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Editorial

Des temps difficiles

Il s'agit du premier Bulletin publié depuis juillet 2019, après une pause d'environ neuf mois. La difficulté croissante à recevoir des articles de qualité pour le Bulletin a été abordée à plusieurs reprises dans le passé, et lors de sa 54e Réunion à Bratislava, le CIML a pris la résolution n° 2019/30 dans le but d'identifier des "mentors" pour le Bulletin qui prendront la responsabilité d'augmenter durablement le nombre d'articles techniques.

J'ai donc demandé au BIML de préparer, et de rendre public, un plan pour identifier les sujets clés pour les huit à dix prochaines éditions du Bulletin. Le Bulletin de l'OIML est la seule revue internationale au monde qui soit consacrée à des sujets de métrologie légale. Par conséquent, malgré les temps difficiles et exigeants, dans l'esprit de notre Convention, j'encourage tous les Membres du CIML à partager leurs expériences en matière de métrologie légale avec la communauté de la métrologie légale dans le monde entier, et à prendre la responsabilité d'être un "mentor" pour l'une des prochaines éditions du Bulletin.

Je suis reconnaissant à mes collègues de la PTB d'avoir ouvert la voie en proposant dans ce numéro des articles intéressants sur le "contrôle de la vitesse moyenne" et le projet "European Metrology Cloud".

S'il y avait eu un éditorial en janvier, il aurait été optimiste. J'aurais jeté un regard très positif sur l'année 2019, ayant bénéficié d'une Journée mondiale de la métrologie exceptionnelle en 2019 marquant le lancement du SI révisé, d'un atelier d'apprentissage en ligne réussi et d'une réunion du CIML très bien organisée à Bratislava avec de nombreuses publications nouvelles ou révisées et un certain nombre de nouveaux projets approuvés.

Une perspective positive sur l'année 2020 aurait également été présentée, et j'aurais mentionné que je rencontrerais le nouveau président du CIPM, le Dr Wynand Louw, et le directeur du BIPM, le Dr Martin Milton, pour discuter d'une éventuelle coopération plus étroite avec le BIPM sur la base de la résolution 2019/12 du CIML. J'aurais écrit que plusieurs réunions et ateliers clés étaient prévus, tels que le Conseil de la présidence annuel et les réunions quadripartites, que la troisième réunion du Comité de management de l'OIML-CS se tenait à Delhi, qu'un atelier de l'OIML sur la "Transformation numérique en métrologie légale" était prévu les 27 et 28 mai 2020 à Berlin, et, très important, que notre 16e Conférence se tiendrait à Suzhou, en République populaire de Chine, sans parler de tous les importants travaux techniques en cours.

Mais... comme pour beaucoup d'autres dans le monde, la "crise de Corona" a considérablement perturbé nos projets ! Nous sommes maintenant confrontés à une pandémie mondiale qui affecte et perturbe de plus en plus les processus normaux de vie et de travail. Des réunions sont annulées, des restrictions et des interdictions de voyage sont imposées, ce qui affecte également le travail de l'OIML. La réunion du Comité de management de l'OIML-CS a dû être annulée (bien qu'il soit prévu d'organiser des réunions virtuelles), le Conseil de la présidence et d'autres réunions ont été tenues en partie en personne, en partie en ligne, et des plans d'urgence doivent être élaborés. Le New York Times a même récemment titré "Le virus Corona a mis l'économie mondiale en mode de survie".

En ces temps difficiles, il est important que nous utilisions la vidéoconférence et d'autres moyens en ligne pour rester en contact et poursuivre nos travaux techniques, les travaux de l'OIML-CS et les activités du CEEMS. Peut-être que ces temps difficiles et éprouvants peuvent nous apprendre à mener notre travail encore plus efficacement avec moins de déplacements.

Gardons donc la tête froide et restons confiants en ces temps difficiles ! ■

Roman Schwartz
CIML President

Challenging times

This is the first Bulletin that has been issued since July 2019, following a pause of about nine months. The increasing difficulty in receiving high quality articles for the Bulletin has been addressed several times in the past, and at its 54th meeting in Bratislava the CIML took Resolution no. 2019/30 with the aim of identifying "mentors" for the Bulletin who will take responsibility for sustainably increasing the number of technical articles.

I have therefore asked the BIML to prepare, and make publicly available, a plan to identify key topics for the next eight to ten editions of the Bulletin. The OIML Bulletin is the only international journal worldwide which is dedicated to legal metrology topics. Therefore, despite the challenging and demanding times, in the spirit of our Convention I encourage all CIML Members to share their legal metrology experiences with the legal metrology community worldwide, and to take responsibility as a "mentor" for one of the next editions of the Bulletin.

I am grateful that my PTB colleagues have led the way by providing interesting articles on "Average speed control" and the "European Metrology Cloud" project in this edition.

Had there been an Editorial in January, it would have been an optimistic one. I would have looked back in a very positive way on the year 2019, having enjoyed an exceptional World Metrology Day 2019 marking the launch of the Revised SI, a successful e-Learning Workshop, and a very well organized CIML meeting in Bratislava with many new or revised publications and a number of new projects approved.

A positive outlook on the year 2020 would also have been featured, and I would have mentioned that I would be meeting the new CIPM President, Dr Wynand Louw, and the BIPM Director, Dr Martin Milton, to discuss the possible closer cooperation with the BIPM based on CIML Resolution 2019/12. I would have written that several key meetings and workshops were planned, such as the annual Presidential Council and Quadripartite meetings, that the third OIML-CS Management Committee meeting was taking place in Delhi, that an OIML Workshop on "Digital Transformation in Legal Metrology" was scheduled for 27–28 May 2020 in Berlin, and very importantly that our 16th Conference would be taking place in Suzhou, P.R. China, not to mention all the important ongoing technical work.

But... as for many across the globe, the "Corona crisis" has significantly disturbed our plans! We are now confronted with a worldwide pandemic that is increasingly affecting and disrupting normal life and work processes. Meetings are cancelled, travel restrictions and bans are imposed, also affecting the OIML's work. The OIML-CS Management Committee meeting had to be cancelled (although there are plans to hold virtual meetings), the Presidential Council and other meetings were held partly in person, partly online, and contingency plans have to be made. The New York Times recently even headlined "The Corona virus has put the World's Economy in survival mode".

In these challenging times it is important that we use videoconferencing and other online facilities to stay in touch and continue with our technical work, the OIML-CS work, and CEEMS activities. Maybe these difficult and challenging times can teach us how to carry out our work even more effectively with less travelling.

So let's keep a clear head and remain confident in these challenging times! ■

SPEED CONTROL

Effectiveness of average speed control: An on-off analysis

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Introduction

Average speed control (ASC), or section control, is a very effective way of enforcing vehicle speed limits. It works by timing the passage of vehicles through a section of known length, typically several or even many kilometers long [1]. The time of each vehicle's passage by an entrance marker is registered, together with its license plate number. If a vehicle arrives at the end of the section sooner than would be possible when obeying all the speed limits, it can be deduced that the vehicle was moving too fast, and the driver can be fined. Several manufacturers world-wide offer automated systems, where the automation includes the registration of vehicles entering and leaving the controlled section and the photographic and electronic documentation of speeding drivers.

Many studies exist that demonstrate the effectiveness of average speed control [2, 3]. Typical advantages are a significant reduction in the number of accidents (sometimes greater than 50 %) and a better flow of traffic. These studies typically compare the situation on a specific road section before and after ASC has been implemented.

However, in addition to the "before-after" effect, longer-term trends must be considered which have a bearing on traffic safety. For instance, some of the improvements attributed to the implementation of ASC on a section of road might have occurred anyway, even without ASC, thanks to technical improvements to vehicles or changes in traffic or mobility patterns.

In this article we report briefly on a rather unique opportunity to examine the effectiveness of ASC separately from other changes in mobility patterns. This opportunity arose in the wake of legal disputes after the implementation of the first ASC system in Germany, which forced it to be shut down shortly after implementation. Therefore, in this paper we show data related to traffic safety in a road section first without ASC, then with ASC, then without again, and finally with ASC reinstated. This is the "on-off analysis" referred to in the title of this report.

Not surprisingly, one finds that traffic safety is significantly improved when ASC is in operation, compared to the periods during which it is switched off, and that the changes in driver behavior happen without appreciable delay.

The pilot ASC near Hannover, Germany

Figure 1: Entrance portal of the first ASC in Germany. The gantry houses the lane cameras for vehicle identification and the laser scanners for triggering.

The ASC of interest here is a pilot system on a local highway with two lanes in each direction, where both lanes of one direction are subject to ASC over a total length of about 2.2 km (Fig. 1). The highway lies just south of the city of Hannover in Northern Germany and is a route driven daily by 12 000 vehicles, among which many drivers are regular commuters. Being the first ASC in Germany, there has been intense press coverage. As a result, local drivers, and particularly the regular commuters, are well informed about whether the system is in operation or not. In addition, there is a large sign placed at the entrance to the controlled section notifying drivers of the ASC. This sign was installed when the ASC first came into operation and

Table 1: Mean speeds and percentage of speeding drivers during the various phases of the project. Both results varied in line with measurement positions (see Fig. 2). Here the term "maximum" indicates that the values given refer to the position with highest mean speed and to the position with highest speeding rate.

Date	Phase	Maximum mean speed (km/h)	Maximum percentage of drivers speeding
Feb. 2015	Before start of road works but location of future ASC publicly known	105	70
Aug. 2016	Installed hardware visible (gantries, cameras)	101	50
Jan. 2019	Enforcement has begun	97	30
Apr. 2019	ASC switched off by court order	106	75
Dec. 2019	Enforcement resumed	97	30

was marked as invalid when the ASC was not in operation.

In 2014 the local government and local police in Hannover were considering implementing a pilot system for ASC, the first in Germany. The PTB offered to monitor traffic patterns before, during, and after the implementation of the system. A mobile multi-target tracking radar, hidden from drivers' view, was used to count vehicles and their speeds at various positions along the section. This census was performed repeatedly at various stages of the project (see Table 1). Some of these results have been published previously and with more details, up to the "off" phase [4, 5].

Before the ASC plans were put into practice, the mean speed within the controlled stretch of road was locally up to 105 km/h. Up to 70 % of all drivers were speeding locally. Considering that the speed limit along this section is 100 km/h, the fact that the mean speed lies so far above the allowed speed might explain at least partially why this stretch of road had previously been an accident hotspot – which is why this section was chosen for the ASC pilot installation in the first place.

After the hardware for the ASC system had been installed, in particular the gantries carrying the overhead laser scanners and cameras at the entrance and exit to the controlled section, driving behavior improved, resulting in a mean speed of not more than locally 101 km/h and not more than 50 % of drivers still speeding. Although this was still above the allowed limit it demonstrates that ASC works even when there is no enforcement!

Another improvement could be observed when the system went into enforcement mode (see Table 1).

Why was there an "off" phase after that? Well, Germany not only has rules regulating traffic enforcement but also regulating data protection. A driver successfully complained in court that he was registered upon entry into the system although at that point there was no initial evidence against him that he would be speeding. In his view, this constituted a violation of his rights that could only be justified by an explicit legal provision empowering the police to perform this kind of screening. The court followed this line of reasoning and ordered the system to be shut down immediately. Several months later, the parliament of the State of Lower Saxony, where the pilot ASC is located, passed a new police law containing a paragraph explicitly covering ASC. As a consequence, the court lifted the injunction, and the system was subsequently put into operation again.

During this forced "off" phase, the PTB seized the opportunity to examine driver behavior now that the "threat" of being fined was removed. Surprisingly (or maybe not!), within days the driving behavior had returned to that observed before any plans about an ASC at this site were publicly known.

After the system was again switched on in December 2019, within days the driving behavior returned to the previous behavior observed when the system was first in operation.

Results and discussion

Interpretation of the table is obvious even to non-experts. As soon as drivers are afraid that speeding might be sanctioned they reduce their mean speed. Once the threat is removed an immediate relaxation of driving discipline can be observed. This picture does not change when the median velocity instead of the arithmetic mean is used.

A more quantitative analysis is possible using surrogate safety measures such as Time-to-Collision or Time-Headway [4, 5]. This analysis is not included in this overview here. However, one can use the trends extracted from studies on the connection between speeding and accident rates, as was done in a recent study by the European Traffic Safety Council [6]. According to these figures, the reduction in mean velocity from 105 km/h to 97 km/h would amount to a

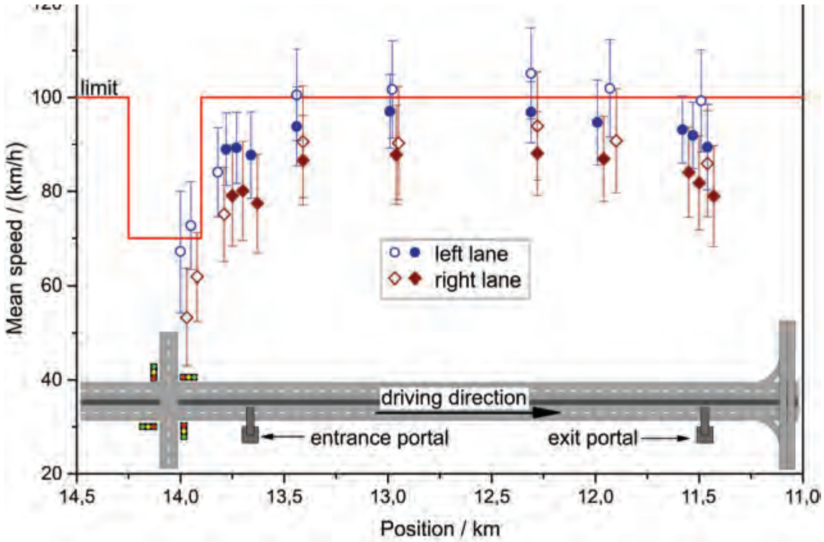

Figure 2: Example of the results of hidden traffic flow measurements at several positions along the controlled section of road. The open dots show the mean speed before setting up the ASC, and the full dots show the mean speed at the beginning of the enforcement phase in January 2019. Circles: Fast (left) lane, diamonds: slow (right) lane.

reduction in injury accident rates by 10 % and a reduction in traffic-related deaths by 25 % (revised power model according to [7]). If the current "on" phase of the system can continue for two or three years one might see whether the inferred improvement in traffic safety will be confirmed by lower accident rates along this stretch of road, and whether it will no longer be an accident hotspot now that ASC is installed.

The results of these traffic flow measurements during the on and off phases of Germany's first ASC implementation show that traffic enforcement is an important pillar of any traffic safety plan (Fig. 2). It complements the other two pillars: education of drivers concerning safe behavior, and constructing roads so that they are inherently safe and/or suggesting safe behavior and appropriate speed to the user. ■

References

[1] D. Lachat, Average speed control, OIML Bulletin, Volume LVI Number 1, January 2015

[2] A. Høye, Speed cameras, section control, and kangaroo jumps–a meta-analysis, Accident Analysis and Prevention **73**, 200-208, 2014

[3] A. Høye, Safety effects of section control – An empirical Bayes evaluation, Accident Analysis and Prevention **74**, 169-178, 2015

[4] J. Kupper, Neue Zeitschrift für Verkehrsrecht **5**, 233-234 (2019) (in German)

[5] J. Kupper, "Section Control in Germany – Findings for the first setup –" (submitted for publication)

[6] European Transport Safety Council, "Reducing speeding in Europe", PIN Flash Report 36, February 2019

[7] R. Elvik. The Power Model of the relationship between speed and road safety–Update and new analyses. TOI report 1034/2009, Institute of Transport Economics, Norwegian Centre for Transport Research, 2009

CLOUD

Designing the European Metrology Cloud

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Abstract

Legal metrology defines regulated processes in which data are exchanged in order to achieve a specific goal while accomplishing the aims of protection in this sector. Nowadays, these processes are only partially digitized and harmonized, hence their optimization is hampered. Many stakeholders employ their own data-systems leading to bottlenecks that hinder process efficiency with regard to time and cost. The European Metrology Cloud Initiative (EMC), coordinated by the Physikalisch-Technische Bundesanstalt (PTB), aims to solve these issues by providing the seamless integration of all stakeholder systems and by streamlining the interactive processes between them. Another goal of this approach is the ability to manage future types of measuring devices such as IoT-devices and distributed measuring systems. This article aims at demonstrating how legal and related requirements are translated into technical requirements. We present the set of requirements relevant for the EMC and the design decisions we extracted from those general demands. Finally, we describe in detail the technical solutions we employed to comply with all these constraints.

