz antennas, and current amplifier unit, as shown in Fig. 3. The system has a 1.2 GHz frequency resolution, typically 4.5 THz spectral range, 80 dB dynamic range, and 100 MHz repetition rate. The experiments were performed in transmission mode. The scanning step was set at 0.5 mm. The main contributions in this work are developing a THz-based resin distribution detection technique and proposing a multi source fusion technique. The details are shown in Fig. 2.

3. Methodology

3.1. Inspection of resin distribution

There are two consequences arising from the uneven distribution of the resin, i.e., the creation of air pockets and the change in fibre orientation. Uneven resin distribution significantly affects the mechanical properties of composite materials. In this paper, a normalized time-domain integration (NTDI) method is used to efficiently and accurately identify the uneven resin distribution [35].

The schematic image of THz-TDS systems is shown in Fig. 3. It is possible to model the received signal T based on Gaussian fitting:

$$T = \sum_{i=1}^N a_i e^{-\left(\frac{x-b_i}{c_i}\right)^2} \quad (1)$$

where a_i , b_i , c_i are the fitting coefficients of the received signal. For general THz-TDS systems, there is always a systematic error, i.e., the incident wave is not a normal Gaussian pulse in the time domain. Of note, the integration of each pulse waveform in the time-domain is negative, which can be given as:

$$\begin{aligned} \Sigma(T) &= \int_{-\infty}^{\infty} \left[\sum_{i=1}^N e^{-\left(\frac{x-b_i}{c_i}\right)^2} \right] dx \\ &= \int_{-\infty}^{\infty} \left[a_1 e^{-\left(\frac{x-b_1}{c_1}\right)^2} + a_2 e^{-\left(\frac{x-b_2}{c_2}\right)^2} + a_3 e^{-\left(\frac{x-b_3}{c_3}\right)^2} + \dots + a_N e^{-\left(\frac{x-b_N}{c_N}\right)^2} \right] dx \\ &= \sum_{i=1}^N a_i c_i \sqrt{\pi} \end{aligned} \quad (2)$$

where $i=1$ $a_i c_i < 0$. By analysing the THz-TDS in transmission mode, it is possible to find that if a THz wave passes through an area with porosities or irregular fibres, a corresponding reflected wave is generated in the time-domain of THz signal. Therefore, it means that the integral in the area of uneven resin distribution is lower than that in the normal area.

3.2. Multi-source fusion technique

In this work, a novel multi-source fusion technique is introduced for three data sources. Two of the data sources are from the same sensors (infrared camera), and own similar data information and imaging mechanism. It is defined as PT-LST fusion. The other data source is the THz sensor, which owns different data information and imaging mechanism. It is defined as IRT-THz fusion. The Dempster – Shafer theory (DST) is used for PT-LST fusion primarily because the main advantage of DST is to deal with uncertainty and conflicts, which are the key issues in homologous data (PT-LST) fusion [36]. The unsupervised network is used for IRT-THz fusion because IRT and THz data have different units of measure, resolution and data characteristics, which is required to capture the complex relationships present in non-linear modelling [37]. Neural networks are powerful non-linear modelling tools that can be adapted to a variety of heterologous data. The pipeline of proposed multi-source fusion model is shown in Fig. 4.

