

# The National Measurement System

*A Customer Survey  
for Three of the Core Labs in the  
National Measurement System*

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## Preface

The National Measurement System (NMS) is the technical and organisational infrastructure which ensures the UK has a consistent and internationally recognised basis for measurement. The existence of a comprehensive measurement infrastructure is a precondition for the competitiveness of a modern industrialised economy. The activities of the NMS facilitate free and open trade, encourage innovation and the spread of new technology, and the creation, promotion and sale of high-quality goods. In short, the NMS underpins trade, industry, and regulation. It is a testament to the successful functioning of the system that, in many instances, the role of the NMS in these areas goes largely unnoticed.

Much of the NMS and the work associated with maintaining it rests with its users, such as employees performing measurements in manufacturing businesses. That is, the NMS extends from researchers developing new measurement techniques to the day-to-day measurements that take place in industry and commerce. The NMS is supported by the Department for Business, Energy and Industrial Strategy (BEIS), who funds specialist work at six UK-based measurement laboratories that are dedicated to world-class measurement science. These specialist organisations form the core of the NMS.

The principal task of the funded laboratories is to maintain, develop and disseminate national measurement standards and provide reference materials. Alongside this core role, these specialist laboratories also provide the co-ordination and regulation, together with a range of measurement services, which form the central ‘hub’ of the system. This hub of laboratories deliver measurement services that underpin a distributed system for the certification of calibrations delivered by a much larger network of fully commercial calibration laboratories. This means that traceable calibrations are underpinned by national measurement standards, whose benefits then fan-out across the economy through a network of calibration laboratories acting as intermediaries.

Although the core labs focus on developing or maintaining the NMS, they differ in terms of legal-form and the amount of public funding they receive. BEIS invests around £65 million each year in the NMS; and the majority of this public funding goes to three organisations<sup>1</sup>:

- The National Physical Laboratory (NPL)
- The National Measurement Laboratory (NML) hosted at LGC, formerly the Laboratory of the Government Chemist.
- The National Engineering Laboratory (NEL).

NPL was founded in the early 19th century to bring scientific knowledge to bear practically upon industrial and commercial life. NPL’s legal-form and its ownership has changed over time; but NPL is now wholly owned by the UK government and receives more than 80% of all the NMS funding.

The NML and the NEL are both run by private companies but receive significant public funding to sustain and advance the nationally beneficial work they perform for the NMS. The NML is the UK’s designated institute for chemical and bio-measurements and is also responsible for the UK Government Chemist, a statutory role as arbiter in legal disputes relating predominantly to the food and feed sectors and advisor to the government in the field of chemical measurement. The NEL is the UK’s designated institute for flow and density measurement and is a world-class provider for flow measurements to the energy, oil and gas industry sectors and to government.

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<sup>1</sup> For further information on these laboratories, see the appendix.

Every few years, this sub-group of NMS laboratories work together to commission a joint survey of their customers, to assess the extent to which the public funding provided by BEIS is converted into economic or societal benefits. In 2018, Winning Moves<sup>2</sup> was commissioned to interview a sample of customers from the private sector, academia and healthcare.

The survey was designed to allow NPL, NML, and NEL to benchmark customers' satisfaction using net promotor scores, learn how the measurement services they supply create value for their users, and to identify opportunities for further improvement. This survey is one part of the NMS programme's mixed-methods evaluation framework. These evaluation activities are designed to ensure accountability for the public investment; and to enable future funding to be allocated based on evidence of what has worked well. The survey also provides useful background information on measurement activities and spending by businesses that use the three NMS laboratories.

The study undertaken by Winning Moves was essentially based on an aggregation of interviews in which customers were invited to provide feedback on their experience of using the laboratories and to rate their satisfaction with services. Furthermore, customers were also asked to think through the contribution that the support from the laboratories made to the success, or otherwise, of their innovation activities. Hence, this study combines a process evaluation focused on the short-term outcomes of engagement with the NMS labs with a contribution analysis based on the testimony of the labs' customers that is ultimately grounded in their judgement and beliefs.

This document is a summary of the main results from the 2018 survey that was conducted by Winning Moves. This summary was written by staff at NPL in collaboration with NML and NEL. A full report was completed by Winning Moves. The survey focused on gathering evidence of the direct benefits ascribed to three NMS laboratories by their customers.



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<sup>2</sup> <https://www.winningmoves.com/>

## Executive summary

The UK National Measurement System (NMS) is the nation's technical infrastructure which underpins trade, industry and regulation. The NMS is supported by the Department for Business, Energy and Industrial Strategy (BEIS) and delivered through six core measurement laboratories who are dedicated to world-class measurement science. These labs deliver services to underpin the certification of calibrations; and they play a vital role in supporting innovation and growth in the UK.

Every three years, the NMS commissions a survey of customers who use one or more of the following labs: NPL; NML at LGC; and NEL. This report will refer to these as the 'NMS labs', although the NMS programme also supports some other organisations that are not included in this study.

In 2018, Winning Moves<sup>3</sup> interviewed a sample of the NMS labs' customers from the private sector, academia, and healthcare. The survey was designed to allow the NMS labs to better understand their customers, benchmark satisfaction, and identify opportunities for improvement. This survey is part of the NMS evaluation plan, designed to maintain accountability for the public investment and to enable future funding to be allocated based on evidence of what worked well.

A full report of the NMS customer survey findings was completed by Winning Moves. This report is a summary of the results from the 2018 survey. It was written by the core labs and led by NPL. It focuses on the direct and immediate benefits that the NMS labs' users enjoy.

The NMS labs have an extensive customer base of approximately 6,000 users in the UK. Most of these users are **business organisations** operating in the private sector, totalling around 4,500 customers. The remaining 1,500 users are **academics** and **healthcare professionals** operating in the public and third sectors. Hence, this report is based on a compilation of three different surveys that were each based on different questionnaires.

**1,429** customers were contacted, representing organisations using or working in partnerships with the NMS labs between 2014 and 2017.

**862** customers responded to the survey.

Many of the businesses operate from multiple sites and indeed sometimes operate overseas, as well as from the UK. To better understand the direct impact on businesses, the survey has been conducted at site-level. That is, business customers were asked about activities at their place of work (e.g. a division of large company) rather than for the whole enterprise, about which a respondent might have much less understanding. The site-level approach allows multiple units from a large 'prime' to be surveyed. For brevity this report refers to 'businesses' but it should be understood that this is short for 'business sites'.

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<sup>3</sup> <https://www.winningmoves.com/>

## Top findings

### *1. The NMS labs have a large reach and their business customers are economically important*

The business customers of the labs make an important contribution to the UK's economy. These businesses collectively **employ just under one million people in the UK**. The sites of the business organisations which engaged with the NMS labs collectively have an **aggregate turnover of around £188 billion**. More than a third of these businesses operate within manufacturing industries, and this group **accounts for 6-18% of the UK's employment in manufacturing**.

Around 6% of these businesses are commercial calibration laboratories. The NMS labs work with around a third of United Kingdom Accreditation Service (UKAS) accredited calibration laboratories in the UK. By supporting these calibration labs, the **reach from the NMS labs is extended**. The survey found **an additional 74,000 organisations were indirectly supported through the fan-out of calibration services**, indicating the significant span of the NMS labs' impact.

