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LorisQ - Global Networking for the Real Predictive Cloud-Based Measuring Equipment Maintenance

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Abstract **– LorisQ is a cloud-based equipment management platform built on the understanding that measuring equipment maintenance is all about exchange of data and information between clients (equipment users) and service providers (calibration labs and others). Scaleability and flexible design is essential precondition for its global use by teams of all types and sizes: testing and calibration labs, manufacturing SMEs, corporate labs, maintenance, quality and purchasing departments, universities, hospitals and small maintenance service providers.**

Its client-provider interconnected workflow happening in the larger network makes both Excel data sheets and expensive database software solutions outdated and unnecessary and opens a way toward a real predictive maintenance by taking into account not just data from your own service provider network, but from the few orders of magnitude bigger one.

On its way to machine learning, LorisQ offers real-time measurement corrections based on latest calibration data measurement, trend analysis and other advanced features so that users can finally cut their purchasing and maintenance costs and predict long term quality of their equipment.

Keywords – Measuring Equipment Management; Predictive Maintenance; Cloud; Big Data; Calibration Data; Trend Analysis

I. INTRODUCTION

Traditionally, the maintenance of measuring instruments and/or lab equipment is a (usually yearly) scheduled activity which is the responsibility of a person or a department in each organization. Depending on the size, preferences or history of the particular organization, regular maintenance is the domain of heads of laboratories, quality managers or heads of maintenance which sometimes delegate this work to somebody else in their departments. This means that all the activities that equipment maintenance is comprised of in the broader sense are planned and executed in its organizational "silo".

However, the flow of all information related to scheduled and especially to ongoing equipment maintenance activities is extremely cross-functional, and even cross-organizational. It is cross-functional because there are many roles and responsibilities in every organization which are related to measuring equipment and which are dependent on proper maintenance (for example, a technician who uses the piece of equipment to measure, test or inspect something, and whose results are instrumental for the whole organization, both in terms of accuracy and reliability, and in terms of time frames in which he has to deliver these results). It is cross-organizational because the maintenance plan is always executed in large part by other, outsourced organizations, most importantly ISO/IEC 17025 accredited calibration laboratories, but remains the responsibility of the organization which is the owner and user of the equipment.

Cross-functional and even more cross-organizational (true) nature of equipment maintenance is regularly overlooked in mostly database software solutions made for helping people to schedule, organize, monitor and approve everything maintenance-related. And equally important - keep track of all the data, certificates and reports which are the results of all these maintenance activities.

Additionally, the data gathered by equipment maintenance activities (especially calibration, but others too) is not used to improve measurements nor to lower risk of malfunction in individual instruments which can cause serious trouble for functioning of the whole organization and the reliability of its products and services. This useful data just sits in folders and databases. One of the reasons why this is the case is again the cross-organizational nature of equipment maintenance, because in practice there is no common software platform for all outsourced organizations engaged in executing the equipment owner's maintenance plan. Such platform would enable all the data to be gathered and used by the equipment owner, regardless of the service providers for particular activity and particular instrument, and regardless of the manufacturer of the equipment.

LorisQ (www.lorisq.com) is a innovative smart platform for measuring equipment management. Its approach is fundamentally different than other software for the same purpose, because it is designed to treat measuring equipment management as a cross-functional and cross-organizational endeavour. In this paper we will especially focus on a simple example how can big data from many instruments and many organizations improve the predictions about a single instrument's long-term behaviour and thus improve risk management worldwide. The improvement of predictions about measuring instruments' behaviour in the future (e.g. instrument going out of tolerance limits between two calibrations) can greatly improve the reliability of testing, diagnostics and inspection results. Moreover it can reduce the number of wrong results and conclusions which often have enormous economic or legal consequences.

II. APPLICATION OF NEW TECHNOLOGIES

Problems and limitations in currently available solutions were our goal in designing and developing LorisQ cloud-based platform was to address all of the problems and limitations of usual software solutions mentioned in the Introduction, having in mind that apart from commercially available database software, the most common tool that people use for the purpose of managing equipment and its maintenance are actually Excel and other Excel-like spreadsheets. We identified 8 areas that most often generate maintenance management problems and limit improvements in all organizations.

