

## **Benefits of Implementation of a mobile laboratory for 200 kg and 500 kg mass standards**

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**Abstract:** Weighing instruments with a minimum capacity of 4,900 kg demand an especial verification unit containing 200 kg and 500 kg mass standards. In Brazil, these instruments are widely used in the agro industry sector, responsible for an important part of the national economy. Consequently, there is a significant concentration of the instrument in remote areas. This study shows the implementation of a mobile laboratory to support calibrations where calibration laboratories are sparse. We also conducted an analysis comparing the costs involving the mobile laboratory and the traditional laboratory, observing a reduction in 60.5% of the costs, mainly due to logistics.

**Keywords:** traceability; legal metrology; calibration.

### **1. INTRODUCTION**

Metrology can be described as part of the human history itself, and measurement systems are observed from ancient societies to modern days. Legal metrology was initially introduced as a necessity to control food in trade [1] and evolved to several different areas that impact either the economy, society, environment or health as well as security. Then, measuring instruments are regulated in order to provide confidence to measurements that somehow affects the society providing more benefits than the non-regulation. Especially in trade, the regulation processes are more cost-effective to the economy than the deregulation [2].

Legal metrology can also be understood as a competitive advantage in the international trade to overcome technical barriers, protecting the national economy in import/export goods which values are based on a measurement.

For example of benefits involving legal metrology, the NIST's investments of around USD 0.5 million in Saudi Arabia resulted in an increase in exports between USD 300-500 million [3]. In Japan, a study proposing a model to evaluate the economy loss involving differences in standards showed that a divergence in 0.05 mg in 1 kg would generate USD 77,000 of losses for the weighing industry [4].

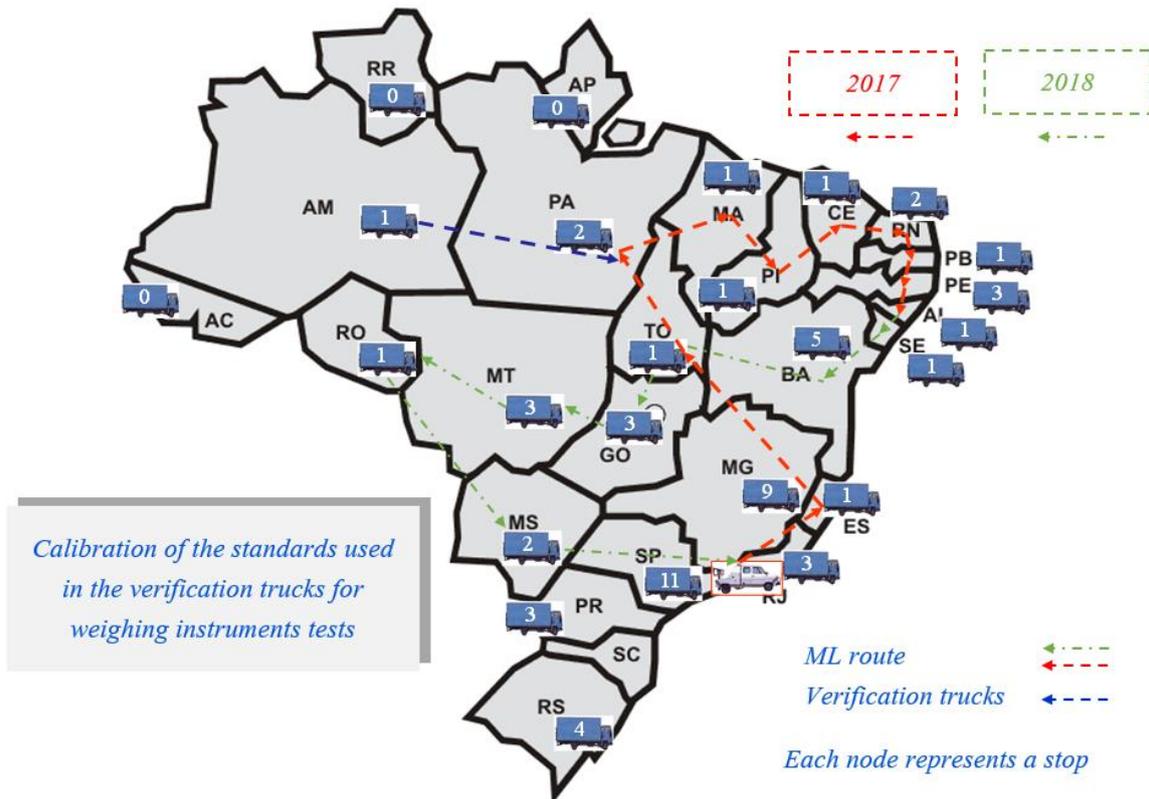
In Brazil, only in 2016, the agro industry produced 184,697,696 t of the following commodities: cereal, oilseed and grain legume crops. The projection to 2017 shows a production of 238,627,189 t [5]. The agroindustry, a mostly weighing based industry is also an important component of the Brazilian's international trade.

Traceability plays a major role in metrology and consequently its application, once an unbroken chain of measurements of known uncertainties provides the necessary confidence

to adjust measuring instruments that affect the society as a whole.

