Remote NDT

Field Applications and User Cases

Philippe Rioux[1], Jonathan Turcotte[1]
Sonatest
305-2900 Quatres Bourgeois Québec, Québec, Canada
Phone: 1 418 683 6222 x117 and x120
e-mail: riouxp@sonatest.com
turcottej@sonatest.com

ABSTRACT

The remote control capabilities of instruments nowadays ease the development of new NDT applications, especially in harsh environments or restricted areas where it can be difficult to bring together measurement instrument and technician. On the other hand, the introduction of cloud technology is another advancement that unlocks the possibilities of collaboration between remote experts and field troopers. This paper explains the challenges and benefits of using such innovations in the field of NDT measurement instruments by presenting two customer cases. The demonstration includes a case of remote control on a deported instrument over a local but relatively long distance and a case where a delocalised expert supports a technician live on site over a mobile network.

Keywords: Remote control, Remote NDT, Cloud, Network, Internet, Mobile, Delocalized, UT, Ultrasonic, Phased Array, Embedded, Field Support

1. INTRODUCTION

With the efforts of innovative manufacturers at integrating today's technologies in their designs, new portable ultrasonic flaw detectors are now following the path of smartphones where mobility is the key. Taking these efforts jointly with the growing accessibility of high-speed mobile networks, this releases instruments from being locked in the users hands as it is now possible to remotely connect, control and transfer data from the field to anywhere around the world.

From the point of view of an inspector, his1 flaw detector instrument can be his best friend as well as become his worst enemy when facing difficulties. So there are significant advantages at extending reach and collaboration through connectivity to ease the work of those field troopers. Today, new tools are developed to deliver better results and the integration of remote control solutions is another practice helping to optimize inspection results by minimizing human errors for instance.

Taking into account that the "remote solution" concept opens the possibility to extend distance between the location where the inspection is done and the inspector, this paper will focus on two approaches:

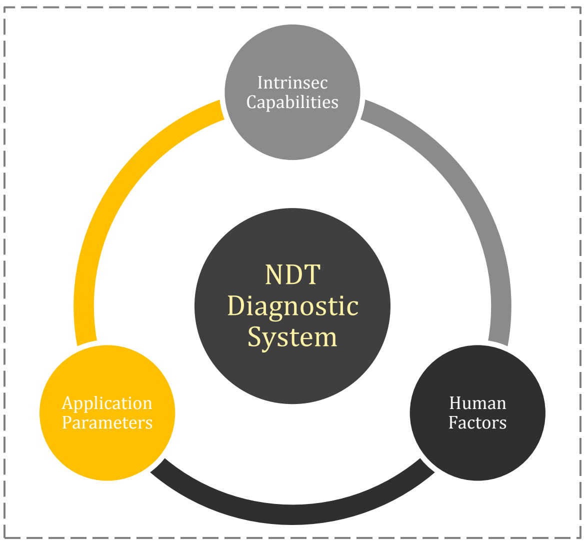
- Deported inspection allowing users to extend reach and
- Live and direct support from a remote layer of experts.

2. An NDT Manufacturer Involved in a Reliability Model

Generally speaking, NDT technicians are dealing with major environment changes from the time they practice in a laboratory or a school to the level of field applications. In fact, the setup for their qualifications and exams does not always reflect the reality of the day-to-day life of an inspector. For example, at many occasions an inspector has to maintain an uncomfortable position to perform the inspection of a critical component and, for this reason alone, it can create a distraction. This important topic retains the expert attention from around the world as it will for instance, be discussed at the 7th European-American Workshop on Reliability of NDE.2

In order to improve practices, the NDT Diagnostic System based on the BAM Modular Reliability Model[3] contains four elements of analysis: the Intrinsic Capabilities, the Applications Parameters, the Human Factors and the Organisational Context. The figure 1 demonstrates the interrelations of these elements for an ultrasonic measurement system:

Figure 1: Organizational Context



- **Intrinsic Capabilities:**
  Pulser/receiver(s) acoustic performances, electronics capabilities, software features, user interface and all the physics around it.
- **Applications Parameters:**
  Inspection plan parameterisation, UT coverage, encoding, surface conditions, work/field conditions of application, etc.
- **Human Factors:**
  User experience, understanding of the procedure, communication, impact of the field conditions of application, etc.
- **Organizational Context:**
  Management culture, business reality and the operational impacts of a NDT task.