### *2. Business organisations who use the NMS laboratories spend a substantial sum of money on measurement*

Business organisations who use the NMS labs allocate significant resources to measurement activities. Business customers of the NMS labs **spend around 5.4% of their turnover on measurement activities** - a larger percentage of turnover than the total percentage of GDP spent on R&D in the UK (1.8%). This spending on measurement equates to around **£10.2 billion** each year by businesses using the NMS laboratories, showing the value of measurement among these customers.

### *3. It's believed that there are many products that would not exist without the NMS laboratories, and these generate a substantial revenue for customers*

Around **80% of the NMS labs' business customers made a change** to their products or processes across the four-year period from 2014 to 2017, such as introducing a new or improved product or process. The creation of new products and processes is the type of benefit realised by the greatest proportion of customers, reported by 72%. **1 in 5 (19%) of those who made a change attribute it to the NMS and believe that the change would not have happened without the support they received from the NMS labs**.

On its own, the 2018 survey is too small to give a meaningful estimate of the impact that the NMS labs have on their users' income from sales of new and improved products. Hence, data from the 2018 survey was pooled with that from two earlier surveys to generate a sufficiently large sample. Annualised data from the 6-years between 2012 and 2017 shows that across this time period:

**£539  
million**

Each year, on average, around 370 UK-based businesses who use the NMS labs receive around **£539 million** in annualised revenue from sales of products that respondents believe would not exist without the support they received from the NMS labs.



In addition to this, a very small number of businesses enjoy exceptionally large revenue increases. Collectively these companies attribute several hundred million pounds to sales of a product that would not have existed without support from the NMS labs. It is believed that the small number of companies receiving very large benefits is normal in the context of R&D projects, but these revenue impacts can't be meaningfully annualised, and are not included in total revenue estimate. The revenue benefits going to this group of outliers are highly unpredictable, however they are not errors or mistakes.

#### 4. *The NMS labs assist academia by helping academics optimise their research strategy and direction*



The NMS labs have worked with academics from a third of universities in the UK (31%). Academics generally interact with the NMS labs through research collaboration and by the co-authoring of articles in peer reviewed journals. Measurement is often key to these users as it is a tool that underpins other areas of scientific research.

Indeed, academics working with scientists at the NMS labs have a high regard for their research in terms of its quality and impact. More than two thirds (68%) of academics said they **work with the NMS to better inform their strategy and research direction**, showing that the NMS labs create value for their customers by aiding their vision and highlighting that it is important for some academics to collaborate with measurement specialists early in their projects to strengthen their research strategy. **For a third of users (34%), the impact created by working with the NMS labs could not have occurred without their support.** These users attribute benefits, such as project breakthroughs, to the support of the labs, which largely reflects the nature of collaborative R&D whereby solutions are co-created.

#### 5. *Measurement is widely used by healthcare professionals for patient safety and to increase efficiency*



For the first-time, the lab's healthcare users were surveyed. However, a lack of easy access to records on collaborators meant that the survey covered less than 30% of the total number of healthcare users who are currently in the NML at LGC's database. The NML at LGC specialises in chemical and bio-measurements, which gives it strong connections to healthcare. However, much of the lab's work is collaborative, and consequently its partner organisations were not invited to participate as they do not show up in invoicing records. Consequently, the results for healthcare customers largely reflect the support and services delivered by NPL rather than for all of the NMS labs. As a result, the healthcare customers in the survey focus heavily on the measurement of ionising radiation for the diagnosis and treatment of cancer. This limitation should be understood and considered when regarding the results from this survey, and future surveys will learn from this error by building a more complete register of healthcare customers and collaborators.

The NMS lab's healthcare customers are clinicians and medical physicists who work at NHS hospitals and trusts. The labs work with healthcare professionals from nearly half of the teaching hospitals in the UK. Surveyed users say measurement is important in the provision of many areas of healthcare, from patient safety to cost savings. 60% of healthcare customers go on to state they use the NMS labs to create cost efficiency benefits. This suggests enhanced measurement practices have the potential to be a key driver of quality, efficiency and savings in healthcare.

Alongside these efficiency gains, other benefits gained by working with the NMS labs include...

|                                                | <i>Proportion of users</i> |
|------------------------------------------------|----------------------------|
| <b>Better safety and quality of healthcare</b> | <b>82%</b>                 |
| <b>Enhanced quality of life for citizens</b>   | <b>61%</b>                 |
| <b>Increased survival of patients</b>          | <b>60%</b>                 |
| <b>Improved recovery of patients</b>           | <b>52%</b>                 |

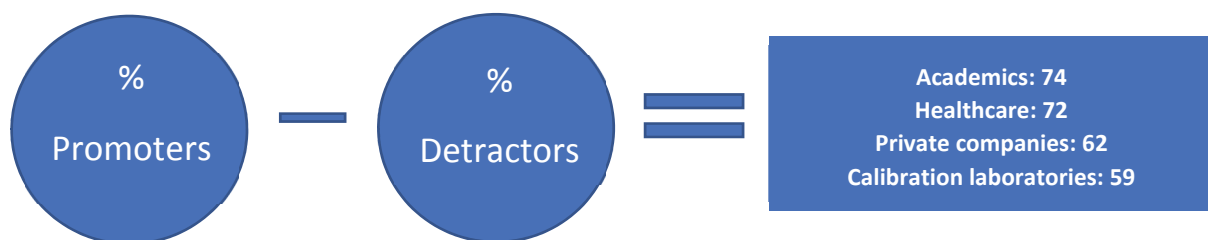
The survey found that hospital and trust-based healthcare customers may be price sensitive when it comes to paying for services from the NMS labs. Just 6% of those who do not use calibration services pay for an alternative service. It is possible that healthcare organisations can buy sufficiently accurate calibrations from cheaper commercial calibration laboratories and consequently have no need for the services of the NMS labs.

Just 4% of healthcare users reported that they couldn't have proceeded with their innovation activities without the collaboration or support provided by the NMS lab that they worked with. This suggests there could be a need to build new capabilities or to adapt existing services to connect more strongly with the needs of the healthcare sector. Despite this, the health sector might be receiving significant indirect support from the NMS labs. This could be occurring through the support that the labs sometimes deliver to pharmaceutical companies and medical instrument manufacturers, improving quality control, validation, and in supporting the adoption of new technologies.

#### *6. Customers are highly satisfied with the NMS labs*

To increase uptake and deliver greater impact in the future, it is important to compare the satisfaction of users over time and between different segments of the user population. A Net Promoter Score (NPS) was calculated from survey results. The score awarded was 'world leading' by customers in academia and healthcare, and 'very good' from private companies.

**Figure 1 – Net Promoter Score results**



## 1. Introduction

### 1.1. The role of the NMS laboratories

The UK National Measurement System (NMS) is the nation's technical infrastructure which exists to provide the nation with dependable measurements. The top layer of the NMS is comprised of six core laboratories, known as the NMS labs, which underpin measurement accuracy in the UK. The NMS labs are responsible for maintaining the UK's national measurement standards and associated facilities. They then make the benefits of this available to users through a wide range of services and knowledge transfer activities.