Introduction

Legal metrology is the application of legal requirements to measurements and measuring instruments. The regulatory systems surrounding legal metrology are designed to establish a chain of trust aiming at ensuring correctness of measurements. Correct and traceable measuring instruments can be used for a variety of measurement tasks: responding to reasons of public interest, public health, safety and order, protection of the environment and the consumer, of levying taxes and duties and of fair trading, and directly and indirectly affect the daily life of citizens in many ways. These measurements may require the use of legally controlled measuring instruments. To this end, all countries employ their own regulatory framework. The task of harmonizing the multitude of the world's regulatory systems in legal metrology is carried out and organized by the OIML and by regional organizations such as WELMEC in Europe. By design, these regulatory systems require a lot of data collection, data exchange and communication between stakeholders within regulated processes.

Technical documentation that is produced within these processes, e.g. for type examination, must be identified first and commonly prepared for further processing by the examination laboratory of the conformity assessment body. In the past, the manufacturer delivered the approval prototype together with its paper-written handbook to the examination laboratory. Meanwhile, the manufacturers are free to hand over documentation (including source code) electronically to the laboratory by local storage media or via e-mail (see Figure 1).

Often, documentation comprises several gigabytes. Obviously, security and privacy is of vital importance for such data. When technical documentation from the manufacturer has arrived at the examination laboratory, the conformity assessment process starts with the formal verification regarding completeness, consistency and congruence with the prototype features and against the legal metrology requirements (e.g. OIML[1], WELMEC[2], EU[3], PTB requirements (PTB-A) and federal law[4]). Normally, at this point, questions and remarks from the examiner arise and are discussed with the manufacturer. This procedure is only completed if a high level of compliance against legal metrological requirements documentation and prototype specification has been achieved. Finally, a positive test report or certificate is released. To support the manufacturer in generating software-relevant documents, a couple of leaflets have been published by the PTB software group, consisting of requirements for writing best reviewable documentation to speed up the software type examination ([5]). Nevertheless, tasks carried out manually such as the preparation of technical documents and identification of changes in huge document stacks remain time-consuming and offer an opportunity to simplify, secure and speed up the document exchange and preparation, e.g. by establishing a standardized secure communication framework between the stakeholders in legal metrology conformity assessment.

Almost all stakeholder organizations in legal metrology (manufacturers, user of instruments, Notified

This work was done in the context of The European Metrology Cloud initiative by the PTB [31].

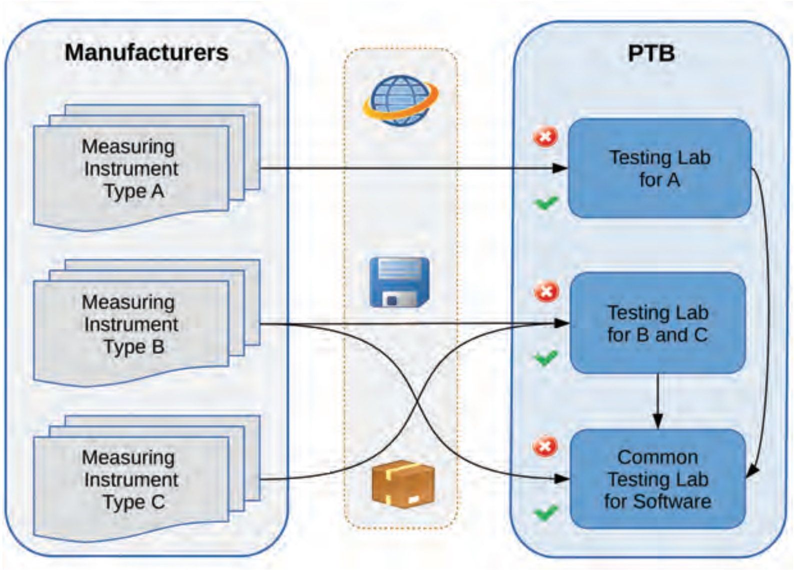

Fig. 1 How documentation finds its way to the examination laboratory

Bodies, market surveillance/verification authorities (MS/VA)), [6], have their own internal computer network of workstations and data-, compute- or application-servers as well as peripheral systems. All such inter-related internal processes are already highly digitized and thus the data produced is available in the digital domain. Since most organizations use their own, purpose-built systems, the data generated will differ in structure, format, language, encoding, physical units used, nomenclature for formulas and thus be, in general, highly heterogeneous. Additionally, on the European level, regulatory demands might differ from country to country due to the concept of the European legal framework, which in turn leads to slightly differently structured processes. In broad terms, the EMC's goal translates into creating a way for all these systems to be easily integrated into a metrology network, to manage and streamline processes and exchange related data. In research, this subject is mostly referred to as data integration (DI) and described as the "800-pound gorilla in the corner" [7] by the well-known expert Michael Stonebraker. This metaphor stands for the often vastly underestimated effort required to integrate even low numbers of data sources. The EMC's goal is thus to integrate thousands of data sources and allow for the implementation of relevant legal processes such as preparing a new measuring device for market deployment (type examination, etc.) or updating the software of existing measuring instruments (MI) in the field.

In simple terms, the EMC aims to create an Integrated Information System (IIS) within the realm of legal metrology [6]. We present an overview of the main design decisions involved in creating such an IIS, describe in detail our own use case and show why it also pertains to many other real-world scenarios. We consider that such systems are often influenced by policies between participants as well as regulatory constraints and not solely by technical optimization.

For the EMC, there are four requirements set by the consortium:

- a secure legal basis for processes involving data shared among the participants;
- data privacy, authenticity and integrity;
- secure data transfer and process execution;
- a query-based information system to access all shared data.

In section I, we identify seven major design options for an IIS fulfilling all four requirements. Section II gives an overview of our solution regarding data integration and explains our choices as framed by the PACELC [9] theorem. Section III states the requirements for the hardware the system is built on and why this is an important topic. In section V, a detailed explanation of our privacy and data storage solution is given. Finally, section VII contains our conclusion and outlook for future work.

I Design options for integrated information systems

Many options for designing an IIS are described in the literature. Some of these options contradict each other or lack practicality. Thus, we aim to present an overview of current design options and explain how our own approach fits within the described range of possible configurations.

From an abstract point of view, data integration (of data systems S_i) could be described as an IIS T not only linking data from all S_i to a combined whole (T) but also mapping processes from all S_i to T and vice versa. In this article we discuss the main design decisions to be made and how a given use case can be easily classified to find the most appropriate system design solution. Assuming that we have too much data for one single machine to handle, data will be spread over several machines which we call *nodes*. The main degrees of freedom for T are:

Data Locality: will the machines/servers be physically close (i.e. data center) or distributed over various locations - this decision mainly affects latency and bandwidth between nodes.

Data Integration: the two main types of data integration are virtual and what we call *manifested*. Simply said, virtual data integration means connecting existing systems to a virtualized whole while *manifested* means integration into a singular data warehouse (DWH) [8]. This decision pertains to implementation effort and to less technical effects such as the willingness of source system owners to change their systems or give data control to third parties.

PACELC: for distributed systems, PACELC [9] always forces us to decide between availability and consistency in the partitioned-network case and between latency and consistency otherwise – this decision affects things such as using or not using (node-/data-) replication as well as enforced vs eventual consistency. PACELC is an extension of the well-known CAP theorem [30].

Hardware: which hardware will the system run on, who chooses the components, what are the storage capacity and other performance indicators – this not only affects overall performance but also cost and system security on the hardware side.

Operating System: which Operating System will the platform run on, how are the software components isolated.

Storage: how and where logs will be stored, who can access what data and which information about other participants can be inferred. The latter is especially important because having immutable logging is one of the main requirements of our system in order to be accepted as proof in legal proceedings. Also affected are storage access times and network traffic.

Privacy: multiple competing stakeholders that share their databases in one system is only possible if the privacy and authenticity of each stakeholder is guaranteed. Protecting that privacy while still having enough transparency to e.g. manage access rights or provide consistent system logs and protocol compliance, raises multiple design questions.

II Data

A. Data Locality

Since we assume we have more data than can be stored on one single machine (and more than one stakeholder), we are left with the need for a network of computers. In the past, the only practical solution for data processing to be handled efficiently was that those systems needed to be physically close together and linked via high bandwidth LAN connections [10]. While this still holds true for most cutting edge applications, compute arrays and web services, thanks to ever-increasing bandwidth available over the internet, a number of systems can be realized without having to keep the machines close together. Some well-known examples of this are peer-to-peer networks (p2p) that realize blockchains such as Bitcoin, or decentralized applications (dApps). With p2p, dApps and similar cloud-based approaches, a growing tendency towards decentralized systems exists and is likely to continue.

In our use case, we have to deal with about 2000 heterogeneous data sources that need to be combined into an IIS. Modern data centers (e.g. cloud services such as AWS) can easily offer that number of servers and deliver very good network bandwidth and minimal latency. On the other hand, allowing participants to freely choose where to put their machines and securely manage the data they want to share with the system is an obvious advantage, since it removes the need for third-party housing and administration of the hardware. Depending on system location, putting all machines in one central location also poses risks such as power outages and other mostly localized phenomena that could be avoided if the nodes are spread over much larger distances and connected via the internet instead of a LAN. This also avoids creating a central honeypot.

B. Data Integration type

When talking about linking heterogeneous data sources, the first step is to define a global mediated schema and map all sources to that schema. The two main ways of doing this are what we call *manifested*, i.e. translate all data once and copy the result into a centralized Data-Warehouse (DWH), or *virtual*, i.e. on-demand by deploying so-called local wrappers for each data source that translate global queries into local ones and the local result sets back to the global schema [11], [8]. There are two main options for this virtual approach: so called *global-as-view* and *local-as-view*. The first means expressing the global schema in terms of local queries while the latter means expressing local systems by queries on the global schema. In general, *schema* refers to the data structure of a given database.

Consider the following simple example: a local field "address", consisting of a street name and a number, is represented in the global system as two separate fields, one for street name, one for the number. In that specific instance, data transformations are required to split or concatenate those fields depending on the direction of the request. Now consider additional sources for the same field, using even more different formats (maybe even GPS coordinates) for the semantically same thing: a physical location. Even from this simple example, it is obvious that those transformations are not trivial and may not be automatically derivable, thus requiring extensive work by a data expert.

Design decision: Data Locality and Data Integration type: Part of our design goals was to have a system with maximum flexibility and security while maintaining better-than-average performance and – mostly for security and scalability reasons – keeping the architecture as distributed and decentralized as possible. We chose to base our system on (potentially) physically distributable nodes, but use a single schema over all nodes.

We do not use node- or data-replication and thus create a distributed database in the exact same way relational tables get spread over multiple nodes: by slicing relations horizontally as well as vertically and distributing the data over all nodes (see Figure 2). That way, there is no need for a centralized data cluster and every participant can choose what data to share via his own node. A node may be shut off at any time, which causes the remaining system to lose access to the data stored only on that node. If a use case allows for the implementation of a centralized authority, this would in general be the simpler but less secure solution. This effectively manifests the whole dataset in a data structure similar to a regular DWH, but instead of being hosted by a central authority it can be deployed in a distributed manner. These design decisions mainly lead to fulfilling requirements (1) and (4) stated in the Introduction.

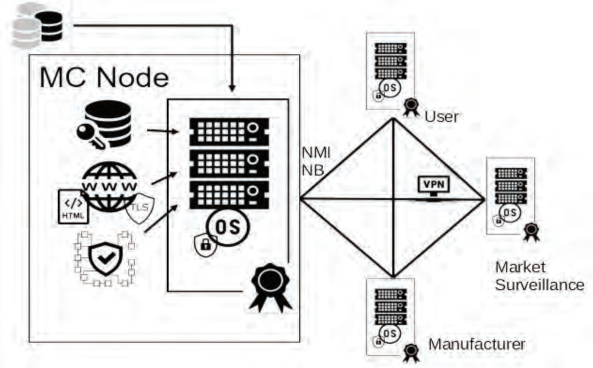

Fig. 2 How data will be distributed over the Stakeholders

C. PACELC

Another degree of freedom for distributed data systems is based on the PACELC theorem. It states the following: in the case of having network partitioning (P), a system designer must choose between availability (A) of the system and consistency (C) (of data replicated across multiple machines). When there is no network partition (E), the designer still must choose between latency (L) and consistency (C). The first part is equivalent to the well-known CAP-theorem. The reason for this is easily explained: to achieve better availability, data can be replicated such that when one of the data nodes A gets too many calls to handle, some of those requests can be transferred to one of its replicas A_i^*, thus increasing availability. Using replication also means that, in case a data change needs to be applied to A, only one replica gets the update, which then would need to be propagated to all other replicas A_i^* (including A itself). This is what introduces the consistency problem where systems using replication only get eventual consistency or lose out on the availability side of things while the system asserts consistency after value updates, which is only achieved once all replicas A_i^* again hold the same values as A.

Design decision: PACELC: As consistency of the data is of utmost importance to fulfill regulatory demands and maintain data integrity, we do not use node-replication. What we might have is a situation where two or more participants have several data cells or even full relations duplicated. In that case, our approach is to solve these issues on query execution when the node merging the result sets gets conflicting overlapping information from other nodes. Thus, we focus on consistency in the non-partitioned case. When dealing with network partitioning, we lose data from other partitions while those nodes cannot be reached, only preventing processes needing that data from continuing.

III Hardware configuration

Given a decentralized system, every node is an equally important security anchor for the overall network. Such trusted systems require a special focus on software security, but this is not feasible without a secure hardware foundation. The commonality of all hardware, software and firmware is directly or indirectly security-relevant and is therefore referred to as a Trusted Computing Base.

Ever since the media-effective publication of the processor vulnerability families Spectre [12] and Meltdown [13], the issue of hardware security has caught the attention of the masses. In most cases, exploiting such vulnerabilities requires code execution on the affected system, which implies the attacker already having direct access to the system. Nevertheless, these gaps should not be underestimated. New zero-day exploits are discovered on a regular basis, and additionally there is a Spectre variant which only requires the execution of a malicious JavaScript in the browser. Spectre and Meltdown exploit hardware bugs, but they are implemented in software and thus can potentially be detected by conventional safeguards such as antivirus software. Another class of threats, that until recently has been assumed to be purely theoretical but has become more prevalent since the release of the StuxNet Virus, is firmware-affecting malware. This type of malware exploits vulnerabilities in the firmware of system components and thus bypasses existing protective measures. In some cases, implementation errors can weaken system security, as was the case with a bug in some TPM chips from Infineon [14]. In other cases, the firmware vulnerabilities even allow unauthorized access to the system, bypassing system protection mechanisms, as it happened with recently discovered bugs in the Intel Active Management Technology [15]. Even permanent modifications of firmware, such as UEFI, are possible which can then provide stealth functionality for other malicious software [16]. Such modifications are very efficient and hard to detect. The potential possibilities extend to the modification of the microcode loaded into the system processors [17], which can be used to influence the execution of the commands in the processor on the lowest possible level. Due to strong encryption, microcode updates for current processors can be considered safe. Fortunately, such firmware attacks today are often limited to specific hardware/firmware versions, but it is to be expected that the number of such attacks will increase over time and diversify to different hardware configurations.

