

Smart NDT Tools: A New Generation of NDT Devices

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Abstract. EADS CRC is designing specific NDT solutions for EADS business units. Prototypes appear often to be difficult to turn into industrial tools, because of adaptable device price or the impossibility to adapt existing apparatus to specific uses. That is why EADS CRC decided to have its own electronics developed, aiming at low cost, portable, versatile and easy to use NDT devices. These were designed as computer peripherals so that some smart adapted functions can be more easily implemented and transferred to end-users. Besides, these peripherals are powered via the connection to the computer, which allows their use on portable computers. Under a given environment, the device may use procedures, settings, modelling results as inputs and produce formatted reports, specific imaging or even simply a diagnosis – for instance a “go / no go” answer – as outputs. These developments will lead to a much easier and cheaper use of NDT devices for our end-users, and thus to a much wider dissemination.

1 Initial motivation for developing the “Smart NDT Tools”

EADS Corporate Research Center (EADS CRC) designs specific NDT solutions for EADS business units. Unfortunately prototypes appeared often to be difficult to turn into industrial tools, the reason being either the price of adaptable devices, or the impossibility to adapt cheaper existing apparatus to specific uses. That is why EADS CRC decided to have its own electronics developed. This allows to keep control over the interfacing - signal processing, data displaying and data storage. It makes the device versatile with different possible interfaces and easy to use when well suited to the situation. A parallel aim was to get low cost and portable NDT devices.

This decision lead to the development of NDT electronics as computer peripherals. As a matter of fact, it appeared to be the best solution, in order to have fully dedicated electronics for eddy currents or ultrasounds and to keep control over the post processing, display and storage of NDT data. This combination of specialized hardware and adaptable software makes it possible to quickly design adapted solutions and to transfer them to the end-users. Moreover, computers are widespread by now and most users may already be familiar with this kind of working environment.

Figure 1 illustrates the Smart NDT Tool concept. Since it is computer based, under a given environment, the device may use multimedia procedures, associated settings, modeling results as inputs and produce formatted reports feed a database, show information under a specific imaging form or even simply give a diagnosis – for instance a “go / no go” answer – as outputs.

