The world of NDT transitioning from Analog to Digital

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What is NDT?

In the current competitive environment, quality of production and residual life of assets is of paramount interest to the consumer. There is a growing awareness regarding the need for test solutions that aid in identifying defects or provide an early warning method to help avoid significantly adverse consequences. This has resulted in an increasing market awareness, acceptance and adoption of a breed of mechanical test techniques known as Nondestructive Testing (NDT).

Also known as Nondestructive Evaluation (NDE), NDT refers to the method of examining materials and components in order to identify and quantify defects and degradations in material properties before they result in failure.

The aim of the NDT is to ensure the safe utilization of engineering structures, as well as to ensuring product quality and performance upon production. As the name suggests, the aim is to evaluate defects in objects without having to physically break them up and test them. NDT is used to:

- To determine the quality and integrity of the system / components
- To monitor/ control manufacturing process
- To assess residual life of components
- To ensure safe and secure operation of infrastructure and assets

NDT encompasses a host of non-invasive measurement techniques including ultrasonic, radiography, electromagnetics etc, and draws its origin from a number of other areas of non-invasive measurement including medicine, geophysical prospecting, sonar and radar envelops a group of non-invasive mechanical procedures. The final users of NDT systems are the production/maintenance departments of large

- Energy utilities (Thermal, Nuclear Power Plants)
- Transportation Industry (Railways, Aviation)
- Manufacturing Companies (Product - Automobile), (Process –Fertilizer)
- Oil & Gas (Pipelines, Oil Rigs)

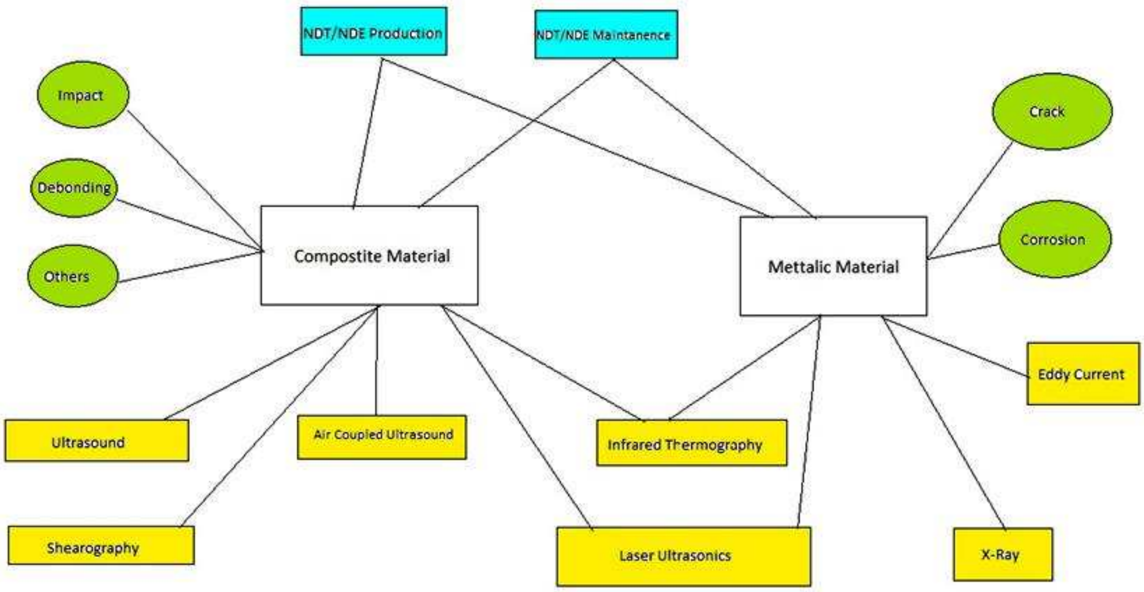


Fig 1 The boxes in yellow signify the NDT techniques.
The ovals in green signify the type of defects that could appear

NDT Today

The Nondestructive Testing (NDT) industry is transitioning from the analog world to the brave new digital world. Industry trends such as digitization of equipment, greater use of automation and rapid development of new techniques point towards greater use of information technology (IT). With increasing sophistication of NDT techniques and equipment - software is becoming the focus of development.