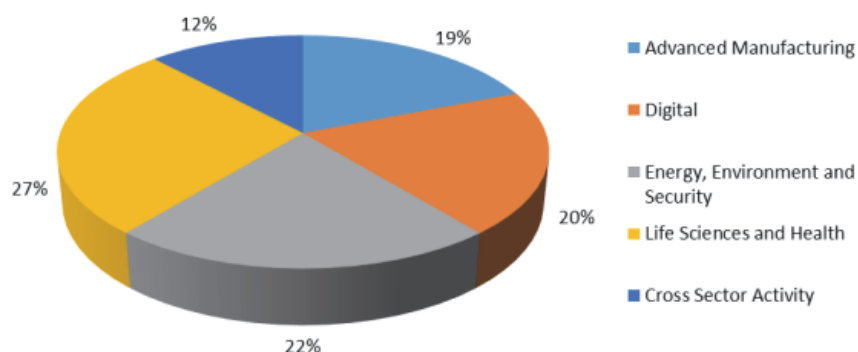
**Table 1 – Details of the six core NMS labs**

|                   |                                                                                                                 |                                          |
|-------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------|
| <b>NPL</b>        | National Physical Laboratory                                                                                    | The UK's National Measurement Institute  |
| <b>NML at LGC</b> | National Measurement Laboratory, at LGC<br>(formerly Laboratory of Government Chemist)                          | Designated for chemical and biometrology |
| <b>NEL</b>        | National Engineering Laboratory                                                                                 | Designated for fluid flow metrology      |
| <b>BEIS</b>       | Office for Product Safety and Standards<br>(part of the Department for Business Energy and Industrial Strategy) | Designated for legal metrology           |
| <b>NGML</b>       | National Gear Metrology Laboratory                                                                              | Designated for gears metrology           |
| <b>NIBSC</b>      | National Institute for Biological Standards and Control                                                         | Designated for bioactivity metrology     |

The core NMS labs have the capacity to support metrology in a range of fields, from mass and nuclear metrology to chemical analysis, fluid flow, and bio-metrology. The NMS labs underpin the UK's technical infrastructure by supplying services to the commercial calibration laboratories, who then go on to calibrate the instruments of their own customers, diffusing measurement accuracy through a chain of linked calibrations. The benefits coming from this second layer of the infrastructure are not discussed in this report, as customers of the commercial calibration laboratories were not interviewed in the survey.

The NMS labs are funded by the Department for Business, Energy & Industrial Strategy (BEIS). BEIS invests £65m annually into the NMS so that it can maintain the national measurement standards needed to supply traceable calibration services, as well as undertake research and development (R&D) into new measurement techniques. The NMS laboratories sell products and services to companies to generate additional revenue for the labs, which is then reinvested into the system to increase the impact of the NMS.

The balance of Government investment is reviewed regularly, and typically split between these aggregated sectors in the following way:



#### Typical breakdown of funding (BEIS, NMS Delivery Plan, 2017)

Investment in these sectors is designed to support the technologies underpinning the Industrial Strategy<sup>4</sup>.

##### 1.1.1. The NMS lab's products and services

The NMS labs work with private companies, academics and healthcare professionals from the NHS and healthcare trusts. The NMS labs offer a range of products and services to these customers, which broadly fit into the categories of measurement services, collaborative research and development (R&D), training, and consultancy.

#### Measurement services

The NMS labs directly support paying customers from the public and private sectors through the testing of materials or artefacts, the provision of reference materials, and the calibration of measuring instruments.

#### Collaborative R&D

The NMS labs work in partnership with organisations who are developing innovative technology to undertake cutting-edge research and development. In these R&D partnerships, NMS scientists and customers co-create new techniques, products, or technologies.

The NMS labs work with companies, such as manufacturers and healthcare customers to help them to create new and improved products, and make sure that these are right-first-time. The NMS labs also help users to strengthen the in-house measurement capabilities needed to ensure that their new and improved products meet quality and safety standards. This enables companies and their customers to have confidence in the quality and reliability of the products sold.

#### Training

The NMS laboratories encourage knowledge transfer (KT) through the provision of conferences, workshops and courses to help organisations improve the skills and capabilities of their employees in order to grow their business. Resources include free online training materials and publications for download, as well as paid-for events and training courses.

#### Consultancy

Consultancy is a paid-for service that enables customers to access expert knowledge while engaged in innovation, such as during the development of new products, allowing them to apply this knowledge to overcome a specific measurement problem.

<sup>4</sup>[https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf)

## 1.2. The NMS customer survey

The NMS customer survey is a telephone survey of customers who work with the National Physical Laboratory (NPL), the National Measurement Laboratory at LGC (NML; formerly The Laboratory of Government Chemist) and the National Engineering Laboratory (NEL). The survey was commissioned by the NMS and run by an independent survey company, Winning Moves<sup>5</sup>. Between April and June in 2018, Winning Moves contacted 1,429 organisations who use the NMS, and 862 of those contacted responded, achieving a response rate of 54%.

In 2018, for the first time, the customer survey was extended to academics and customers working in healthcare, to enable a better understanding of the needs of these users. Representatives from the private sector and calibration laboratories have been surveyed regularly since 2005.

The relationship between the NMS and its users varies between customers from different disciplines. Consequently, private, healthcare and academic respondents undertook a survey that was tailored to their sector. Results from these distinct groups have not been systematically compared due to the differences in the way they use the NMS. The survey was completed by a sample of knowledgeable staff from the organisations with whom the NMS labs work. Details of the weighting, stratification and statistical analysis can be read in 1.2.2.

### 1.2.1. Customer survey aims

The customer survey aimed to:

- 1. Establish the reach of the NMS laboratories in the private sector and identify how economically important their private sector customers are**

The NMS is interested in the scale of economic activity amongst the private organisations the labs work with to enable an understanding of the size and importance of its userbase among the wider population of businesses.

- 2. Understand the value of measurement to business customers who use the laboratories**

The NMS wanted to understand the degree to which business customers value measurement, to give the NMS a better understanding of how important measurement is to customers and to ensure the labs continue to meet their needs.

- 3. Understand the impact of the NMS labs on their users' sales of new and improved products**

Customers who use the NMS labs are often active innovators, using the support they receive to create and improve products and processes. The survey aimed to quantify the annualised revenue generated from the sale of products which business customers think would not exist without the support they received from the NMS labs.

- 4. Understand the impact of the NMS labs on customers in academia and healthcare**

For the first time, representatives from the NHS and academia were interviewed. The customer survey aimed to identify how customers in these sectors use the NMS labs, the benefits these partnerships create, and how the NMS labs can work to better support their needs.

- 5. Capture satisfaction**

The NMS labs calculate a Net Promoter Score (NPS) to capture satisfaction. This is designed to identify what should be improved in order to increase uptake and deliver greater impact in future.

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<sup>5</sup> <https://www.winningmoves.com/>

### 1.2.2. Details of the sample

This report predominantly contains data obtained from the 2018 customer survey. These figures are supported where possible with external and independent contextual figures, to provide an understanding of the surrounding economic landscape. Where external figures are used, the rationale for this can be seen in a footnote.