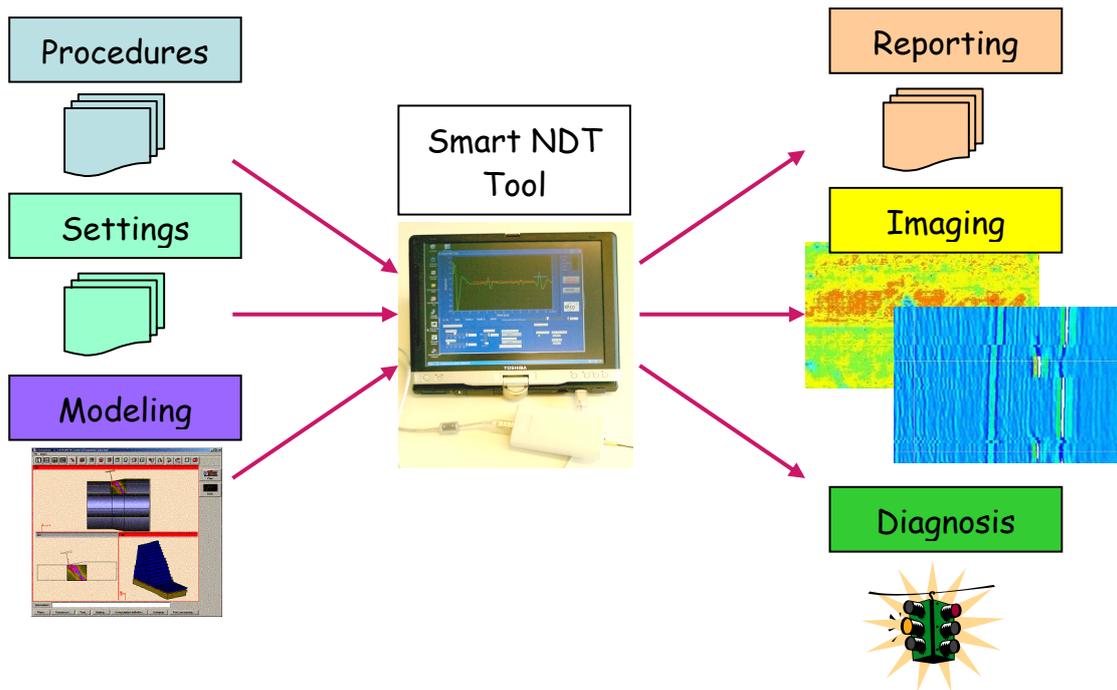


Figure 1: Smart NDT Tool concept

2 Hardware realizations and software solutions

2.1 Hardware realizations

To build the Smart NDT Tools, we chose Universal Serial Bus (USB) port for it is widely implemented now and it allows to power the NDT device. Thus it can be used on portable computers as well. The concept of NDT device, controlled and powered via a computer port, and open to programming, was patented by EADS CRC in August 2004.

Eddy current Testing (ET), Ultrasonic Testing (UT) and phased array UT 8x32 devices were developed as prototypes. Figure 2 shows what they look like physically for the time being.



Figure 2: Smart NDT Tools in UT phased array, UT single channel and ET versions

2.2 Software solutions

Several interfaces were developed, first to test the ability of the hardware/software combination as NDT devices. The first aim of Smart NDT Tools is to transfer easily solutions to our business units that are prototyped in our lab. Thus the first objective is to satisfy these needs. That is why UT single channel device together with a home-made user interface was submitted to Airbus NDT specialists very soon. Their suggestions, remarks, requirements were taken into account to improve the system.

Then first interfaces were derived or re-designed to comply with given application cases. First application cases were defined together with some Airbus NDT people.

2.2.1 Generic interfaces

Figures 3 and 4 hereafter are some snapshots of generic user interfaces.