According to this model, even if the inspector is qualified and masters the technique, external factors like time, schedule or peer pressure may affect the quality of his work. This context combined with the fact that people can be affected by the NDE results; put pressure on the inspector, knowing the consequences of a call (or a false-call) may trigger a long chain of decisions, with significant impact on work in progress and costs. Without quantifying it, an important point raised by Greg Selby from EPRI4 in one of his presentations is that these effects are real and technologies should play a key role to improve not only reliability and Probability of Detection (POD), but also human factors.

Generally, the implication of the measurement instrument is limited to its technical performances, but now with the availability of high-speed mobile networks and remote access technologies, innovative NDT instrument manufacturers can also help to improve some of the human and organisational factors. Two user cases on this will be presented in the next sections of this document.

3. Remote Solutions & Networking Advancements

Network & Performances

When talking about remote solutions for NDT, the network technology is a key element as it will directly drive the performances of the solution. First there is the network design that can be a Local Area Network (LAN) or a Wide Area Network (WAN), then the hardware technology backing it, like a wired GB Ethernet or a wireless Wi-Fi router and finally the Internet source coming from a land "fix" or a mobile carrier. These concepts are exposed in figure 2.

Figure 2 Networking Models

LAN network | WAN network | Wi-Fi or Ethernet network | Mobile or Fix carrier

Now regarding the performances, the data rate (MB/s) is the main metric that can be measured but this metric can also be transferred to a video data rate or Frame per Second (FPS), which represent the amount of images refreshed per second for video monitoring.

Availability of the Technologies

To exploit full potential of the networking and communication tools, massive investments for fixed and mobile internet access are made every year in the development of data centers and infrastructures around the world. Since the development of remote technology is based on these networking performances, accessibility for remote solutions are getting more and more a reality globally and we see more solutions serving different markets. The figure 3 contains colored maps where connectivity has been installed.

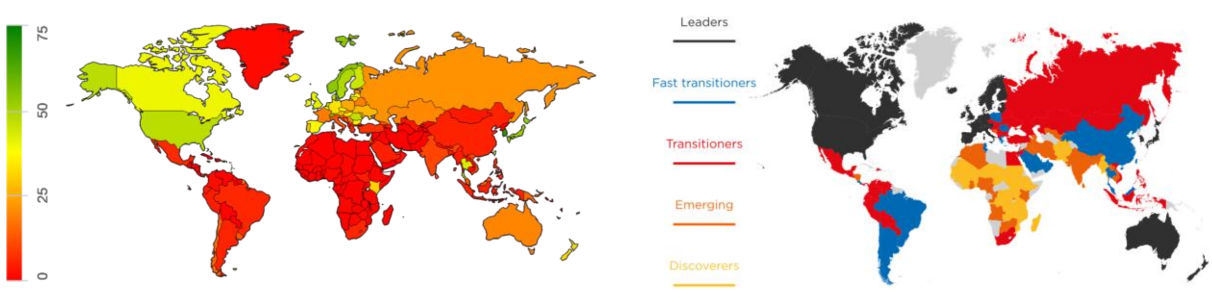


Figure 3 15 Mbps Broadband Availability 2016 [5] and Mobile Connectivity Index Map 2016 [6]

Like computers and smartphones, innovative NDT instrument manufacturers follow the same mobility trend by embedding connectivity technologies in their design. From there, it becomes very simple to remotely connect to an instrument and develop a local remote control solution for instance. These remote solutions can be extended even further when connected to Internet using a hotspot mobile aircard or the simple tethering function of a smartphone. When combined together, all these separate advancements can give a real advantage to optimize processes and support technicians in the field.

Today, the manufacturers who invest at developing connectivity functionalities in their NDT instruments normally target high end product lines first because these are fully loaded with quality electronic components and cutting edge piece of software that can support such technologies. In the case of this paper, the instruments used for analysis is the Sonatest veo+ phased array ultrasonic flaw detector, but it is normal to think that these technologies will soon be integrated in other instruments like conventional flaw detectors or even thickness gauges per example.