#### *The private sector*

Private sector customers represent around two-thirds of NMS customers. 554 representatives from private sector organisations were interviewed, reflecting the large number of customers with whom the NMS laboratories work. Private sector customers include a sub-set of calibration laboratories. The two groups are discussed together in this report, however, the details of the two groups are explained here.

|                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Calibration laboratories</b>                      | <p>Between 2014 and 2017, the NMS labs worked with 190 businesses who described themselves as calibration laboratories. These include dedicated calibration labs that supply commercial calibration services to many external organisations, and internal calibration units within larger manufacturing businesses.</p> <p>There are 367 UKAS accredited calibration laboratories in the UK. Of the 190 labs who work with the NMS labs, 88 respondents were from UKAS accredited calibration laboratories; meaning that at least two thirds (64%) of the calibration labs with whom the NMS labs work are accredited, and that the NMS labs work with at least 33% of the UK's accredited calibration labs<sup>6</sup>. The surveyed sample represents 46% of calibration laboratories using the NMS. Representatives from calibration laboratories completed a similar survey to the other private businesses, however they also answered questions on fan-out.</p>                                                                                                                                                                                                                                                                                                                                                              |
| <b>Other businesses (excluding calibration labs)</b> | <p>For-profit businesses, such as manufacturing companies, make up the largest proportion of the NMS laboratories' customers. The NMS laboratories worked with 2,915 private sector businesses between 2014 and 2017, and consequently this group is represented by the greatest number of survey respondents (466). The sample represents 16% of the NMS labs' private sector customers.</p> <p>Due to the diversity of companies operating in the private sector, this segment was further stratified by type and size. Large industry organisations were defined as those with 250 or more employees, whilst small and medium sized enterprises (SMEs) were defined as those with 249 or fewer employees. These divisions were created to cluster together users with common traits which might influence their use of the NMS labs.</p> <p>Business users were also segmented by the strength of their relationship with the NMS labs. When businesses had used the labs for commercial research and development; calibration services; consultancy; or collaborated with a scientist they were classified as 'high intensity' users. When businesses had only used the labs to access publications; software and download guides; training courses; or to attend an event, they were classified as 'low intensity' users.</p> |

<sup>6</sup> Calculated assuming non-responses meant that that calibration lab didn't have any accredited services.

Respondents from the private sector answered the survey based on their knowledge of the site where they are based; they provided answers at 'site-level'. Where some companies work with the NMS labs out of multiple sites, respondents only responded on behalf of their site.

Weighting was applied to the sample of respondents from the private sector to adjust for how they were sampled and stratified. To adjust for non-responses, the sample was re-weighted. The estimates have also been grossed up to reflect the populations from which they were drawn.

2 in 5 (41%) interviewees from the private sector work at a managerial level and a quarter (24%) work as directors. This level of seniority means a large proportion of the respondents had good oversight of their business' strategy and direction. A third of respondents were engineers or scientists within the company (33%), who conversely were probably able to respond with a greater understanding of the scientific concepts and provide more details about the day-to-day activities.

Analysis was undertaken on the economic impact that the NMS labs generate for their private sector users, and the value of measurement amongst this sample. When impact figures are reported, these represent an annualised figure from across three different waves of the survey. In these cases, and more generally, where statistical analysis has been undertaken, the methodology for these processes are included in the chapter.

#### *Academic respondents*

##### **Academics**

183 academics were interviewed from 51 universities, representing 31% of the UK's universities. The NMS has worked with approximately 1,000 academics, meaning this sample represents around 18% of these customers.

Interviewees were those who have been directly involved with the NMS labs, having collaborated with a scientist or attended a course. Half (52%) were senior academics, such as professors and senior lecturers, whilst over a quarter were junior lecturers (27%), and 14% were technical staff. When interviewed, academics responded on a personal level, or on an 'individual-level', expressing their own personal relationship and experience of working with the NMS labs. As this was the first-time academics were interviewed, the data was not compared to previously collected data or stratified, and only represents NMS laboratory users, not the whole sector.

#### *Healthcare professionals*

##### **Healthcare professionals**

125 healthcare professionals were interviewed. 350 individuals from healthcare organisations have worked with the NMS, meaning this sample represents approximately 36% of the total customer base.

Respondents from the healthcare sector are predominantly medical physicists, scientists or heads of department. They collectively represented 55 healthcare organisations, consisting of 49 hospitals or NHS trusts and 6 other organisations. Of the 49 hospitals, 19 were teaching hospitals (35%).

When interviewed, healthcare staff responded on a personal level, expressing their own relationship and experience of working with the NMS labs. As this was the first-time healthcare professionals were interviewed, the data was not compared to that which had been previously collected, and only represents NMS laboratory users, not the whole sector.

The total sample of the 862 survey respondents consists of 554 private sector companies, of which 88 are calibration laboratories and 466 are other businesses, 183 academics and 125 healthcare professionals.

|                                            | Sample (n) | Weighting Factor | Population (N) | Response unit |
|--------------------------------------------|------------|------------------|----------------|---------------|
| <b>Calibration laboratories</b>            | <b>88</b>  | <b>2.16</b>      | <b>190</b>     | Site-level    |
| <b>Other businesses:</b>                   | <b>466</b> | <b>NA</b>        | <b>2,915</b>   | Site-level    |
| <i>High Intensity / Large Organisation</i> | 86         | 6.09             | 524            |               |
| <i>Low Intensity / Large Organisation</i>  | 24         | 10.67            | 256            |               |
| <i>High Intensity / SME</i>                | 221        | 4.09             | 904            |               |
| <i>Low Intensity / SME</i>                 | 38         | 17.42            | 662            |               |
| <i>High Intensity / Unknown size</i>       | 74         | 4.65             | 344            |               |
| <i>Low Intensity / Unknown size</i>        | 23         | 9.78             | 225            |               |
| <b>Academics</b>                           | <b>183</b> | -                | -              | Person-level  |
| <b>Healthcare organisations</b>            | <b>125</b> | -                | -              | Person-level  |
| <b>Total</b>                               | <b>862</b> |                  |                |               |

**Table 2 - Distribution of interview sample and total number of interviews achieved<sup>7</sup>**

Differences exist between the analysis of the private and public sector respondents. Unlike users from the private sector, public sector respondents were asked to consider the impact of the NMS labs on the job they perform rather than on the university or hospital to which they belong, whereas private users considered the impact on their organisation's site as a whole. This means that for users from the public sector, impact was analysed at the individual level. This was done because respondents often don't have a wider knowledge of the relationship the NMS has with their institution as a whole. Whilst this approach is limited in that it cannot be used to estimate the impact of the NMS on the public sector, it generates invaluable feedback from this segment of users.

<sup>7</sup> When interviewed, 619 of the organisations on the database (representing 10% of the total customers) turned out not to use measurement within their organisation or not recall their interaction with the NMS labs. A full interview was therefore not conducted with these organisations. Data concerning the population of academics and healthcare organisation could not be collected as no reliable indications of population exist. Consequently, the data for these groups weren't stratified and weightings were not issued.

### 1.2.3. Survey limitations

This was the first-time academics and healthcare users were interviewed. Crucially, the sample of healthcare users is largely limited to those who use NPL. The sample frame omitted many of the partners and collaborators who undertake collaborative R&D with NML at LGC. Consequently, the sample does not fully reflect the NMS labs' customer base, particularly, in the case of healthcare customers.

Alongside concerns about the completeness of the sample frame, it's acknowledged at the outset that there are three other major limitations to the evidence generated by this study:

Firstly, this report does not provide a full account of the benefits generated by the NMS. It is important to recognise that the NMS extends well beyond the three specialist laboratories featured in this report. The full scale and number of benefits transmitted through the chain of traceable calibrations that fan-out from the national measurement standards (or the reference materials, in the case of the NML) are not quantified, as well as the full reach of spill-over benefits within companies and beyond. Whilst it is understood that these fan-out and spill-over benefits are substantial, they cannot be fully assessed and quantified in a survey of this scale. Assessment of this will be at the centre of a future evaluation project.

In particular, this study entirely neglects the benefits generated through supporting legal metrology, such as maintaining a technical infrastructure for the enforcement of weights-and-measures regulations by Trading Standards officers. The report further does not explore the reach or spill-over impact of the NMS on an international scale, despite the understanding of the role it's services play in a number of sectors. Again, due to the scope of endeavour, it could not be effectively assessed in this project.