These examples are intended to show that without secure hardware, integrity of the software cannot be achieved. In addition, hardware security can only be assumed for a certain period of time and this estimate can be subject to change. This results in a requirement to reduce hardware diversity to a manageable level, providing a better overview of the current threats and thus enabling faster reaction in terms of software or even hardware updates. Unfortunately, the use of typed hardware and software also allows the potential attacker to completely focus on the given system. The choice between typed and non-typed hardware is therefore of a political nature. No hardware typing is associated with the tacit acceptance of some compromised network participants, while highly standardized hardware leads to an all or nothing situation. Both variants are found in the market: for example, the MacOS operating system from Apple requires typed hardware, while Microsoft only sets the minimum requirements for their operating systems.

A secure node prevents unauthorized entities from gaining access to the user data, but another security risk remains, namely the user himself. If the user logs into the node from an untrustworthy device, his credentials can be stolen and used for extensive manipulations according to his authorization level. This would require that all devices used to access the node are subject to strict security requirements similar to the node itself, however, this solution is hardly practical. Therefore, it is more convenient to protect the authorization attributes by storing the user's key material on external hardware. The hardware itself does not offer any security against theft and should therefore be combined with other features, such as biometrics, in order to be able to assume the physical presence of the person in certain situations. Some actions require a higher level of authorization than others (e.g. password entry, browser cookies, hardware presence, biometric authorization), so that a tiered authorization concept is considered useful.

Design decision: Hardware: For our system, the solution with typed hardware appears to be the preferred variant, as it not only keeps the development and maintenance effort within manageable limits, but also makes the security of the overall system easier to assess. Due to standardized components, the operating system no longer needs to support a variety of hardware and can therefore be stripped to the core functionalities, further reducing the attack surface while increasing the system efficiency. In order not to reinvent the wheel, the decision was made to develop the hardware token for user authentication based on the FIDO2 standard [18], [19], tailored to the special requirements of our use case. In order to support many different devices, the hardware token should offer a USB interface and, if possible, NFC or Bluetooth to include mobile devices. The outsourcing of key material to secure external hardware allows less trustworthy devices to log into the metrology cloud network without greatly compromising security, making it more convenient for users. The concepts described lay the foundations for data security, authenticity (2) and secure data transfer (3).

IV Operating system

The approval of a measuring instrument is a trustworthy process and accompanied with the processing of sensitive technical data in a competitive environment. Therefore, the protection of these documents in a distributed environment plays a significant role for the construction of a digital quality infrastructure in legal metrology. Today, the general purpose / multi-user operating systems (OS) are equipped with comprehensive tools for remote diagnostic and maintenance. Unfortunately from the manufacturer's data privacy perspective, an intrinsic connectivity to proprietary cloud systems is mostly configured by default (and sometimes cannot be switched off) to share technical and customer-specific data with the manufacturer of the operating system. Often these systems hide their source code completely or partially, which complicates an examination of the shared data by the laboratory.

A second decision that has to be made is whether and how to use virtualization to separate and protect sensitive data. By default, the underlying OS delivers some protection techniques, e.g. memory protection, process isolation or sandboxing to avoid unauthorized access to the data. With operating system virtualization, applications can be more strictly separated, each one or a bundle is running in a specified environment, but is sharing the same host OS kernel (container) [20]. To go one step further, hardware virtualization separates programs and data into different operating systems (virtual machines), controlled by a hypervisor and thus delivers the most flexibility, referring to the underlying hardware. Also virtualization solutions often come with productive failover-features and provide high portability and scalability. A major drawback of virtualization is its performance overhead, caused by inter-process-communication through all layers of the architecture, and some effort for the setup and design of the virtualization-layer.

Design decision: Operating systems: We decided to use a proven-in-use and widely adopted OS such as Debian Linux, which results in less effort and lower costs in developing the platform, while its open-source nature leaves full control over a large number of fine-grained configuration settings, that can be made easily and transparently on different aspects such as user permissions, network access, etc.

To meet requirement (2) and (3) we will combine the decision for Linux with the hardware virtualization technique on a microkernel-based hypervisor in the future when it comes to the distribution of the platform. To address the performance issue, high-performance, energy-efficient hardware will be used (see section III).

V Storage and privacy

The choice for a distributed system with a single data schema based on typed node hardware results in no further restrictions concerning the storage technology for the data itself beside robustness, capacity, etc., although the system logs need to be stored in a different, more complex way, i.e. distributed over all nodes. This again raises new privacy issues.

A. Immutable Logging

To fulfill requirement (1), all interactions in legally relevant processes need to be logged. We identified the following requirements for such a logging service:

- immutability of logs by any stakeholder and any malware;
- availability of logging service;
- persistency of log files over time;
- scalability;
- secure against future developments such as quantum computers.

In general there are three possibilities for immutable logging in distributed systems:

- A hardware solution (HS) [21], for example write-once/read-many (WORM) storage as provided by optical drives (physical WORM) or flash storage (physical but mostly achieved by a device controller). Each node logs its own interactions and keeps the log files. The logging devices need a unique and authentic identifier, that will be registered. Devices whose storage capacity is exhausted have to be stored.
- A trustworthy third party entity (TWE), that keeps logbooks about processes that are conducted on the platform. All interactions are reported to the TWE which creates and maintains a centralized logbook.
- A distributed ledger (DL) [22] under control by the consortium shared across all stakeholders, with its integrity being provable by cryptographic means.

Immutability: The first requirement is fulfilled by HSs as well as by software solutions such as logbooks kept by a TWE or DL under public control.

Availability: As processes rely heavily on the logging service, a centralized logbook on a single node is a single point of failure. HSs require specialized hardware that is more costly than software solutions that only require more standard hardware.

Persistency: If the legal frame requires storing of log data for an extended period, the storage has to be permanent and redundant. HSs would require physical copies as offsite backup, which would become costly and a logistical challenge. Logbooks by a TWE can be backed up with standard archiving software and the archive can be stored offsite. DLs are very durable based on their intrinsic replication across nodes.

Scalability: Scalability is needed if the system is expected to grow over time but also to satisfy the availability requirements while the system is under heavy load. This can be achieved in both software and hardware solutions. As mentioned before, specialized hardware is more costly than software solutions that only require more standard hardware.

Future-proof: Quantum computers are becoming more and more reliable and powerful [23], so we have to assume that there will be practically usable quantum computers within the next three decades. There are well-known symmetric encryption and hashing schemes known to be resistant against quantum computers, but until now there are no asymmetric signature/encryption schemes that have been proven to be resilient against quantum computers and at least as resistant as ECC against conventional computers[24]. Therefore a TWE cannot be assumed to fulfill this requirement. HS by themselves are not assumed to be vulnerable to quantum computers, but the bookkeeping of the logging devices and the way in which authenticity is proven may be vulnerable.

Design decision: immutable logging: We conclude that a DL would fit our use case best, as HS would be too expensive, which might prevent stakeholders from joining. If a stakeholder decides to e.g. add a file to the system, he/she commits a file creation event to the ledger. Other stakeholders can now interact with that file, depending on their respective access rights. The logging is implemented by letting other stakeholders set a so-called *lock* on a committed file or data object, assuming they were granted the appropriate rights from the owner of that file. Once a file is *locked* by another stakeholder, any changes to that file need to be communicated to and approved by every *lock*-holder. To guarantee compliance with these rules, DL technology in the form of a blockchain is utilized, i.e. every event or process involving sensitive data of a stakeholder is written to the blockchain once consensus in the network has been established, thus guaranteeing that an established lock cannot be removed without permission from all *lock*-holders. Having consensus-based logging also implies a certain level of security against quantum computer based attacks.

B. Privacy vs verifiability

The decision to utilize DL technology to implement immutable logging prompts the question of how the data is written to the ledger. The data written to the blockchain might contain sensitive information about the respective stakeholder that should only be visible to selected other stakeholders. A possible solution is a symmetric encryption scheme in which each authorized stakeholder shares the same secret key. To prevent any form of invalid transactions from entering the blockchain and thus exposing potentially compromised nodes, each new block (and therefore every new transaction) is verified by at least one other node in the network. To enable a node to verify a newly proposed block, that node must, at least partially, be able to read the transactions in that block. This heavily compromises the privacy of each participant, especially considering the case that multiple stakeholders could trace all transactions of their respective competitors, given their node is involved in the verification process. The concepts of transparency and privacy are contradictory. This is even more important, given that most participants in the network are competing business entities. Any revelation of sensitive information could cause tremendous damage to the participant involved, thus rendering participation in such a system unappealing. This problem however is well-known and existing blockchain technologies already implement processes to preserve varying levels of privacy.

Blockchains can be differentiated into permissioned and permission-less blockchains, depending on how new nodes are allowed to join the network. In permissioned blockchains, the privacy issue can be simplified since nodes are assumed to be more trustworthy, resulting in a less demanding verification process, e.g. in the form of a centralized control. A fully decentralized permission-less blockchain, on the other hand, always requires the majority of the network to verify and approve each transaction. The following list gives a short overview of concepts deployed by blockchains with the goal of preserving privacy(2):

- Bitcoin [25] utilizes multiple obfuscation schemes to hide the complete transaction history of an identity, e.g. a user can create multiple accounts (wallets) with unique private keys, thus allowing him to divide up his transactions. Other approaches are “Bitcoin laundries", that allow multiple users to mix their transactions, thus obfuscating transaction history.

- Ethereum is working on implementing zero-knowledge succinct non-interactive arguments of knowledge (zkSNARKs) in their blockchain, e.g. ZoKrates [26]. Based on zero-knowledge proofs, this technology allows verification of computations, without knowing the actual content of the computation. The same technology is applied in *Zcash*, a blockchain with a focus on zkSNARKs to allow "shielded" transactions.
- Monero is implementing RingCT [27], a technology based on ring signatures. A ring signature proves that the signer's private key corresponds to one of a set of public keys without identifying the specific key.
- Hyperledger Fabric [28] is a permissioned blockchain that solves the privacy issue by introducing channels that hide the transactions from all peers that are not members of the channel the transactions are posted to. Only peers participating in the channel can see and verify the content of the transactions.

Preserving privacy in public ledgers is a difficult task, since a majority of the network is required to verify all transactions to prevent attacks such as double-spending. A general solution to the problem are zero-knowledge proofs. However, the current implementations are still in an early development stage and require a lot of resources in deployment [29]. Ethereum is also working on implementing zkSNARKs in their blockchain, but due to the Turing-complete virtual machine behind the blockchain, the process is even more resource-intensive compared to using a zkSNARK for specific tasks, as is done in Zcash.

Preserving privacy on permissioned blockchains on the other hand can often be simplified, since the participating nodes are more trustworthy.

Design decision: privacy vs verifiability: Privacy on DLs is always based on encryption. Different technologies can be applied, resulting in different levels of transparency. Ring signatures can be implemented to obfuscate the identity in a group or simple symmetric encryption to enable only the key owners to see and verify the respective transactions. The latter can be used in a scheme where consensus is only established if every single owner of a group of symmetric key owners has signed a transaction encrypted with that key. This could be described as an undisclosed ledger. The ideal solution would be a low-cost and fast zero-knowledge proof, enabling every node to verify every transaction without reading the actual content. Applied to our use case: if a party e.g. proposes a transaction to delete a file, the current verifier only needs to evaluate the fact that no other party has an active *lock* on that file. The identities of those involved and the content of the file itself bear no relevance to the verification process. This variant can be described as a hybrid approach between verifiability and privacy.

VI Current demonstrator state

Based on the design decisions detailed above, we developed a first demonstrator of such an information system, which was presented at last year's EMC consortium meeting (see Figure 3). An advanced version implementing a number of improvements will be ready for test deployment to interested stakeholders sometime this year and is going to be demonstrated at our consortium meeting in May 2020.

VII Conclusion

We showed that our consortial platform setting is a new challenge and we developed an appropriate solution for it. Some design decisions are cascading (see Figure 4), as data locality implies different requirements for all the following decisions. We described our solution that satisfies all the given requirements, including data locality, data integration, a platform trust anchor and tamper-proof logging with an emphasis on privacy issues.

Fig. 3 First demonstrator of the described system approach

Designing an IIS for a consortial platform is a relevant task for various other scenarios in the industry. Combining the varying interests of different stakeholders in a system that implements immutable logging of processes to be available as legal proof can be applied to areas such as healthcare, insurance policies, and similar scenarios. The design decisions presented in this paper give an overview of what technologies we consider appropriate for a consortial platform. There is still a lot of room for deciding which specific implementations are the most efficient. An evaluation of existing and comparable solutions is required in order to decide which implementations can be applied to our scenario. ■

Fig. 4 All design options we identified and the choices we made (red bar). Dependencies among decisions are indicated by a chain linking the items.

References

[1] OIML, "General requirements for software controlled measuring instruments (OIML D 31), edition 2008," 2008, last seen: 2019. [Online]. Available: https://www.oiml.org/en/files/pdf_d/d031-e08.pdf

[2] WELMEC, "WELMEC 7.2 Software Guide (Measuring Instruments Directive 2014/32/EU)," 2015, last seen: 2019. [Online]. Available: https://www.welmec.org/documents/guides/72

[3] European Parliament, "DIRECTIVE 2014/32/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the Harmonisation of the Laws of the Member States Relating to the Making Available on the Market of Measuring Instrument," 2014, last seen: 2019. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0032&from=EN

[4] J. Gauck, “Gesetz über das Inverkehrbringen und die Bereitstellung von Messgeräten auf dem Markt, ihre Verwendung und Eichung sowie über Fertigpackungen (Mess- und Eichgesetz - MessEG),” 2013, last seen: 2019. [Online]. Available: https://www.gesetze-im-internet.de/messeg/ BJNR272300013.html

[5] Physikalisch-Technische Bundesanstalt (PTB), Working Group Metrological Software, 2020, last seen: 2019. [Online]. Available: https://www.ptb.de/cms/en/ptb/fachabteilungen/abt8/fb-85/ag-851. html#maincontent_informationen_header

[6] F. Thiel, M. Esche *et al.*, “A digital quality infrastructure for Europe: The European metrology cloud,” *PTB-Mitteilungen. Volume 127*, pp. Issue 4, Page 83 to 97 0030–834, 2017, iSSNX.

[7] M. Stonebraker, “Big Data, Disruption and the 800-pound Gorilla in the Corner,” 2018. [Online]. Available: http://web.stanford.edu/class/ ee380/Abstracts/160601-slides.pdf

[8] P. Ziegler and K.R. Dittrich, *Data Integration — Problems, Approaches, and Perspectives*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2007, pp. 39–58. [Online]. Available: https://doi.org/10. 1007/978-3-540-72677-7_3

[9] D. Abadi, “Consistency Tradeoffs in Modern Distributed Database System Design: CAP is Only Part of the Story,” *Computer*, vol. 45, no. 2, pp. 37–42, Feb 2012.

[10] M. Stonebraker, S. Madden *et al.*, “The End of an Architectural Era: (It’s Time for a Complete Rewrite),” in *Proceedings of the 33rd International Conference on Very Large Data Bases*, ser. VLDB ’07. VLDB Endowment, 2007, p. 1150–1160.

[11] Z. Abedjan, L. Golab, and F. Naumann, “Profiling relational data: a survey,” *The VLDB Journal*, vol. 24, no. 4, pp. 557–581, Aug 2015. [Online]. Available: https://doi.org/10.1007/s00778-015-0389-y

[12] P. Kocher, D. Genkin *et al.*, “Spectre Attacks: Exploiting Speculative Execution,” *arXiv e-prints*, p. arXiv:1801.01203, Jan 2018.

