Improving the productivity of ultrasonic inspections with digital and mobile technologies

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In recent years, digital and mobile technologies have made electronic devices smaller, lighter and more powerful. They have also made dealing with data seamless and have enabled immediate collaboration. However, despite these changes, ultrasonic inspection devices that are present on the market have not changed much. They remain difficult to learn, featuring small screens and numerous buttons on outdated hardware. Their reporting and collaboration capabilities are limited. By comparison, today’s mobile devices e.g. smartphones and tablets, are thousands of times faster compared to the computers that landed man on the moon 50 years ago.

This paper will introduce mobile-first ultrasonic inspection solutions and will demonstrate how they deliver three main benefits to asset owners and inspectors alike. They greatly improve the user experience and flexibility of ultrasonic flaw detectors, thus reducing the time for new users to become competent users. They reduce total product costs and improve inspector productivity due to gesture-driven user interfaces. They lead to more accurate, timely and consistent results with less effort and potential for errors.

As a result, we demonstrate how mobile and digital technologies will beneficially disrupt the traditional way of performing inspections and of managing the life-cycle of collected inspection data.
1. Introduction: Purpose and history of Ultrasonic NDT

The 1960s and 1970s saw the introduction of industrial instruments for ultrasound testing of products, equipment and infrastructure assets. Such tests were designed to ensure that there were no defects above the target size, to classify and track major defects and to quantify their size. Since then, the use of Ultrasonic Non-Destructive Testing (NDT) has become commonplace for quality assurance. Ultrasonic NDT is currently used in a number of industries, including construction, engineering, aviation, oil and gas (O&G) and transport. The information collected on the part being examined is typically used as input to models to predict the remaining life based on fracture mechanics.

It is important to note that the inspection end user usually does not care for nor is interested in the type of instruments employed or the inspection process that has been performed by staff. The end-customer needs a solution that meets the proven quality-assessment framework as easily and as quickly as possible.

2. Ultrasonic NDT: Current situation and realities

We identified and addressed three major areas of concern related to the end-to-end Ultrasonic NDT inspection process as described above. We did this by observing and interviewing NDT equipment users in manufacturing and service environments. [REF (1)].

2.1. Legacy equipment for experts by experts

If we deconstruct a modern ultrasonic flaw detector into its main components, we can study the issues for inspection legacy systems used for inspections. We do not consider the electronics to be differentiated across competing flaw detectors, the hardware specifications have been consistent for decades and is not a source of pain for inspection operators.

2.1.1. The ultrasonic flaw detector display

The display is a fundamental part of inspecting. The operator using the flaw detector must closely monitor the A-Scan on the display to look for discrete changes caused by indications. Current flaw detectors have display screens built on top of the ultrasonic electronics. These screens can vary between a size of 2.5” to 7”, be monochrome or full colour and have refresh rates up to 60Hz. With larger screens, the devices are heavier, so typical flaw detectors weigh between 400g to 3kg. The operator must make a trade-off between a big, heavy screen or a lightweight, portable device. The big, heavy device is difficult to carry for the 10-12 hour shifts an operator typically works and cumbersome to put into a position so the screen is viewable easily while the operator is scanning the part.
With small, lightweight devices, the operator risks eye strain from viewing a tiny screen and would also find it problematic to review data and report the results at the inspection location.

2.1.2. The ultrasonic flaw detector software

Most of the available NDT equipment nowadays not only looks complex (especially to the untrained eye), but it is also complicated to operate. As a result, the market for Ultrasonic NDT equipment is rife with products featuring an “everything but the kitchen sink” approach to features; complicated menus imposing a high cognitive load on the operator even for the simplest of inspection jobs; and cryptic design decisions that force users to become familiar with how just one piece of equipment works. In our observations, we have seen operators reject to use certain equipment because they “have never used this set before” despite them having the required qualifications to allow them to test.

Even if there is at worst no impact on the outcome of the inspections and at best a significant increase in productivity, a reduction in manual error is well proven from a system that is easier to operate.