Secondly, the study does not account for the indirect benefits that come from supporting the work of the British Standards Institute (BSI) or the UK Accreditation Services (UKAS). For example, significant indirect benefits can be created through promoting the adoption of more reliable measurement techniques in areas like blood testing. Furthermore, the following report does not discuss the support that the NMS gives to government departments responsible for the provision of "non-market goods", such as the environment, security, and defence.

Lastly, due to the nature of the survey, the impact analysis within this study is based on self-reported data. In particular, respondents have attributed impact based on their beliefs about what the outcome of projects would have been without support from the NMS labs, that is, the survey provides information about what users believe would have been lost if the labs' support hadn't been available. Estimating the counterfactual by asking users what might have happened without the labs' support is sometimes thought to produce questionable results due to a range of psychological biases affecting a respondent's answers. Hence, the evidence in this report does not constitute the type of quantitative (e.g. quasi-experimental) impact analysis that can be rated on the Maryland Scale.<sup>8</sup>

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<sup>8</sup> The Maryland scale is used by BEIS to rate the rigour of an impact analysis. At the top end of this scale are randomised control trials and at the bottom end are basic before-and-after studies focussed on the turnover and employment of supported businesses.

## 2. The private sector

### Headline findings

The NMS labs have a large reach. The userbase includes 4,500 private sector customers, of which 3,105 used the NMS laboratories between 2014 and 2017. This group is made up of private sector organisations and calibration laboratories.

The reach of the NMS labs is extended beyond direct users, through the fan-out by calibration laboratories, to around 74,000 organisations.

The NMS labs work with 6 - 18% of the manufacturing sector, based on employment at manufacturing sites supported by the NMS labs. Furthermore, the NMS labs work with a third of all UKAS accredited calibration laboratories operating in the UK.

The private companies who work with the NMS labs are economically important. They employ just under one million people in the UK and have an aggregate turnover of around £188 billion.

It is estimated that, on average, businesses working with the NMS labs spend 5.4% of their turnover on measurement. This equates to £10.2 billion of spending each year among the labs' private sector customers.

Each year, around 400 UK-based companies who use the NMS labs state they benefit financially through the introduction of improved products and processes. They collectively receive around £539 million in annualised revenues from sales of products that respondents believe would not exist without the support they received from the NMS laboratories.

A very small number of customers enjoy exceptionally larger revenue increases. Collectively these companies attribute several hundred million pounds from sales of a product that would not have existed without support from the NMS laboratories. It is believed that these skewed results are a consequence of the nature of R&D, but are not amenable to straightforward statistical analysis.

The NMS labs create innovation impact for customers, allowing them to make improvements effectively and quickly, and to be able to innovate with reduced risk.

The NMS has high customer satisfaction in this group, with a 'very good' net promoter score of 62 among private industry companies and 59 among calibration laboratories.

In total, around 4,500 private sector companies have used the NMS laboratories, accounting for about 90% of the NMS laboratories' UK-based customers. The customer survey interviewed 554 such companies, representing 18% of the 3,105 businesses who used the laboratories between 2014 and 2017. The sample of 554 companies divides into 88 calibration labs and 466 other private companies who did not identify themselves as calibration labs.

Companies were further stratified by their size-class (SME or non-SME), as well as the intensity with which they had used the NMS labs during the period from 2014 to 2017. Weighting was applied to the sample of respondents from the private sector to adjust for how they were sampled; and the data were grossed up to reflect the populations from which they were drawn.



## 2.1. Private user demographics

### Section findings

The NMS labs have a large userbase. This includes 4,500 private sector customers, of which 3,105 used the NMS laboratories between 2014 and 2017. This group is made up of calibration laboratories and other private sector companies.

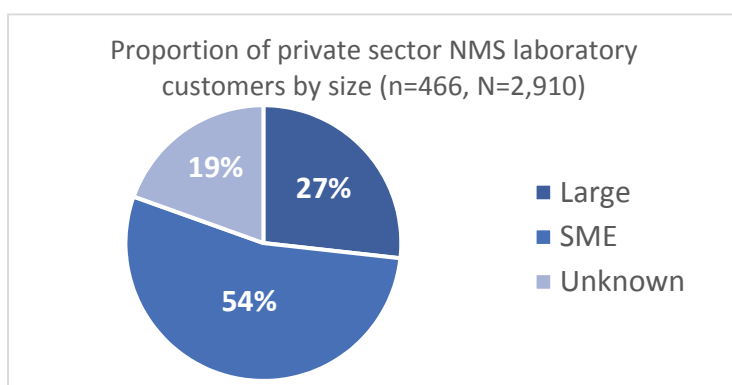
These customers are spread across the UK, however, there is a cluster of users in the South East, reflecting the business landscape and the location of NPL and NML at LGC.

When comparing the userbase to the geographic distribution of relevant firms, the South East of England and Scotland have a greater proportion of users compared to the total proportion of relevant firms operating in the regions. This deviation from the geographical distribution of potentially relevant businesses in the UK could once again reflect the locations of NPL and NML at LGC in the South East, and of NEL in Scotland.

#### 2.1.1. Customer profile

Over the years, the NMS laboratories have worked with around 4,500 private sector customers, of which 3,105 used the NMS laboratories between 2014 and 2017. Private sector users represent the largest proportion of NMS lab users, with around half (54%) of this group being SMEs.

**Figure 2 - Proportion of private sector NMS lab customers broken down by organisation size**



This customer base is made up of private sector organisations and calibration laboratories.



#### Private sector organisations (excluding calibration labs)

Private sector organisations make up the largest proportion of NMS lab customers. The NMS labs work with 2,915 private sector organisations. High-level Manufacturing is the largest group of customers within this, accounting for 35% of the userbase. Companies associated with Professional, Scientific and Technical services are the second largest group that the labs work with, accounting for 24% of users.



### Calibration laboratories

Calibration laboratories are defined as organisations that self-identified as calibration laboratories, cross-referenced with the list of UKAS accredited laboratories. The NMS labs work with 190 calibration laboratories. There are 367 UKAS accredited calibration laboratories in the UK. Of the businesses who work with the NMS labs, 88 respondents were from UKAS accredited calibration laboratories, meaning two thirds (64%) of the calibration labs the NMS labs work with are accredited, and that they work with 33% of the UK's accredited calibration labs.