With the focus expanding from just qualitative inspection, to inclusion of quantitative NDT methods, the need to monitor the number of times a defect appears, and store this information has resulted in the need to develop a new breed of equipment that promote digital storage and transmission of data. The influence of computers in this market, to improve instrumentation has been paramount. The ability to interface recordings from the NDT equipment either to its onboard computer or to a separate industrial computer has resulted in the capability to store large volumes of test records. The industry continues to evolve. At the onset, all the Analog applications were directly translated to Digital and no major conceptual changes were made. Currently the industry is becoming more Software driven as the power of the digital revolution drives further innovation.

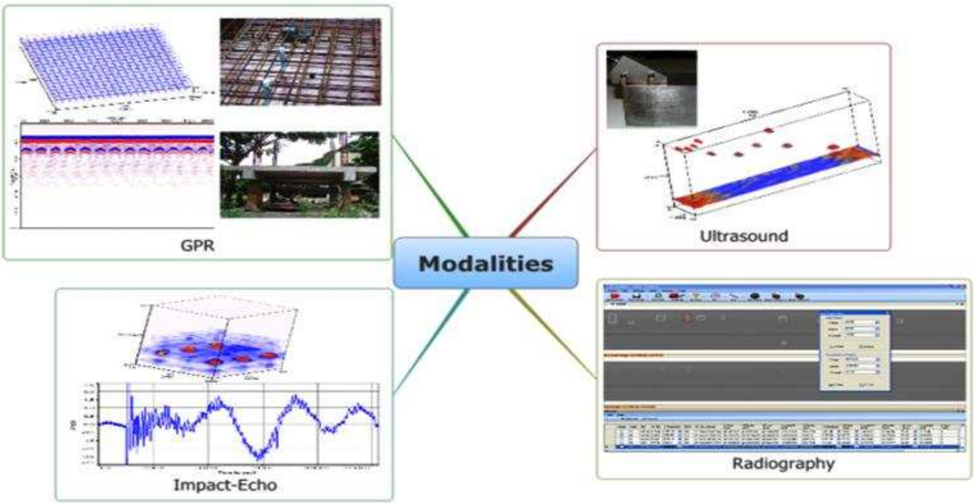


Fig 2 Images from some techniques developed on Lucid's Kovid software platform
(the only multi modal software platform in the industry)

This transition can be understood through the evolution in X ray testing and ultrasound inspection which are two of the most widely practised techniques in NDT.

In Radiography, there has been a growing trend towards real time and digital based equipment that replace film, by introducing digital systems. Furthermore, the integration of techniques such as computed tomography (CT) into NDT has started producing results. CT is very important for Additive Manufacturing