Read More

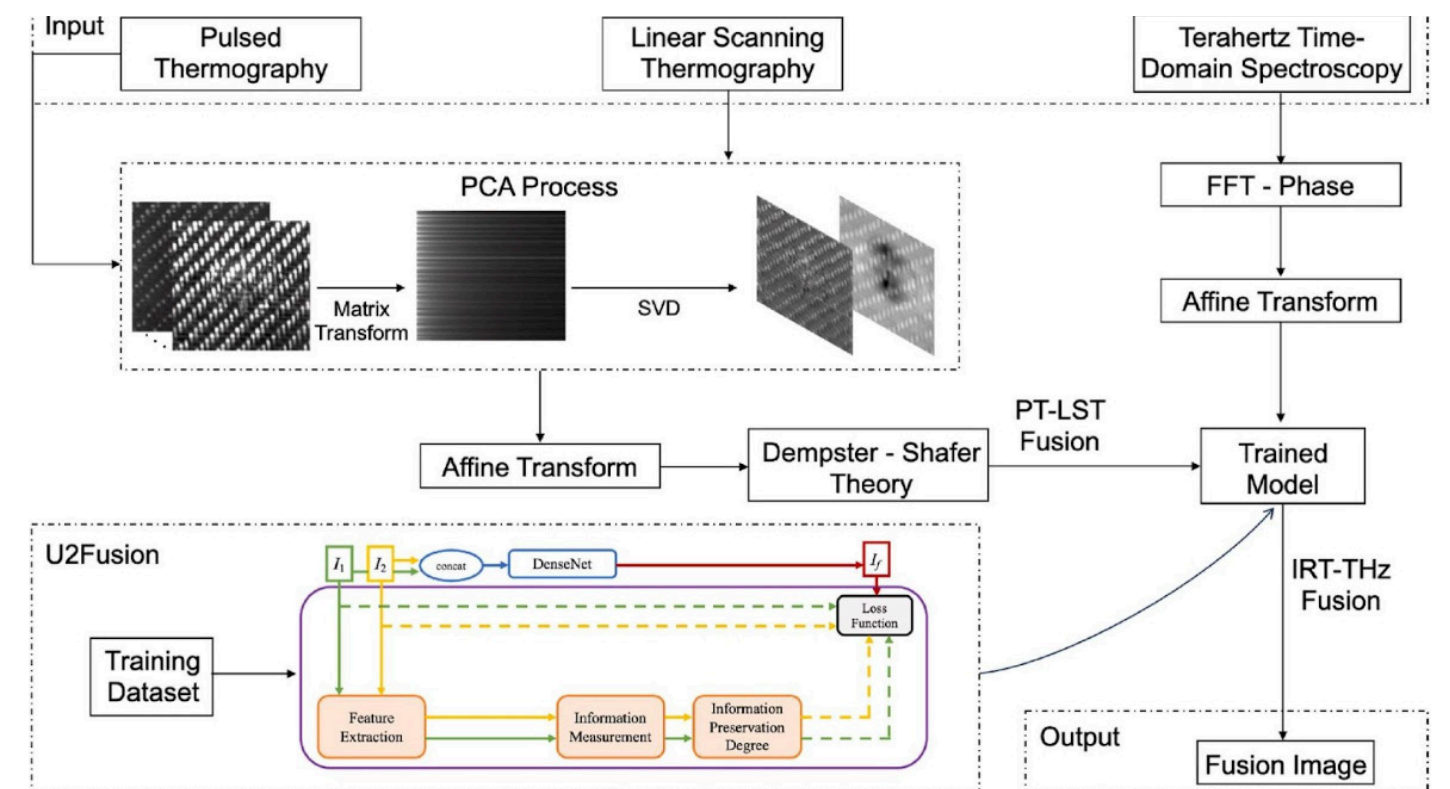


Fig. 4. The pipeline of proposed multi-source fusion model.

YESTERDAYTODAYTOMORROW

CarestreamNDT

At Carestream NDT, we're committed to continuous innovation to create a safer world.

Fieldview is an acquisition and validation software extension of Carestream NDT's powerful INDUSTREX suite. Provided on a rugged, industrial-grade tablet with an intuitive touch screen, it simplifies image acquisition in hard-to-reach places.

Fieldview enables digital radiographic image review right at the inspection point. Verify ID's, markers, proper positioning and IQI sensitivity before moving to the next exposure. Instantly adjust and retake or wirelessly transfer the image immediately to a nearby review station for interpretation.

LEARN MORE

CARESTREAM NDT AND YOU.
WE'RE BETTER TOGETHER.