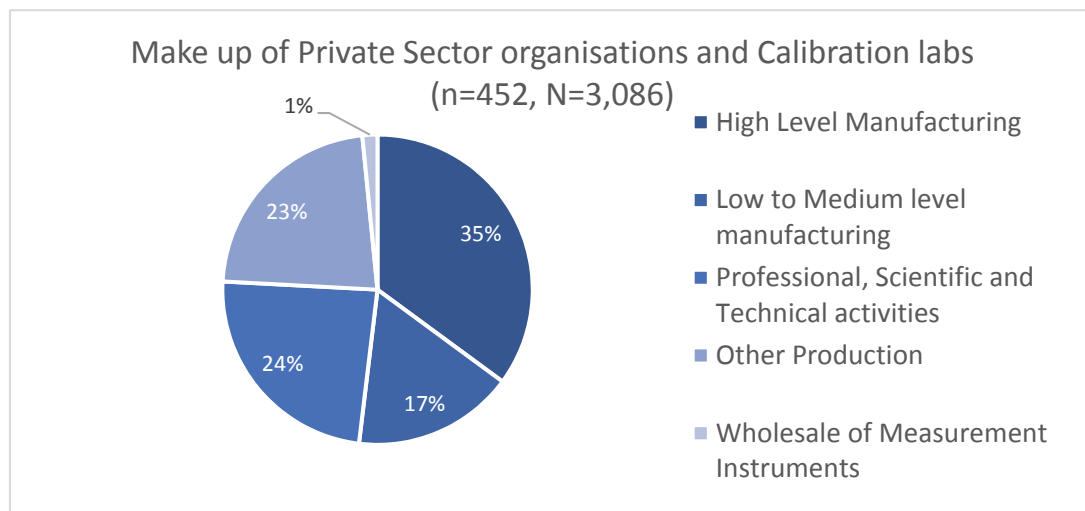


Figure 3 - Proportion of NMS lab users from each of the industries<sup>9</sup>

<sup>9</sup> Groupings were created using sic code groupings. These correlate to sic codes in the following way: High and Low to Medium level Manufacturing – Section C, Other Production – Section A,B, D, E, F, Professional, scientific and technical activities – Section M, NMS sample (n) = 452, Wider population (N) = 3,086. The sample size was as such due to non-responses. For the source the manufacturing breakdown see: [https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech\\_classification\\_of\\_manufacturing\\_industries](https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries).

### 2.1.2. Location of users

The NMS laboratories have users from the private sector based in each of the regions and nations of the UK, however, there is a concentration of private sector users in the South-East, where around a quarter (25%) are based.

When comparing the location of firms in the userbase to the geographic distribution of potentially relevant firms<sup>10</sup>, it was found that the South East of England and Scotland account for a higher proportion of users than one would expect based on the proportion of relevant firms that are based in these regions of the UK. This deviation from the UK's background business landscape could be a consequence of the location of NPL and NML at LGC in the South East, and of NEL in Scotland.



NEL specialises in fluid flow and is based in Glasgow. The NMS lab customers based in Scotland reflect the larger number of businesses who require flow metrology, such as oil and gas firms.

Indeed, 32% of the UK's oil and gas firms are located in Scotland. Because of its proximity to the North Sea, Scotland accounts for 40% of UK-based jobs in the industry, with the remaining 60% widely distributed across the regions of England<sup>11</sup>. Therefore, the cluster of oil and gas users around NEL is probably a consequence of its location and the location of its userbase, allowing these customers easy access to the **flow** metrology services they require.



Broadly, in the remaining English regions, Northern Ireland and Wales, the proportion of users reflect the proportion of relevant businesses in these parts of the UK. Statistics, known as location quotients, suggests the reach of the NMS labs is proportionate in these areas. Conversely, fewer NMS customers are based in London and the East of England than the proportion of relevant companies in these locations, however, this is probably just an artefact of the head-office effect, whereby relevant companies may have their head-offices in London but are unlikely to conduct their manufacturing activities there.

<sup>10</sup> Relevant firms were identified and clustered using SIC codes. An explanation of what these are and why they are relevant can be seen in Appendix D.

<sup>11</sup> [https://oilandgasuk.co.uk/knowledge\\_centre/](https://oilandgasuk.co.uk/knowledge_centre/).

The remaining roles in oil and gas are distributed across the UK: 10% are in South-East England, 6% are in North West England, whilst the West Midlands and East England both account for 5% each.

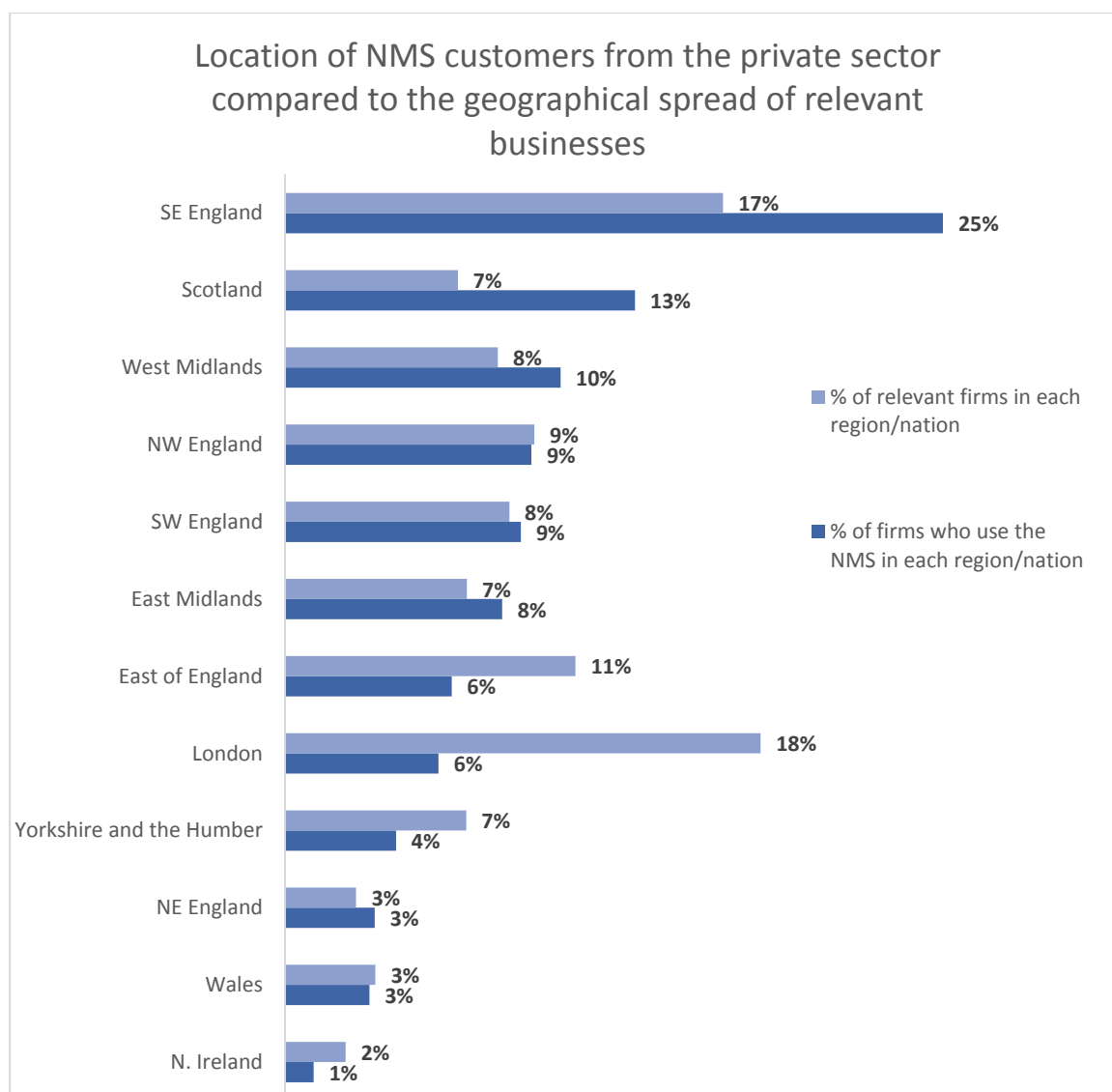


**Figure 4 – Proportion of NMS customers in each of the UK’s regions and nations, compared to the geographical spread of relevant businesses in the UK<sup>12</sup>**

In the NMS customer survey, more than a third of respondents reported that proximity is important for their use of products and services. Therefore, when considering the lower number of customers outside of the regions where the NMS labs are based, the apparent discrepancy is not surprising. Proximity was particularly important for instrument manufacturers (45%), as well as customers who require face-to-face services, such as those using events and training. The relative cost of being able to access the NMS labs’ products and services may be a further barrier, particularly to smaller companies, when travel and an overnight stay may be required.

