Katri Peltoniemi

Calibration Services Markets in Europe: Exploratory Study – Flow, Torque, and Force Measurement in Focus

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KAJAANIN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

THESIS ABSTRACT

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This was an exploratory study the aim of which was to have an overall view of the calibration services markets in Europe. The goals were to indicate some of the market participants, where they operated and what sort of operators they were. Based on the study, decisions could be made regarding future research in defining whether entering to new markets in Europe would be lucrative for MIKES.

Previous studies and literature of calibration service markets were reviewed in an attempt to explain the competitive structures and the role of different participants in the markets and to point out some essential figures. European calibration services market generated revenues of 1.09 billion USD in 2011. Germany, UK and France had the largest markets while Eastern Europe was the most rapidly growing market. Moreover, a desk research was conducted whereby a list of 371 accredited laboratories was gathered. Information was collected on the geographical areas the listed organisations operated in and what type of operators they were.

The main findings were that a variety of different types of operators exists and few organisations focus on calibrations alone. Eastern Europe as an emerging market still has potential for new entrants providing good quality calibration service. Countries such as Romania and Ukraine, for example, should be further investigated. Quick turnaround times and good quality of calibration should be emphasized in creating comparative advantage among other market participants.

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KAJAANIN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

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Tämän kartoittavan tutkimuksen tarkoituksena oli muodostaa yleisnäkemys kalibrointipalveluiden markkinoista Euroopassa. Tavoitteena oli hahmoittaa toimijoita markkinoilla, näiden toimijoiden operaointialueet sekä millaisista toimijoista ylipäätään oli kysymys. Tutkimuksen perusteella pystyttäisiin päättämään seuraavista tarkemmista tutkimuksista Euroopan kalibrointipalvelumarkkinoiden houkuttelevuudesta MIKES:lle.

Aiemmista kalibrointipalvelujen tutkimuksista ja kirjallisuudesta tehtiin katsaus. Tarkoituksena oli selittää alan kilpailun rakenteita ja eri toimijoiden rooleja markkinoilla sekä esittää avainlukuja. Euroopan kalibrointipalvelut kokonaisuudessaan tuottivat 1,09 miljardia dollaria vuonna 2011. Saksa, Iso-Britannia ja Ranska olivat suurimmat markkina-alueet itäisen Euroopan kasvaessa nopeimmin. Empiirisessä osiossa listattiin yhteensä 371 akkreditoitua kalibrointilaboratoriota Euroopassa. Näistä laboratorioista kerättiin tietoja mm. niiden operointialueesta ja toiminnan muodosta.

Kalibrointimarkkinoilla on monia erilaisia toimijoita, joista vain pieni osa keskittyy ainoastaan kalibrointeihin. Itä-Eurooppa kasvavana markkina-alueena on potentiaalinen uusille tulokkaille, jotka voivat tarjota laadukasta palvelua. Maat kuten Romania ja Ukraina voisivat olla tulevan tarkastelun kohteena. Nopeat toimitusajat ja laadukas kalibrointi ovat myyntivaltteja, joita tulisi kilpailussa hyödyntää.

Kieli	English
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ABBREVIATIONS

CAB – Conformity assessment body

CIPM – International Committee for Weights and Measures

CMC – Calibration and measurement capabilities

EA – European Co-operation for Accreditation

IAF – International Accreditation Forum

ILAC – The International Laboratory Accreditation Cooperation

MRA – Mutual recognition agreement

NAB – National accreditation body

NMI – National metrology institute

OEM – Original equipment manufacturer

OIML - International Organisation of Legal Metrology

PSS – Product service system

RMO – Regional Metrology Organisation

GCWM – General Conference of Weights and Measures

CONTENTS

1 INTRODUCTION

The thesis was commissioned by CEMIS (Centre for Measurement and Information Systems as a part of marketing research that CEMIS is carrying out for MIKES Kajaani unit. MIKES that is currently offering its calibration services in the quantities of flow, force, torque and mass within Finland seeks for wider opportunities in the European markets focusing on Eastern Europe especially. The idea was to map some of the participant in the European calibration services markets and to carry out an exploratory study of the markets based on which decisions can be made of which direction to take concerning future research.

Indeed the aims and objectives of the study could not be specifically defined but to have a general overview of the markets and perhaps find some indications of market opportunities. Therefore, the study aimed at mapping some calibration service hotspots in the Eastern Europe and emerging markets in the region, concentration of companies in certain areas or indications of credibility issues of local operators.

The empirical part of the study consisted of a desk research; gathering a list of accredited laboratories dealing with calibrations in flow, force, or torque around Europe and browsing through the websites of those organisations. While browsing through the organisations websites the main point was to collect information on the geographical areas they operate in. Finally, approximately 370 laboratories were looked into most of which located in the Western European countries, some operating internationally, even globally and some only locally.

In this paper, first the main concepts of metrology and its structures are explained including an introduction of the key organisations in the European context. Second, the calibration services of Mikes Kajaani are shortly explained; i.e. services concerning flow, force and torque measurement. Third, previous studies and literature of calibration service markets and industrial services are reviewed. By the literature review the aim is to explain the competitive structures and the role of different participants in the markets and the role of calibration and measurements as part of national quality system, as well as, to point out some figures of the European calibration services markets, in particular. Finally, the empirical part of the study, the methodology used and the key findings are introduced followed by discussion and conclusions.

2 METROLOGY – DEFINITIONS AND STRUCTURES

This chapter explains the basics concepts of metrology, as well as the structure of the metrology system in the European context. It also attempts to give an overview of what calibration is and what is its position in the metrology system. Thus some terminology and definitions of the key concepts and also the main metrology organisations are introduced.

2.1 Terminology and definitions

Metrology is the science of measurement and covers three main activities:

1) *the definition* of internationally accepted units of measurement such as the metre;

2) *the realisation* of units of measurements by scientific methods (e.g. the realization of a metre by the use of lasers);

3) *the establishment of traceability* chains by determining and documenting the value and accuracy of a measurement and distributing the knowledge. For instance, between the primary laboratories. (EURAMET 2008, 9.)

Categories of metrology

Metrology can be subdivided into three main categories according to varying levels of accuracy and complexity.

1) Scientific metrology – concerns the development of measurement standards and their maintenance at the highest level.

2) Industrial metrology – deals with ensuring the adequate functioning of measurement instruments used in industry production and testing processes for ensuring quality of life for citizens and quality for academic research.

3) Legal metrology – regards measurements which influence the transparency of economic transactions and which require legal verification of the measuring instrument, in particular. (EURAMET 2008, 10.)

Subject fields

Scientific metrology can be divided into nine different subject fields: acoustics, amount of substance, electricity and magnetism, ionising radiation and radioactivity, length, mass, photometry and radiometry, thermometry, time and frequency. EURAMET further categorizes three additional subject fields: flow, interdisciplinary metrology and quality. In Figure 1 the subject fields related to this research are introduced.

Figure 1. Subject fields – Mass and related quantities, flow.

Subject field	Subfield	Important measurement standards
Mass and related quantities	Force and pressure	Load cells, dead-weight testers, force, moment and torque converters, pressure balances with oil/gas-lubricated piston cylinder assemblies, force-testing machines, capacitance manometers, ionisation gauges
Flow	Gas flow (volume) Flow of liquids (volume, mass and energy)	Bell provers, rotary gas meters, turbine gas meters, transfer meter with critical nozzles. Volume standards, Coriolis mass-related standards, level meters, inductive flow meters, ultrasound flow meters

(EURAMET 2008, 13, 15.)

Traceability

In order to ensure the quality of industry related processes as well as quality of life, metrological activities, calibration and measurement must take place. Thus, there is a need to demonstrate traceability. Recognition of metrological competence at each level of the traceability chain is established by mutual recognition agreements (such as CIPM MRA and ILAC MRA), through accreditation and peer review. (EURAMET 2008, 13.)

The traceability chain is an unbroken chain of comparisons which ensures that the measurement value at the bottom level of the chain relates to the references at the higher level the primary standards being at the top. See Appendix 1. An end-user may obtain the highest

level of traceability from an NMI or a secondary accredited laboratory. (EURAMET 2008, 17.)

As Williams (2002, ix) suggests, measurement error will increase at each stage from the primary standard to the point where the actual measurement takes place. For instance, on a production line, the accuracy of a gauge will be checked against the company reference standard on a regular basis, the reference standard in turn will be checked against the national standard which will be checked against the primary standard that may be located in another country. The checking process is called calibration. See Appendix 2 for the descriptions of different standards.

Calibration

Calibration of the measuring equipment or system is the basic tool for ensuring traceability of measurements. Calibration determines the performance characteristics of measuring instruments, systems or reference materials. Basically, calibration is done by directly comparing the performance of the measurement instrument against measurement standards or certified reference materials. Calibration certificate is issued to the calibrated item to prove its accuracy. The reasons for calibration are to indicate traceability, to assure consistency of the readings of an instrument with other measurements, to determine the accuracy of the instrument readings, and to establish reliability of the instrument. (EURAMET 2008, 17.)

Calibration and Measurement Capabilities

Calibration and Measurement Capabilities (CMCs) is the calibration and measurement capability available to customers under normal conditions. The CMCs of NMIs are published in the BIPM key comparison database (KCDB) which was established as part of the CIPM MRA. The CMCs are in the form of tables describing the uncertainties for various measurement quantities and different levels of measurement. (BIPM 2010, 1, 4.)

Conformity assessment

Conformity assessment is defined in the International Standard ISO/IEC 17000 as "a demonstration that specified requirements relating to a product, process, system, person or body are fulfilled." Conformity assessment provides assurance of an item fulfilling certain requirements specified in regulations and standards. Conformity assessment is implemented through procedures such as testing inspection and certification, yet the type of conformity

assessment depends on the purpose it is done for. (ISO Central Secretariat 2006.) Conformity assessment bodies (CABs) can be testing and calibration laboratories, medical laboratories, product certification bodies, for example.

Accreditation and Certification

Accreditation and certification are important concepts with regards to calibration and conformity assessment in general and the terms can be easily mixed up with each other. ILAC (2013) defines accreditation as "the independent evaluation of conformity assessment bodies against recognised standards to carry out specific activities to ensure their impartiality and competence. Through the application of national and international standards, government, procurers and consumers can have confidence in the calibration and test results, inspection reports and certifications provided."

Certification can be easily confused with accreditation. Certification takes place when an organisation, product, or person is assessed and conforms to certain requirements of a standard. Certification bodies assess the conformity and certification can be carried out under accreditation. In other words, the difference between accreditation and certification is that only legal entities may be accredited, entities that carry out conformity assessment. For instance, a fire extinguisher cannot be accredited, but the body conforming that the extinguisher meets the standards can be. Certification on the other hand is carried out by the accredited or non-accredited conformity bodies depending on whether certification under accreditation is required or not. (SWEDAC 2012.)

2.2 Metrological organizations and metrology infrastructures

There is a variety of organizations involved in the measurement processes and working at the different levels of the traceability chain. In the following the organizations at different levels are shortly introduced.

The International Bureau of Weights and Measures

The International Bureau of Weights and Measures (BIPM) was established to provide a worldwide basis for a single coherent system of measurements which is traceable to the International System of Units (SI system). BIPM's work is done by direct dissemination of

units, as well as by coordination of international comparisons of national measurement standards. (BIPM 2013.)

CIPM Mutual Recognition Arrangement

CIPM Mutual Recognition Arrangement (CIPM MRA) is an agreement between NMIs, signed in 1999. The objectives behind the agreement are to establish a degree of equivalence of national measurement standards, provide mutual recognition of calibration and measurement certificates issued by the member institutes and to provide a foundation for governments and other organizations to wider agreements concerning trade, commerce and regulatory issues. The objectives are reached through the process of peer reviews of Calibration and Measurement Capabilities (CMCs); international comparisons of measurement standards of NMIs and DIs; and peer reviews of the quality systems of NMIs and DIs. (EURAMET 2008, 31.)

Multilateral Recognition Arrangement

The idea of the Multilateral Recognition Arrangement (MLA) is that the accreditations and the certificates issued by certification or registration bodies, which are accredited by members of the MLA, are recognised by the other members of the MLA as well. The objective is to eliminate the need for suppliers of products or services to be certified in each country where they sell their products, following the principle "certified once, accepted everywhere". The aim is that the MLA will cover all accreditation bodies in all countries in the world. (IAF 2013.)