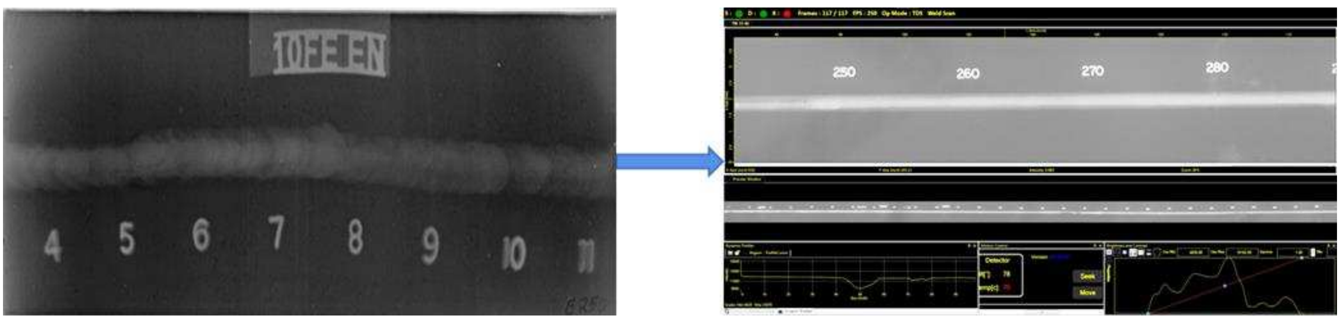


*Fig 3 *Film Radiography (Left)* *Digital Radiography (Right)*

The increasing use of digital radiography lends itself nicely to automation or semi automation of analysis. This is referred to in industry speak as Assisted or Automated Defect Detection. Almost all of the inspection data acquired is analysed by trained technicians and this is the opportunity/challenge in the new world of digital imaging. The Aerospace industry is a good example to understand this situation. The industry has very high quality standards and has adopted advanced manufacturing practices which has brought down rejection rates to the order of 1% or lower. Yes, many of these parts require 100% inspection (welds for example) and inspectors have to trawl through 100% of the data to identify the bad 1%. Further the use of Digital Radiography has ensured that the images produced are of a consistent and reliable nature which makes it feasible for an algorithm to interpret. Most digital x ray images are available as Tiff or Diconde formats which eliminates the data compatibility issue. ADR in turn has opened up avenues for Artificial Intelligence (AI) & Machine Learning (ML)

The world of Ultrasound (UT) presents greater challenges and possibly greater rewards as well. The trend that is slowly coming to the fore is the development of specialised applications for inspection of welds, corrosion mapping etc. The medical industry for e.g. has moved to specialised devices as in UT device for a cardiologist or UT device for a gynaecologist. The NDE industry teams has largely used general purpose machines and depended more on the training and skill of the inspectors for the diagnosis. The significantly greater data volumes and complexity of technologies such as advances in Phased Array are leading to a shift away from general purpose machines.

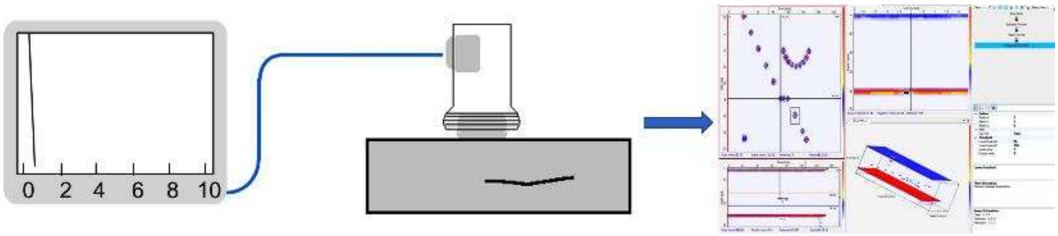


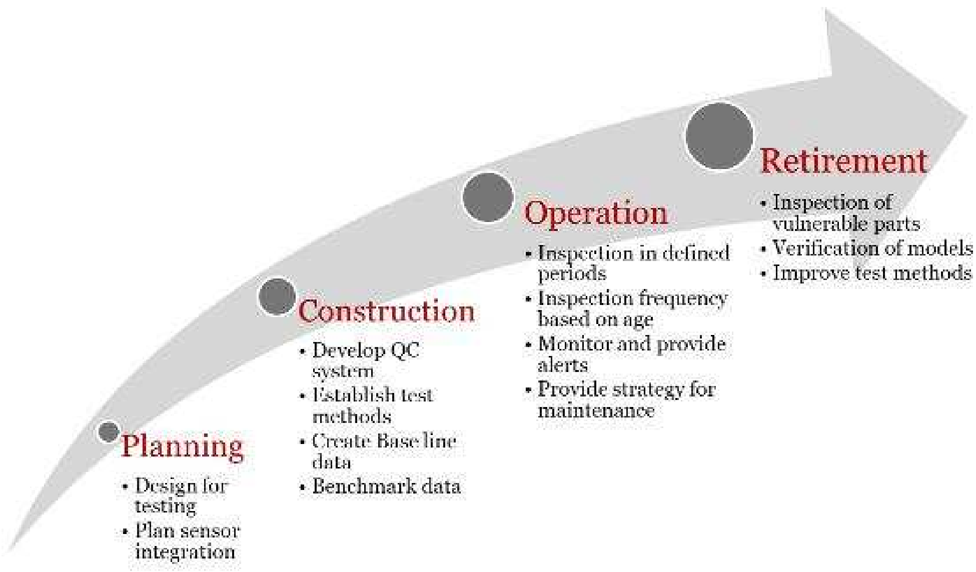
Fig 4 Analog UT (Left) *Digital Ultrasound (Right)*