[13] M. Lipp, M. Schwarz *et al.*, “Meltdown,” 2018.

[14] “CVE-2017-15361.” Available from MITRE, CVE-ID CVE-2017-15361., Oct. 16 2017. [Online]. Available: https://www.cvedetails.com/ cve/CVE-2017-15361/

[15] “CVE-2017-5689.” Available from MITRE, CVE-ID CVE-2017-5689., Feb. 1 2017. [Online]. Available: https://cve.mitre.org/cgi-bin/cvename. cgi?name=CVE-2017-5689

[16] C. Kallenberg, X. Kovah *et al.*, “Extreme privilege escalation on windows 8/uefi systems.” 2014. [Online]. Available: https://www.blackhat.com/docs/us-14/materials/ us-14-Kallenberg-Extreme-Privilege-Escalation-On-Windows8-UEFI-Systems.

[17] P. Koppe, B. Kollenda *et al.*, “Reverse engineering x86 processor microcode,” in *26th USENIX Security Symposium (USENIX Security 17)*. Vancouver, BC: USENIX Association, Aug. 2017, pp. 1163–1180. [Online]. Available: https://www.usenix.org/conference/ usenixsecurity17/technical-sessions/presentation/koppe

[18] F. Alliance, “FIDO Specifications,” 2019, last seen: 2020. [Online]. Available: https://fidoalliance.org/specifications/download/

[19] W3C, “WebAuthn Specification,” 2019, last seen: 2020. [Online]. Available: https://www.w3.org/TR/webauthn/

[20] J. M. Murugiah Souppaya and K. Scarfone, “Application Container Security Guide,” *NIST Special Publication*, pp. 800–190, 2017. [Online]. Available: http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP. pdf, September2017

[21] B. Laurie, “Network forensics,” *Queue*, vol. 2, no. 4, p. 50–56, Jun. 2004. [Online]. Available: https://doi.org/10.1145/1016978.1016982

[22] L. Aniello, R. Baldoni *et al.*, “A prototype evaluation of a tamper-resistant high performance blockchain-based transaction log for a distributed database,” in *2017 13th European Dependable Computing Conference (EDCC)*, Sep. 2017, pp. 151–154.

[23] F. Arute, K. Arya *et al.*, “Quantum supremacy using a programmable superconducting processor,” *Nature*, vol. 574, pp. 505–510, 10 2019.

[24] D. J. Bernstein, *Introduction to post-quantum cryptography*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2009, pp. 1–14. [Online]. Available: https://doi.org/10.1007/978-3-540-88702-7_1

[25] S. Nakamoto, “Bitcoin: A peer-to-peer electronic cash system,”,” 2008. [Online]. Available: http://bitcoin.org/bitcoin.pdf

[26] J. Eberhardt and S. Tai, “Zokrates - scalable privacy-preserving offchain computations,” in *2018 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData)*, July 2018, pp. 1084–1091.

[27] S. Noether, “Ring signature confidential transactions for monero,” 2015, https://eprint.iacr.org/2015/1098.

[28] E. Androulaki, A. Barger *et al.*, “Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains,” in *Proceedings of the Thirteenth EuroSys Conference*, ser. EuroSys ’18. New York, NY, USA: Association for Computing Machinery, 2018. [Online]. Available: https://doi.org/10.1145/3190508.3190538

[29] E. C. Company, “Cultivating Sapling: Faster Zk-SNARKs,” 2017. [Online]. Available: https://blog.z.cash/cultivating-sapling-faster-zksnarks

[30] S. Gilbert, N. Lynch, “Brewer’s Conjecture and the Feasibility of Consistent, Available, Partition-Tolerant Web Services” in SIGACT News, June 2002, pp. 51-99, doi = 10.1145/564585.564601

[31] “Digital transformation of legal metrology - The European Metrology Cloud”. OIML Bulletin, vol. LIX, January 2018, pp. 10-21)

ECONOMIC DISTORTION

An Input-Output approach to evaluate economic distortion in trade metrology

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1 Introduction

Trade involving weights and measures is responsible for a significant part of all countries' GDP. Deviations caused by aggregate values of measurements along a product supply chain may cause significant distortions to the economy. The monetary unit associated with this market asymmetry implies financial losses to the economy. Studies conducted by several nations have demonstrated the relevance of products whose value is based on measurements in both local and global markets [1–3].

Legal metrology is responsible for applying regulations to measuring instruments that impact both the economy and society [4], establishing requirements such as maximum permissible errors (MPE) in order to provide the necessary accuracy for fair exchange, maintaining trade-related measurement errors within acceptable levels, and thus assuring confidence in the market [5].

In the 19th century, Charles Babbage [6] realized that the transaction costs also include a cost element integrated in the final price of verifying the "goodness" of what the consumer is purchasing. In trade metrology these costs involve the legal metrology activities conducted by the State, such as verifications and surveillance. Products and services related to weights and measures are vital to any economy, for example, the production and distribution of electricity, whose infrastructure corresponds to one of the three highest impacting infrastructures in the UK GDP [7].

Moreover, society and other institutions demand that rational use is made of national resources to justify the budget applied in legal metrology, and so it is vital to be able to quantitatively evaluate the benefit component of legal metrological control [8]. Additionally, the impact of metrology and measurement technologies are not well known, so the budget allocated to research in the field is under constant pressure [9]. The economic distortion due to measurement deviations can impact the economy in both international trade, where deviations in standards between the exporter and the importer can cause asymmetry, and also the domestic market, where the deviation cause a distortion between the buyer and the seller, leading to financial losses.

Such distortion in the economy has been exhaustively studied by laureate economists such as Arrow, Akerlof, Spence, Rothschild and Stiglitz [10–14]. In legal metrology the study of economic distortion caused by inaccuracy of measuring instruments in the market has been investigated by studies conducted by Stiefel [8], Birch [15] and Usuda and Henson [16]; nevertheless, a consolidated model to evaluate the impact of legal metrology in the economy is an open issue [17]. A series of models are under constant development with the aim of having more accurate models to evaluate the impact on the economy.

The Input-Output Model ("I-O Model"), developed by Wassily Leontief allows the interconnections among the various sectors of economy to be identified due to the relation between the output of a sector and the input to other sectors of the economy [18]. The idea of the model is to consider that deviation in an input also affects the interdependent areas on that input, generating a chain reaction throughout the sectors which influences the whole economy, since the sectors are all interconnected. For example, a deviation in the fuel sector affects not only the final users, but also all transportation services based on fuel. This model has been widely used in a range of studies such as oil production, water consumption, energy, and CO_2 emissions [19–22]. One of the main aspects of the model is that it is possible to see how the change in one demand affects the entire economy.

While most of the literature that aims to estimate the impact of metrology on the economy presents theoretical studies, surveys and test cases using secondary indicators such as the number of patents, expenditure and costs for certification, as already reviewed in the paper entitled "*Measuring the benefit of legal metrology to place it in the National Quality Infrastructure*" [23], there are no consolidated models that can be applied to every economy in order to identify the losses due to measurement deviations in the market, allowing comparisons among countries.

The objective of the present study is to introduce a formulation based on the I-O Model to compute the economic distortion due to measurement errors of instruments used in the market, considering how an individual distortion in one economic sector or product propagates throughout the various productive sectors and thus affects the entire economy. Thus, the goal is to use a very consolidated economic model, providing a robust database, contributing to the state of art once it incorporates the interconnection of the productive sector to the economy, since a deviation due to a measurement error in one input will affect an output in other sectors. The simulation uses the Brazilian I-O matrix and was conducted in key sectors of the Brazilian economy (fuel, utilities and commodities), in order to obtain economic distortion curves based on the measurement deviation or measurement error.

2 Methodology

2.1 The I-O Model

The present research was based on the I-O Leontief static analysis, detailed in this section. We propose a formulation to measure economic distortion, introducing a percentage deviation δ, representing a measurement deviation, using the classical I-O Model. For simplicity, we used only positive deviations.

Afterwards, the approach was applied to certain key products representing major economic sectors: commodities, fuel and utilities. For that, we used the 2015 Brazilian I-O Tables, published by the Brazilian Institute of Geography and Statistics. Finally, simulations were conducted using the Scilab version 5.5.2 software. It is also worth noting that results were displayed in USD, which allowed comparisons among countries. The exchange rate is 1.000 USD = 3.3315 BRL, representing the average exchange rate in 2015 [24].

The I-O Model was developed by the Russian economist Leontief, professor at Harvard, during the 1960's. Leontief was awarded the 1973 Nobel Prize for Economics for his development of the I-O Model. The model was based on the general equilibrium theory by Léon Walras [25] and on the assumption that production processes are connected, and the findings occur whenever the output of one process becomes the input to another [18]. This interdependence is represented in a matrix equation system, where the outputs of processes are represented by the lines, and the inputs are represented by the columns. The goal of the I-O analysis is to describe economic reality as closely as possible [26]. The more basic form of the I-O Model, using the industry technology assumption, states that the product output is represented by the final demand of products $\boldsymbol{F}$ plus the intermediate consumption of industries $\boldsymbol{U}$, as seen in (1) [27]. $\boldsymbol{V}$ is the productions matrix, representing the production for each sector. The aggregated products in the sectors are represented by $\boldsymbol{g}$, as shown in (2):

$$\boldsymbol{q} = \boldsymbol{U} + \boldsymbol{F} \qquad (1)$$

$$\boldsymbol{g} = \boldsymbol{V} \qquad (2)$$

The basic definitions of the model are given in (3) and (4):

$$\boldsymbol{U} = \boldsymbol{B} \cdot \boldsymbol{g} \qquad (3)$$

$$\boldsymbol{V} = \boldsymbol{D} \cdot \boldsymbol{q} \qquad (4)$$

where represents the product by industry use coefficient matrix and the industry by product use coefficient matrix. Using (1), (2), (3) and (4), the product output and the industry output are given by (5) and (6), respectively:

$$\boldsymbol{q} = \boldsymbol{B} \cdot \boldsymbol{g} + \boldsymbol{F} \qquad (5)$$

$$\boldsymbol{g} = \boldsymbol{D} \cdot \boldsymbol{q} \qquad (6)$$

Combining (5) and (6), the I-O Model is represented by (7), where I represents the identity matrix:

$$\boldsymbol{q} = [\mathbf{I} - \boldsymbol{B} \cdot \boldsymbol{D}]^{-1} \cdot \boldsymbol{F} \qquad (7)$$

Equation 7 represents the fact that the industry output is dependent on the final demand for products.

The inverse Leontief matrix $[\mathbf{I} - \boldsymbol{B} \cdot \boldsymbol{D}]^{-1}$ represents the interdependence between final demand and the industry output matrices. The matrix $[\boldsymbol{B} \cdot \boldsymbol{D}]$ represents the product by the product coefficient matrix. The sum of the industry output p is represented in (8):

$$p = \sum_{i=1}^{n} q_i \qquad (8)$$

2.2 An approach to measuring economic distortion

The I-O analysis shows production related to the economy, considering the intermediate consumption by the productive sectors and the final demand. The proposed model considers that consumers are not only represented by the final demand, but also by industry, responsible for producing goods to the final demand as well as inputs to other productive processes.

Then, trade is also represented when an industry purchases inputs to its process, and during this commercial transaction distortions are also involved. This aspect represents the goal of the Leontief analysis and it is incorporated into our model when a measurement distortion δ is applied to the matrices that represent either the intermediate consumption of industries $\boldsymbol{U}$ and the final demand of products $\boldsymbol{F}$. Both matrices are given in monetary units and represent the amount of money spent by the productive sectors and the final consumer. Here, the deviation δ is applied to whichever product represents the average error of the measuring instruments used in the sector, aggregating not only systematic errors, but also external factors that may affect a measurement such as weather conditions, operator expertise and others. The deviation applied to U and F is represented in (9):

$$q' = \delta \cdot \boldsymbol{U} + \delta \cdot \boldsymbol{F} \qquad (9)$$

Consequently, the I-O Model with the δ matrix is represented by (10), where g' represents the industry output considering the deviation. The elements of the matrices $\delta \cdot \boldsymbol{U}$ and $\delta \cdot \boldsymbol{F}$ can be represented by (10), applying a deviation δ to the $k-th$ element:

$$\begin{pmatrix} u_{11} & u_{12} & \cdots & u_{1k} & \cdots & u_{1n} \\ u_{21} & u_{22} & \cdots & u_{2k} & \cdots & u_{1n} \\ \vdots & \vdots & \ddots & \vdots & \cdots & \vdots \\ \delta_k . u_{k1} & \delta_k . u_{k2} & \cdots & \delta_k . u_{kk} & \cdots & \delta_k . u_{kn} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ u_{m1} & u_{m2} & \cdots & u_{mk} & \cdots & u_{mn} \end{pmatrix} \qquad (10)$$

$$\delta_k \cdot \boldsymbol{F} = \boldsymbol{F'} = \begin{pmatrix} f_1 \\ f_2 \\ \vdots \\ \delta_k . f_k \\ \vdots \\ f_m \end{pmatrix} \qquad (11)$$

Consequently, the I-O Model with the δ matrix is represented by (12), where g' represents the industry output considering the distortion of the deviations:

$$\boldsymbol{q'} = [\mathbf{I} - \boldsymbol{B'} \cdot \boldsymbol{D}]^{-1} \cdot \boldsymbol{F'} \qquad (12)$$

The sum of industrial output considering the distortion δ, p' is representing by (13):

$$\boldsymbol{p'} = \sum_{i=1}^{n} q'_i \qquad (13)$$

Finally, the economy distortion due to measurement errors in the proposed model is given by the difference between the sum of the production vectors p and p', as shown in (14):

$$ED = \sum_{i=1}^{n} (p_i - p_i) \qquad (14)$$

2.3 Limitation of the model

Products and sectors are inserted into the I-O table according to their relevance to the local economy, so an important product in one economy may not be relevant to another. Since the formulation is based on the I-O Model, the economic distortion can be simulated only for those products that are represented as an element in the matrix and may be difficult to compare for different countries in some specific areas. Another aspect is the fact that the model only computes the economic impact in monetary units, therefore intangible characteristics provided by legal metrology control such as security, health and environmental aspects are not considered in this formulation.

2.4 Case study

The analysis of the economics of trade metrology was conducted using the latest I-O report data published by the Brazilian Institute of Geography and Statistics, representing the economy in 2010 [28]. Resources consumed by the production processes $\boldsymbol{U}$, the demand $\boldsymbol{F}$, the production by product $\boldsymbol{q}$ and the technical coefficient matrix $\boldsymbol{D}$ were used as an approach to the model.

Different key products were selected in order to understand how a measurement deviation in a product would affect the whole economy. The products were selected in line with their impact on the Brazilian economy, as shown in Table 1. The deviations were set from 0.5 % to 10 % in order to obtain the economic distortion curve for each product.

Table 1 Products simulated to compute the economic distortion

Commodities	Fuel	Utility
Corn	Gasoline	Electricity, gas and utilities
Soybean	Ethanol and other biofuels	Water, sewerage and waste management
Coffee	Diesel - biodiesel	

In order to identify the impact curve for each product individually, the matrices $\delta \cdot \boldsymbol{F}$ and $\delta \cdot \boldsymbol{U}$ were obtained for the $k-th$ product according to (10) and (11). For the Brazilian I-O matrix, $m = 127$ and $n = 67$. The Scilab version 5.5.2 software was used to simulate the economic distortion of the products shown in Table 1. The code is shown in Figure 1.

The algorithm developed considers the given matrixes $\boldsymbol{D}$, $\boldsymbol{q}$, $\boldsymbol{U}_n$ and $\boldsymbol{F}_n$. For systems where $\boldsymbol{D}$ is not given, it can also be easily computed according to (4). It is also worth noting that the coefficient matrix $\boldsymbol{B}$ is dependent on the distortion δ, differently to $\boldsymbol{D}$.