1. People forget their individual maintenance tasks. When we take into account that the equipment maintenance is comprised of many different activities performed both internally and externally (outsourced), some of which should be performed very rarely (e.g. every two years), but still regularly, and others should be performed much more often (e.g. weekly), forgetting is understandable, even if we know that there is a plan with a schedule and it is not hidden from anyone. There are always other things to do, some of them unplanned, and very often - quite pressing.

   LorisQ software solution: Every person in a team has its own individualized roles and responsibilies which combine with maintenance plan and schedule to generate individualized daily notifications and alarms.

2. It is difficult to coordinate many different external (outsourced) service providers. Part of this difficulty is connected with making sure that they start their work in the exact moment that we need them to, part is connected to monitoring their workflow, but maybe the most important part is related to processing (and approving) their certificates, reports and data and information in general. It is really difficult to work on the execution of maintenance plan throughout the year, with different teams which are outside of our line-of-command and totally unrelated to each other.

   LorisQ software solution: Owners/users of the equipment connect/network with their service providers (just like on social networks), which enables coordination and single dashboard visualization of all internal and outsourced activities from everyone engaged in maintenance processes from start to finish (cross-organizational approval of documents included).

3. Information and data that we gather through maintenance activities is not available to everyone in organization who need it, whenever they need it. There are many people at different levels of hierarchy and responsibility inside every organization, but whom are all dependant on equipment information and data. For example, technician might need the newest calibration results from the outsourced organization when he makes some critial measurements, while the head of quality assurance might need some other details of last quarter's maintenance activities during the unexpected internal or external audit.

   LorisQ software solution: In a cloud, the same information and data is available 24/7 for everyone in a team, while being updated in real-time.

4. Useful practical knowledge and news about particular equipment is not shared in the team, or is not shared quickly enough among everyone. For example, one person might notice something out of the ordinary to happen while working with a particular piece of equipment, which would have repercussions for other people's work in real-time, and would usually save a lot of time and trouble for the whole team.

   LorisQ software solution: Digital shared equipment logbook in a cloud allows for every new information to be distributed to the whole team at the same time.

5. Ongoing maintenance activities cannot be monitored simultaneosly by everyone. The consequence is that everyone in the team is not informed simultaneously when some critial maintenance activity starts, ends or is approved and this often causes miscommuncation and late decisions.

   LorisQ software solution: Fundamentally same as 2., with a graphical interface shown in *Fig 1.*

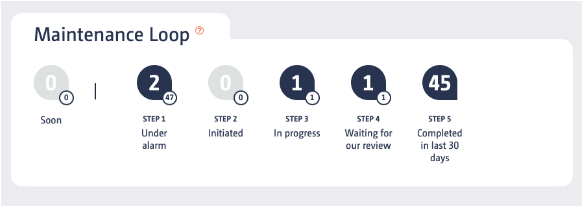

Fig. 1. An overview of all ongoing activities in LorisQ

6. Chronology of maintenance events and both internally and externally-made records related to equipment is difficult to keep because of so many internal and external people generating them, sometimes in the same day. This chronology can be very important in figuring out what went wrong, when it goes wrong.

   LorisQ software solution: Automatic logging system of every change in the records, accross the network.

7. Every organization gathers a lot of data after regular equipment maintenance activities, and especially after calibration of instruments. This data can be used for trend analysis which is important in cutting maintenance and purchasing costs in the future and instrumental in predicting malfunction and out-of-tolerance events. However, this data is not gathered in a way or a form which can be easily used to analyze trends and have to be manually entered in manually designed spreadsheets to perform trend analysis. Real people in real organizations very rarely have the time to do it and unfortunately, great opportunities are missed.

   LorisQ software solution: Because of networking between owners/users of the equipment and their service providers on the platform, the data is entered and shared in a standardized format among all organizations, which allows for automatic generation of long-term trend graphs *(*shown in *Fig 2.* and *Fig 3.*) and subsequent both visual and mathematical analysis of the data from all sources. In the next section we show a simple example how big data from many instruments can improve the predictions about single instrument’s long-term behaviour and thus improve risk management.