National Metrology Institutes

The role of National Metrology Institutes (NMIs) is to develop and maintain national measurement standards, based on the definitions in the SI system or, where not yet possible, to other internationally recognized standards. NMIs disseminate metrological traceability to industries, laboratories, proficiency testing (PT) providers and others and thus are the foundation of metrological traceability in their State. Traceability is provided, in particular, through the provision of calibration services to accredited calibration laboratories. NMIs are signatories to the CIPM MRA and take part in the key comparisons that are the basis for the declaration of CMCs. Many NMIs may have their measurement services assessed through both accreditation and the inter-regional review process of the CIPM MRA even though the

CIPM MRA does not require NMIs to have their measurement and calibration services covered by accreditation. However, accreditation for some or all the services of an NMI is often considered beneficial. (ILAC, AIC & BPM 2012, 2-3.)

Designated institutes

Only one institution of a country may sign the CIPM MRA agreement, however, other institutes holding recognized national standards may partake in the agreement as a signatory NMI. These types of institutes are referred to as designated institutes (DIs). (EURAMET 2008, 30-31.)

EURAMET

EURAMET, the European Association of National Metrology Institutes, is a European Regional Metrology Organisation (RMO) and leads the cooperation NMIs of the member countries. It also represents Europe in the international metrology forum CGPM. (EURAMET 2011.)

Accreditation organisations

The purpose of accreditation bodies in different countries (such as FINAS in Finland) is to assure that there is control of an authorative body over conformity assessment bodies. The accreditation bodies are assessed by peers to prove their competence and they sign arrangements through which acceptance of products and services across national borders is improved. Therefore, accreditation is one of the processes contributing to the removal of technical barriers to trade. (ILAC 2013.)

Accreditation bodies essential in the European context are IAF, ILAC and EA. IAF (International Accreditation Forum) together with ILAC (International Laboratory Accreditation Cooperation) manage the arrangements such as MLA. Their aim is to enhance the accreditation and conformity assessment worldwide. ILAC focuses on the field of laboratory and inspection accreditation and IAF on the fields of management systems, products, services, personnel and other similar programmes of conformity assessment. (ILAC 2013.)

EA (European Co-operation for Accreditation) leads the European accreditation infrastructure and works towards the same goals as ILAC and IAF (certified once, accepted everywhere principle) only within the European community. It manages a peer evaluation system

withtin Europe and acts as a technical resource for EU policy-making regarding accreditation. EA is also a signatory to the ILAC and IAF MLAs and maintains its own EA MLA. (EA 2013.)

3 CALIBRATION SERVICES OF MIKES KAJAANI

In this chapter, MIKES and FINAS and their inter-relation is explained. In addition, the key calibration services that MIKES offers in its facilities in Kajaani are shortly introduced.

3.1 MIKES and FINAS and their interrelation

MIKES – Centre for metrology and accreditation (Mittatekniikan keskus) is the NMI of Finland. It realizes the SI system measurement units in Finland, performs high level metrological research and develops measuring applications in partnership with industries. Its tasks are to ensure that the measurements, tests and inspections carried out in Finland are reliable and internationally comparable; to maintain and develop the national measurement standards system through research; and to provide high-class calibrations and expert services of metrology. Moreover, within MIKES also operates the accreditation unit FINAS (Finnish Accreditation Service) which is the national accreditation body of Finland for laboratories, inspection and certification bodies and verifiers. (MIKES 2013a, 2013b.)

MIKES has facilities in Espoo and Kajaani. The MIKES Kajaani laboratory focuses on calibration of force, mass, and torque measuring devices as well as the development of online flow measurement devices. The competence areas of MIKES Kajaani are:

1) industrial metrology;

2) force, torque and mass primary standard measurements, measurement methods and devices;

3) liquid flow primary standard measurements, measurement methods and devices.

(CEMIS 2013.)

According to Nieminen (2012, 14-15) MIKES metrology department is highly respected in the national and European fields of metrology being amongst the five most significant metrology institutes in Europe. Nonetheless, one of the challenges of MIKES is that its work is not well known in the industry sector and R&D activities. Thus, it is suggested that the visi-

bility of MIKES and its offerings to companies should be enhanced as, often, quality of measurements, certifications and accredited calibrations can be essential factors in marketing and productization.

FINAS (Finnish Accreditation Service) is the national accreditation body responsible for organising the accreditation activities in compliance to the international criteria. FINAS offers accreditation services for testing and calibration laboratories, inspection bodies, certification bodies, providers of proficiency testing, GHG and EMAs verifiers. FINAS is an independent department within MIKES both in operational and economical terms. All its services are accessible to all applicants and are not conditional upon any reason e.g. the size of the applicant organisation. FINAS services are carried out following self-financing principle and the organisation operates non-profit. (MIKES 2013c.)

3.2 Flow, force and torque measurement

In this paper the focus is on calibration services with regards to 1) force measurement, 2) torque measurement, and 3) liquid flow measurement as these are the three fields in which MIKES Kajaani provides its services. The three subject fields are introduced shortly in the following.

Flow

According to SP Technical Research Institute of Sweden (2013) flow meters are relied on in nuclear power stations, pharmaceutical industries, oil refineries, laboratories, chemical and process industries, district heating plants and waterworks. Moreover, the flow can be either liquid or gas. As for liquid flow, it can be various type of liquid e.g. petroleum, chemical or water.

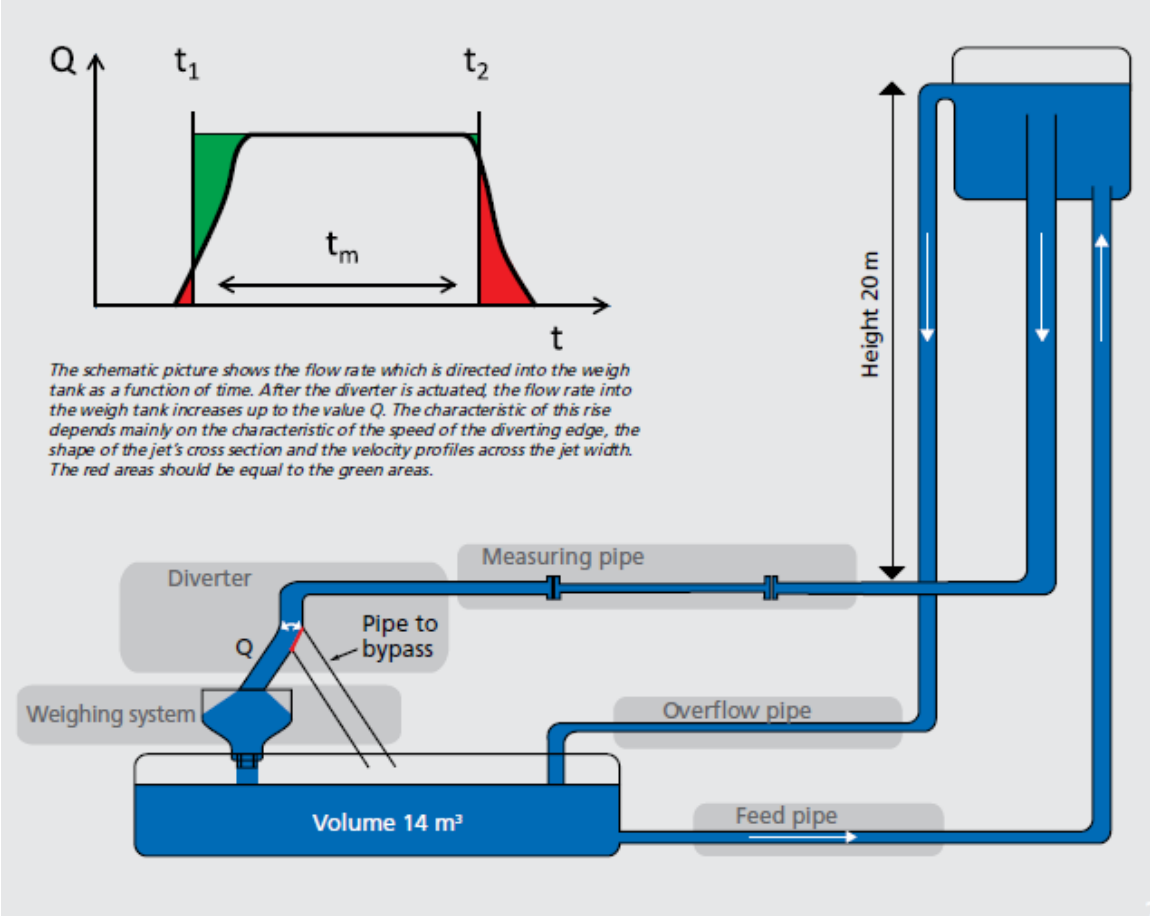
A flowmeter obtains the measure of the flow rate or quantity of fluid flowing in a conduit typically in the form of electrical signal. The signal should not be affected by the operating environment nor the inlet or outlet pipework. (Baker 2000, 9.)

There are three distinguished sets of devices for liquid flow measurement and related research: fibre content fluid analysis equipment, fluid flow gauge reference calibration equipment and a pressure constant water standard based on weighing water. The first one is con-

venient for pulp analysis, for example. Using the reference equipment it is possible to calibrate water flow meters and to conduct flow profile analysis using a Laser Doppler Velocimetry (LDV) device. (CEMIS/MIKES.)

According to MIKES (2011) the flow calibration facilities in MIKES Kajaani are interesting in terms of the European market, as the equipment can calibrate meters from 20mm to 600mm the flow rate being maximum of 800 litres per second. Altogether, as the environmental regulations are becoming more and more strict, environmental measurements' role is becoming more important and the MIKES Kajaani calibration service of flow meters enhances the qualifications of the players in the field. (MIKES 2011.)

Figure 2. Flow measurement facility



See Figure 2 for the flow measurement facility that MIKES utilises in Kajaani. The gravimetric reference standard of water flow is based on weighing the water. Water is constantly pumped upto a headtank 20 m above ground level. The water level is held constant in the tank by overflow and by adjusting the water flow in a measuring pipe section in which the tested flow meter is placed. As the desired water flow rate is achieved and stabilised, the wa-

ter flow (Q) is diverted into the weighing tank. Measuring starts (t_1) and the output of the tested meter is registered. After a specified time (t_m) the water flow is diverted to pass by the diverter and the measurement stops (t_2). (MIKES 2013.)

Force and torque

Force is a quantity in which many other quantities are based on, quantities such as torque, thrust and pressure. Force measurement is required in a variety of applications and industrial processes relating to the strength of materials, weighing, quality control during production and consumer safety. For instance, aircraft industry requires force measurements in testing the structural integrity of plane component and parts. (NIST 2011.)

Force is based on the force generated by a known mass in the Earth's gravitational field. Traceability is based on the calibration of the masses used and the accurate measurements of the Earth's gravitational acceleration on site. In order to maintain accuracy, MIKES frequently takes part in international comparison measurements. The equipment in MIKES Kajaani can calibrate sensors within a temperature range of -60 degrees to +100 degrees Celsius. (CEMIS/MIKES.)

Torque

Torque measurements are used in several industries including aerospace, automotive and manufacturing, usually during product assembly and testing (NIST 2008). Torque is a derived quantity formed by known masses and length of lever. Traceability is possible to achieve for the masses and length separately, however, authorised overall torque values are largely ensured by comparison measurements conducted between laboratories. (CEMIS/MIKES.)

4 SOME CHARACTERISTICS OF CALIBRATION SERVICES MARKETS

This chapter gives a review of the existing literature and previous studies regarding calibration services markets. It attempts to explain the competitive structures and the role of different participants in it and the role of calibration and measurements as part of national quality system. Moreover, some key issues and figures of the European calibration services markets are pointed out.

4.1 Competitive structures in calibration service markets

Calibration service markets can be divided into different sub-segments according to the type of calibration: electrical, mechanical, physical, and thermodynamic (Frost & Sullivan 2012, 10). Flow, force and torque measurement all belong to the group of mechanical measurement.

Frost & Sullivan (2008, 2/33) describe the calibration services market as highly fragmented; that is, there are many local providers offering their services in a specific geographic segment and furthermore not all providers offer calibration regarding all parameters. Some only focus on a certain segment of the business. *The players* in the markets can be divided into three categories: original equipment manufacturers (OEMs), national metrology institutes (NMI's) and regional third party calibration vendors.

OEMs

Traditionally, the OEMs mainly calibrate the equipment that they manufacture and sell, and calibration service is regarded as a support service to the core business. However, there are some examples of OEMs being more aggressive in promoting their calibration portfolio acting as a third-party vendor. The strength of the OEMs is their better understanding of their own equipment than that of the third party vendors, for instance. Yet, they are likely to focus on their core competencies of calibration parameters. Even though the OEMs have technical advantage in calibrating their own equipment, they are not very competitive in terms of service prices. (Frost & Sullivan 2008, 2/32,34.)