Carestream.com/ndt

Carestream

INDUSTREX Fieldview

NEW

Meet Venom

Flexible by design, tough by nature.

EKOSCAN

ekoscan-ndt.com
contact@ekoscan.fr

Portable HD Industrial Endoscope

Inspector Plus with HD Revolution

RVI

Infinity

Innovation

ACE ACFMT

Next Generation Portable

ACFMT Inspection Technology

ETHER NDE

LEARN MORE »

THE REAL FLEXIBLE DIGITAL

X-RAY DETECTOR

TRUST THE ORIGINAL!

HD-CR 35 NDT

COMPUTED RADIOGRAPHY SYSTEM

- Unique 30 µm basic spatial resolution
- Scans flexible imaging plates up to 35 cm in width
- Widest range of applications thanks to TreFlo Technology
- Intuitive handling & easy transition from film
- Portable and compact (17.5 kg)
- Powerful D-Tect X software

DÜRR

NDT

Your 38DL and D790

deserve cables that are

designed for flexible,

lightweight, all-

temperature

performance.

ECHO

ultrasonics

Learn more at EchoUltrasonics.com

RADIA Family

Accessible Scientific

Infrared Cameras

TELOPS

EXOSENS GROUP

THORNETIX

SMART TRAINING

Insight, Embedded

Move ultrasonic inspection to robotic platforms while maintaining inspection grade data quality at the point of inspection.

Explore TALISMAN

EVIDENT

What the Experts Use

NEW OmniScan™ X4 128:128PR*

Learn More »

GAMCPR

Close Proximity Radiography

GammaTec

CPR is "The conducting of radiography in close proximity to authorized radiation workers, members of the public or radiation sensitive monitoring devices in such a way as to ensure continuous operations".

www.gammatecsa.com
info@gammatecsa.com

DISCOVER MORE

THE ONLY HANDHELD

ANALYZER THAT

MEASURES CARBON

WITH PRECISION

As the only laser-based (LIBS) handheld with the precision needed for NDT/PMI across all alloy bases, the Z sets a new standard in speed and accuracy. Its powerful high-frequency laser and onboard argon purge enable unmatched performance, excelling in aluminum alloys by detecting key elements like Mg, Si, Li, Be, and B.

SciAps

Lizard

Lizard M8 for Top Side & Subsea Inspection

Advanced Electromagnetic Defect Detection & Corrosion Mapping system for structural & Material Integrity Assessments.

Learn More

42

March 2026

Classified

March 2026

43



Intelligent NDT Management from Site to Report

Software designed for long-term asset monitoring and evaluation.

Explore Now



INSPECTION STARTS WITH US.

As world leaders in nondestructive testing, we offer the broadest portfolio of industrial inspection solutions, from industrial radiography and computed tomography to remote visual inspection, ultrasound, and robotic inspection.

With more than 125 years of NDT experience, we provide safety, quality and reliability for customers around the world.

waygate-tech.com





COMPLETE SOLUTIONS FOR ULTRASONIC TESTING

High-end Plug & Play HW
Phased Array, Multi-Channel UT & FMC/TFM

Applications focused SW
Standard TPAC SW, UT Win & Crystal™
Plug in to CIVA & ULTIS

TPAC UNIQUE IN NDT

www.tpac-ndt.com
contact@tpac-ndt.com



MagnaCheck 4D

Tangential Field Strength Meter

BAUGH & WEEDON NDT

LEARN MORE »



3rd European Green Steel Summit 2025

✖ Steel Digital Transformation Forum

What We Do in the Next Five-year to Meet the Climate Target?

🕒 25-26 March 📍 Dusseldorf, Germany



A large jet engine is the central focus, mounted on a complex metal maintenance stand. The stand is made of dark metal with many horizontal and vertical beams. The engine is white with a dark, circular intake. In the background, a large window with a grid pattern lets in bright light. The overall scene is industrial and technical.

NDT
Trends.

Global NDT Community

Connecting Dots, Elevating NDT

www.onestopndt.com