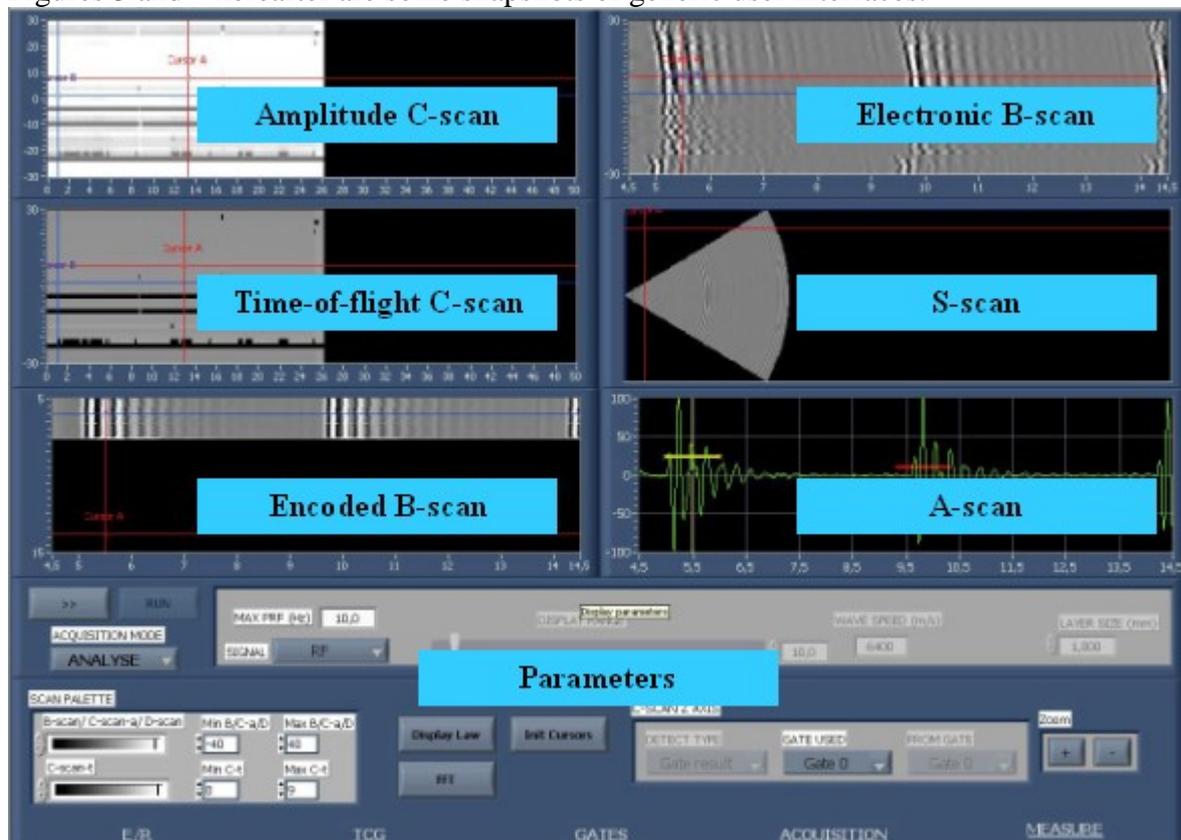


Figure 3: UT phased array device, test of displaying tools

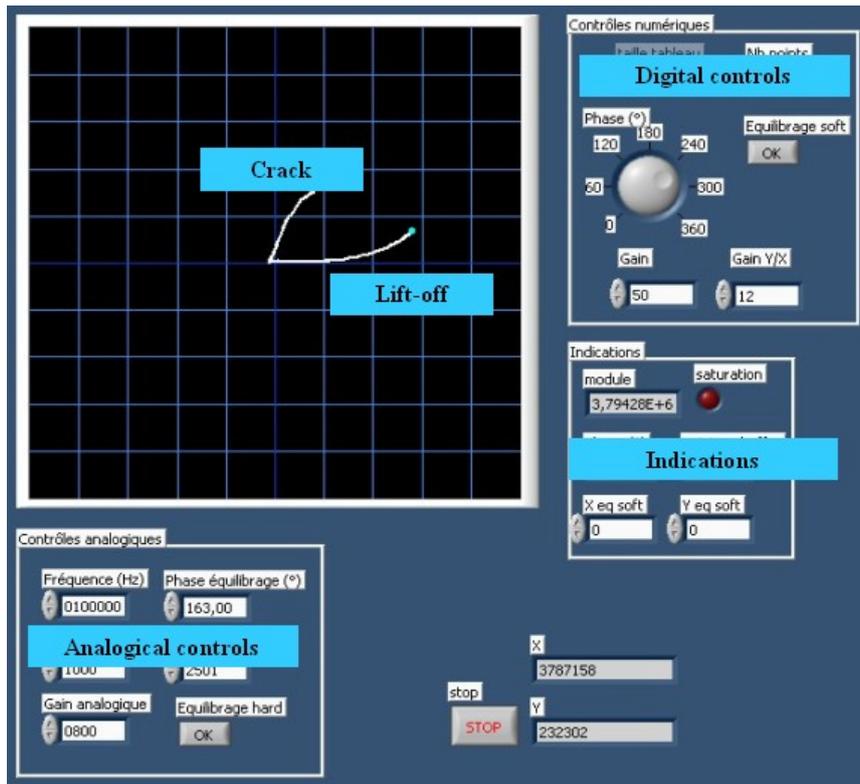


Figure 4: ET device, test of balancing algorithm and detection ability

Following requirements by our end-users, our own ideas or special needs, first generic interfaces were re-designed or simply derived.

2.2.2 UT single channel device specific interfaces

The first use of this device outside EADS was in a research project funded in the 5th Framework Research Program of the European Commission. This project was called INDeT which stands for "Integration of Non Destructive Testing". It aimed at taking advantage of Information Technology (IT) tools in the present aeronautic maintenance environment. One of the main outcomes of the project was a demonstrator called "Multimedia Maintenance Portal", giving access to multimedia procedures, on-line assistance, a troubleshooting expert system and NDT tools driving. UT first interface was adapted as NDT tool driving to comply with other parts of the demonstrator. This project was an opportunity to test many tools:

- Hand-free parameter adjustment thanks to voice recognition.
- Interface modification according to user level.
- Display on the same support – a tablet PC in this case – of NDT device interface and multimedia procedures. Interaction was envisaged but not implemented because it was not planned in terms of time and resources.
- User identity check with a biometric USB key as "digital signature".