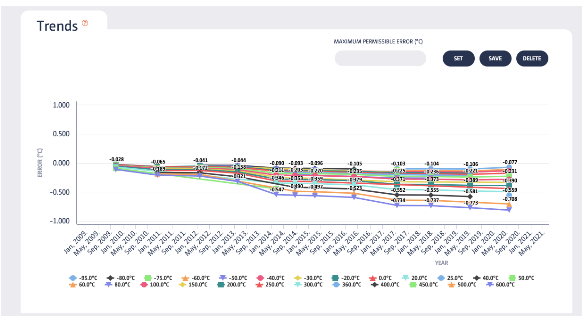

Fig. 2. Trend analysis graph in LorisQ (thermometer)

Fig. 3. Trend analysis graph in LorisQ (micrometer)

8. Calibration data is not used to improve the accuracy of measurements, apart from rare cases where equipment itself is designed to enable it. But these cases are extremely rare and are mostly related to expensive equipment. There are many cheap instruments involved in majority of crucial measurements worldwide (the best example right now are probably infrared thermometers involved in Covid-19 checks all around the world), for which the accuracy corrections after calibration can only be done manually. And in this case manually does not mean that we can adjust the instrument manually, but we cannot adjust it at all. In this case manually means - head, pen and paper.

   LorisQ software solution: Similar to the solution for issue #7, the way the data is handled across the network allows for automatic generation of measurement correction graphs (shown in *Fig 4.*) and subsequent calculation of corrections. Initial results of big data analysis show that for example, for a typical temperature measurement performed with thermometer calibrated in a typical ISO/IEC 17025 accredited lab, the accuracy would be improved 2-3 times on average by using LorisQ, although this is not the subject of this paper.

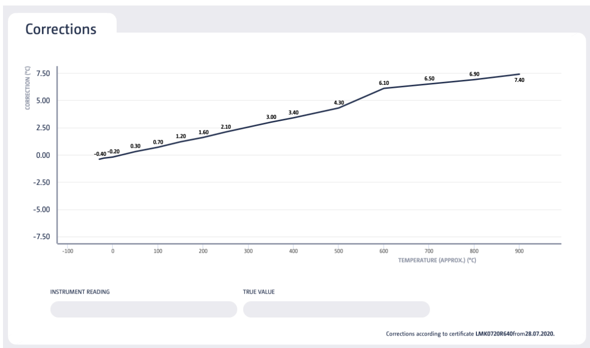

Fig. 4. Corrections calculator in LorisQ (IR thermometer)

To make a software solution that would solve all of these 8 problems at the same time in the way we described, we had to turn to:

a) cloud technology, because it enables 24/7 access to information, updated in real-time to everyone in a team

b) network-based structure designed to enable the flow of information not just between the people in a single team/organization, but between the owner and user of the equipment on one side, and different service providers on the other side.

Traditionally, none of these 2 key technologies were used in equipment maintenance. But apart from the fact that with their implementation in LorisQ we managed to solve all the before-mentioned 8 traditional cross-functional and cross-organizational problems in equipment maintenance and management, they open the door to future gathering of big data, sharing of aggregate data between the organizations worldwide, and using these aggregate data to build maching learning algorithms which would benefit every organization, no matter how big or small. (For example, as we mentioned earlier, calibration data from all the units of some particular instrument model gathered by all the calibration providers worldwide, could be used to more accurately predict the behaviour of every single unit of this instrument in individual organizations.)

III. DESCRIPTION OF THE METHOD

Out of 8 improvements made available by our use of 2 technologies which were described in the previous chapter, our goal here is to show the advantage of using larger set of data in predicting the behaviour of a single measuring instrument (improvement #7). Direct application in reality would be assessing risk of a single measuring instrument going out of tolerance.

For this simple demonstration we used real data from 8 type T thermocouples owned and used by ISO/IEC 17025 accredited calibration laboratory Metroteka from Zagreb, Croatia. Thermocouples were calibrated together with its readout system 13 times between August 14th 2013 and June 27th 2016 at many different temperature points, but for this purpose we used only their calibration results at temperature point of 0 °C. As is usual for thermocouples in use, their errors varied from calibration to calibration.