NMIs

Each country has its own NMI whose tasks are to develop and maintain national standards for one or several quantities. The structure, ownership and status of the NMIs in different countries vary: in some countries all national standards are centralized to one institutions, in others they are decentralized between different organizations. They can be owned by the government or private. Moreover, some NMIs are primary laboratories, i.e. they are internationally recognised for providing primary standards; some are exclusively reference laboratories providing a national standard traceable to a primary standard. Many NMIs focus on pure metrology whereas others may practice commercial activities. In addition all countries have at least one NMI which is given responsibility for legal metrology. The most common form of legal metrology is the regulation of weights and measures for trading. (Williams 2002, ix.)

Both Quinn & Kovalevsky (2005, 2314-2315) and (Wallard, 2) discuss the changed role of NMIs over the past decades. Quinn & Kovalevsky suggest that, whereas formerly the NMIs laboratories were carrying out high-level calibrations to industries, they now only carry out few. Today calibrations are mostly carried out by independent laboratories and the role of NMIs is to provide national standards and disseminate the expertise to the independent laboratories through calibrations and so evaluate their competence. Wallard states that, the NMIs used to be the only facilities where calibrations could be carried out and the large number of staff employed by NMIs mostly worked on routine measurements. The rapid growth in world trade as from the mid-70s generated an extensive need for industry calibrations and thus created demand for independent calibration laboratories that NMIs now have to compete with.

Third-party vendors

Third-party providers are companies which offer calibration services as their primary line of business. The market is highly fragmented in which regional participants are active. However, as these companies do not have a large portfolio of calibration services, the trend seems to be that bigger players absorb the smaller ones. (Frost & Sullivan 2008, 2/35.)

In-house laboratories

In-house calibration laboratories refer to the laboratories that end-user organizations have of their own. These laboratories carry out calibrations internally independent from service providers. Nevertheless, due to evolving end-user technologies and consequent need for specialized services there is a shift towards the use of third-party and OEM services at least in Europe. (Frost & Sullivan 2012, 39.)

End-users of calibration services

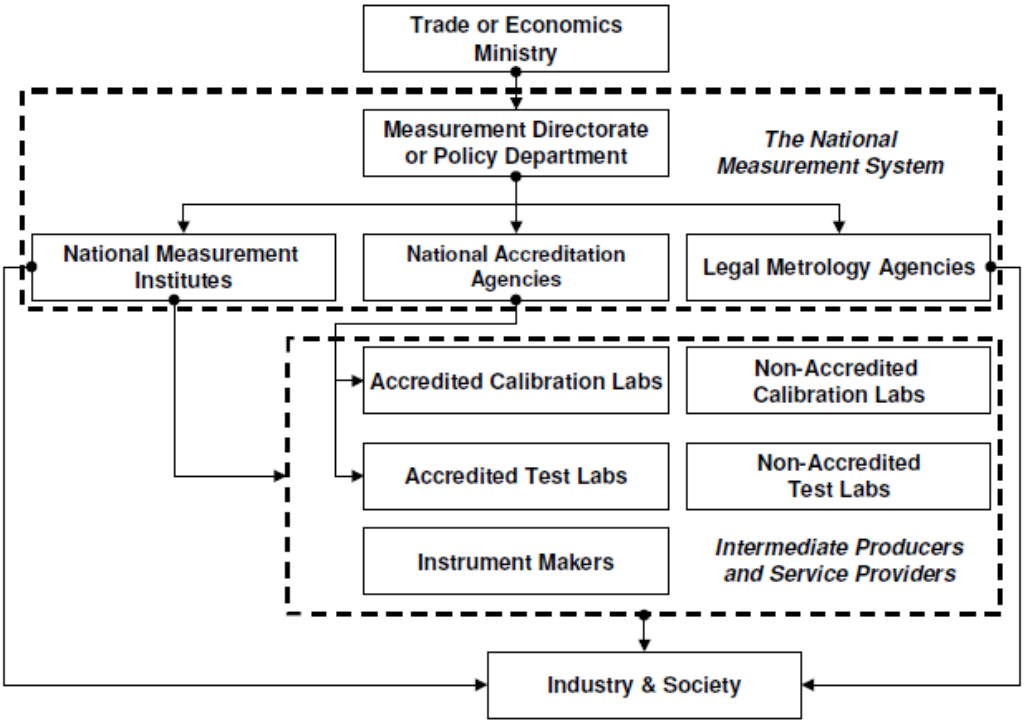
The *key end-user* groups may be subcategorized with regards to their industry they are involved in. Frost & Sullivan (2008, 2/33) list the end-user segments as communications; industrial and automotive; aerospace and defence; electronic manufacturing; pharmaceutical; and food and beverages.

Primary and secondary markets

Racine (2011, 137) divides calibration markets into primary and secondary markets. The primary calibration market concerns NMI's services to independent laboratories and thus provision of traceability to reference standards. The secondary calibration market regards the end-users of metrology equipment in industry such as manufacturers or product designers. The national measurement system is well illustrated by Williams (2002, 3) in Figure 3. Williams describes how NMIs, NABs and legal metrology agencies work under a ministry serving both accredited and non-accredited laboratories and instrument makers (OEMs), (primary markets according to Racine), as well as, the industries (secondary markets).

As Racine (2011, 238, 240-241) suggests, often, both NMIs and independent laboratories compete in the secondary markets. The percentage of calibrations offered in the secondary markets by NMIs varies from country to country. For instance, in Germany PTB provides only 20 % of its calibrations in the secondary market whereas in Bulgaria, Hungary and Turkey 75-95% of NMIs' calibrations are provided in the secondary market. Moreover, the density of industrial activity affects the development of private calibration laboratories i.e. in states where many industries exist requiring measurement devices private calibration markets are likely to develop. On the opposite are the states with limited demand and difficult business environments in which usually states incentives to NMIs sustain the calibration services.

Figure 3. The National Measurement System. (Williams 2002, 3.)



Furthermore, there is variation in the type of calibrations the NMIs carry out in different countries. It is likely that in a small economy the NMI carries out plenty of simple routine industrial calibrations whereas in a large economy, such as Germany, the NMI specializes on sophisticated calibrations. (Racine 2011, 237.)

Relationship between NMIs, NABs, and calibration laboratories

Commonly, a firm establishes traceability by letting an accredited calibration laboratory to calibrate its measuring instruments. The calibration laboratory, in turn, ensures traceability to NMI's standards directly or mediated through an accreditation body. Thereby, the unbroken traceability chain is connected to the NMI. (MacDonald et al. 2002, 13.)

The NMI of a country has the technical competence and measurement standards and holds the national reference standards for the national accreditation system. Close collaboration between the National accreditation body (NAB) and the NMI is required, as it is considered a good practice for NABs to use NMI experts as technical assessors in the accreditation procedure. Moreover, cooperation is essential in inter-laboratory comparisons for calibration laboratories. (EURAMET, 2008b 7.)

According to EURAMET (2008b, 7) national policies may stipulate rules in regard with unfair competition in case in which similar calibration services are offered both by the NMI and by calibration laboratories. Even some NMIs have established policies refusing calibration service provision to customers when the same level of calibration can be provided by an accredited calibration laboratory. However, the so-called high-end calibrations, i.e. services beyond the capabilities of calibration laboratories as well as dissemination of related expertise remain the task of the NMI.

Competitive factors

According to Frost & Sullivan (2008, 2/31, 32, 33) the *key competitive factors* in the calibration services market relate to price, quality of calibration, and equipment downtime. Indeed, pricing and turnaround time are the main commercial factors influencing the end-users decision-making. Nonetheless, compliance to quality standards is the main driving factor in industries using critical applications, for instance those in aerospace and pharmaceuticals. In general, pricing pressure has been the driving force for mergers and acquisitions in the calibration markets. Another consideration regarding pricing is the high complexity of calibration which allows a laboratory to charge higher rate for services. Also accredited laboratories charge premium prices for calibration services, since the cost involved in laboratory certifications is high. The accredited laboratories are, in fact, expected to be more profitable than the non-accredited ones.

Current market trends

According to Frost & Sullivan (2008, 2/34) in geographic regions such as Asia pacific and Latin America OEMs and NMIs perform most calibrations and only few third-party vendors exist providing good-quality services. Therefore, the leading calibration service providers are expected to expand their services to these new regions. Furthermore, acquisitions seem to have been a trend amongst the calibration service companies as the big players acquire the smaller ones.

4.2 European calibration services market

In 2007 Europe was the largest market for calibration services with a 45 % share of the global market. In Western Europe the market is mature experiencing moderate growth only. Manufacturing companies are shifting to low-cost regions such as Asia or Eastern Europe. Therefore, some leading calibration service providers have started setting up laboratories to these regions. For example, Trescal has expanded its operations to Poland and Romania. (Frost & Sullivan 2008, 2/20.)

Drivers and restraints in the European calibration services market

Frost & Sullivan (2012, 15) have listed the key market drivers and restraints in calibration services which are shortly introduced in the following:

Drivers

1) Focus on quality and compliance with regulations increases the need for calibration services. In short, this means that the end-users recognize calibration as part of quality management and internal auditing. As well certain standards such as ISO and regulations and legislation (environmental, health etc.) drive calibration.

2) Greater demand for onsite calibration is fueled by need for minimum downtime. That is, minimum down-time is more cost-effective and saves the trouble of logistics compared to offsite calibration. Offsite calibration is yet needed when the laboratory environment is the prerequisite.

3) Service revenue rises due to increasing installed base. That is, simply, the service demand raises the more installed base of equipment there is. Moreover, there is a demand for longer life-expectancy of equipment and together with increasing awareness of the benefits of calibration in equipment maintenance create an opportunity for calibration services.

4) Service provider offerings are strengthened by outsourcing between OEMs and third-parties. That is, a level of cooperation is established between third-party vendors and OEMs in a way that calibration of OEMs own brand products is out-

sourced to the OEM itself even though the calibrations in general were maintained by another party.

5) Demand for faster turnaround time is driven by the need of end-users to increase productivity. Turnaround time is a competitive advantage for third-party labs compared to OEMs as they are located in proximity of their clientele whereas OEMs may be in a further distance. Nonetheless, OEMs focus on more specialized equipment calibrations which cannot be conducted by any other provider, which extends the calibration turnaround time. Large OEMs have advantage of global networks in reducing the turnaround times.

6) Importance of calibration services is emphasized due to increasing customer awareness. That is, importance of calibration has been realized to reduce downtime and inventory costs and also, global competition creates pressure for companies to invest in accredited calibration in order to demonstrate improved quality and enhanced performance. Calibration is more and more seen as core maintenance procedure as well as a strategy to improve productivity , decrease replacement costs, gain competitive edge and thus enhance profitability.

(Frost & Sullivan 2012, 17-22.)

Restraints

1) Overall market growth is affected by price pressure. There is intense price competition that has forced suppliers lower their prices eroding profit margins.

2) Growth of smaller firms is influenced by consolidation; a few big OEMs dominate the European market top seven companies controlling approximately 50 per cent of the total market revenue.

3) Overall service contracts are affected by extension of calibration cycles; that is, strict cost-control strategies in companies encourage them to postpone calibration schedules for reduction of downtime and operational overheads.

4) European market growth is restricted by globalization as end-user industries are becoming more global. Investments are directed to emerging economies while Europe

becomes secondary target for investment influencing the consumption growth of calibration services.

(Frost & Sullivan 2012, 23-27.)