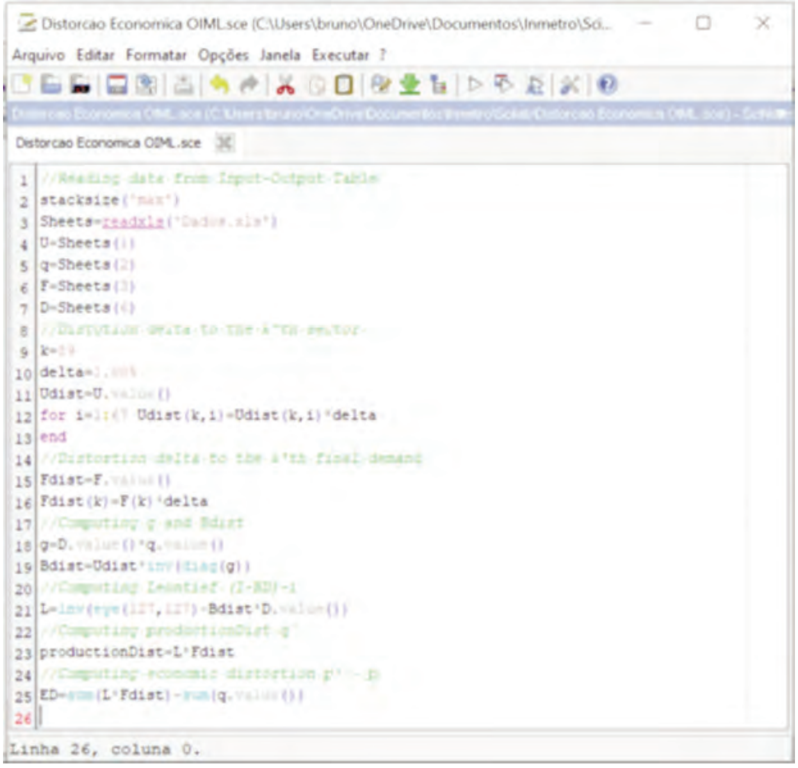

Figure 1 Scilab code simulating the economic distortion

3 Results and discussion

A linear feature curve, as seen in Figure 1 (R^2), was obtained for each product, given the economic distortion as a function of the deviation. Additionally, Table 2 shows the economic distortion for all the simulations carried out. *Electricity, gas and utilities* are displayed as a single product as well as *Water, sewerage and waste management*, representing a single element in the Brazilian I-O Matrix. The linear dependence is also given in Table 3.

Electricity, gas and utilities have the greatest impact amongst all the simulated products, followed by *diesel, biodiesel*, *gasoline*, *soybean*, *ethanol and other biofuels*, *water, sewerage and waste management*, *corn*, and finally *coffee*.

Identifying economically relevant products is an important aspect of the proposed model, allowing the national governments to strategically allocate resources to those products that have more influence on the local economy, enhancing legal metrology control and consequently national competitiveness as well as fair competition at the national level, reducing losses due to measurement errors.

As can be seen from Figure 2, costs for electricity, gas and utilities suffer a high impact from measurement errors, that can spread along the whole production chain linked to them. Diesel and biodiesel represent other sensitive area that can spread extra costs to the production sector processes. Related to grain production, errors in soybean measurement represent higher costs to industry than for coffee, for example, mainly due to the use of soybean in a longer production chain than coffee.

4 Conclusion

The proposed model using distortion applied to the Leontief I-O Model allowed the economic distortion due to measurement errors to be determined in products whose value is based on measurements subject to legal metrology requirements.

The goal of the proposed model is to compute all the interconnections in each sector of the economy, thus allowing the economic distortion in the whole economy to be evaluated. It also shows that the model is appropriate to national economies once the intermediate processes besides the final demand are considered when measuring the economic distortion due to deviations. Another contribution is the use of the model to identify those products that demand more accurate metrological control, resulting in better formulation of metrology policies and budgets.

The resulting economic distortion shows the importance of ensuring that an adequate national

Table 2 Economic distortion for each simulated values and product

Deviation	Economic distortion / 1 000 000 USD							
	Corn	Soybean	Coffee	Gasoline	Diesel, biodiesel	Ethanol and other biofuels	Electricity, gas and utilities	Water, sewerage and waste management
0.5 %	$77.64	$282.71	$42.25	$303.36	$419.10	$209.73	$807.24	$151.85
1.0 %	$155.29	$565.44	$84.51	$606.73	$838.27	$419.49	$1,618.55	$303.72
1.5 %	$232.94	$848.20	$126.76	$910.09	$1,257.49	$629.29	$2,433.97	$455.62
2.0 %	$310.59	$1,130.98	$169.02	$1,213.46	$1,676.78	$839.11	$3,253.54	$607.55
2.5 %	$388.24	$1,413.78	$211.27	$1,516.84	$2,096.12	$1,048.96	$4,077.27	$759.49
3.0 %	$465.90	$1,696.60	$253.52	$1,820.21	$2,515.53	$1,258.85	$4,905.21	$911.46
3.5 %	$543.55	$1,979.45	$295.78	$2,123.59	$2,935.00	$1,468.76	$5,737.39	$1,063.46
4.0 %	$621.21	$2,262.32	$338.03	$2,426.97	$3,354.53	$1,678.70	$6,573.83	$1,215.48
4.5 %	$698.88	$2,545.21	$380.29	$2,730.36	$3,774.12	$1,888.68	$7,414.58	$1,367.53
5.0 %	$776.54	$2,828.12	$422.54	$3,033.75	$4,193.77	$2,098.68	$8,259.66	$1,519.60
5.5 %	$854.21	$3,111.06	$464.80	$3,337.14	$4,613.49	$2,308.71	$9,109.11	$1,671.69
6.0 %	$931.88	$3,394.01	$507.05	$3,640.53	$5,033.26	$2,518.78	$9,962.96	$1,823.81
6.5 %	$1,009.55	$3,676.99	$549.31	$3,943.93	$5,453.10	$2,728.87	$10,821.25	$1,975.95
7.0 %	$1,087.23	$3,960.00	$591.56	$4,247.33	$5,872.99	$2,939.00	$11,684.01	$2,128.12
7.5 %	$1,164.91	$4,243.02	$633.82	$4,550.73	$6,292.95	$3,149.15	$12,551.28	$2,280.31
8.0 %	$1,242.59	$4,526.07	$676.07	$4,854.14	$6,712.97	$3,359.33	$13,423.09	$2,432.52
8.5 %	$1,320.27	$4,809.14	$718.33	$5,157.54	$7,133.05	$3,569.55	$14,299.47	$2,584.76
9.0 %	$1,397.95	$5,092.24	$760.58	$5,460.95	$7,553.19	$3,779.80	$15,180.47	$2,737.03
9.5 %	$1,475.64	$5,375.36	$802.84	$5,764.37	$7,973.40	$3,990.07	$16,066.13	$2,889.32
10.0 %	$1,553.33	$5,658.49	$845.10	$6,067.79	$8,393.66	$4,200.38	$16,956.46	$3,041.63

Table 3 Linear approaches for each product

Product	Line approach
Corn	y = 15534x - 0.095
Soybean	y = 56587x - 0.8684
Coffee	y = 8451x - 0.0041
Gasoline	y = 60678x - 0.113
Diesel - biodiesel	y = 83943x - 2.3546
Ethanol and other biofuels	y = 42007x - 1.1617
Electricity, gas and utilities	y = 169957x - 165.98
Water, sewerage and waste management	y = 30419x - 0.9392

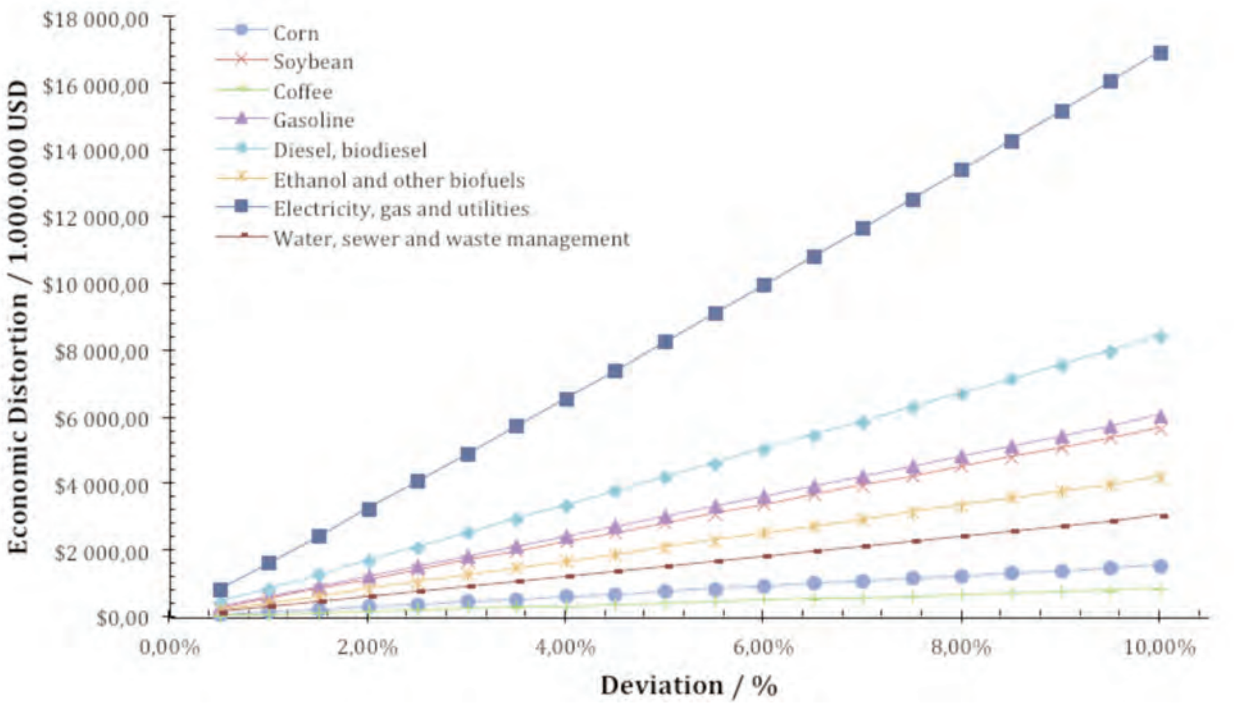

Figure 2 Linear curve representing the ED as a function of the deviations for each product

system is in place to control and monitor the measurement deviations in view of the impact on the economy of a single product. A linear dependence was also observed between the economic distortion and the measurement error, where the I-O simulations allow the angular inclination of the curve to be obtained, permitting the determination of which distortion on measurements of products have more impact on the economy. The model may also support national regulations in order to set maximum permissible errors according to economic distortion, or even distinct MPEs for different segments of the production sector and the final demand, in order to minimize losses to the economy.

The main disadvantage of the model remains the fact that not all products are represented in the I-O matrices, for example in the utility sector product simulated, where electricity, water, gas and sewerage are computed as a single product for the Brazilian case. ■

References

[1] Birch J. *Benefit of legal metrology for the economy and society - A study for the International Committee of Legal Metrology*. Paris, France: International Organization of Legal Metrology - OIML.

[2] Sanders R. Why do we regulate measuring instruments used for trade. *OIML Bulletin* 2011; LII: 13–15.

[3] Swann P. *The economics of metrology and measurement*. United Kingdom: National Measurement Office.

[4] OIML. *International Vocabulary of Metrology: Basic and General Concepts and Associated Terms (VIM)*. BIPM, Bureau International des Poids et Mesures, 2012.

[5] Birch J. Economic and social benefits of legal metrology. *OIML Bulletin* 2004; XLV: 10–13.

[6] Babbage C. *On the Economy of Machinery and Manufactures*. London: Charles Knight Pall Mall East, 1832.

[7] Kelly S, Tyler P, Crawford-Brown D. Exploring Vulnerability and Interdependency of UK Infrastructure Using Key-Linkages Analysis. *Netw Spat Econ* 2016; 16: 865–892.

[8] Stiefel SW. Management assistance for weights and measures progress, measuring inaccuracy's economic distortion. In: *Report of the ... National Conference on Weights and Measures*. The Bureau, 1973.

[9] Bowns S, Bradley I, Knee P, et al. Measuring the economic benefits from R&D: improvements in the MMI model of the United Kingdom National Measurement System. *Res Policy* 2003; 32: 991–1002.

[10] Arrow K. *The Limits of Organization*. New York: W. W. Nortorn, 1974.

[11] Akerlof GA. The Market for 'Lemons': Quality Uncertainty and the Market Mechanism. *Q J Econ* 1970; 84: 488–500.

[12] Spence M. Job Market Signaling. *Q J Econ* 1973; 87: 355–374.

[13] Rothschild M, Stiglitz J. Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information. *Q J Econ* 1976; 90: 629–649.

[14] Stiglitz JE. *Globalization and Its Discontents*. W. W. Norton, 2003.

[15] Birch J. *Benefit of Legal Metrology for the Economy and Society*. Expert Report, Paris, France: OIML, 2003.

[16] Usuda T, Henson A. Economic Impact of Equivalence of Measure Standards. *NCSL Int Meas* 2012; 7: 62–70.

[17] Rodrigues Filho BA, Gonçalves RF. Legal metrology, the economy and society: A systematic literature review. *Measurement* 2015; 69: 155–163.

[18] Leontief W. Structure of the world economy: Outline of a simple input-output formulation. *Proc IEEE* 1975; 63: 345–351.

[19] Kerschner C, Hubacek K. Assessing the suitability of input–output analysis for enhancing our understanding of potential economic effects of Peak Oil. *Energy* 2009; 34: 284–290.

[20] Arbex M, Perobelli FS. Solow meets Leontief: Economic growth and energy consumption. *Energy Econ* 2010; 32: 43–53.

[21] Velázquez E. An input–output model of water consumption: Analysing intersectoral water relationships in Andalusia. *Ecol Econ* 2006; 56: 226–240.

[22] Su B, Huang HC, Ang BW, et al. Input–output analysis of CO2 emissions embodied in trade: The effects of sector aggregation. *Energy Econ* 2010; 32: 166–175.

[23] Rodrigues Filho. Measuring the benefits of legal metrology to place it in the National Quality Infrastructure. *OIML Bulletin* 2017; LVIII: 19–21.

[24] Institute of Applied Economic Research - IPEA, http://www.ipeadata.gov.br/ExibeSerie.aspx?serid=31924&module=M&chart=ChartsImage40417902344583176 (accessed 3 June 2020).

[25] Guilhoto J. *Input-Output Analysis: Theory and Foundations (Análise de Insumo-Produto: Teoria e Fundamentos)*. SSRN Scholarly Paper ID 1900073, Rochester, NY: Social Science Research Network, https://papers.ssrn.com/abstract=1900073 (1 August 2011, accessed 5 May 2017).

[26] Davar E. LeontiefF and Walras: Input-Output and Reality. Macerata, Italy, p. 12 p.

[27] *Handbook of Input-output Table Compilation and Analysis*. UN, 1999.

[28] IBGE. *IBGE | Biblioteca | Detalhes | Matriz de insumo-produto : Brasil : 2010*. Rio de Janeiro: IBGE, http://biblioteca.ibge.gov.br/biblioteca-catalogo?view=detalhes&id=298180 (2016, accessed 5 May 2017).

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Bratislava 2019

The 54th CIML Meeting and associated events were held at the Hotel Doubletree by Hilton in Bratislava, Slovak Republic, during the week of 21–25 October 2019.

Hotel Doubletree by Hilton

The Guest Speaker was Dr Vojtech Ferencz, First State Secretary of the Ministry of Economy of the Slovak Republic. His welcome speech is reproduced in full.