Conversely, proximity is important to significantly fewer testing and calibration laboratories (27%) than is the case for the NMS labs’ users on average, perhaps because these companies are used to having to send or transport equipment as part of their business.

<sup>12</sup> Data on UK business landscape from ONS Business Survey: NMS sample: n=3,105, Wider population: N=246,200.

## 2.2. Reach of the NMS laboratories in the private sector

### Section findings

The private companies who work with the NMS labs are economically important. They employ just under one million people in the UK (about 3% of the workforce) and have an aggregate turnover of around £188 billion.

The reach of the NMS labs is extended far beyond their direct users through the fan-out of secondary and tertiary calibrations along the calibration chain. The 300 commercial calibration labs, who take traceability from the NMS labs, supply calibrations to around 74,000 organisations.

It is estimated that the NMS labs work with 6 - 18% of the UK's manufacturing sector, based on employment, and a third of the UKAS accredited calibration laboratories operating in the UK.

NMS users are highly innovation active, even compared to high-tech manufacturing enterprises, as reported in the 2017 UK Innovation Survey.

### 2.2.1. Economic activity

The survey asked private sector customers about the employment and turnover at their business site or unit, to assess the contribution these sites or units make to the economy.

The aggregate number of employees in the sites supported by the NMS labs amounts to around **1 million people, accounting for around 3% of the labour force**.<sup>13</sup> Breaking employment down by industry found that over half of private sector users operate within manufacturing or 'other production'<sup>14</sup>. The employment at manufacturing sites that are supported by the NMS labs accounts for 6 - 18% of all the people working at manufacturing firms within the UK.

The survey revealed that sites who work with the NMS labs are economically important and highly innovative.

**£188  
Billion**

The business sites using the NMS labs collectively **employ just under one million people in the UK** and have an **aggregate turnover of around £188 billion**<sup>15</sup>.

**80%**

Moreover, the sites with these **users are also highly innovation active**: 80% reported their site innovated in the last 3 years, compared to 49% of all enterprises and 67.5% of high-tech manufacturing enterprises as reported in the 2017 UK Innovation Survey<sup>16</sup>.

These figures emphasise that the business sites containing private sector users of the NMS labs create substantial economic value, and it's possible that some fraction of this economic activity could be put at risk without continued support from the NMS labs.

<sup>13</sup> 95% CI [-683,000, ~1,242,000]

<sup>14</sup> 'Other production' group comprised of utilities, energy production, oil and gas, agriculture organisations.

<sup>15</sup> 95% CI [-95.6, ~281]

<sup>16</sup> <https://www.gov.uk/government/statistics/uk-innovation-survey-2017-main-report>

### 2.2.2. Direct reach

The NMS laboratories have estimated the number of organisations they work with in the private sector to understand how far their direct reach extends. Analysis of the 3,105 private sector users currently using the NMS labs shows that the NMS labs have a deep reach in to manufacturing and commercial calibration.

#### Among the 2,915 business sites containing private sector users of the NMS labs (excluding calibration labs)...

- Over half of the private sector users operate within manufacturing or 'other production'. By employment, these **business sites account for 6 - 18% of the UK's manufacturing sector**.
- However, the customer base represents less than 1% of the firms in relevant industries<sup>17</sup>.

#### Among the 190 private calibration laboratory customers...

- **The NMS laboratories work with 33% of all accredited calibration laboratories in the UK<sup>18</sup>.**
- Two in three calibration laboratories have worked with the NMS for more than 25 years.
- These important customers use the NMS labs to maintain the accuracy of their instruments, so that they can reliably calibrate instruments for thousands of their own customers.

A little more than half (54%) of the NMS labs' users from the private sector are SMEs. Whilst calibration laboratories represent less than a third of this group, over two thirds are private companies. In the UK, there are around 246,200 SMEs in 32 relevant industries. When considering the reach of the NMS, this means that the laboratories work with fewer than 1% of all the relevant SMEs. This figure, though appearing low, represents a sustainable level of direct support going to SMEs. The hundreds of thousands of potentially relevant SMEs means that significantly boosting the proportion of the population that receive direct support is unrealistic given the current capacity of the NMS labs. Moreover, at times, direct support is probably unnecessary due to the spill-over benefits that flow to SMEs from the lab's activities.

<sup>17</sup> Relevant private organisations were quantified using ONS businesses data. (<https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/bulletins/ukbusinessactivitysizeandlocation/2018>). Companies within the SIC codes 5-43, 49-51, 60-63, 71, 72, and 74 were classified as 'relevant'. For explanation of the sic code groupings, see the appendix.

<sup>18</sup> There are 367 UKAS accredited calibration laboratories in the UK, excluding those who use the NMS: <https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/ukbusinessactivitysizeandlocation>

### 2.2.3. Beyond direct customers and users

The direct reach of the NMS labs is greatly extended by the fan-out of calibration services that are funnelled through the commercial calibration laboratories. The accuracy and traceability of calibrations are transferred through an unbroken chain of calibrations spreading out across the economy. This fan-out is central to the **indirect impact** generated by the NMS labs and maintained by the NMS labs. Calibration laboratories use the NMS labs to calibrate their instruments, assuring traceability to the primary standards that embody the SI units. In-turn, these commercial laboratories go on to calibrate the instruments of other companies, such as firms in the manufacturing sector.

All 98 organisations who self-identified as a calibration laboratory or reference material supplier were asked about the number of organisations to which they provide traceability. 67 provided a response<sup>19</sup> which provides evidence on the extent to which traceability fans out throughout the economy

Fan-out has been estimated for all the NMS lab's users self-identifying as a calibration lab or reference material supplier; with the results also split between whether or not they are UKAS-accredited.

This analysis found that the calibration services provided by the NMS labs have an initial fan-out to around **74,000 organisations**. This first stage of the fan-out corresponds to the five calibrated instruments in the figure above.

This estimate represents just the first 'level' of fan-out, whereby the NMS labs' customers provide services to their direct customers. It does not include the services these recipients then go on to deliver to their own customers, as data on this was not captured in the survey. If quantified, the number of organisations whose calibrated apparatus is traceable to the NMS labs would be considerably higher.