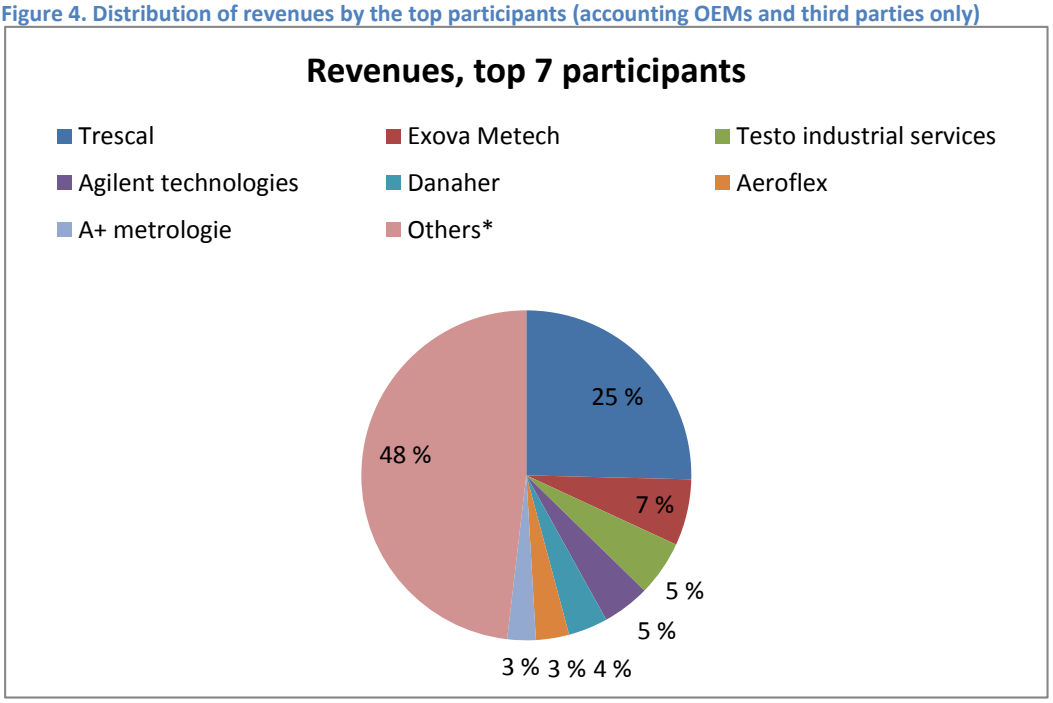
Market size and growth projections

The whole European calibration service market generated 1.09 billion USD in 2011 and is expected to grow upto 1.55 billion USD by 2018 as compliance to regulations and trend toward periodic calibrations drive demand. Of the total sales mechanical calibration counted for 30.6 per cent. Looking at the revenues of OEMs and third party calibration service providers alone, the study of Frost & Sullivan shows that, in 2011, the revenue of these participants totaled for 646 million US dollars of which the top seven participants contributed 51.9 per cent as illustrated in Figure 4. (See also Appendix 3.) Trescal as the market leader has been aggressive in increasing its market share in the recent years; since 2007 it has acquired 10 companies. (Frost & Sullivan 2012, 10, 12, 44-45.)

Eastern Europe (EE) accounted for 11.1 per cent of sales of the total European calibration services market in which Germany, UK, and France had the largest share by 16.8 %, 12.5 % and 13.1 %, respectively. It generated 110 million USD in 2011, sales increasing by 7.1 per cent from 2010. EE experienced the most rapid growth among European regions as in the rest of Europe the growth between regions varied between 4.6 to 6.1 per cent. (Frost & Sullivan 2012, 41.)

The revenue forecast of the mechanical calibration segment of Frost & Sullivan (2012, 55) indicates revenues growing steadily between 2013 and 2018 in Europe. At the same time growth rate is expected to escalate until 2015 upto 5.8 per cent and start to decline slowly. In 2018 the growth rate is expected to be around 4 per cent revenue totaling for 470 million USD. In comparison, the revenues in the mechanical calibration segment in 2012 totaled for 350 million USD. The growing need for calibration services is driven by the increase in mechanical test equipment installed base.

Figure 4. Distribution of revenues by the top participants (accounting OEMs and third parties only)



NMIs financial standing point is slightly different from the other participants in the markets as they receive part of their funding from the governments since they are significant contributors to scientific metrology in their countries. Yet commercial activities form an essential source of income to many NMIs. According to Williams (2002, 8) every country in Europe provides public support to the NMIs. However, the level of public provision can vary greatly from a country to another. On average 64 per cent of the funding was from the member state government and commercial activity accounted on average for 26 per cent in total in the year 2002. See Appendix 4 for the level of funding of NMIs in different European countries.

4.3 Measurement and calibration – the role in the national quality system

Racine (2011, 3-4) suggests that the national quality infrastructures consists of six components: inspection bodies and testing laboratories; certification bodies; calibration laboratories; national standard bodies; national accreditation bodies; and national metrology institutes. The national quality infrastructure of a country can help firms to make products that meet the quality requirements of global markets and thus promote competitiveness.

According to (Schmid, W. & Leitner, A., 2009) there is a growing need of emerging economies to demonstrate conformity of their products as they become more active in the global

markets. Even some of the EURAMET member countries represent these emerging economies, some with national quality systems still under development. EURAMET participates the development process by having established a Focus Group for "Facilitating National Metrology Infrastructure Development".

According to Beges, Drnovsek & Pendrill (2010, 147) CMCs are a crucial component in stating the metrological performance of NMIs with respect to participating key comparisons as well as demonstrating the equivalence of the various national metrology systems and offering calibration services. Notably, the CMCs vary among different countries reflecting both the country's competence in existing measurement science and its perceived national needs for traceable calibration. Nonetheless, NMIs have to outperform the secondary laboratories in their CMCs.

Beges et al. (2010, 148) further suggest that, misleadingly, the number of CMCs is often being related to the size of the national economy of a country and used as a proxy for the efficiency of national systems. However, it is needed to examine the CMCs in a much wider context of a conformity assessment and not solely reflected against broad indicators such as national economy.

Corruption in some countries can hamper the national quality infrastructure. Racine (2011, 200, 209) discusses corruption in Commonwealth of independent countries (CIS) where corruption is rampant throughout the state-owned testing, certification and calibration laboratories. For instance, a study (2005) indicated that in Ukraine one tenth of respondents subject to mandatory standards reported the need to make unofficial payments. Corruption leads to issuing of certificates even though no testing or calibration is carried out. There is no chance for development in terms of quality assurance unless the firms demand for it and the conformity assessment market will develop only if there are enterprises requiring quality, Racine states.

4.4 Calibration as a part of industrial services

Apart from viewing calibration as a separate service for industries, it can be viewed as an essential service among other industrial services such as maintenance, repair and spare parts

supply. In fact, often calibration can give an indication of defects in machinery and is also part of so-called predictive/preventive maintenance.

Paloheimo, Miettinen, & Brax (2004, 23) divide industrial services according to the object of service as presented in Figure 5. The table illustrates the kind of services that the concept 'industrial services' may consist of. Moreover, Paloheimo et al. (2004, 63) make difference between traditional after-sales services that include training, installation, spares and wears for example, and "new age" of services built around an equipment's whole life-cycle such as preventive maintenance, service contract, upgrades and exchange programs.

Figure 5. Industrial services according to the object.

Object	Example of the service
Equipment	Delivery, installation, calibration, commissioning, servicing, maintenance, upgrades
Equipment use in process	User and technical training, maintenance management, operation, equipment availability, exchange programs, process optimization
Business	Plant availability, plant optimization, equipment financing, asset management, consultation

Several authors discuss the growing trend of firms in outsourcing some of the industrial services to contractors. For instance, with regards to maintenance, OEMs roles are shifting from pure manufacturing towards service provisions throughout the equipment life-cycle. The more and more competitive environment and increased demand from industries has forced OEMs to look for better profitability through long-term and full-service maintenance contracts.

According to Stremersch, Wuyts & Frambach (2001) industrial firms in many industries are increasingly interested in taking a full-service approach to their customers; i.e. offering comprehensive product/service bundles for total need fullfilment of the client. The trend is driven by demand from industries and it emphasises long-term relationship with a specific supplier. In their empirical study Stremersch et al. found that firms consider the purchase of maintenance contracts based on their overall value proposition and appreciate obtaining proper solutions matching their needs rather than getting a low price of an individual maintenance service. For the service provider full-service contracts mean higher margins as

in traditional maintenance markets sales margins are approximately 0.5%, in full-service offerings they can reach upto 10-15%.

Panesar & Markeset (2008, 178-179) investigated the Norwegian oil and gas (O&G) industry and also recognise the growing dependecy of oil and gas companies to industrial service companies. Aging production facilities as well as investments in development by O&G firms creates generates demand for such services. Moreover, the firms are more focused on improving efficiency in operations, maintenance and support activities, as well as on reducing costs.

Alsyouf (2009, 212, 216, 222) suggests that just-in-time management systems (JIT), lean and agile manufacturing and the use of automated and integrated systems have caused production to become vulnerable to risks. Thus maintenance has become vital adding to customer value in terms of profit, quality, time and service, and subsequently, competitiveness. In the study of the Swedish firms' maintenance practices, Alsyouf found that Swedish companies spent on average 4% of their turnover on maintenance and those companies with outsourced maintenance activities the outsourcing activities consumed approximately 20% of the total maintenance budget. The study also indicated that lack of planning and scheduling can hamper the maintenance department reaching its objectives and thus negatively affects the business profit maximization.

Colen & Lambrecht (2) state that serving the installed base has become a big business for the OEMs as they have recognised the profit potential of services and have shifted their strategies from pure manufacturing towards integrated strategies of value creation together with the client. These integrated solutions are called product service systems (PSS). In a PSS an OEM takes care of a set of after-sales services and thus become responsible for activities such as waste disposal, component replacement and energy use, as well. This type of business model is seen promising in terms of profitability and comparative advantage but also in terms of sustainability as the manufacturer takes responsibility of the sold equipment throughout its life-cycle and thus thrives at reducing costs over the total life of the equipment.

Also Tsang (2002, 11,13) discusses maintenance as a business function that is often been outsourced. The outsourcing arrangement gives the company a chance to focus on its core competencies. Nevertheless, Tsang notes that sometimes the maintenance function is found

viable to keep within the company even though it was not a core capability. In such a case the firm ought to look into commercializing the expertise and provide it to other firms.

Moreover, Tsang (2002, 13-14) introduces a clssification of three types of contractual relationships existing between the maintenanace outsourcer and contractor, namely work-package, performance, and facilitator contracts. First, work-package contracts present the most basic form of contract whereby the planning, control, and spare-parts management is in the hands of the firm and it simply orders maintenance activities from the contractors when needed. Second, in performance contracts a comprehensive range of maintenance activities is handed to a single contractor and the contract stipulates the targeted performance outputs such as failure rates, response time, and time for restoration. In this type of contract the maintenance planning, decisions as well as implementation belong to the supplier. Third, in facilitator contracting the customer is solely the user of the physical assets and the ownership of the assets belonging to the contractor. Naturally, this type of contract requires a long-term relationship.

5 METHODOLOGY

This study was an initial marketing research study and very broad in nature. It was implemented as a desk research using secondary data from online sources mainly. The type of data gathered was qualitative.

5.1 Research design and scope of the study

According to Burns & Bush (2006, 116) a research design is the set of advance decisions that specifies the methods and procedures for collecting and analysing needed information. There are three types of research designs: exploratory, descriptive, and causal. The research design is chosen after considering the problem and research objectives.

Exploratory research

Exploratory research is used in various situations in order to gain background information, define terms, clarify problems and hypotheses and establish research priorities. Commonly, exploratory research is unstructured and informal in nature and is undertaken in order to gain background information with regards to the general nature of the research problem. Informality of the research refers to the fact that there are no test hypotheses, objectives, sample plan, or questionnaire used. The unstructured nature of exploratory research means that there is no pretermined set of procedures but the nature of the research rather changes as more information and knowledge is gained along the process. It should be noticed that usually every research includes exploratory research as a part of the study at least. (Burns et al. 2006, 117-119.)

Secondary data analysis

Secondary data analysis is one method of carrying out exploratory research. Essentially, it is the process of searching and interpreting existing information that are relevant to the research objectives. Secondary data is the data gathered for other purposes by someone else and can be found in books, journals, reports etc. (Burns et al. 2006, 119.)

The research design for this study was exploratory using secondary data available online. The objective was to get an overall view of the calibration services markets in Europe in order to decide how to continue the marketing research for MIKES and to identify possibilities in the markets. Possible further studies may, in turn, take other type of research designs as the research problems are defined more specifically.

The main questions that needed answering in this exploratory research were: who are the players in the markets, either competitors or potential customers of MIKES, and the geographical locations where these participants in the markets operate in. At this point, of the identified players, neither is it defined who are direct or indirect competitors nor potential customers. No in-depth organization profiling was made. Moreover, the study was limited on the flow, force and torque calibrations providers and thus does not present the view of the whole calibration service market but is a sufficient sample to gather some insights of the markets.

5.2 Factors affecting the validity of the research

There are certain considerations to be taken into account as using secondary data and online information. First, the information searched for is not always available or it might be too general. Second, language of the websites may cause language barriers as not every organization in all the researched countries has English web-sites.