CIML President Dr Roman Schwartz also gave an opening address and delivered a full report to the CIML.

The Resolutions of the 54th CIML Meeting are available on the OIML website under the "Structure" section.

Bratislava Castle

BRATISLAVA 2019

54th CIML Meeting

22–25 October 2019 Bratislava, Slovak Republic

Opening address by Dr Roman Schwartz, CIML President

Ladies and Gentlemen, dear Colleagues and Friends, distinguished guests,

It is my great pleasure to welcome you to the Fifty-fourth Meeting of the International Committee of Legal Metrology. Welcome to Slovakia – welcome to Bratislava!

Thank you to our hosts and thank you all for coming!

Again we have an excellent participation with about 150 attendees, with more than 50 Member States present or represented, with 15 Corresponding Members, with several organisations in liaison and manufacturer's associations.

We will again have a very busy Committee meeting with a number of important items and decisions on the agenda, for instance, the election of the CIML Second Vice-President.

It is now my pleasure to extend a special welcome to a distinguished guest, namely Dr Vojtech Ferencz, First State Secretary of the Ministry of Economy of the Slovak Republic, who has kindly agreed to give us an opening address today.

Beforehand let me briefly introduce Dr Ferencz:

- He studied economics at the respective universities in Prague, Bratislava and Košice, received a Master degree in 1995, and a PhD in Business Economics in 2010;
- His political career started in 2007, when he became Director General of the Strategy Section of the Ministry of Economy of the Slovak Republic;
- In 2010 he became Deputy Director for Economy of the Slovak Water Management Enterprise in Košice; and
- In 2012 State Secretary of the Ministry of the Environment;
- Since 2016 he is the First State Secretary of the Ministry of Economy of the Slovak Republic.

Dr Ferencz, we feel very honoured having you with us today. May I now invite you to the stage, please, to address our meeting. ■

Opening address by Dr Vojtech Ferencz, First State Secretary of the Ministry of Economy of the Slovak Republic

Mr President, Mr Director, Ladies and Gentlemen,

As the State Secretary of the Ministry of Economy, of the Slovak Republic, I am very pleased to be taking part in the opening of the Fifty-fourth meeting of the International Committee of Legal Metrology, which is

Dr Schwartz gives his opening address

Dr Ferencz gives his opening address

being held this year in my beautiful country.

On behalf of the Slovak Government I would like to welcome all members of the CIML, with their delegations, together with the representatives of major co-operating organisations, and associations.

The government of the Slovak Republic is aware of the importance of metrology and all its pillars (scientific, legal, and industrial metrology) for all areas of the national economy. The goal of metrology, as well as of the Slovak Republic, is to ensure protection within trade relations, health, and environmental protection, transportation safety, and protection in other areas of human activities, for the benefit of citizens, the environment, state and business entities.

Slovakia is an export orientated country focused on industrial production, where the automobile industry represents an especially important sector. Therefore, Slovakia needs to have internationally accepted metrology, both in the field of calibration of measuring instruments, and in the field of metrological verification of measuring instruments.

To secure the functioning of metrology, the Slovak Republic has established a separate office, the Slovak Office of Standards, Metrology, and Testing, that is directly sub-ordinated to the government of the Slovak Republic. The office submits draft legislative regulations to the government of the Slovak Republic, and issues binding technical regulations and decrees in the field of metrology.

Ladies and gentlemen, I wish you a very beneficial event, fruitful discussions, either here at the meeting, or during personal meetings, many new interesting findings in the field of metrology, and of course I wish you a pleasant stay in the capital city of the Slovak Republic here in Bratislava, and in the whole of Slovakia which certainly has a lot to offer. Thank you very much. ■

Delegates attending the 54th CIML Meeting

BRATISLAVA 2019

54th CIML Meeting

22–25 October 2019
Bratislava, Slovak Republic

Summary report

Fifty-fourth Meeting of the International Committee of Legal Metrology (CIML)

Bratislava, Slovak Republic
22–25 October 2019

The 54th CIML Meeting was held from 22–25 October 2019 in Bratislava, Slovak Republic and was hosted by the Slovak Office of Standards, Metrology and Testing (UNMS). 52 Member States were present or represented together with 11 Corresponding Members, and representatives from organisations in liaison.

The CIML President Dr Schwartz reported on OIML activities during the last year and presented his vision for the future of the Organisation.

A key event during the meeting was the election of Dr Mathew (Switzerland) as CIML Second Vice-President for a six-year term.

BIML Director Mr Donnellan reported on the activities and achievements of the Bureau and its staff, particularly the efforts to improve the effectiveness of OIML technical work and activities in favour of Countries and Economies with Emerging Metrology Systems (CEEMS), the OIML Certification System (OIML-CS), World Metrology Day, and work with liaison organisations. Mr Donnellan also emphasised the cost-saving measures the Bureau has achieved.

The OIML currently has 61 Member States and 61 Corresponding Members and efforts are ongoing to encourage new economies to join the Organisation.

The accounts for 2018 were approved and Mr Donnellan reported that the Organisation continues to be in a strong financial position.

Rapport succinct

Cinquante-quatrième Réunion du Comité International de Métrologie Légale (CIML)

Bratislava, République slovaque
22–25 octobre 2019

La 54ème Réunion du CIML s'est tenue du 22 au 25 octobre 2019 à Bratislava (République slovaque), accueillie par l'Office slovaque des normes, de la métrologie et des essais (UNMS). 52 Etats Membres étaient présents ou représentés, ainsi que 11 Membres Correspondants et des représentants des organisations en liaison.

Le Dr Schwartz, Président du CIML, a rendu compte des activités de l'OIML au cours de l'année écoulée et a présenté sa vision de l'avenir de l'Organisation.

L'un des évènements marquants de cette réunion a été l'élection du Dr Mathew (Suisse) en tant que Second Vice-Président du CIML pour un mandat de six ans.

Le Directeur du BIML, M. Donnellan, a rendu compte des activités et des réalisations du Bureau et de son personnel, notamment des efforts visant à améliorer l'efficacité des travaux techniques de l'OIML et des activités en faveur des Pays et Economies dotés de Systèmes de Métrologie Emergents (CEEMS), du Système de Certification de l'OIML (OIML -CS), de la Journée Mondiale de la Métrologie, et de la collaboration avec les organisations en liaison. M. Donnellan a également souligné les mesures d'économie réalisées par le Bureau.

L'OIML compte actuellement 61 Etats Membres et 61 Membres Correspondants et des efforts sont en cours pour encourager de nouvelles économies à rejoindre l'Organisation.

Les comptes de l'année 2018 ont été approuvés et M. Donnellan a indiqué que la situation financière de l'Organisation restait solide.

Le BIML a rendu compte de ses activités avec les organisations en liaison. En outre, le Dr Miki a présenté un résumé des discussions tenues lors de la Table Ronde des Organisations Régionales de Métrologie Légale (RLMO) qui s'est tenue le matin du 22 octobre. Le Dr Milton, Directeur du BIPM, a présenté un rapport détaillé sur les activités du BIPM au cours de l'année écoulée, en mettant l'accent sur la révision très réussie du SI et sur la collaboration du

The BIML reported on its activities with organisations in liaison. In addition, Dr Miki presented a summary of the discussions held during the Regional Legal Metrology Organisations (RLMO) Round Table held on the morning of 22 October. Dr Milton, BIPM Director, presented a detailed report on the BIPM's activities over the past year, focussing on the very successful revision of the SI and the BIPM's collaboration with the BIML, most notably World Metrology Day.

Other organisations in liaison (CECIP, IAF, ILAC, OECD and UNIDO) also reported on their activities.

The CIML approved the following publications:

- Revision of D 31 *General requirements for software-controlled measuring instruments*
- New Document D 33 *Reference standard liquids (Newtonian viscosity standard for the calibration and verification of viscometers)*
- New Document D 34 *Conformity to Type (CTT) - Pre-market conformity assessment of measuring instruments*
- Revision of B 6 *Directives for OIML technical work*
- New Basic Publication B 20 *Rules for the use of OIML logos*
- New Basic Publication B 21 *Framework for OIML Training Centers and OIML Training Events*
- Revision of R 117 *Dynamic measuring instruments for liquids other than water*

The CIML approved the following new projects:

- Revision of D 31 *General requirements for software controlled measuring instruments*
- New publication: *R 87 prepackage template*
- Revision of R 142 *Automated refractometers: Methods and means of verification*
- New publication *Rotary viscometers - Determination of dynamic viscosity - Verification method*
- Revision of B 11 *Rules governing the translation, copyright and distribution of OIML Publications*

The BIML gave a report on the work of high-priority projects and provided a summary of the training programme organised by the BIML for Project Group conveners.

A discussion took place on the OIML Bulletin and the need for more contributions from the Membership in the form of articles.

Mr Mason, vice-chairperson of the CEEMS Advisory Group (AG), delivered a report on the activities of the AG, including the meeting held on 21 October. His report focussed on progress related to the 2018 CIML resolution concerning CEEMS. In addition, Mr Mason provided a report on the outcomes of the e-Learning Workshop held on 21 October. Following the resignation

BIPM avec le BIML, notamment sur la Journée Mondiale de la Métrologie.

D'autres organisations en liaison (CECIP, IAF, ILAC, OCDE et ONUDI) ont également rendu compte de leurs activités.

Le CIML a approuvé les publications suivantes :

- Révision de la D 31 *Exigences générales pour les instruments de mesure contrôlés par logiciel*
- Nouveau Document D 33 *Liquides de référence (étalon de viscosité newtonien pour l'étalonnage et la vérification des viscosimètres)*
- Nouveau Document D 34 *Conformité au Type (CTT) - Evaluation de la conformité avant la commercialisation des instruments de mesure*
- Révision de la B 6 *Directives pour les travaux techniques de l'OIML*
- Nouvelle Publication de Base B 20 *Règles pour l'utilisation des logos OIML*
- Nouvelle Publication de Base B 21 *Cadre pour les Centres de Formation OIML et les Evènements de Formation OIML*
- Révision de la R 117 *Ensembles de mesurage dynamique de liquides autres que l'eau*

Le CIML a approuvé les nouveaux projets suivants :

- Révision du D 31 *Exigences générales pour les instruments de mesure contrôlés par logiciel*
- Nouvelle Publication : *R 87 Feuille de relevés pour les préemballages*
- Révision de la R 142 *Réfractomètres automatiques : Méthodes et moyens de vérification*
- Nouvelle Publication *Viscosimètres rotatifs - Détermination de la viscosité dynamique - Méthode de vérification*
- Révision de la B 11 *Règles relatives à la traduction, aux droits d'auteur et à la distribution des Publications de l'OIML*

Le BIML a présenté un rapport sur les travaux des projets hautement prioritaires et a résumé le programme de formation organisé par le BIML à l'intention des organisateurs de Groupes de Projet.

Une discussion a eu lieu sur le Bulletin de l'OIML et sur la nécessité de nouvelles contributions de la part des Membres sous forme d'articles.

M. Mason, Vice-président du Groupe consultatif pour les CEEMS, a présenté un rapport sur les activités de celui-ci, y compris la réunion du 21 octobre. Son rapport s'est concentré sur les progrès liés à la résolution de 2018 du CIML concernant les CEEMS. En outre, M. Mason a présenté un rapport sur les résultats de l'atelier *e-Learning* qui s'est tenu le 21 octobre. A la suite de la démission de M. Pu of Mr Pu (P.R. China), Mr Mason was appointed as chairperson of the CEEMS AG, and Dr Ulbig (Germany) was appointed as vice-chairperson.

Mr Oosterman, OIML-CS Management Committee (MC) Chairperson reported on the activities of the OIML-CS, including the MC meeting held in March 2019. His report highlighted the increased participation in the OIML-CS, promotion and awareness-raising activities and the key issues that the MC will be addressing in the future.

OIML medals were awarded to Mrs Lagauterie (France), to Dr Borzyminski (Poland) and to Dr Miki (Japan) in recognition of their outstanding contributions to international legal metrology. A Letter of Appreciation was presented to Mr Oosterman in recognition of his work as OIML-CS MC Chairperson.

The 16th International Conference and 55th CIML Meeting will be held in Suzhou, P.R. China, in October 2020.

The 54th CIML Meeting Resolutions, documents and presentations can be found on the OIML website at:

https://www.oiml.org/en/structure/ciml/sites ■

(République populaire de Chine), M. Mason a été nommé Président du Groupe consultatif pour les CEEMS et M. Ulbig (Allemagne) a été nommé Vice-président.

M. Oosterman, Président du Comité de Management de l'OIML-CS a rendu compte des activités de l'OIML-CS, notamment lors de la réunion du MC en mars 2019. Son rapport a mis en évidence la participation accrue à l'OIML-CS, les activités de promotion et de sensibilisation et les questions clés que le Comité de Management traitera à l'avenir.

Des Médailles OIML ont été décernées à Mme Lagauterie (France), au Dr Borzyminski (Pologne) et au Dr Miki (Japon) en reconnaissance de leurs contributions exceptionnelles à la métrologie légale internationale. M. Oosterman a reçu une Lettre d'appréciation en reconnaissance de son travail en tant que Président du Comité de Management de l'OIML-CS.

La 16ème Conférence Internationale et la 55ème Réunion du CIML se tiendront à Suzhou, en République populaire de Chine, en octobre 2020.

Les Résolutions, documents et présentations de la 54ème Réunion du CIML sont disponibles sur le site de l'OIML à l'adresse suivante :
https://www.oiml.org/fr/structure/ciml/sites ■

Delegates attending the 54th CIML Meeting

OIML Awards

During the Bratislava CIML Meeting three OIML Medals and one Letter of Appreciation were presented.

◀ OIML Medal: Dr Jerzy Borzyminski

▲ OIML Medal: Mrs Corinne Lagauterie

▲ OIML Medal: Dr Yukinobu Miki

OIML Letter of Appreciation: Mr Cock Oosterman ▶

BRATISLAVA 2019

Workshop on e-Learning

21 October 2019
Bratislava, Slovak Republic

An OIML e-Learning Workshop was held during the week of the 54th CIML Meeting. Its aims were:

- to examine various online training systems which had already been made available by different organisations;
- to assess the e-Learning needs and priorities of economies within the OIML membership; and
- to make recommendations on what the OIML should do in this area in the future.

The Workshop was attended by around 140 participants from OIML Member States, Corresponding Members, and liaison organisations.

Session 1 – Introduction

Dr Bobjoseph Mathew (METAS, Switzerland) set the scene for the Workshop by explaining that e-Learning could be considered to be a learning environment outside a traditional classroom using digital technology as a platform for teaching courses, programmes and learning activities. He said that its advantages included:

- requiring only an internet connection and basic computer skills;
- being a cost-effective method for delivering a large amount of content to a large community; and
- the ability for courses to be customised and to be on-demand, self-paced, or instructor-led.

It was therefore a very effective method for delivering customised training to a wide target audience across geographically dispersed locations.

He stated that e-Learning could improve the OIML's ability to provide training programmes to a wide target audience, and this was in line with Objective 4 of OIML B 15:2011 *OIML Strategy*:

> "To promote and facilitate the exchange of knowledge and competencies within the legal metrology community worldwide."

He concluded that the aim of the Workshop was to examine how the OML could make the most of e-Learning to achieve this objective by considering the needs and priorities of its members, and by considering the various platforms and material which were already available.

Session 2 – What already exists today?

This session examined a number of e-Learning platforms which had already been made available by different organisations, and which used different approaches. The aim was to give participants some idea of the possibilities when considering future options for the OIML.

APLMF (Asia-Pacific Legal Metrology Forum)

Mr Phil Sorrell, Trading Standards Team Leader, Compliance and Inspection, of MBIE, New Zealand presented the work they had done on developing e-Learning material aimed at Trading Standards Officers and Accredited Persons. The current course covers class III and IIII non-automatic weighing instruments (NAWI) with a capacity of up to 300 kg.