These legacy devices have been developed irrespective of their increasing outdatedness and unevenness to the needs of the market, because they are difficult to replace, particularly if they have been validated alongside the procedure or form important business processes within the company [REF (2)]. The perceived risk of changing the status quo by switching to the latest technology may be too high if the process of setting critical inspection criteria is different from that of the legacy system.

2.2. Incomplete traceability

Until today, NDT equipment operators have had to manually document the measurement procedures in such a way that they can prove that the required guidelines have been followed and that the instruments and probes used have been properly calibrated and verified. To date, this type of activity has been entirely manual. It also suffered from fragmented sources of information, a lack of overview of the operator's step-by-step workflow and any changes or deviations from the original procedure. Such problems have led to a lack of traceability throughout the process.

2.3. Complex, time consuming reporting processes

Communicating a result in the field has traditionally been both one of the most time-consuming tasks within an end-to-end inspection process, and yet also the most overlooked task. Our field observations [REF (1)] have shown that the time spent on this task can be a factor between one and two times the actual time spent on the measurement task. The sharing of findings has become an important element of the inspector’s job when dealing with colleagues on a large plant, back-office, suppliers or consumers.
To date, data have usually been stored on paper, on the NDT system itself, or on removable storage; all three options with a high risk for data to be noted incorrectly on paper, to be overwritten or face the fate of a broken/malfunctioning/stolen or otherwise unavailable NDT system, or to be corrupted or lost if stored on e.g. a USB drive. Even in the case where data have been successfully stored and retained on such electronic equipment, the working process after the inspection relies on a manual export of data, followed by the import of this data into PC software tools to analyze the data, derive insights, and generate a reporting document with the findings.

This is not only a long and laborious process, but also one in which the place, time and means of evaluation and reporting are usually somewhat different from those of calculation and data acquisition. Experience with the implementation of the "Lean" principles [REF (3)], in manufacturing and other types of operations, has demonstrated that the increasing separation of such steps in the end-to-end inspection process is a driver of delays, errors, misunderstandings and an overall reduction in quality, together with an increase in the lead time between the inspection requested and the verdict delivered to the end-customers in the form of a clear, comprehensive and comprehensible report.

3. Current state of technology

Nowadays, smartphones, web-based email services, wireless connectivity and on-demand streaming are consumer products that we mostly all take for granted. Mobile devices of the latest generation have shown how operations can be simplified to a level where even children or elderly persons without prior exposure to such technology can make use of them.

Whilst the adoption of today’s digital technologies is obvious and easy to demonstrate in consumer-facing applications (including in those utilizing medical technologies), the speed of adoption has paled by comparison in the NDT industry, its customer industries, and its vendors of inspection equipment. The combination of this laggard behaviors means that established inspection processes and workflows have, unsurprisingly, stagnated.

In many of today’s commonly used applications, social media networks and platforms, such as Facebook, Dropbox, Skype, and Amazon, user interfaces have many layers of customization options, in order to satisfy their diverse user base—especially given the multitude of applications and use cases that the products need to address. That diversity and multitude are also why the development teams of such products have emphasized the design of attractive, habit-forming user interfaces for their apps. This pursuit of simplicity typically does not exclude more-expert usage of the app by those able and willing to do so, as a more detailed configuration of advanced settings can be done in hidden interface dialogs. At the same time, new users can immediately start using these tools without any prior knowledge of the product itself—and, for sure, without any need to read printed
documents, such as leaflets with Operating Instructions or thick User Manuals composed of more than 200 pages.

The "Internet of Things" (IoT) is a phenomenon that is evolving and is still in the early stages of growth. We created [REF (4)] our own definition of IoT as a network of accurate measuring sensors connected to mobile devices and securely connecting these mobile platforms through the Web to allow for interaction with other systems. This includes interactions within the complex social system of the inspection job’s operator(s) and stakeholders.

4. Overcoming these issues using the latest consumer technology

In the following sections, we will go into the details of how ultrasonic NDT can use today’s technology to address the issues mentioned. It will also be demonstrated how addressing these issues can allow the inspector to concentrate on value-adding operations that ultimately support the end-customer’s goals. One side-effect is less effort spent on secondary, low-value-adding aspects of their role, such as reporting, and data storage and management. Another, farther-reaching side-effect is the beneficial impact of those ideas, concepts, and countermeasures on the role of the inspector itself, its attractiveness, future orientation, and by extension on the trajectory of the inspector pool and the wider NDT industry.