There are many different ways and industry practices that laboratories are using to predict long-term error drift between the last and next (yet unknown) calibration results. These predictions are performed in order to assess the contribution of this long-term drift on measurement uncertainty in calibration (mainly in calibration laboratories), to assess the risk of going out of tolerance, or to decide the calibration interval according to ILAC G24:2007 (Guidelines for the determination of calibration intervals of measuring instruments).

We compared 2 ways to make this prediction, a traditional one (and just one of many similar ones used globally) which is in use in Metroteka lab and a new one which takes into account not just data from the single instrument under assessment, but also other instruments of the same manufacturer and model. As we said, this sample is not large (8 thermocouples from the same organization) at all, but already it shows great advantage which would be multiplied by using big data from many different organizations. In both cases we took first 12 calibration results for every thermocouple and then tried to make a prediction about where the 13th result will fall.

A traditional way in question here is to take 4 last calibration results for a given instrument and calculate the differences between adjacent ones on the time axis, thus getting 3 actually measured drifts (1-2, 2-3 and 3-4). Then we take the largest one out of these 3 drifts and predict that our next drift would not be larger than that.

A new way we used here is to take all calibration results from all 8 thermocouples of the same type, model and manufacturer, disregard 5% of the largest calculated drifts in the sample, and predict that our next drift would not be larger than the biggest out of 95% remaining drifts. As with every prediction, the goal is not to be 100% sure (because it is quite easy to do), but to have a reasonable range of most likely possible future outcomes which would guide our decisions. These 5% can be seen disregarded both because their likelihood is small and because there is always a possibility of a human error in measurement.

IV. RESULTS AND DISCUSSIONS

Table 1. Traditional and new predictions

Thermocouple	Last error (°C)	Traditional prediction (°C)	New prediction (°C)	Actual new error (°C)
1	+0.36	(+0.22, +0.50)	(+0.04, +0.68)	+0.50
2	+0.23	(+0.17, +0.29)	(-0.09, +0.55)	+0.41
3	+0.08	(-0.06, +0.22)	(-0.24, +0.40)	+0.28
4	-0.19	(-0.41, +0.03)	(-0.51, +0.13)	+0.03
5	-0.10	(-0.19, -0.01)	(-0.42, +0.22)	-0.15
6	+0.21	(+0.09, +0.33)	(-0.11, +0.53)	+0.02
7	+0.34	(+0.22, +0.46)	(+0.02, +0.66)	+0.12
8	+0.41	(+0.24, +0.58)	(+0.09, +0.73)	+0.23