He explained that the course aimed to provide a learning resource and single source of technical information for all parties, as well as being a training and competence screening tool for Accredited Persons and Trading Standards Officers.

He demonstrated some samples of the course, which consisted of written test procedures and short animations demonstrating those procedures. The knowledge acquired was then checked by means of quizzes and assessments.

Mr Sorrell said that the course had been introduced to all Accredited Persons over a six-month implementation period, and that initial feedback had been very positive.

The experience had taught them some valuable lessons:

- the need for a methodical approach;
- the importance of vendor selection;
- the need for an "editor friendly" platform; and
- the importance of universally acceptable animations, images and language.

As a result, APLMF Guide 8 *How to develop an eLearning Module* had been produced to guide future efforts. These would include further modules covering other classes and capacities of NAWI, as well as covering the verification procedures in OIML R 76 *Non-automatic weighing instruments*.

Mr Sorrell then gave an overview of APLMF Guide 8, which he said covered the following:

- a document control system;
- a timeline linked process flow;
- a system of templates; and
- an appendix with worked examples.

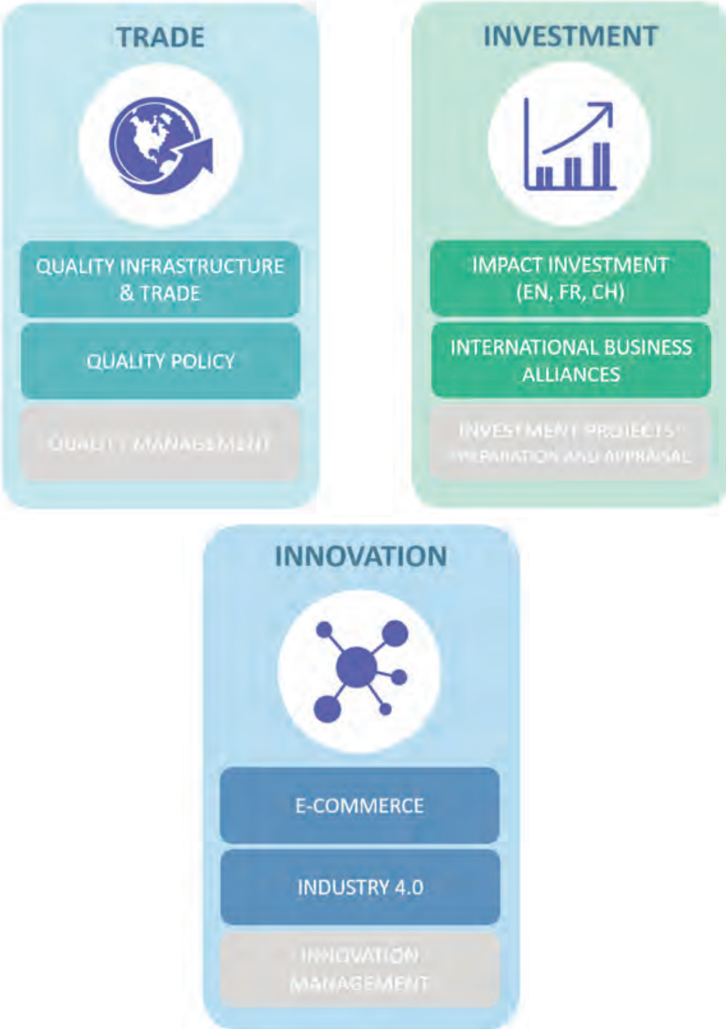
The Guide can be downloaded from the APLMF website at www.aplmf.org.

Sample test animation

Accuracy of the zero-setting device

UNIDO (United Nations Industrial Development Organization)

Ms Dorina Nati gave a short introduction to the work of UNIDO and its Trade Investment and Innovation (TII) Division. She went on to explain that a lot of their information was shared through the TII Knowledge Hub (https://tii.unido.org), and that an e-learning platform had recently been added to this.



Ms Nati explained that the content was freely accessible subject to registration, and demonstrated the *Quality Infrastructure & Trade* module in detail. Each module includes a final test in order to obtain a completion certificate, and the platform provides discussion forum facilities. She explained the rationale behind the development of the platform, details of the phases which had been used in the development of training modules, and the way in which the necessary human resources fitted into this process. It had been decided to host the system on UNIDO servers for ease of future development and for monitoring/reporting purposes. A UNIDO publication *Methodological guide for impactful online training* had also been produced, to ensure consistency of approach. She described some of the challenges which had been encountered during the platform's development and explained the measures that had been put in place to deal with these.

Ms Nati concluded by saying that the main lessons learnt from the establishment of the UNIDO TII e-Learning platform were that planning was key to the success of the project, and that the human and time resources required should not be underestimated.

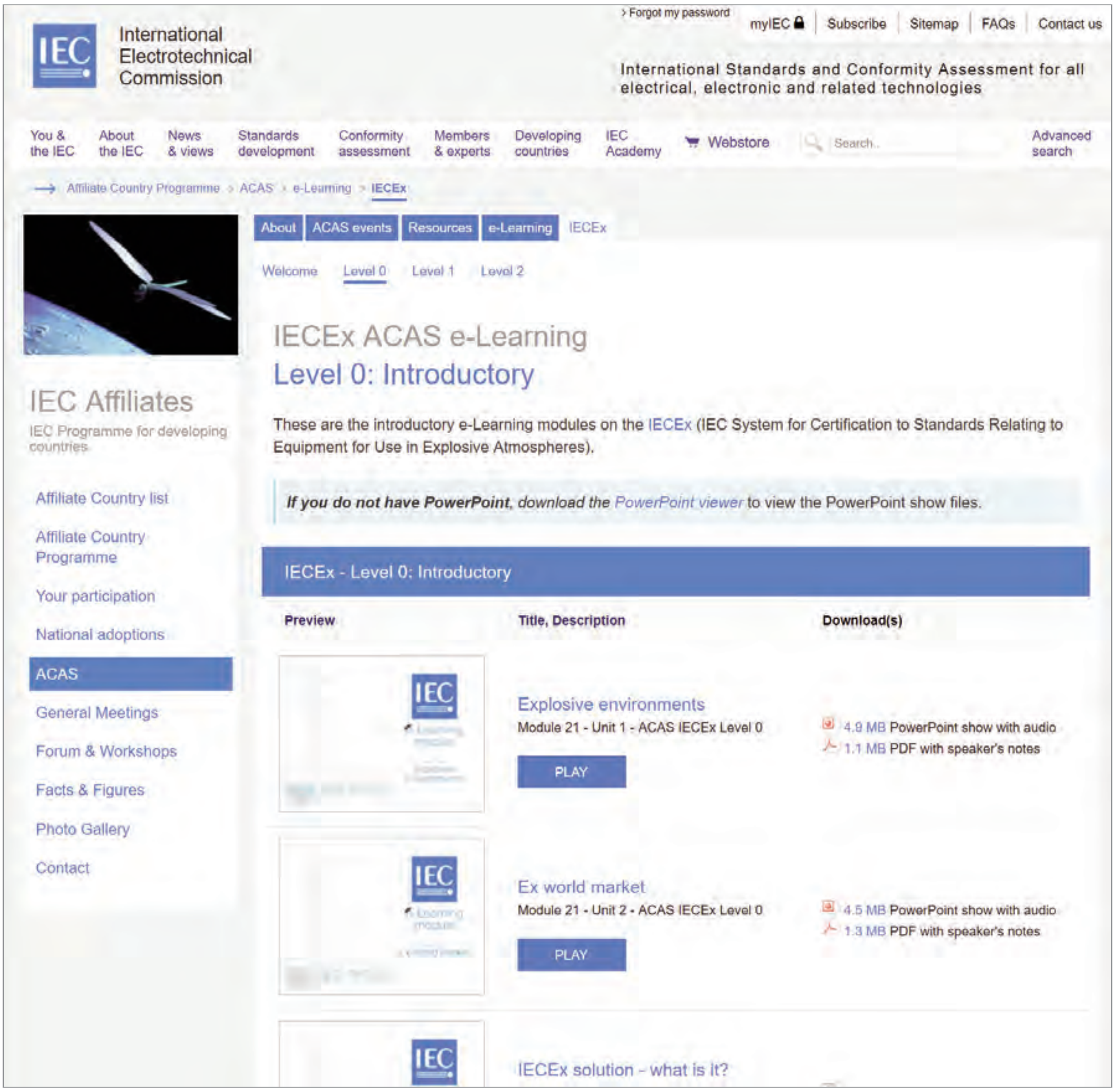
IEC (International Electrotechnical Commission)

Since the IEC had been unable to attend the Workshop, Mr Ian Dunmill (BIML) gave an overview of the e-Learning system this organisation had put in place to further IEC Affiliate Country participants' understanding and involvement in IEC Conformity Assessment activities. He explained that courses were available on four IEC schemes:

- IECEE Electrical and electronic equipment;
- IECEx Hazardous environments;
- IECRE Renewable energy; and
- IECQ Electronic components.

He explained that the courses were organised into several "levels", but that level 0 was freely available to all. The IEC had taken a different approach to those described previously, and each level consisted of a narrated PowerPoint slideshow and an accompanying annotated PDF file. This had enabled comparatively quick development of e-learning courses based on existing training material.

Mr Dunmill also demonstrated similar general awareness-raising material on the IEC, which formed part of the IEC Young Professionals training course.



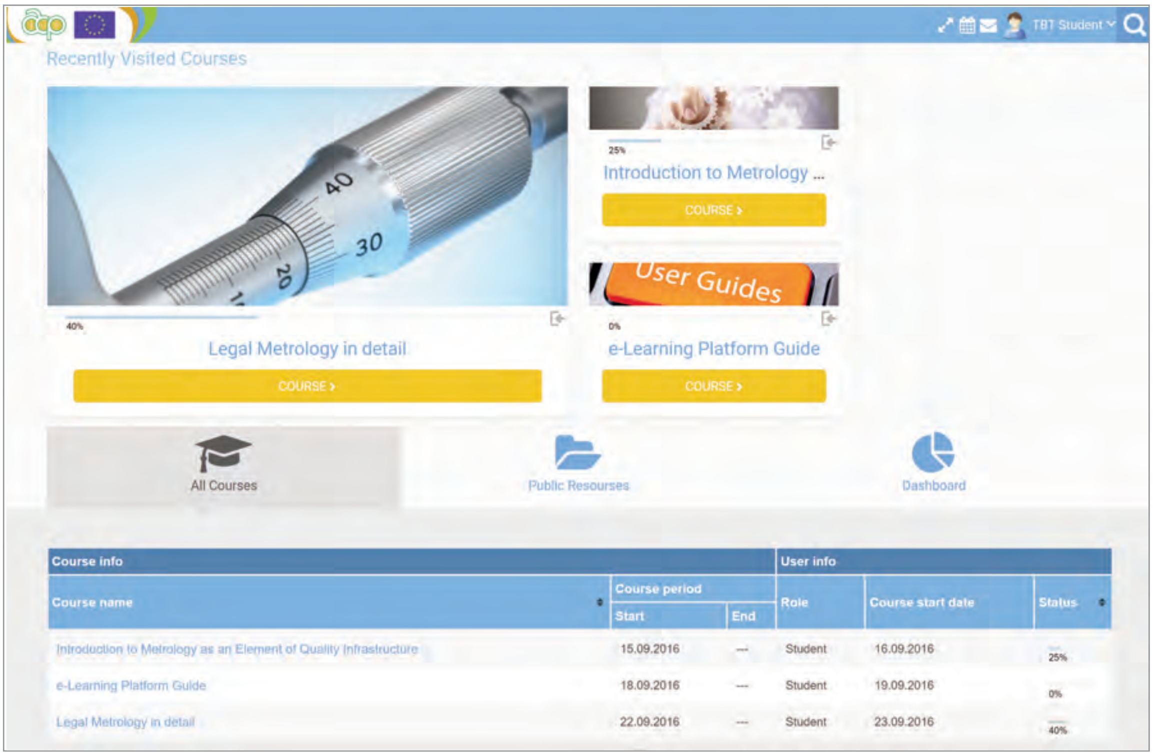
OIML (ACP EU TBT Programme platform)

Mr Dunmill explained that the OIML's current e-Learning platform had been developed in association with the ACP EU TBT Programme following the seminar *"Developing an OIML package for assistance to Countries and Economies with Emerging Metrology Systems (CEEMS)"* which had been held at the time of the 50th CIML Meeting in Arcachon, France in 2015. He said that two regional organisations, AFRIMETS (Africa) and CROSQ (Caribbean) had been involved, and that the work had been done by experts contracted by the ACP EU TBT Programme, using some material from previous AFRIMETS metrology schools.

He explained that the platform was hosted on an OIML server to ensure the sustainability of the platform after the end of the ACP EU TBT Programme's funding, as well as to facilitate maintenance. The platform was freely available (subject to registration) and was based on Moodle, which is a widely used open-source product. There had so far been nearly 1600 distinct users from 140 countries, with up to almost 200 logins per day.

Mr Dunmill said that the materials were currently available in English, but had also been translated into French and Spanish. This had exposed some problems in the English version, so the translations had not yet been implemented. Problems had also been encountered due to the limited time which had been available for the development and testing of the courses, as well as the fact that the material, which had come from face-to-face training courses, had not been designed for "virtual" delivery.

Mr Dunmill concluded by giving an overview of one of the courses, as well as its quizzes and final test.



Session 3 – What are the needs and priorities of economies?

This 75-minute session of the Workshop was led by Dr Peter Ulbig (PTB, Germany) and was organised into twelve breakout groups, which considered the following questions:

- Who do you think should be the target audience for OIML e-Learning in the future?
- What current OIML publications should be covered by e-Learning tools and why?
- What additional topics should be covered?

The breakout groups were also asked to provide their top five priorities, and to indicate whether they might be able to help in addressing these. Facilitators were available to guide the groups and to answer questions.

◀ Breakout groups were asked to provide their top five priorities ▼

Session 4 – What should we do in the future?

Representatives of each of the breakout groups gave a short presentation of their findings and priorities, and participants in the Workshop were able to ask questions and discuss these results. Dr Mathew and Dr Ulbig then provided an overview of the common priorities (see opposite). These priorities cover a wide range of subjects and the need for each subject to be addressed at a number of levels.

1- R 76 *Non-automatic weighing instruments*
(aimed at verification officers/inspectors, manufacturers, consumers)

2- R 117 *Dynamic measuring systems for liquids other than water* (specifically for fuel dispensers in this case)
(aimed at verification officers/inspectors, manufacturers, consumers)

3- D 31 *General requirements for software-controlled measuring instruments*
(aimed at verification officers/inspectors, test laboratories, manufacturers)

4- Basic legal metrology, including D 1 *Considerations for a Law on Metrology*
(aimed at students, law makers)

5- Prepackages
(aimed at verification officers/inspectors)

Session 5 – Summary and closing remarks

Dr Mathew explained that the needs and priorities identified by Workshop participants would be presented to that afternoon's CEEMS Advisory Group (AG) meeting, which would develop a proposal to be presented to the CIML during its meeting the same week. If the CIML could then adopt a resolution on this subject, it would mean that the OIML then had a clear mandate on which to base its future development of the e-Learning platform.

He concluded the Workshop by thanking the participants, the speakers and the organising team, and reassuring participants that their work would be very valuable for the future of the OIML's training facilities.