Heavy load weighing instruments are an important component of several important sectors to the economy, as an example, the already mentioned agro industry.

As a continental country, occupying an area of 8,515,759.090 km<sup>2</sup> and 5570 municipalities [6] the Brazilian legal metrology systems is decentralized and the legal control comprising verifications and surveillance of measuring instruments is conducted to 26 delegated bodies across the national territory [7].



**Figure 1.** Mobile laboratory logistics in 2017 and 2018.



**Figure 2.** Mobile laboratory and a calibration procedure.

The National Institute of Metrology, Quality and Technology – INMETRO is responsible for regulation in legal metrology, as well as for accreditation, maintenance of the national standards and traceability of the standards of the delegated bodies.

Especially for mass standards of 200 kg and 500 kg, used to calibrate the heavy load weighing instruments the costs involving transportation are significant. Then, to overcome this difficulty, the present study presents the implementation of a mobile laboratory of mass calibration (ML), which provides the necessary infrastructure demanded to calibration of mass standards used to verify and inspect heavy load scales. We also present the benefits reaped compared to the expenditures of the ML.

## 2. METHODOLOGY

For this study, automatic instruments for weighing road vehicles, rail-weighbridges and non-automatic weighing instruments with a minimum capacity of 4,900 kg are described as heavy load weighing instruments, hereinafter called weighing instruments for simplicity.

The delegated bodies for legal metrology activities in Brazil are responsible for verification and inspections. In 2016, 19,555 were verified (initial, periodic and after repair). Each delegated body has a truck containing the necessary standards for the verifications. The verification truck contains mass standards of 20 kg, 200 kg and 500 kg, necessities for the weighing instruments according to the tests based on the International Organization of Legal Metrology Recommendations.

Regardless its continental area, Brazil concentrates most of its industry in south/south-east territories. As a consequence of this polarization of the industry, the calibration laboratories are also located mostly in the south/south-east regions. Moreover, as the north

and the west contains most of the agro industrial sector, the area contains a large number of weighing instrument. Therefore, the delegated bodies working in the agro industry area demands calibration for their masses standards.

Moreover, the logistic for calibration of the mass standards used for verification in weighing instruments, for the scope of this study, involves large costs as the transportation processes for standards of 200 kg and 500 kg are not simple, demanding heavy machinery and special trucks.

Figure 1 shows the number of verification trucks per State, as well as the routes of the ML to calibrate the standards involving in the process. Figure 2 displays the ML as well as a calibration process being conducted inside the laboratory.

An investigative research was also conducted in order to compare the economic advantage of the ML over private laboratories, in order to provide traceability to the mass standards used for verifications of weighing devices. The costs of the ML includes the logistics (displacements expenditures according to the planned routes seen in figure 1 and tolls) and workforce. The comparison also includes the loss of profit due the inoperative of the verification trucks from the verifications taxes.

According to the number of calibrations to be conducted by the ML, the laboratory has a two years schedule, covering all the 13 delegated bodies that demand calibration. The remaining delegated bodies have their mass standards calibrated by private laboratories.

## 3. RESULTS

The costs involving in the ML are 60.5% inferior in comparison to the calibrations conducted by a private laboratory. The costs of a private laboratory also include the logistics to transport the standards from the States to the laboratory, increasing significantly the costs. Table 1 shows the costs for both the ML and the private

laboratory, for the 13 States comprising 16 verification trucks used for the legal control of measuring instruments.

**Table 1.** Comparison between the costs of calibrations in a private laboratory and using the ML, in USD\*.

Delegated Body	Verification Trucks	Costs Private Lab.	Costs Mobile Lab.
CE	1	15,905.09	5,647.83
PI	1	4,982.94	4,807.96
MA	1	13,636.53	7,089.36
SE	1	3,822.69	4,665.03
AL	1	5,917.74	5,238.58
RN	1	6,981.89	5,400.96
MS	2	22,481.44	19,476.27
RO	1	6,120.13	5,997.14
TO	1	5,320.10	6,300.11
PA	2	19,022.26	7,279.39
AM	1	4,273.28	5,237.14
PE	2	43,415.22	12,471.13
PB	1	8,180.59	7,233.26
<b>Total</b>	<b>16</b>	<b>160,059.89</b>	<b>96,844.15</b>

\*exchange rate based on 2016 [8].

Table 2 shows an estimative of the number of mass standards demanding calibration in the ML for the years 2017 and 2018.

**Table 2.** Estimative of calibration in 2017 and 2018 using the ML.

	Mass standards demanding calibration			
	20 kg	200 kg	500 kg	Total
2017	160	24	244	428
2018	200	40	440	680
Total	360	64	684	1108

#### 4. CONCLUSION

The implementation of a mobile laboratory to calibrate mass standards of 200 kg and 500 kg used in the verification of heavy load weighing

instruments decreased the costs regarding calibration in 60.5%. These instruments play an important role especially in the Brazilian economy as they are widely used in the agro-sector, an important economic sector in Brazil.

The future project aims to expand the ML to all delegated bodies, calibrating the mass standards of all verification trucks.

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