Validity of the researched was taken into account in choosing the information sources e.g. by using official organization websites only. Moreover, it was essential having systematic and organized working procedures when collecting the data. For instance, in listing the accredited calibration organizations different countries databases were gone through carefully organization by organization so that as many laboratories could be listed as possible.

Certainly, there is always the problem that not all information can be gathered; in the list of companies most probably some laboratories are missing and additionally the language barrier issues also contribute to relevant data not being gathered. Also, not recognizing some of the technical vocabulary could contribute to ignoring relevant information unintentionally. Furthermore, as one could not spend too much time per one website e.g. when browsing through the final list of almost 400 organisations, the limited time may induce misinterpreta-

tions of information. Nevertheless, as the aim of the study was not to drill deep into the organizations and thus the validity of the research compared to its aims of providing cues and indication for further studies was adequate.

5.3 Progress of the research

The research started by investigating metrology structures, the calibrations industry in general and the type of organizations involved in it, as well as, getting acquainted with the measurement technologies related to flow, force and torque. The key points are reported in the theory part of the thesis. Moreover, articles or any related material of the calibration services markets and calibration services as a business were searched for.

There are different types of organizations offering calibration services. In order to understand the market it was essential to understand the role of different metrology organizations. Therefore, an effort was made to explain the types of the organizations and their roles.

Listing the accredited organisations

Firstly, a list of the accredited calibration laboratories in the European countries was collected. EA website was used to get a listing of the national accreditation bodies (NABs) in Europe and the NAB website of each country, in turn, provided a listing of the accredited calibration laboratories. While collecting the information on accredited laboratories the findings where already filtered and shortlisted in the way that only organizations that possessed CMCs in the service branches of liquid flow, force or torque were listed. See Appendix 5 for BIPM service branches categorization.

After the listing was made, the organizations websites were browsed through. Information was collected on the organization websites regarding the geographic areas they operate in and the industries that they serve. Moreover, the organizations were classified into six categories based on what type of operator they are. All information was collected in an Excel worksheet with company contact information. If calibration service prices were available the link to the information was added as well.

Market presence

The market presence was described in three separate columns: Western Europe, Eastern Europe and Global in order to make it easier to process the data. Some organizations clearly stated the market areas that they operate in whereby the countries could be listed specifically. Market presence could be listed based on the office locations that the organization had, the representatives it had in other countries, the reference lists of customers or ongoing and past projects in different locations. It must be noted that the market presence does not necessarily describe the markets of calibration services directly but it should be viewed in regards with the type of the organization since not all of them provide solely calibration services.

Some organisations described vaguely their presence or did not mention it at all. In this case the presence was listed based on the laboratory location. However, some assumption could be made based on the company website; for instance, if it is only in the national language and not very professionally constructed or providing only very basic information, it could be assumed that the company operates locally only. The companies could also state that they operate internationally but not really specific locations; in that case 'international' was marked, whereas some big players had so many locations in several continents that they could be marked as 'global'.

Furthermore, attention was paid to whether the companies were part of larger organizations and therefore in the 'remarks' column some notes have been listed in that regard. Thus, some conclusions could be made of the big players in the calibration services markets.

Classifying the organizations

Based on the information provided on the web-pages the organizations were classified based on what type of an organization they were and what was the role of the calibration services in the organizations' service mix. It was found necessary to extend the division of Frost & Sullivan (OEM, third-party, in-house) and finally the categories were six: OEM, equipment supplier, other, research institute, and in-house. See Appendix 6 for specifications and the classification criteria. In some cases the classification was not very straight forward and, in fact, many companies could have fallen into many of the categories. Therefore, the classification is quite rough and done based on the first impressions of the organizations and their product offerings, however, it can be useful giving the idea of what sort of company is in question.

Customer segments

Finally, the industries that the organizations served were listed. Still, in many cases the information was not available, and thus could not be recorded. Again, some organizations listed their customer segments very specifically, some more generally on industry level and some very vaguely or not at all.

Analysing the gathered information

When analyzing the gathered information of the calibration laboratories, the focus was on the laboratories operating in the Eastern Europe (EE). Eastern Europe was in focus since the industries have more growth potential in there rather than in the Western Europe and the calibration services are assumed to follow the trends in industry growth. Also, as stated by Frost & Sullivan, the calibration markets in Western Europe have reached a level of maturity and thus it was more interesting to concentrate on the still growing markets.

When looking at the findings one ought to keep in mind that the study mainly regarded laboratories dealing with flow, force or torque calibrations. When listing down the laboratories only those ones were regarded with one or more service among the three fields. However, it can be that those laboratories that were picked and the organizations behind them provide calibration services in other fields of measurement as well.

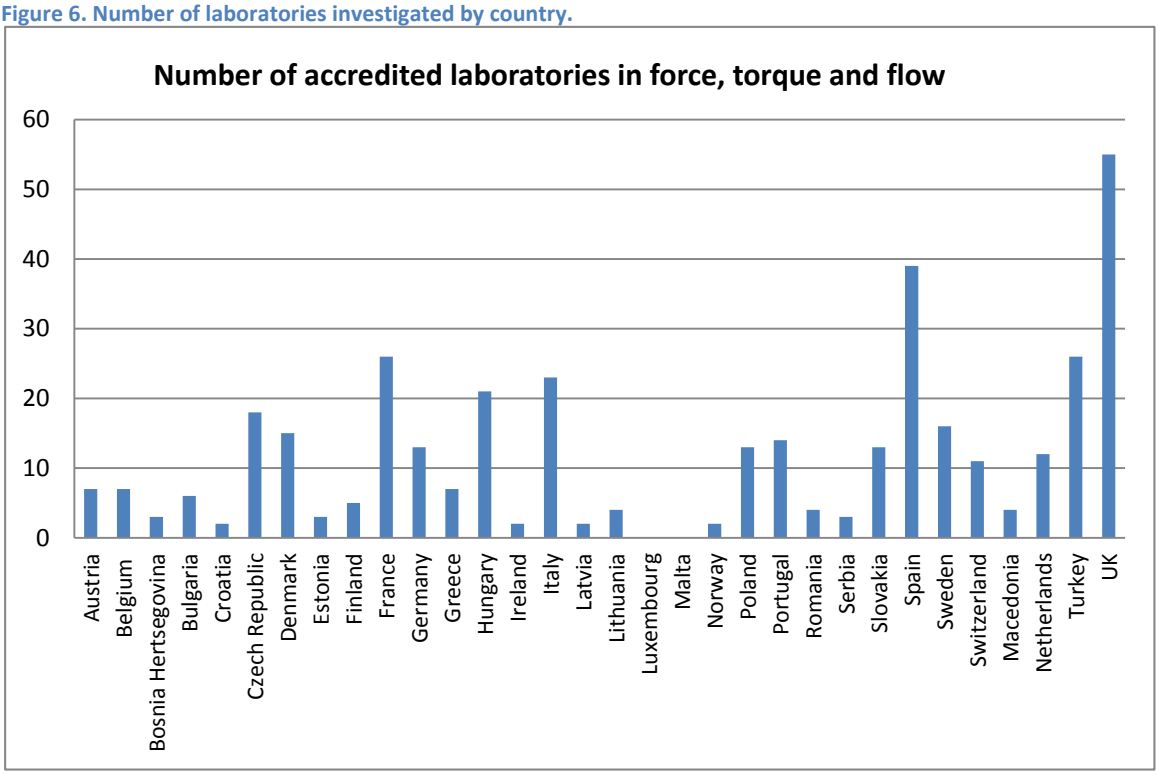
6 KEY FINDINGS OF CALIBRATION SERVICE PROVIDERS IN EUROPE

In this chapter, the findings of the study of accredited calibration laboratories in Europe are presented. Firstly, some background information is presented followed by the type of players in the markets, and introducing some major market participants. Secondly, some findings concerning the Eastern European markets are explained.

6.1 Researched organisations

For the final list, 371 laboratories were found all of which were accredited either in the field of flow, force or torque. Of the total number of listed laboratories some were part of same organisations only having different locations, so the number of organisations investigated was actually less than 371. A little less than half of the organizations behind the laboratories were operating in the global markets. The web-pages of all the 371 organizations were browsed through, even though some organisations' web-pages were not found or some other technical difficulties occurred. Figure 6 indicates the distribution of accredited laboratories that were researched, by country they were accredited in. Note that only EA full member countries are presented in the graph as no reliable information was found on the EA associate member countries laboratories. See Appendix 7.

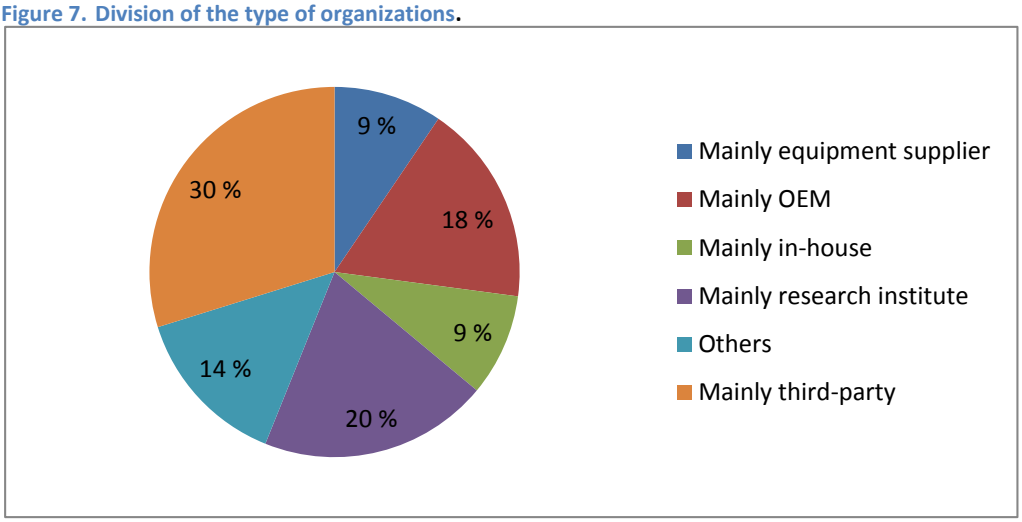
Figure 6. Number of laboratories investigated by country.



6.2 Types of players in the markets

Classifying the organizations was not straight-forward. In fact, when trying to classify the organizations it was found out that there is a great variety of different types of operators in a continuum from pure calibration service providers to bodies that produce or supply measuring equipment; to inspection, testing and consultancy providers; to industrial operations designer and manufacturer companies. In the other end of the continuum are the companies that use calibrations for the internal purposes only. Figure 7 indicates the division of different type of organizations that were presented in the sample of researched organizations. The division was drafted based on what is the primary interpretation of the role of calibrations in a company's service mix. Since it was not obvious that an organization falls clearly into one category, in the graph laboratories have been categorized according to their primary purpose.

Figure 7. Division of the type of organizations.



The segment 'others' includes several types of companies such as inspection, verification and testing companies; consulting companies; companies involved in water supply or water treatment; industrial designing or engineering companies; manufacturers of industrial process equipment and other products and so on. Maintenance and manufacturing companies related to the transport sector seems to be one essential provider of calibration services among of which are aircraft maintenance and manufacturing, ship building, railroad maintenance, car diagnostics to mention but a few.

6.3 Major market participants

There were certain organizations that had laboratories accredited in several countries some of which also were regarded as the leading operators in the European calibrations services markets in the study of Frost & Sullivan (2012). Altogether 60 calibration laboratories were regarded as part of a larger organization most of which operating internationally. Those larger international organizations were 26 in total. The companies with most references are presented in Figure 8. The organizations are listed in detail in Appendix 8.

Figure 8. International groups that occurred in the research.