Figure 4 Sonatest Connected Instrument

For the purpose of this paper, tests have been conducted using the Sonatest Veo+ and UTLink remote control software solution to measure performances using different network configurations. From the results shown in the table below, remote video monitoring of the instrument can be done with excellent results when using a fix Ethernet or Wi-Fi LAN network. Interestingly, when passing through an Internet link, the remote performances were also acceptable down to a mobile 3G network. This result shows that the solution presented here is applicable not only to local users, but also to deported users that can be anywhere around the world as long as they have a decent 3G mobile internet access.

Table 1 Connection in Numbers

Type of Connection	Data Rate Specs (Typical) MB/s*	Equivalent FPS**	Download typical time for a 250MB file
Local Area Network (No Internet)			
LAN - Gb Ethernet	125 (118)[7]	315	3 sec.
LAN - Wi-Fi (N)	75 (1 to 12,5)[3]	3 to 33	20 sec. to 4 min.
Wide Area Network (Via the Internet)			
WAN - Gb Ethernet from 100 Mbps broadband	12,5 (12,5)	33	4 min.
WAN - Wi-Fi (N) from 100 Mbps broadband	12,5 (1 to 12,5)[3]	3 to 33	20 sec. to 4 min.
WAN - Wireless from a mobile LTE or 4G	37,5 (1 to 15)[8]	3 to 40	17 sec. to 4 min.
WAN - Wireless from a mobile 3G	5,25 (up to 3,75)[9]	Up to 10	11 min.
Minimum real time display rate performances to be workable using a veo+	3,75	10 FPS [10]	-

*MB/s = Mega Bytes per second, converted network speed (1MB/s = 8Mbps). Those numbers depend on the mobile provider, signal quality, distance and walls.

**FPS = Frame Per Second data rate conversion, it represents the display refresh rate.

4. Remote Solutions & NDT

In the NDT market, the benefits of a remote solution is not always for the end user only, as it can be explained in the second section, the outcomes of the NDT inspector job can have huge impacts on the organization. A remote solution can help access to weak location faster or simply improve efficiency via collaboration between the site inspector and internal experts or even external resources (contractual level 3, remote experts).

Typically, remote software could transmit the complete inspection data set in real time to perform the live analysis on the remote computer. This approach requires very high data rate performances usually available from a local wired network but is definitely not designed to run over the mobile network because of the limitations of the carrier technology available today. A lighter approach based on remote video monitoring is however available and, as seen in the table 1 performance results, this one is much more compatible with mobile networks, as well as high-speed local wired network of course.

Based on the information presented earlier on this paper, a typical remote control solution can be divided in three sections: the remote software, the network and the instrument (see figure 5). According to the technology embedded on the instrument, the remote video monitoring will require different data rate performances from the network.

1- Remote Software

Expert will normally use proprietary software associated to the instrument manufacturer to do remote video monitoring or data transfer.

2- Network

Wired or wireless, this is the communication pipeline between a remote expert and the site, the selection is made according to the technology availability.

3- NDT Instrument

This is the instrument in the field that is used by the inspector and that will be connected to the network for remote accessibility.

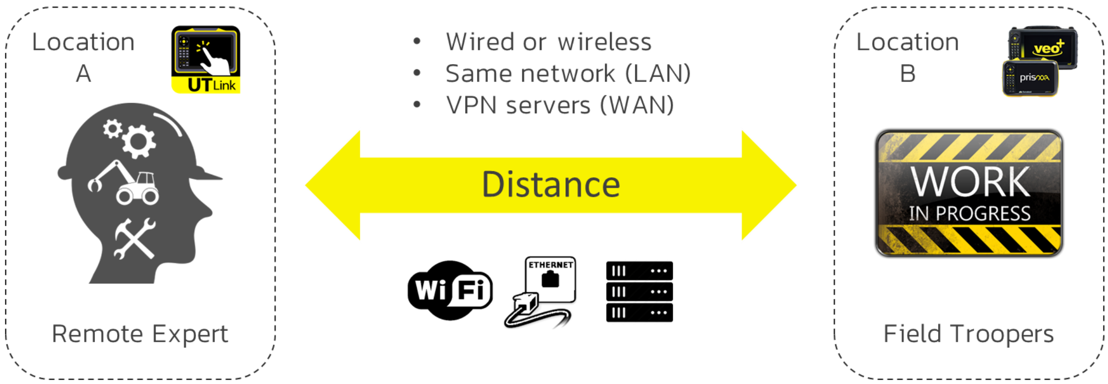


Figure 5 Remote Software Solution

User Case #1
Remote Automated UT

The first user case considers the use of remote control capabilities to access area or working zones that are difficult to reach or that requires time and investment to bring inspector safely to the site of inspection. The example chosen here is the inspection of welds using phased array ultrasonic technology of a spherical pressure vessel used for storage of compressed gases in a liquid stage.