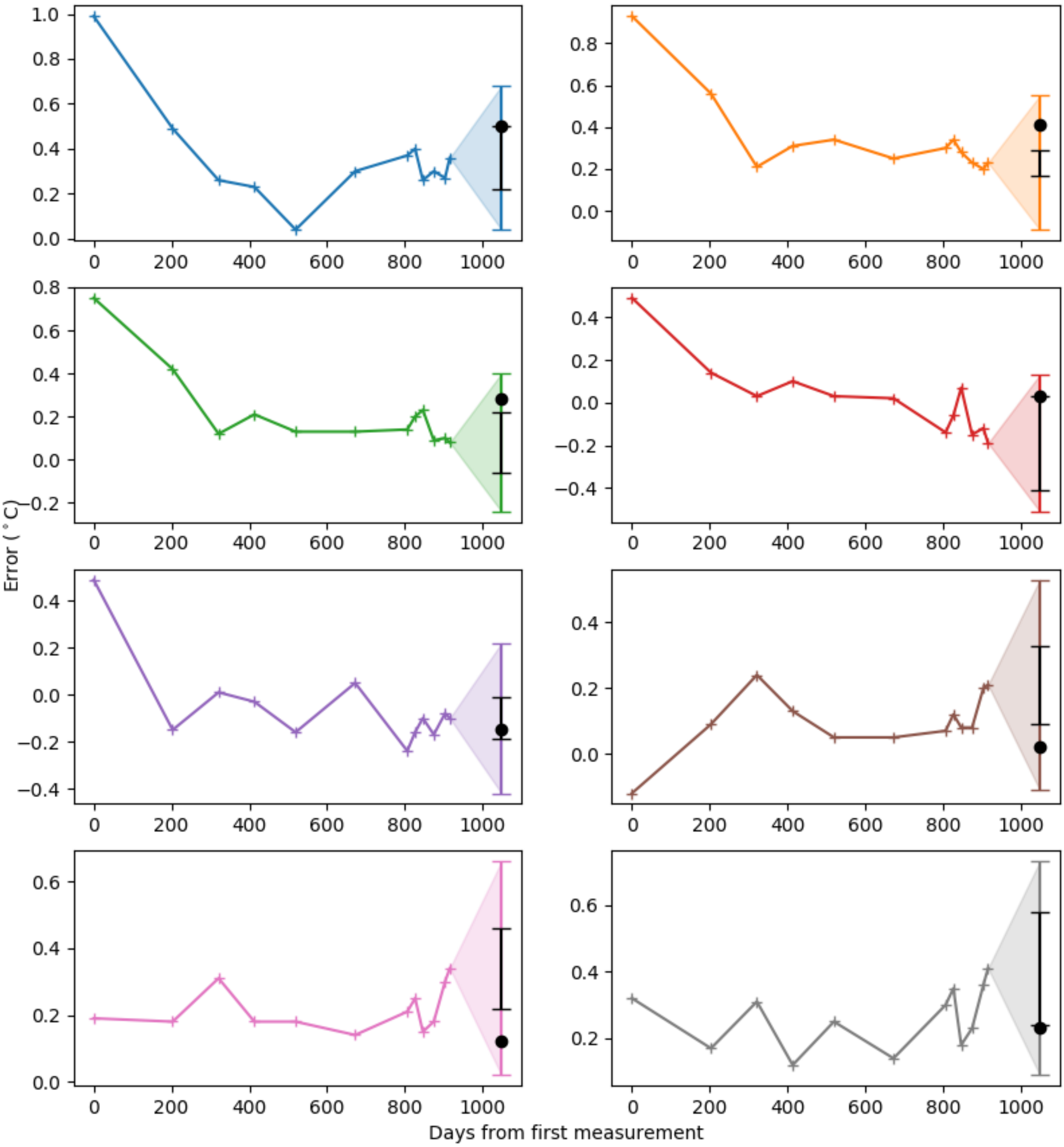

Fig. 5. Prediction of the interval in which the next calibration result will lie, calculated traditionally (black error bars) and using a new approach (coloured error bars), compared with actual measurements (black dots).

As we see from this table, relying to the traditional prediction succeeded in only 1 of 8 cases, failed in 5 of 8, and was borderline in 2 of 8. New prediction on the other hand succeeded in predicting 8 out of 8 cases.

The results are shown graphically in *Fig 5.* The triangles and error bars in different colours between the 12th and 13th calibration result are showing the new way predictions where our result would be, and the black error bars are showing the prediction calculated traditionally.

We understand that apart from this sample being really small and statistically unsignificant, it is also the fact that the temperature intervals in the new prediction are generally much larger and thus it is quite expected that they would “catch” the future results for actual new errors. However, if we look more closely to the results of a new prediction we see that the actual new errors are evenly spread across the new prediction intervals (and not concentrated in its center), which means that already from this small sample we got the realistic behaviour of this type and model of instrument. Moreover, unlike the traditional prediction, it is very important that it can be applied to new thermocouples which do not have any history of their own.

V. CONCLUSIONS AND OUTLOOK

The purpose of this paper was to describe many of the improvements that can be attained (and are already attained in LorisQ software) with application of technologies already used in many other areas to measuring equipment management used in testing worldwide. Additionally, we showed on just a simple example and with a small sample of thermocouples how networking between organizations through LorisQ for big data collection and analysis will surely benefit everyone’s measurements and reliability.

Future work should include testing of different prediction models and maching learning algorithms on much larger samples and for different instruments for the further development of the LorisQ platform.

REFERENCES

1. ISO/IEC 17025:2017 (General requirements for the competence of testing and calibration laboratories)
2. ILAC G24:2007 (Guidelines for the determination of calibration intervals of measuring instruments)