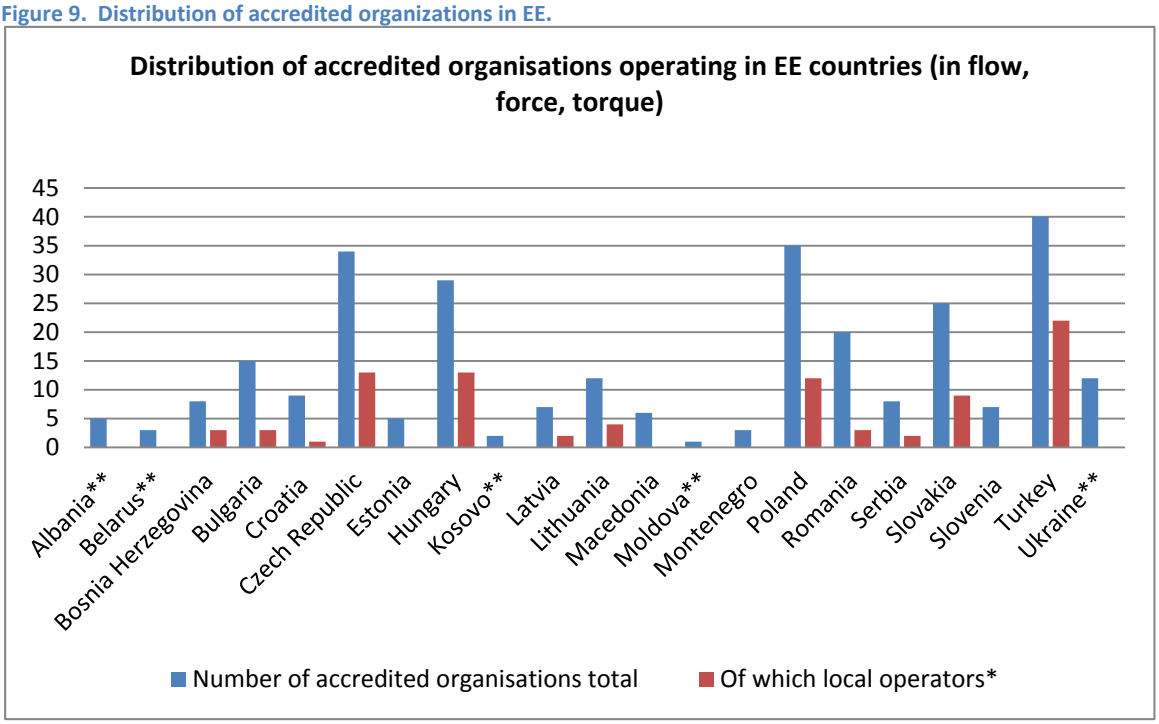
	Group Name	Number of laboratories in the listing
1	Trescal	9
2	Energotest network	5

3	Sensus group	4
4	SGS group	4
5	Exova Metech	3
6	Zwick Roell group	3
7	EADS group	2
8	Element materials technology group	2
9	Krohne group	2
10	Diehl metering group	2

6.4 East European countries

Of all the listed organisations approximately 180 had operations in the Eastern Europe of which app. 85 operated globally (outside Europe). When counting the number of operators specifically per EE country those organizations of which no specific information was found on which countries they operate in were excluded. Therefore the sample size was 137 organisations. The distribution of accredited organizations per country is presented in Figure 9. Apart from the total number the chart illustrates how many of the organizations operated mainly locally.

Figure 9. Distribution of accredited organizations in EE.



[1]

Figure 10. GDP in EE coutries, 2011. Source: World Bank.

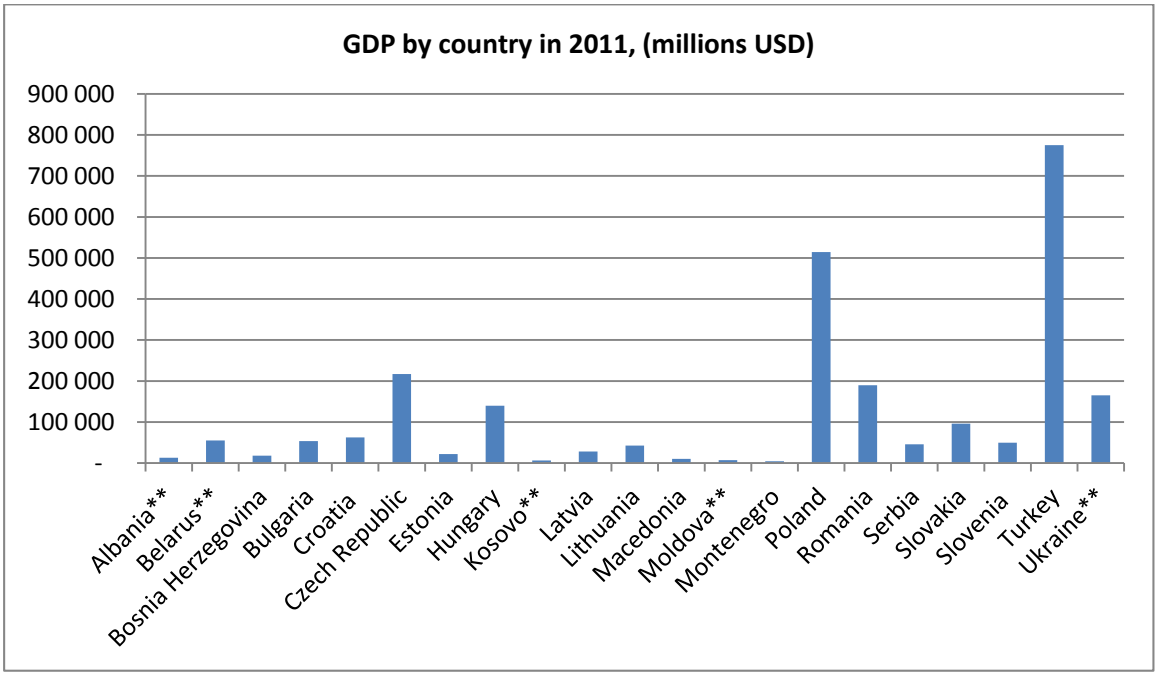


Figure 10 illustrates national GDP in the Eastern European countries. When comparing the GDP of a country to the number of accredited organizations, one can see the trend that the

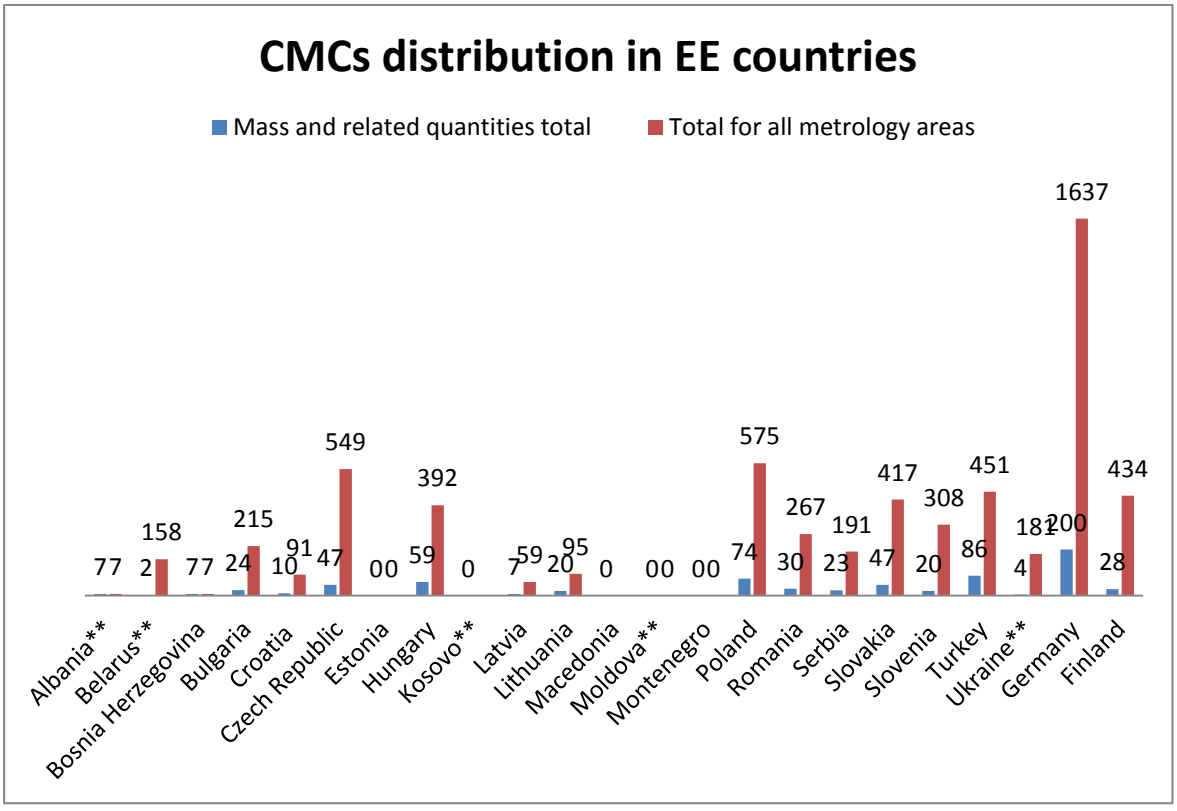
[1]* Usually operating only in the country where accredited.

**EA associate members.

number of laboratories in a country is related to the national GDP; i.e. those countries with the highest GDP also stand out in the rank of calibration laboratory number. Czech Republic, Poland and Turkey clearly have the highest GDP in the EE and also the highest number of organizations in accredited calibrations.

Some inconsistencies in the trend seem to occur in case of Hungary, Slovakia, Romania, and Ukraine. Among these countries Romania and Ukraine have higher GDP than Hungary and Slovakia, yet Hungary and Slovakia have relatively much more laboratories than Romania and Ukraine do. Moreover, Romania and Ukraine stand out in the ratio of international to local calibrations providers; they do not seem to have a lot of local calibration laboratories. In case of Ukraine, it was difficult to find information on the accredited laboratories due to which none of them ended up on the collected list of organizations which could be one of the reasons as to why no local operators are shown.

Figure 11. Distribution of CMCs in Eastern Europe and comparison countries (Germany & Finland).



Source: BIPM KCDB 2013.

To some extent, CMCs can indicate the state of metrology in a country. In Figure 11 the CMCs distribution in Eastern European countries is presented. Germany and Finland were

included in the graph for comparison. Comparing the numbers with the accredited organisations again it is shown that Czech Republic, Hungary, Poland, Slovakia and Turkey are leading while Romania and Ukraine have less CMCs than Slovakia and Hungary even though their GDP is higher.

6.5 Customer segments

The organizations involved in the calibration industry serve end-customer in a variety of industries such as automotive, aerospace, defense, chemical, civil engineering, construction, energy, metal, pharmaceutical, oil & gas, water, food etc. Based on this study it is not possible to draw reliable conclusions of some trends regarding the customer segments. However, it can be is assumed that the distribution of calibration laboratories in a country follows the trend of the size of industries present in a country. For instance, in areas with a lot of automotive industry also the need for calibration services of force and torque are needed.

7 DISCUSSION

There seems to be a growing trend in industries to recognize calibration as part of maintenance activities and as a crucial factor for sustaining product quality as mentioned in much of the literature. Moreover, the requirements of global markets work through international standards such as ISO that push companies to enhance the quality control in production.

In literature it is suggested that, as the markets for equipment becomes saturated in the developed markets, especially in industries with capital intensive equipment that have long-life cycles, after-sales/life-cycle oriented business models are the way to go for OEMs. That is, the OEMs offer bundled support services to the buyer of the equipment or full-service contracts. Moreover, in the environment with growing awareness of sustainability and sustainable practices, PSS models as suggested by Colen & Lambrect could be expected to become more and more popular.

One of the questions arising is, what is the role of third party service providers in industrial services such as calibration, if the demand from industries increasingly shifts towards full-service contracts with OEMs. A solution for a calibration laboratory could be to partner up with an OEM and provide the expertise in this one field of industrial services. Indeed, some indications of such business models, came up in the empirical study that laboratories have, either exclusive or non-exclusive service contracts with certain OEMs. Thus the third party is able to service the equipment of a manufacturer in their own operational area to which an OEM itself would find difficult to reach. Actually, in the empirical part those companies selling other producers equipment were classified as 'equipment supplier' which gives a cue of agency-type of functions and partnering within the calibration market.

Still, one cannot underestimate the role of third-party laboratories and especially NMIs with the concentrated expertise in special services like calibration and in case of MIKES for example their special flow calibration equipment that is found out to be of great importance within Europe at least. The main question is how they can offer their services in the markets and how to reach the potential customers. This research was the first step to start the work in finding the way to the markets.

In this sense, perhaps further research on the business models existing in the calibration market could be implemented and of the networks that exist. For instance, Frost & Sullivan

suggest that big players are acquiring smaller ones and that outsourcing between OEMs and third-party laboratories take place. It could be useful to map out such relations a bit further.

Obviously a lot of work and research is still needed in defining the markets viable to be entered. Also, as this research mostly views number and types of operators in countries it does not tell about the actual size of the markets. Information concerning revenues and turnover of laboratories should be gathered. Moreover, the research does not tell how sophisticated calibrations the laboratories are carrying out or how many calibrations altogether. For instance, a country may have several small operators which carry out very simple low cost calibrations. Thus the turnover of calibration labs in such country may be relatively small if compared to countries with fewer laboratories but with higher revenues of high-end calibration services.