Moreover, during the project, some airliners and maintenance centers were interviewed about introducing modern IT tools in their work and about the final demonstrator. Both interviews were welcomed and gave good results. It comforted us in our work. A fully IT-equipped NDT operator is less and less science-fiction, since more and more things are made possible at reasonable cost.

Besides, Airbus asked us to work on thickness measurement issues. Parts concerned are plates made of CFRP for which the design office requires precise thickness assessment.

We implemented several signal processing methods and tested them against standard thickness gages: peak-to-peak time of flight, correlation, Fourier transformations handling, averaging. See on figure 5 an example of thickness measurement with peak-to-peak time of flight and averaging.

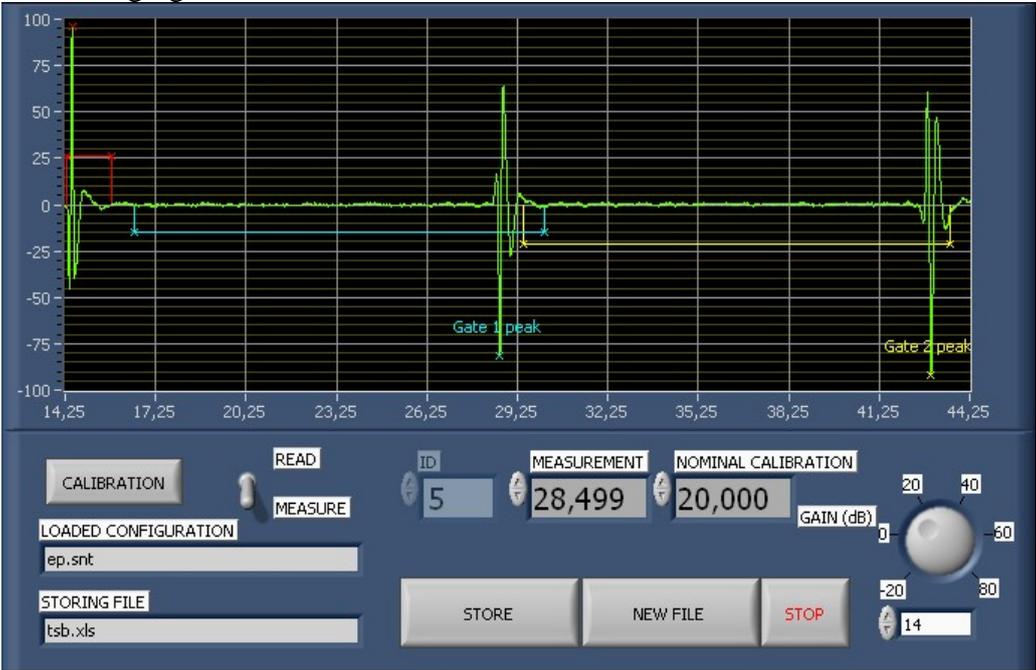


Figure 5: Example of thickness measurement based on peak-to-peak time of flight and averaging

After the choice of the most appropriate method, we modified the software part to get as close as possible to what NDT operator are used to. In this case, the interface specification work is easy because there are some existing comparison elements. Final decision is now in the hands of Airbus NDT specialists according arguments summarized in Table 1. The main remaining issue is calibration because it relies on a reference measuring method. It appears to be difficult because of the precision required.

Table 1: Consequences of a “Smart NDT Tool” choice for thickness measurement

<i>Drawbacks</i>	<i>Advantages</i>
Weight and size, because of the PC, even if it is a really compact one. Need for the operators to get used to a new device.	Control by qualified NDT specialists of measurement method. Precision of the method. Possibility to customize. Possibility to use the device for other ultrasonic measurements.

2.2.3 ET device specific interfaces

Specific tools were implemented with eddy current testing device, adapting the generic interface. The two major ones are measurement tools. The first one measures conductivity of metals, giving a result expressed either in MS units or in %IACS. The second one assesses thickness of non conductive layer – like painting or primer – deposited on metal. Figure 6 is an illustration of this tool.