4.1. Vast improvement in business continuity with easily accessible spare parts

The most common repair / replacement to inspection equipment found in our study was usually a cracked display or faulty battery pack. The existing process to repair the unit was to send the unit back to the local representative, or to the main OEM’s facilities and raise a purchase order for the replacement part. Typically, we found that the whole process was at least 3 weeks. These weeks are where the device cannot be used, and therefore the inspection service provider, whether a large organisation or sole proprietor cannot sell their services. Based on a 60-hour working week at a charge out rate of $25 per hour, this downtime results in lost revenue of at least $4500, plus the cost of repair. The service provider would therefore need to keep extra inventory on stock to cover for the risk of this downtime, in turn increasing their overhead. If no replacement is available mid inspection, then the service provider risks financial or reputation damages if the work cannot be completed.

New devices, for example the Proceq UT8000, have split the ultrasonic electronics away from the display and made use of consumer products, like the Apple iPad for displaying the A-Scan and uses standard AA batteries for power. The operator can now choose a comfortable screen size based on their ergonomic preference and no longer has the trade-off on screen size and weight. Typical weights that are in the operator hand now range from 300-700g including a protective case and screen sizes are from 7” – 11”.
With off-the-shelf consumer spares, replacement screens, and extra battery packs can be purchased in all large supermarkets or electronics stores worldwide. If the device has a cloud connection, all the previously collected data is safe in the cloud and the operator can continue the inspection, using the same settings as before the interruption, maintaining traceability and business continuity.

4.2. Video tutorials for bite-sized learning on the go

Nowadays, online videos represent an instant source of knowledge for millions of people. If one video is not enough, there will surely be another in the sidebar (of, e.g., YouTube) that could fill any gaps in knowledge. Quick-and-dirty how-to videos have greatly accelerated the process of skill acquisition.

The video classes are far more engaging and interactive in nature than the print-media tools. Numerous subjects that are difficult to understand are made easy through videos. It is easier to learn quicker visually, and it has been shown that viewers retain 95% of a message when they watch it in a video compared to 10% when reading it in text [REF (5)]. Therefore, videos can be found on the student-inspector’s smartphone or tablet. Another advantage of videos is that user does not need to be fluent in the language to understand them. In some cases, videos can even be language-neutral.

4.3. Improve productivity end-to-end

If we take an approach to inspection focused on the “jobs-to-be-done” [REF (6)], the customer of the inspection service needs a reliable result: for example, to confirm that their asset is suitable for use for a defined period, or to understand the extent of the defects found and so decide on repairs needed – or to scrap the part. Typically, this result is in the form of a paper-based report that needs to be archived for a long period of time.

Contemporary mobile devices use secure cloud-storage and immediate synchronization of data with other partners in collaboration or the distribution of reports to external parties. A browser-based software product also enables access to data regardless of location, time or hardware platform. Predefined templates for common export file formats such as PDF or CSV are used to share results outside the secure ecosystem. Direct report generation and immediate access to the inspection data results in significant time savings by eliminating waiting times and transcription errors.

The same technology can be used to support vendor site assistance, as it is becoming increasingly difficult and costly to deploy vendors to remote site locations worldwide. In initial tests of these new technologies, studies have shown that savings of up to 35% have been achieved on inspection costs using remote support [REF (7)], which can enable quicker feedback and speed up critical decision-making.
5. Conclusion

It has been shown that the progress of digital technologies opens new opportunities to address chronic pain points of Ultrasonic NDT inspectors. Such advances future-proof the role of the inspector by increasing ease-of-use with user-friendly and intuitive user interfaces, higher accuracy and efficiency by reducing errors and rework in workflows, establishing traceable procedures with less effort and potential for errors, improvements in business continuity and enabling unobstructed data sharing for collaboration and quality assurance.

6. References