Since the West European calibration service markets have reached the level of maturity already, it was viable to focus on looking into the markets in Eastern Europe. Emerging economies in the Eastern Europe such as Poland, Romania and Ukraine may be subject to further investigation. Especially, in Ukraine and Romania according to some of the literature, and based on the empirical investigation as well, there might be some issues in terms of the national quality infrastructures calibration being part of it. Therefore, as the level of industrialization grows in these countries, opportunities for calibration service providers known for quality probably follows. However, the demand must come from the industries and as Racine discussed the quality may not always be required by the companies.

There is a variety of different types of participants in the markets, accredited laboratories possibly only the tip of the iceberg. Demand of accredited services depends on the firms (end-users) willingness to invest in quality. Again, Eastern Europe may be challenging in case a lot of companies there provide product to local market that do not require certain standard and if national requirements do not expect it.

When looking at the types of market participants it was seen useful to broaden the classification suggested by Frost & Sullivan. Organisations in the calibration business can be classified in many ways, one approach is to look at the calibration orientation in the company service mix. Different types of organisations are placed along a continuum in which third-parties are very calibration oriented and in the other end are the in-house laboratories which are only for internal use. The original equipment manufacturer, equipment suppliers, re-

search institutes and others are somewhere in between with several product and service mix offerings. The classification was useful in order to recognize the different types of operators and to draw some insights of what kind of networks or business models may exist in the markets. In fact, a lot of the calibration service providers did not offer calibration alone but testing, consultation, maintenance, engineering, asset management, supply of equipment and spare parts and a bunch of other services as well. The literature reviewed enforced the idea of companies looking to buy a set of industrial services under one roof, so-called one-stop shopping. This sort of arrangement is a win-win situation for both the client and supplier as the supplier gets more profitable business in terms of long-term relationship and higher premiums and the client gets hassle free asset management.

The classification can be also used in customer segmentation for MIKES when continuing the marketing research whereby perhaps different type of organisations can be approached in different ways. For instance, in-house laboratories can be seen as secondary markets and third parties and the rest as primary markets.

In the very competitive markets, basically, much comes down to what MIKES can offer that other participants in the markets cannot. Be it quicker turnaround times, better level of accuracy or smooth good quality service. In fact, turnaround time is something MIKES could grasp on in the marketing strategy it being one of the most important factors for industries even over price in their choices of calibration providers.

8 CONCLUSIONS

All in all, based on this study not a lot of conclusions can be drafted as the whole purpose of the study was to sketch some ideas for further research. The data gathered was very general in nature and thus the findings presented should be considered with some criticism and take into consideration its limitations.

In the literature review calibration services alone are discusses, as well as, calibration services being part of maintenance and industrial services. The facts presented in the literature mostly supported the findings in the empirical part. Indications were found of the big players having extended their services all around and acquiring larger market share by mergers and acquisitions with smaller companies. It was found that only a small part of the calibration service providers offer only calibrations but often calibration is one service among other industrial services the company offers to its clients. Also, outsourcing between OEMs and third-party laboratories was witnessed while doing the research, which was pointed out by e.g. the Frost and Sullivan studies already.

Market potential for MIKES services

Certainly, there seems to be potential in the calibration services markets for quality service providers such as MIKES in the European markets. The whole market is still expected to grow and revenues to increase as the installed base of measurement and testing equipment become larger. Demand for calibrations is growing due to increased knowledge of its role in preventive maintenance as well as the stricter global standards and regulations in terms of product quality. The calibration services market in all measurement areas in the whole of Europe was USD1.09 billion in 2011 expected to grow upto USD1.55 billion by 2018. Calibration services is a big business and so accessing even a marginal share of the whole market can bring significant income to newcomers like MIKES.

Both literature and the research indicate that there may be some issues in the developing economies in the Easter Europe such as Romania and Ukraine regarding the production quality systems, which can be potential market areas for good-quality calibration service providers such as MIKES. Furthermore, the East European calibration service market is expected to grow more rapidly than other regions in Europe. One way of approaching the

markets could be partnering with some of the OEMs that already have foothold in these countries or are planning to expand to the new markets.

All in all, full-service contracts seem to be a growing trend for industries whereas the type of services that are built around the whole life-cycle of equipment provides better profits for the service provider and foster sustainability in terms of both economic and environmental aspects. At the same time the full-service contracts free the industry from maintenance management activities and provide predictability concerning the costs of maintenance.

Quick turnaround times of equipment and good quality of calibrations are the competitive factors that even exceed in importance over price, at least in certain industries that require high accuracy in measurements such as pharmaceuticals. Sometimes cost-savings for not having to interrupt production can be greater than the cost of calibration. For MIKES the quick turnaround time could be one of the main competitive factors that should be emphasized.

Limitations of the study

The study was limited to accredited laboratories that had CMCs in flow, force or torque calibrations or a mix of them. However, this does not mean that the listed laboratories could not have capabilities in other fields of calibration as well. At least when looking at the GDP of nations and comparing it to the numbers of laboratories listed and operating in the country, a clear connection can be seen. Based on the assumption that the size of calibration market follows the amount of industrial production, it could be stated that the research has adequate validity even though some factors may have affected the accuracy a little as explained in methodology section. Still this was an exploratory research and the aim was not to even provide very in-depth information.

Moreover, when reading this paper, the results of the study should be viewed keeping in mind that, at this point, only the number of laboratories per country was examined together with some qualitative data. However, in order to determine the true size of the markets per country it would be necessary to define the size of the calibration laboratories in terms of turnover and revenues. Yet, the study can give some cues of the lack of quality in calibration services in certain countries; it should tell something if accredited laboratories simply do not exist in a country or if they are very few.

Future research

For this study did not seek into turnovers of laboratories in order to define markets in certain regions, a subject for further investigation would be to examine the revenues of calibration laboratories in the interesting regions.

Furthermore, based on this research it can be suggested to carry out further studies drilling deeper into the markets that are especially interesting. In the research that may follow, one could make more specific profiling of the listed laboratories; i.e. what type of laboratories they have (mobile vs. permanent), which companies offer similar calibrations as those of MIKES exactly, and what are the prices and turnaround times of the other laboratories. It should be considered that there are direct and indirect competitors; the direct competitors are those that carry out calibrations in laboratory environment and indirect the ones that calibrate onsite. One could also map what kinds of companies need very accurate measurements that are willing to spend a bit more for the service.

Apart from investigating the competitors or potential customers, examining the general environment in the chosen regions is essential. For instance, it could be looking into the trends and projections of East European economies, industrial development and which industries in particular are experiencing positive development in the region. It is obvious that the trend of the size of calibration services market follows the trends of the size of industries in which the calibrations services are needed.

Therefore, when examining market opportunities in an area, also the general industrial landscape should be studied. For instance, as multinational companies shift production from western countries to countries of lower production cost such as in East Europe, it can be expected that the need for calibration services in those countries increase as well. Nevertheless, the foreign companies are used to certain level of standards concerning calibration for example and require the resources nearby, resources that may not exist readily in the local markets. Thus the opportunities for MIKES could possibly exist in the emerging markets in the Eastern Europe.

Moreover, as the EU is tightening cooperation with the East-European non-member countries economic activities between the community and the not-yet-members can be expected

to enhance and grow, which means possible increase in trade and commercial activities. Enhanced relations thus as well create increased opportunities for industries in the East.

Another perspective of future research could be looking into the material test services markets in which mechanical calibrations are as well required. In the study, a lot of the companies listed were, in fact, involved in testing and inspection services. Broadening research to material test services market may as well provide some information on the calibration market.

This study basically was limited on the primary markets as accredited laboratories were in focus. Thereby, if almost four hundred companies were found representing the primary markets, then secondary markets must be even much wider. All in all calibrations are needed widely in all industries but depends on the firms if they like to invest in quality and demand for very accurate calibrations. Thus, investigating why companies in so-called secondary markets would be interested in the service of the NMIs, when they can access the services of accredited laboratories as well would be interesting.

The list of accredited companies that was gathered during this study can be used as a database of potential customers or as a starting point for mapping the customers that the listed laboratories are serving, for example. It can also be used as a contact list for the researcher in doing further research of the listed companies such as finding out the sizes of the laboratories.

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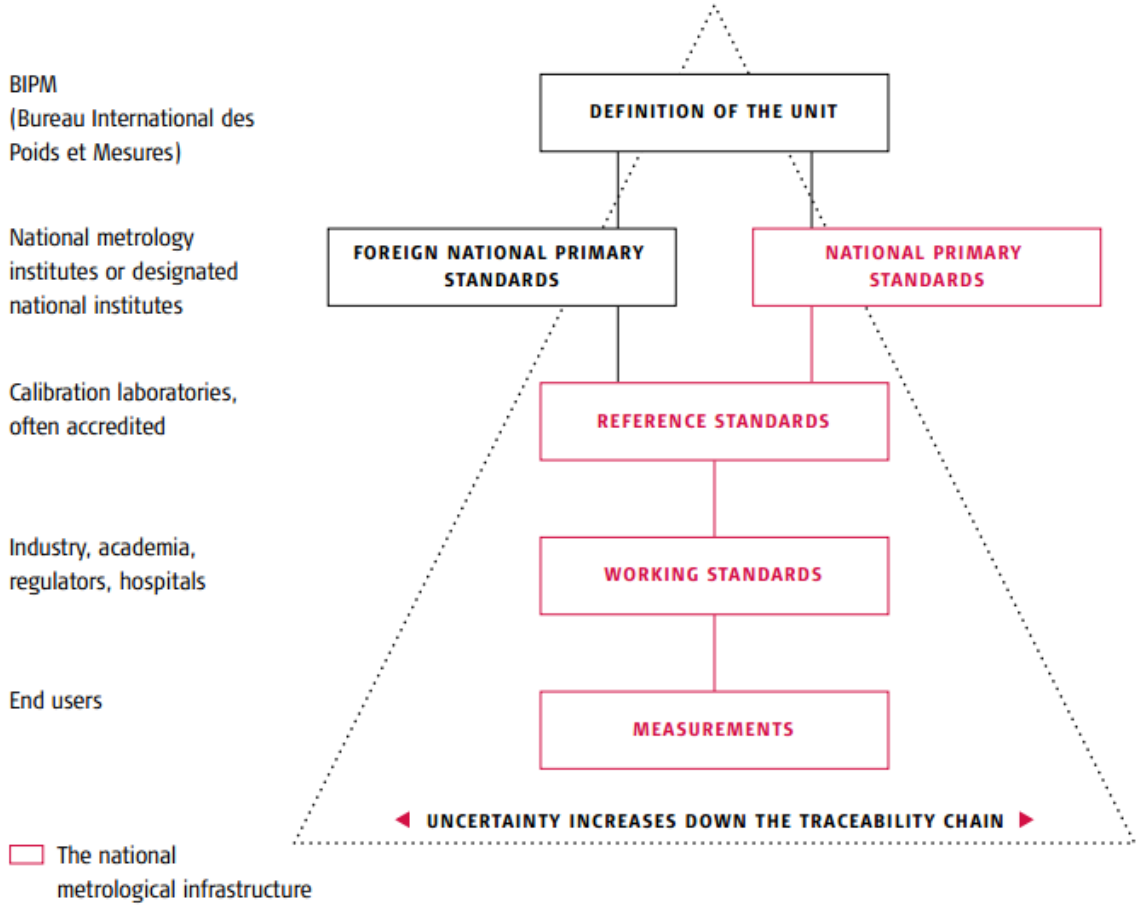
LIST OF APPENDICES

Appendix 1. The traceability chain



Source: EURAMET (2008, 20).

Appendix 2. Measurement standards definitions

Measurement standards	Definition	Example
International standard	Measurement standard recognized by signatories to an international agreement and intended to serve worldwide.	The international prototype of the kilogram.
National standard	Measurement standard recognized by national authority to serve in a state or economy as the basis for assigning quantity values to other measurement standards for the kind of quantity concerned.	
Primary standard	Measurement standard established using a primary reference measurement procedure, or created as an artifact, chosen by convention.	Primary measurement standard for pressure based on separate measurements of force and area.
Secondary standard	Measurement standard established through calibration with respect to a primary measurement standard for a quantity of the same kind.	A measurement standard having its quantity value assigned by a ratio primary reference measurement procedure is a secondary measurement standard.
Reference standard	Measurement standard designated for the calibration of other measurement standards for quantities of a given kind in a given organization or at a given location.	
Working standard	Measurement standard that is used routinely to calibrate or verify measuring instruments or measuring systems.	A working measurement standard is usually calibrated with respect to a reference measurement standard.