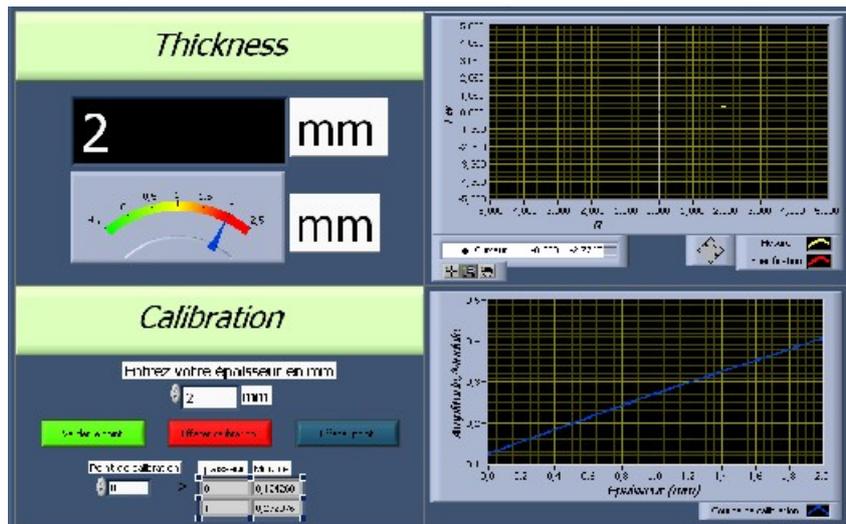


Figure 6: Illustration of thickness assessment interface

The next tool should be able to detect and assess scratches, displaying a simple signal such as a traffic light. The idea behind is to have a prepared device setting and a specific signal processing that are designed by NDT specialists, in order to allow low qualified operators to carry out the task. In this case we have to design a specific probe, too. This application case was inspired by the needs of NDT people in final assembly lines, where many people work around an aircraft and have the risk to hit it with their tools. This kind of implementation is a good illustration of making “NDT Tools” “Smart”. Still the interface has to be defined and validated.

2.2.4 UT phased array specific interfaces

UT phased array standard interface was based upon UT single channel one, with additional features related to focal laws or to displaying abilities for instance. The first specialization scenario deals with inspection of stiffeners on composite panels. This application case was submitted by Airbus.

As a matter of fact, in production, the overall surface of composite panels is controlled by immersion UT. Where there are stiffeners, immersion UT is not efficient and these areas are inspected manually with monolithic transducer, which lasts a lot. The goal is to quicken and to enhance the control by using phased array UT. Corresponding Smart NDT Tool seems to be a good candidate because of its lower price compared to other phased array devices and because of its ability to fit exactly the needs in ergonomic terms. Whatever the choice of the electronics, this application also requires to design a specific probe and probe holder. This is part of the solution we will deliver.

3 Next steps for Smart NDT Tools

3.1 Different environments, different objectives

Next steps differ depending on the field of application.

In production, mainly in EADS business units, we aim at a consolidation of the first identified application cases, and a wider and wider use thanks to the adaptability and low cost of Smart NDT Tools. In a mid term the goal is to develop instruments based on Smart NDT Tools, approved by qualified people and then simply used by operators.

In maintenance, the INDET project proved that the use of Smart NDT Tools could be very useful. Discussions are on-going with customer supports of different EADS business units in order to introduce some INDET project results in their maintenance policy.

In academic environment, Smart NDT Tools could be used in two ways: either as a mean to train students, to show living examples of ultrasonic testing, of signal processing, of image processing; or as an opportunity of partnership between universities and EADS CRC for new developments.

3.2 Other perspectives

Of course, Smart NDT Tools may be used outside EADS. They are still low cost NDT devices open to programming. On the other hand it is not the vocation of EADS CCR to manufacture and sell industrial products. That is why we contract license concessions with specialized companies. They are free to sell Smart NDT Tools but they are bond to special conditions with EADS business units.

Besides, new developments are on-going:

- 64 channel full parallel UT device. It will enable a much wider range of phased array applications.
- Combined UT/ET device on a single electronic card, to supply NDT operators with an “all-in-one” hardware solution.
- Integration of a coder on UT device to enable encoded acquisition. An application would be the assessment and sizing of ply waviness in composite parts.

4 Acknowledgements

We would like to thank EADS Corporate for funding this project and our NDT colleagues of Airbus for funding this work and giving their requirements and feedback for our developments. We also want to thank the European Commission for funding INDET project which was a great opportunity and motivation for Smart NDT Tools.