Full details of the Workshop as well as the presentations mentioned in this report can be found on the OIML website at:

http://bratislava.oiml.org/workshop.html

Delegates attending the e-Learning Workshop

Post-Workshop developments

The outcome of the Workshop was discussed at the CEEMS AG held on the afternoon of 21 October 2019. A draft resolution was put forward to the 54th CIML Meeting which met from 22–25 October. Resolution 2019/18 was approved under agenda item 8.1 as follows:

The Committee,

Thanks Dr Bobjoseph Mathew, Dr Peter Ulbig, and the BIML for having organised the Workshop on e-Learning which took place on Monday 21 October 2019,

Thanks Ms Dorina Nati (UNIDO) and Mr Phil Sorrell (New Zealand) for their excellent presentations at this Workshop,

Considers that the development of an e-Learning concept for the benefit of the legal metrology community and others should be a priority activity for the Organisation,

Requests the CEEMS Advisory Group to establish one or more ad hoc working groups to develop, with the assistance of the Bureau, an e-Learning concept taking into account the following elements:

1 a summary, analysis and prioritisation of the outcomes of the e-Learning seminar,
2 the optimum means of capturing expert input from Technical Committees and Subcommittees in developing and maintaining high quality content,
3 collaboration with other appropriate organisations,
4 consideration of the appropriate platform and technology for the e-Learning concept,
5 consideration of appropriate funding mechanisms and sources,

Instructs the BIML Director to take into account this e-Learning concept when preparing the budget for the 2021–2024 financial period.

To begin the follow up of this Resolution, a meeting was held on 24 January 2020 between Dr Mathew, Dr Ulbig, Mr Juan Pablo Davila (UNIDO) and Mr Dunmill to consider the outcome of the breakout groups in detail and to develop more detailed proposals on how work on e-Learning should progress. The outcome of this meeting was then presented for discussion and endorsement at the Presidential Council meeting on 10–11 March 2020. The BIML is now working to put the proposals into action, and updates will be provided as this work progresses.


World Metrology Day
Measurements for global trade
AFRIMETS
AA&W
Legal Metrology Egypt
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kg
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OIML
20 May 2020
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OIML Certification System (OIML-CS)

Introduction

The OIML-CS is a system for issuing, registering and using OIML Certificates and their associated OIML type evaluation reports for types of measuring instruments (including families of measuring instruments, modules, or families of modules), based on the requirements of OIML Recommendations.

The OIML-CS comprises two Schemes: Scheme A and Scheme B. Competence of the OIML Issuing Authorities and their Test Laboratories is demonstrated through self-declaration under Scheme B and accreditation or peer assessment under Scheme A.

The aim of the OIML-CS is to facilitate, accelerate and harmonize the work of national and regional bodies that are responsible for type evaluation and approval of measuring instruments subject to legal metrological control. In the same way, instrument manufacturers, who are required to obtain type approval in some countries in which they wish to sell their products, should benefit from the OIML-CS as it will provide evidence that their instrument type complies with the requirements of the relevant OIML Recommendation(s).

It is a voluntary system and OIML Member States and Corresponding Members are free to participate. Participating in the OIML-CS commits, in principle, the signatories to abide by the rules of the OIML-CS that are established in OIML B 18:2018 *Framework for the OIML Certification System (OIML-CS)*. Signatories voluntarily accept and utilize OIML type evaluation and test reports, when associated with an OIML Certificate issued by an OIML Issuing Authority, for type approval or recognition in their national or regional metrological controls.

The OIML-CS was launched on 1 January 2018 and has replaced the former OIML Basic Certificate System and the OIML Mutual Acceptance Arrangement (MAA).

Further information can be found at:

www.oiml.org/en/oiml-cs

For enquiries regarding the OIML-CS, please contact the OIML-CS Executive Secretary Paul Dixon (executive.secretary@oiml.org).

OIML certificates

OIML certificates issued under Scheme A and Scheme B can be downloaded from the database on the OIML website at:

https://www.oiml.org/en/oiml-cs/certificat_view

The database also includes certificates issued under the former OIML Basic Certificate System and the MAA. Although these two systems are no longer in operation, the certificates remain valid.

OIML Issuing Authorities, Utilizers and Associates

A summary of the approved OIML Issuing Authorities is given on the page opposite, and on the following pages a summary is published of those Utilizers and Associates that have declared that they will accept OIML certificates and/or OIML type evaluation reports as the basis for a national or regional approval.

Transition update

OIML Recommendations R 51 *Automatic catchweighers* and R 117 *Liquids other than water* transitioned from Scheme B to Scheme A on 1 July 2019.

R 46 *Active electrical energy meters* and R 137 *Gas meters* transitioned from Scheme B to Scheme A on 1 January 2020.

R 61 *Automatic gravimetric filling instruments*, R 85 *Level gauges for stationary storage tanks* and R 129 *Multi-dimensional measuring instruments* will transition from Scheme B to Scheme A on 1 July 2020.

Recent OIML-CS events

The third OIML-CS Management Committee meeting and associated events were due to be held in New Delhi, India in March 2020, but were cancelled due to the COVID-19 pandemic. However, there are plans to hold virtual meetings on 19 May and 2 June 2020.

OIML Certification System (OIML-CS)

List of OIML Issuing Authorities and their scopes

The list of OIML Issuing Authorities is published in each issue of the OIML Bulletin and can be downloaded at www.oiml.org/oiml-cs/oiml-issuing-authorities

Updated: 2020-03-26

		R 21:2007	R 46:2012	R 49:2006	R 49:2013	R 50:2014	R 51:2006	R 60:2000	R 60:2017	R 61:2004	R 61:2017	R 75:2002	R 76:1992	R 76:2006	R 85:2008	R 99:2008	R 106:2011	R 107:2007	R 117:1995	R 117:2007	R 126:1998	R 129:2000	R 134:2006	R 137:2012	R 139:2014	R 139:2018
AU1	National Measurement Institute Australia (NMIA)					■							■	■												
CH1	Federal Institute of Metrology (METAS)					■		■		■				■			■	■			■		■			
CN2	National Institute of Metrology, China (NIM)					■	■	■	■	■	■		■	■				■					■			
CZ1	Czech Metrology Institute (CMI)				■							■		■	■										■	
DE1	Physikalisch-Technische Bundesanstalt (PTB)				■		■	■		■		■		■												
DK2	FORCE Certification A/S					■	■	■	■	■				■			■	■				■	■			■
FR2	Laboratoire National de Métrologie et d'Essais (LNE)					■		■						■							■					
GB1	NMO	■				■		■		■			■	■	■		■	■				■	■			
JP1	NMIJ/AIST							■					■	■												
NL1	NMi Certin B.V.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SE1	Research Institutes of Sweden (RISE)						■	■	■	■	■			■	■				■	■						
SK1	Slovak Legal Metrology (SLM)			■	■									■												

OIML Certification System (OIML-CS)

List of Utilizers, Associates and their scopes

The list of Utilizer and Associate scopes is published in each issue of the OIML Bulletin and can be downloaded at www.oiml.org/oiml-cs/utilizers-and-associates

Updated: 2020-03-26

1 = Scheme A only
2 = Scheme A and MAA
3 = Scheme A and B
4 = Scheme A, B and MAA
5 = Scheme B only

		R 16:2002	R 21:2007	R 35:2007	R 46:2012	R 49:2006	R 49:2013	R 50:2014	R 51:2006	R 58:1998	R 59:2016	R 60:2000	R 60:2017	R 61:2004	R 61:2017	R 75:2002	R 76:1992	R 76:2006	R 81:1998	R 85:2008	R 88:1998	R 93:1999	R 99:2008
AU	National Measurement Institute, Australia (NMIA)						2					2					2	2					
BE	Federal Public Service Economy		3		3		3	3	3			1		3		3		1		3		3	
CA	Measurement Canada											2	1			1		2					
CH	Federal Institute of Metrology (METAS)				1	2	2	1	1			2		1		1		2					
CN	State Administration for Market Regulation (SAMR)								1			2	1	1	1		2	2					
CO	Superintendencia de Industria y Comercio (SIC)		3		3	4	4	3	3			2		3		3	2	2		3		3	
CU	Oficina Nacional de Normalizacion (NC)	3	3	3	1		1	3	1	3	3	1	1	3	3	3		1	3	3	3	3	
CZ	Czech Metrology Institute (CMI)						1											1					
DE	Physikalisch-Technische Bundesanstalt (PTB)		5		3	3	4	3	3			2		3		3		2					5
DK	FORCE Certification A/S					2	2	1	1			2		1			2	2					
FR	Laboratoire National de Métrologie et d'Essais (LNE)		1		1	1	1	1	1			1		1		1	1	1		1		1	
GB	NMO Certification		3			4	4	3	3			2		3			2	2		3			
IN	Legal Metrology Division, Department of Consumer Affairs		3		3		4	3	3			2		3		3		2		3			
JP	NMIJ/AIST											2					2	2					
KE	Weights and Measures Department			3	3	4	4		3			4	4	3	3		4	4		3			
KH	National Metrology Centre (NMC)		3		3	3	3	3	3			1		3		3	1	1		3		3	
KI	Ministry of Commerce, Industry and Cooperatives	5	5	5	5	1	1	5	1		5	1	1	5	5	5	1	1	5	5			
KR	Korea Testing Certification (KTC)																2	2					
LV	LNMC Ltd. Metrology Bureau																						
NA	Namibian Standards Institution				3	4	4	3	3			2		3			4	4		3			
NL	NMi Certin B.V.		3		3	3	4	3	3			2		3		3	1	2		3		3	
NZ	Trading Standards (Ministry of Business, Innovation and Employment) (MBIE)					4	4	3	3			2					2	2		3			
RU	VNIIMS																						
RW	Rwanda Standards Board	3	3	3	3	3	3		3	3	3	1	1	3	3		1	1				3	
SA	SASO (Saudi Standards, Metrology and Quality Organization)				3		1						1					1					
SE	RISE Research Institutes of Sweden AB								3			2	1	3				2		3			
SK	Slovak Legal Metrology (SLM)																	2					
TN	National Agency of Metrology (ANM)		3		3	2	2	3	3			2		3			2	2		3		3	
UG	Uganda National Bureau of Standards (UNBS)				3	1	3					1	1				1	1					
US	National Conference on Weights and Measures (NCWM)											2											
ZA	NRCS: Legal Metrology					3	3		3			1					1	1		3			
ZM	Zambia Metrology Agency		3		3	3	3	3	3			1		3		3	1	1		3			

OIML Certification System (OIML-CS)

List of Utilizers, Associates and their scopes (Cont'd)

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Updated: 2020-03-26

1 = Scheme A only
2 = Scheme A and MAA
3 = Scheme A and B
4 = Scheme A, B and MAA
5 = Scheme B only

		R 102:1992	R 104:1993	R 106:2011	R 107:2007	R 110:1994	R 117:1995	R 117:2007	R 117:2019	R 122:1996	R 126:1998	R 128:2000	R 129:2000	R 133:2002	R 134:2006	R 136:2004	R 137:2012	R 139:2014	R 139:2018	R 143:2009	R 144:2013	R 145:2015	R 146:2016
AU	National Measurement Institute, Australia (NMIA)																						
BE	Federal Public Service Economy			3	3			3					3				3	3					
CA	Measurement Canada																						
CH	Federal Institute of Metrology (METAS)			1	1						1		1		1		1						
CN	State Administration for Market Regulation (SAMR)																						
CO	Superintendencia de Industria y Comercio (SIC)			3	3		3	3			3		3		3		3	3					
CU	Oficina Nacional de Normalizacion (NC)	3	3	3	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3	3
CZ	Czech Metrology Institute (CMI)																						
DE	Physikalisch-Technische Bundesanstalt (PTB)			1	3			3					3		1	5	3						
DK	FORCE Certification A/S			1	1								1		3								
FR	Laboratoire National de Métrologie et d'Essais (LNE)			1	1			1			1		1		1		1	1					
GB	NMO Certification			3	3		3	3					3		3								
IN	Legal Metrology Division, Department of Consumer Affairs			1	3			3					3		1		3	3					
JP	NMIJ/AIST																						
KE	Weights and Measures Department			3			3	3			3				3	3	3	3	3				
KH	National Metrology Centre (NMC)			3	3		3	3			3		3		3		3	3					
KI	Ministry of Commerce, Industry and Cooperatives			5		5	1	1						5	5		5	5	5				
KR	Korea Testing Certification (KTC)																						
LV	LNMC Ltd. Metrology Bureau										3				3								
NA	Namibian Standards Institution			3	3		3	3			3		3		3								
NL	NMi Certin B.V.			3	3		3	3			3		3		3		3	3					
NZ	Trading Standards (Ministry of Business, Innovation and Employment) (MBIE)			3	3		3	3					3		3								
RU	VNIIMS						3	3															
RW	Rwanda Standards Board	3	3	3		3	3	3		3	3		3	3	3		3			3	3		3
SA	SASO (Saudi Standards, Metrology and Quality Organization)							3															
SE	RISE Research Institutes of Sweden AB						3	3															
SK	Slovak Legal Metrology (SLM)																						
TN	National Agency of Metrology (ANM)			3	3		3	3			3		3		3		3	3					
UG	Uganda National Bureau of Sandards						1	1	3						3		3						
US	National Conference on Weights and Measures (NCWM)																						
ZA	NRCS: Legal Metrology				3	3		3	3		3		3		3		3	3					
ZM	Zambia Metrology Agency	3			3	3		3	3		3		3		3		3	3					

info

The OIML is pleased to welcome the following new

CIML Members

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Mr. Mehmet Bozdemir

United Kingdom:
Mr. Will Creswell

Corresponding Member: Mali

Committee Drafts

Received by the BIML, 2019.08 – 2020.04

Revision of OIML R 129: Multi-dimensional measuring instruments	4.1 CD	TC 7/SC 5/p 1	AU/CA	2020-04-08
Revision of OIML R 54: pH scale for aqueous solutions	1 CD	TC 17/SC 3/p 1	RU	2020-03-20
New Recommendation: Continuous totalizing automatic weighing instruments of the arched chute type (improved 3CD)	3 CD	TC 9/SC 2/p 9	UK	2020-02-21
Revision of OIML D 1: National Metrology Systems - Developing the institutional and legislative framework	2 CD	CEEMS/p 1	CEEMS AG	2020-02-07
Revision of OIML D 10: Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories	2 CD	TC 4/p 9	SK	2020-02-04
Revision of OIML R 129: Multi-dimensional measuring instruments	4 CD	TC 7/SC 5/p 1	AU/CA	2019-12-20
New Document: Petroleum measurement tables	2 CD	TC 8/p 7	JP	2019-12-19
New Document: Pipe provers for testing measuring systems for liquids	2 CD	TC 8/p 8	JP	2019-12-19
Revision of OIML D 5: Principles for the establishment of hierarchy schemes for measuring instruments	3 CD	TC 4/p 2	SK	2019-12-17
Revision of OIML D 1: National Metrology Systems - Developing the institutional and legislative framework	1 CD	CEEMS/p 1	CEEMS AG	2019-12-03
Revision of OIML R 126: Evidential breath alcohol analyzers	2 CD	TC 17/SC 7/p 3	DE+FR	2019-10-10
Revision of OIML R 16-2: R yyy: Non-invasive automatic sphygmomanometers	2 CD	TC 18/SC 1/p 2	CN	2019-09-27
Revision of OIML R 16-1: R xxx: Non-invasive non-automatic sphygmomanometers	3 CD	TC 18/SC 1/p 1	CN	2019-09-27
New Recommendation: Continuous totalizing automatic weighing instruments of the arched chute type	3 CD	TC 9/SC 2/p 9	UK	2019-08-26
Revision of OIML D 30: Guide for the application of ISO/IEC 17025 to the assessment of Testing Laboratories involved in legal metrology	1 CD	OIML-CS/SC 7/p 1	BIML	2019-06-09

Call for papers

OIML Members
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Liaison Institutions
Manufacturers' Associations
Consumers' & Users' Groups, etc.

- Technical articles on legal metrology related subjects
- Features on metrology in your country
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- Announcements of forthcoming events, etc.

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