NDT in Asset Integrity Management

NDT inspections are utilized throughout a facility or products' lifecycle. This cradle-to-grave approach is an important element of asset integrity management**.** Furthermore, NDT inspections provide historical data about the facility's process units and provide information on how often a component should be inspected, repaired, or replaced. Inspection intervals and tests may be changed depending on where the equipment is in its lifecycle (e.g. newly manufactured equipment vs. aging equipment). Performing multiple assessments throughout the equipment's lifecycle may seem expensive. However, inspections conducted at specific intervals may end up saving an organization millions of dollars if testing reveals threats and equipment is repaired before shutting down the facility or experiencing a catastrophic failure. When planning an NDT inspection, there are four considerations one should account for:

1. The type of damage mechanism to be inspected for
2. The minimum detectable flaw size, shape, and orientation of the defect
3. Where the defect is located (surface or internal)
4. The sensitivities and limitations of the NDT method

With the above factors considered, operators can optimize facility production and increase personnel and environmental safety.



Fig, 5 Role of NDT in various stages of life cycle management of an asset

The Future of NDT
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With the industry driving towards digital NDT techniques there comes a need for better storage of data (Cloud), automation of inspections (Automatic Defect Recognition), AI and Robotics to make NDT easier for users and customers alike. Cloud services for NDT data will enhance and simplify the exchange of data between the inspectors performing the test and auditors that are taking decisions based on the results shown by the inspector. Access to information from remote sites and instantaneous decision making to rectify/reject parts produced, or infrastructure will increase the quality standards, reduce costs and minimize safety concerns. It will also be easier to pull up history of a job to check the maintenance requirements for any authorized personnel.

Fig 6 – NDT on the Cloud

Production cycles are getting shorter and shorter and the market is calling for faster Ramp-up times. The development of Automated Defect Recognition (ADR) systems, which detect errors automatically after a human did a component-specific parameterization is in the forefront. This will reduce the time taken to complete Inspections and get you more accurate indications without the human error to account for. ADR is starting to be featured in high critical areas with positive feedback and a recognition rate of about 90% being seen. Through the combination of robotics, 3D sensors and image registration a high positioning repeatability can be achieved without additional components. This system will now be combined with the new AI solutions, reducing the ramp-up process from several days to a few hours.

There are several new opportunities in testing of new materials in both traditional and non-traditional NDT applications. As we move to faster and more complex productions, the advancements in NDT will follow.

Another stride being taken towards the future is NDT inspection through Unmanned Aerial Vehicles (UAVs) or drones. The drone-based NDT inspections provides a wide range of possibilities that take advantage of the mobility of the drone as well as the non-destructive nature of the tests. Drones also are extremely flexible and can be fitted with different types of pay loads that can perform multiple NDT inspections giving comprehensive data of a wide variety. They are also able to access hard to reach and hazardous locations that need to be inspected. Data can be collected remotely with the inspector positioned at a safe distance. For e,g, these tests can help the oil and gas companies to identify defects and reduce the rate of failures and unplanned shutdowns.

The future of NDT is digital, robotic and automatic.

About the author

Madhusudan is the Director of Lucid Software Ltd., a company founded by IIT alumni. Lucid provides software for the global Nondestructive Testing (NDT)/Nondestructive Evaluation (NDE) industry. Lucid's focus is on industries where safety is a critical issue and secure operations are a must. These include Nuclear Power, Aerospace, Civil Engineering Infrastructure, Oil and Gas. Lucid has developed a number of Assisted Defect Recognition (ADR) algorithms for automation of analysis that enhance operator productivity and increase reliability of inspections.

Madhu is the President of the Chennai Chapter of IIMB Alumni since 2009 and serves as the Secretary of IIT Madras Alumni Association from July 2017. His corporate assignments include: Head of European Business @ Future Software Ltd, Business Manager @ Sify, Business Head @ Lucent Power Systems, Sales Manager @ Eicher, and Quality Engineer @ MUSCO. Madhu is an alumnus of Indian Institute of Management, Bangalore PGDM (1991 – 1993) and Indian Institute of Technology, Madras B Tech, Metallurgy (1985 – 1989). He is a professional member of American Society for Nondestructive Testing (ASNT), Indian Society for Nondestructive Testing (ISNT) and Charter Member, TiE, Chennai.