Source: BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML (2012, 45-46).

Appendix 3. Calibration services market, total revenues of OEMs and third parties, top 7 participants 2011

Company	**Revenue million US dollars**
Trescal	164.0
Exova Metech	42.0
Testo industrial services	35.0
Agilent technologies	30.0
Danaher	25.0
Aeroflex	21.0
A+ metrologie	18.0
Others*	311.0
TOTAL	**646.0**

Source: Frost & Sullivan 2012, 45.

*Others include
Optical test and calibration
National instruments
TMS Europe Ltd
GE Kaye Ltd.
Hitek calibration services
NPL
CIS calibration labs
Ametek calibration instruments
EMC calibration services

Appendix 4. Funding of NMIs in Europe 2002, percentage distribution by source

Country	Total income €	Core government funding %	EU %	Commercial activity (incl. Government tenders) %	Industrial partnership %	Other %	TOTAL %
Austria	5800000	86	0	14	0	0	100
Belgium	3150000	100	0	0	0	0	100
Denmark	5449344	24.3	3.1	56.8	2.2	13.7	100
Finland	7755724	78	0.6	14.6	1.5	5.4	100
France	23967353	86.3	4.8	8.4	0.2	0.2	100
Germany	234800000	90.8	1.4	3.9	3.8	0	100
Greece	1047000	73.8	0	26.2	0	0	100
Ireland	3990000	71.1	1.3	27.6	0	0	100
Italy	21485000	71.8	2.6	19.7	3.3	2.6	100
Netherlands	15800000	56	3	41	0	0	100
Portugal	8031127	9.8	0.1	90.1	0.1	0	100
Spain	6150000	58.8	11.8	14.7	2	12.7	100
Sweden	45765169	10	2	82	6	0	100
United Kingdom	139058377	47.9	2.4	47.5	2.2	0	100
European Union	30000000	0	90	10	0	0	100
TOTAL (/total average)	**552249094**	**63.9**	**6.8**	**25.9**	**2.9**	**0.5**	**100**

Source: Williams 2002, 10.

Appendix 5. Classification of services in mass and related quantities

CLASSIFICATION OF SERVICES IN MASS AND RELATED QUANTITIES

2 January 2013

METROLOGY AREA: MASS AND RELATED QUANTITIES

BRANCH: MASS

1. Mass

1.1 Mass standard

1.1.1 Mass standard[1]: *mass standard*

BRANCH: DENSITY

2. Density

2.1 Density of solid

2.1.1 Density of solid: *solid density artefact*

2.1.2 Volume of solid: *solid artefact*

2.2 Density of liquid

2.2.1 Density of liquid: *density measuring device, standard volume vessel*

BRANCH: PRESSURE

3. Pressure

3.1 Absolute pressure

3.1.1 Gas medium: *pressure measuring device, standard pressure generator, vacuum gauge, pressure gauge, digital piston manometer, barometer, pressure balance*

3.1.2 Liquid medium: *pressure measuring device, standard pressure generator, pressure gauge, pressure balance*

3.2 Gauge pressure

3.2.1 Gas medium: *pressure measuring device, standard pressure generator, pressure gauge, digital piston manometer, manometer, pressure balance*

3.2.2 Liquid medium: *pressure measuring device, standard pressure generator, pressure gauge, pressure balance, pressure multiplier*

3.3 Differential pressure

3.3.1 Gas medium: *pressure measuring device, standard pressure generator, pressure gauge, digital piston manometer, manometer, pressure balance, pressure divider*

3.3.2 Liquid medium: *pressure measuring device, standard pressure generator, pressure gauge, pressure balance*

3.4 Dynamic pressure

3.4.1 Gas medium: *pressure measuring device, standard pressure generator, pressure gauge*

3.4.2 Liquid medium: *pressure measuring device, standard pressure generator, pressure gauge*

BRANCH: FORCE

4. Force

4.1 Tension

4.1.1 Tension: *force measuring device*

4.2 Compression

4.2.1 Compression: *force measuring device*

4.3 Tension and compression

4.3.1 Tension and compression: *force measuring device*

[1] The instrument or artefact is indicated in italic characters for each service.

BRANCH: TORQUE, VISCOSITY, HARDNESS AND GRAVITY

5. Torque

5.1 Torque

5.1.1 Torque: *torque measuring device*

6. Viscosity

6.1 Certified Newtonian reference liquids

6.1.1 Certified Newtonian reference liquids

6.2 Capillary viscometers
6.2.1 Capillary viscometers
6.3 Viscosity measurement of Newtonian liquids
6.3.1 Viscosity measurement of Newtonian liquids

7. Hardness
7.1 Hardness
7.1.1 Hardness

8. Gravity
8.1 Gravity
8.1.1 Gravity

BRANCH: FLUID FLOW

9. Fluid Flow
9.1 Volume liquid flow rate
9.1.1 Volume water flow rate
9.1.2 Volume hydrocarbon flow rate
9.2 Volume gas flow rate
9.2.1 Volume gas flow rate
9.3 Mass liquid flow rate
9.3.1 Mass water flow rate
9.3.2 Mass hydrocarbon flow rate
9.4 Gas flow rate
9.4.1 Mass gas flow rate
9.4.2 Molar flow rate
9.5 Volume of liquid
9.5.1 Volume of liquid
9.6 Mass of liquid
9.6.1 Mass of liquid
9.7 Flow speed
9.7.1 Gas flow speed
9.7.2 Liquid flow speed
9.8 Multiphase flow
9.8.1 Multiphase flow
9.9 Heat flow rate
9.9.1 Heat flow rate

Source: BIPM 2013. Available at: http://kcdb.bipm.org/appendixc/m/m_services.pdf

Appendix 6. Classifications criteria for type calibrations service providers

Abbreviation	Type of the organisation	Criteria
OEM	Original equipment manufacturer	Manufacturer of the measuring/testing equipment. Services offerings may include installation, consultation, etc. Calibration is an additional/support service.
ES	Equipment supplier	Supplies measuring/testing equipment to companies, not self-manufacturing. Services offerings may include installation, consultation, etc. Calibration is an additional/support service.
Third-party	Third-party calibration laboratories	Purely a service provider, no manufacturing. Calibration services is one of the core functions among testing or other metrology activities.
Other	Other	Not providing equipment, nor calibrations as a core business but calibration services are part of a service mix e.g. safety or environmental consultancy, industrial engineering etc.
RI	Research institute	Offers calibration services, but is not a fully commercial service provider. Practices R&D activities. Services may include concultancy and education. Can be a state or municipal organisation or private research institute. Universities belong to this group. Includes NMIs which are marked as 'NMI' in the classification.
In-house	In-house laboratories	Not offering calibration services to third parties, the calibration laboratories are for the company's internal use to support the core functions. Includes district heating/water companies, different product manufacturers.

Appendix 7. Distribution of researched laboratories by country

	Country	Number of accredited laboratories
EA full members	Austria	7
	Belgium	7
	Bosnia Hertsegovina	3
	Bulgaria	6
	Croatia	2
	Czech Republic	18
	Denmark	15
	Estonia	3
	France	26
	Germany	13
	Greece	7
	Hungary	21
	Ireland	2
	Italy	23
	Latvia	2
	Lithuania	4
	Luxembourg	0
	Malta	0
	Norway	2
	Poland	13
	Portugal	14
	Romania	4
	Serbia	3
	Slovakia	13
	Spain	39
	Sweden	16
	Switzerland	11
	Macedonia	4
	Netherlands	12
	Turkey	26
	UK	55
	TOTAL	**371**
EA associate members	Albania	0
	Belarus	0
	Moldova	0
	Kosovo	0
	Ukraine	0
	TOTAL	**0**

Appendix 8. Major players in the calibration service markets in Europe

		Markets				
Group	**Country of accreditation (capabilities in flow, force, torque)**	**WE**	**EE**	**World**	**Type of organisation**	**Customer segments**
AMETEK Test & Calibration Instruments	**UK**	UK, global	Global	Global	OEM/ES	na
Applus group	**Spain**	global	Czech, Poland, Slovakia, Turkey	global	Other, inspection and testing	aeronautics, automotive, manufacturing industries, logistics, oil&gas, power, water, telecommunications
Bowers metrology group	**UK**	UK, International	Czech, Hungary, Poland, Romania, Slovakia, Turkey		OEM	na
Controls group	**Italy**	Italy, Spain, France, UK	Poland	North-America, Latin-America, middle-east, south-east asia, Australia	OEM	construction
Crane group	**UK**	global	global	global	OEM	na
Danaher corp.	**UK**	UK, global	Global	Global	OEM	construction material producers, quality control laboratories

Diehl metering group	**France Germany**	France, Austria, Germany, Spain, UK, Denmark	Hungary, Poland,	Brazil, Dubai, China	OEM	water, energy, gas
EADS group	**Germany Spain**	Global	Global	Global	OEM/In-house/other, de-fence&security	defence&security
Element materials technology group	**Netherlands UK**	Belgium, Nether-lands, Germany, UK		USA	Other, testing and consulting	aerospace, defense, oil, gas, energy, transport
Elster Group	**Slovakia**	central Europe	East Europe, Slo-vakia, Ukraine	Russia	OEM	na
Endress+Hauser group	**Switzerland**	global	global	global	Other, automation engineering	na
Energotest net-work	**Hungary**	international	Hungary, interna-tional	international	ES / Other	automotive
Exova metech	**Denmark UK Sweden**	Denmark, Sweden, Finland, Germany, Norway	Czech		Third-party	Aerospace&defence, medical, energy, engi-neering
Gigasense AB	**Sweden**	Global	Latvia, Turkey	Global	third-party	na
Illinois Tool Works	**UK**	UK, International	International	International	OEM/other Scale components and systems manufac-turing	agriculture, chemical, construction, food, manufacturing, mining, transport, waste

Intertek group	**Sweden** **UK**	Global	Bulgaria, Czech, Hungary, Poland, Romania, Serbia, Turkey, Ukraine	Global	Other, consultancy, inspection, testing	automotive, aerospace, chemical, telecommunications, construction, medical, forestry, textile
Kiwa corp.	**Netherlands**	Netherlands, Belgium, Germany, Norway, Sweden, UK, Spain, Italy	International	International		concrete, construction
Krohne group	**Netherlands** **UK**	global	Albania, Belarus, Bosnia Hertsegovina, Bulgaria, Croatia, Czech, Estonia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Slovakia, Slovenia, Turkey, Ukraine	global	Other, manufacturer of industrial process instruments	oil & gas, water & wastewater, chemical & petrochemical, food & beverage, power, minerals & mining and marine
MTS Systems corp.	**Italy** **Sweden**	Global	Global	Global	ES/other	automotive and aerospace, medical, fuel, construction, mining
Sensus group	**France** **Germany** **Slovakia**	global	Czech, Poland, Slovakia	global	OEM	energy, water

SGS group	**Italy** **Netherlands** **UK**	Global	Bulgaria, Czech, Hungary, Poland, Romania, Serbia, Turkey, Ukraine	Global	Other, inspection, verification, certification	agriculture, food, automotive, chemical, construction, consumer goods, energy, finance, industrial manufacturing, life sciences, logistics, mining, oil&gas
TRESCAL	**Belgium** **France** **Denmark** **Italy** **Spain** **Netherlands** **UK**	Belgium, Luxembourg, France, Germany, Denmark, Italy, Netherlands, Spain, Sweden, Switzerland, UK	Czech, Romania,	US , Tunis	Third-party	several industries
TÜV SÜD	**UK**	UK, global	Global	Global	Other, technical consultancy, research, testing, flow measurement and programme management services	Aerospace & Defence, Electrical & Electronics, Machinery, Marine, Medical & Health Services, Nuclear, Oil & Gas, Radio & Telecommunications, Rail and Renewable Energy
Vishay precision group	**Sweden**	International	International	International	OEM	Chemical, oil&gas, metal, paper, food, pharmaceutical, mining
VÍTKOVICE MACHINERY GROUP	**Czech Republic**	France, Germany, UK, Italy, Norway	Czech, Hungary, Poland, Slovakia, Romania	USA, Russia, China	Third-party/OEM	

Zwick roell group	**Turkey** **Sweden** **UK**	Global	Turkey, Czech, Poland, Slovenia	Global	OEM	na