The standard approach would suggest mounting a scaffolding structure around the tank so the inspector(s) can access safely the different zones of inspection and cover 100% of the structure. The table 3 below compares a second approach using a motorized magnetic scanner (wall crawler) solution equipped with phased array probes and the phased array flaw detector instrument directly bolted on the scanner. The user controls the scanner and the flaw detector instrument at the base of the structure using a wireless or wired communication network.

Table 3 User Case 1 Comparison

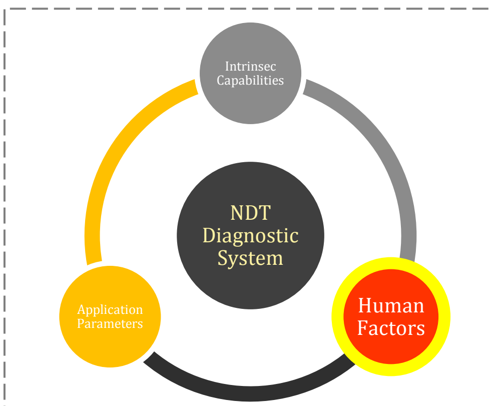
Scaffolding & UT Solution	Remote Automated UT Solution
	 
Advantages • Human access with direct visual and marking • Restricted zone can be done manually **Disadvantages** • High cost and long time for scaffolding itself • Security issues related to structure access • Some zone can be difficult to reach (awkward position)	**Advantages** • Fast solution to deploy • Limited security issues related to structure access • No awkward position for the inspector • Better SNR (short PA cables) **Disadvantages** • Some restricted zones can be difficult using a robot • Equipment cost

User Case #2 - On-Site Pressure, Critical Call & Remote Support

The second user case refers to the BAM model presented at the beginning of this document where it has been suggested that the environment around the inspector could make a difference in his work. In the below table are highlighted two different situation from the training school or lab to the field reality and how the use of remote technology could help.

The support of remote collaborators, either being skilled - but far away - colleagues or contractual experts, is already available in a number of industries, including NDT. The support of such remote expertise can make a real difference on the human factors identified earlier.

Figure 6 Organisational Context



- Even experimented inspectors performing tedious tasks in a restricted zone will feel pressure to keep focus on finding the flaws. Teaming up with a remote helper can help to share that pressure.
- A newbie will eventually turn into a skilled and experimented inspector. Having access to a remote colleague on demand can help them ramping up faster without compromising quality of the work.
- After the finding of a potentially major issue, an immediate counter-validation from a colleague can help to sort-out a situation before triggering a crisis management plan with a customer.

Finally, the table below exposes again the differences between school training, site inspector real life and highlight the advantages of having access to remote resources.

Table 4

Training Lab Training on Test Sample	**Power Plant Shutdown Pressure Vessel Maintenance Inspection**	**Collaboration with a Remote User Advantages**
Quiet & excellent lighting.	Poor lighting system, fatigue & often awkward position.	Support team is not subjected to the inspector environment.
Teacher, technician and classmates available for questions.	Work in isolation.	Less stress for the technician.
The sample contains a flaw. I will find the flaw.	Requires trust in his technique. Multiple flaws or no-flaw, both situations may appear as abnormal if repeated for a long period.	Remote team focused on the flaw finding while the field tech focuses on the technique.
Teacher in place for important call.	Deal alone with critical calls and with a long chain of command.	Call made in confidence with the support of a second eye.

5. Conclusion

The development of remote solutions in the NDT field brings a lot of advantages as it has been shown in this paper. Not only to implement new technique like automated UT for instance, but a lot of these benefits can also be shifted to improve the Human Factors when unfortunately, the user of the system is sometimes left out of the equation, especially when it comes the time to optimize existing solutions. These new tools are without a doubt a big part of the puzzle for the future of NDT, since this industry is based on a lot of technology, but will always be driven by human. The development of remote solutions can help bring down boundaries for better collaborations between experts and now, it can be extended even further using mobile networking technologies.

6. Reference

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