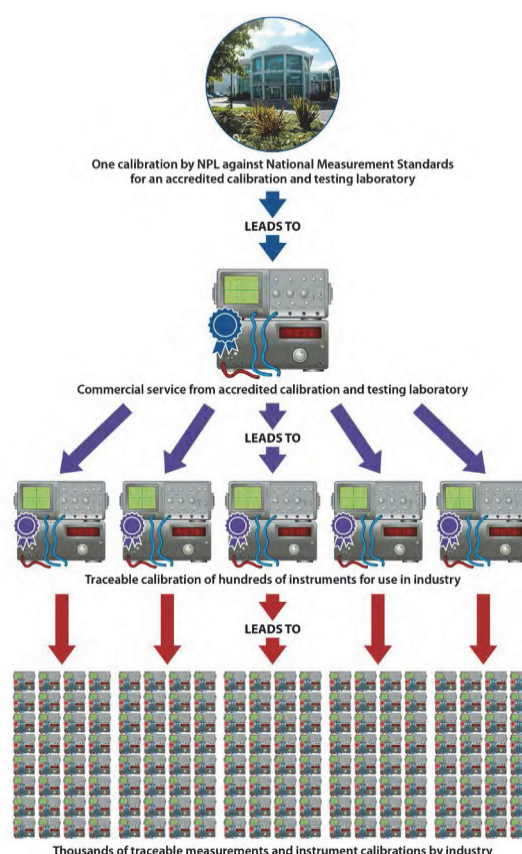


**Figure 5 - Graphic demonstrating fan-out and traceability (BEIS, UK Measurement Strategy, 2017)**

|                            | n  | N   | Median | Total  |
|----------------------------|----|-----|--------|--------|
| <i>Total</i>               | 67 | 302 | 20     | 74,087 |
| <i>UKAS accredited</i>     | 54 | 198 | 96     | 71,312 |
| <i>Non-UKAS accredited</i> | 13 | 104 | 3      | 2,775  |

**Table 3 - Number of laboratories calibration labs provide traceability to<sup>20</sup>**

<sup>19</sup> The remainder were either unwilling to say, didn't know or provided a global number.

<sup>20</sup> n= sample, N= Population sample represents.

### 2.3. Scale and value of measurement

For the first time, we can understand the scale of measurement spending by private sector users of the NMS labs, using data from the 2018 customer survey. Data on measurement spending has not been collected in previous waves of the NMS survey and is not available elsewhere. The value of measurement is assessed in multiple ways, which include: measurement spending as a percentage of turnover; employment of staff in roles connected to measurement; and how measurement was used during the 2014-2017 period.

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#### Section findings

**It is estimated that on average, businesses working with the NMS labs spend 5.4% of their turnover on measurement annually. This equates to £10.2 billion of spending each year among private sector users of the NMS.**

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**Calibration laboratories and large companies spend a considerable amount of money on measurement, with 41% of calibration labs and 31% of SMEs spending 20% or more of their turnover on measurement.**

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**Measurements done in-house make up the largest amount of measurement spending, accounting for 54% of customer's spending on measurement.**

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**Around 95% of private sector users employ staff who have measurement as part of their role.**

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It is clear from the stated needs of customers, and their use of the NMS labs, that measurement is important. The NMS laboratories want to comprehensively understand the degree to which their users value measurement. In the customer survey, users were asked to share information about their measurement spending, which was used as an indicator of this.

Manufacturing customers were asked if measurement was important to their site during various stages of the product lifecycle. Measurement was found to be important to manufacturers as their product progressed from a design on the page, to being ready to buy in the shops or to entering a supply chain.

85% of manufacturing companies using the NMS laboratories reported that measurement is important for them during design and development. A similar proportion (89%) said measurement is crucial at the production stage, whilst significantly more manufacturers (94%) use measurement at the quality assurance stage<sup>21</sup>. These figures highlight that for many manufacturers using the NMS labs, measurement is important throughout the design and production stages, and that it is important to nearly all manufacturers during final quality assurance.

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<sup>21</sup> These data have been t-tested. Please see the appendix for details.

### 2.3.1. Measurement spending

An assessment of measurement spending and measurement intensity has been completed to enable an understanding of the value ascribed to measurement among users. It is assumed that people make rational spending decisions and therefore value the things they buy more than the money that's been committed. Consequently, an observable lower bound for the value of something to a user is the amount of money that someone spends on it.

When customers make spending decisions on measurement, it is believed that they set their budget around the following rational considerations;

- The volume of measurements they need to undertake,
- The environment in which those measurements are made, and
- The precision and the accuracy a measurement requires.

These parameters determine the range and volume of measurement services that organisations will purchase.

Measurement generates information that is valuable to businesses, enables them to operate in a more efficient way, and ensures production is undertaken to the necessary quality and standard. When assessing spending on measurement, across the 2014-2017 period, it was found that on average:



Companies commit 5.4% of their turnover to measurement spending. This figure equates to £10.2 billion each year among NMS customers operating in the private sector.

#### Methodology

'Measurement intensity' is defined as the proportion of turnover that a business spends on measurement. Businesses were asked how much of their company's turnover is spent on measurement. The turnover associated with a respondent's site had to be estimated by multiplying their company's turnover by the proportion of the company's staff that are employed at the respondent's site, as respondents generally did not know the turnover of the site but did know the turnover of their company. A site's spending on measurement was estimated by multiplying the company's measurement intensity by its estimated turnover.

When asked, 132 respondents were able to give an estimate of their turnover and an estimate of the proportion of their turnover that is spent on measurement. The weights were adjusted to account for non-responses. This allowed an estimate to be made of the money spent on measurement by users. This has not been extrapolated to the whole UK business population, as NMS users are not necessarily representative of all businesses.

### Measurement budgets across the different private sector industries

Spending on measurement can be broken down to show differences between users' budgets. Perhaps unsurprisingly, the survey found calibration laboratories who use the NMS labs spend the greatest proportion of their turnover on measurement, with 4 in 10 (41%) spending more than 20% of their turnover on measurement.

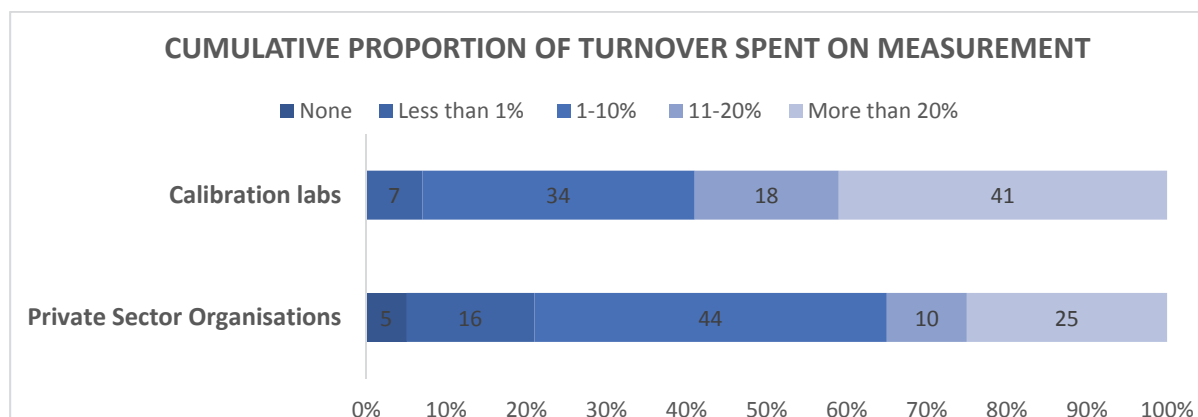


**Figure 6 - Proportion of resources spent on measurement split by calibration labs and other businesses<sup>22</sup>**

Aside from calibration labs, private organisations often require staff with measurement expertise for their development projects and innovation activities, as well as for compliance and quality, usually for advancing a specific product or technology. The nature of innovation means these companies invest heavily in metrology, with 25% spending more than 20% of their turnover on measurement.

### Company size and measurement budget

When it comes to company size, smaller companies appear to spend a greater proportion of their turnover on measurement. Almost a third (31%) of the smaller companies surveyed spent more than 20% of their turnover on measurement, compared to around a fifth (19%) of the larger organisations. However, further analysis shows that this sub-group contains many calibration laboratories who are naturally measurement intensive.

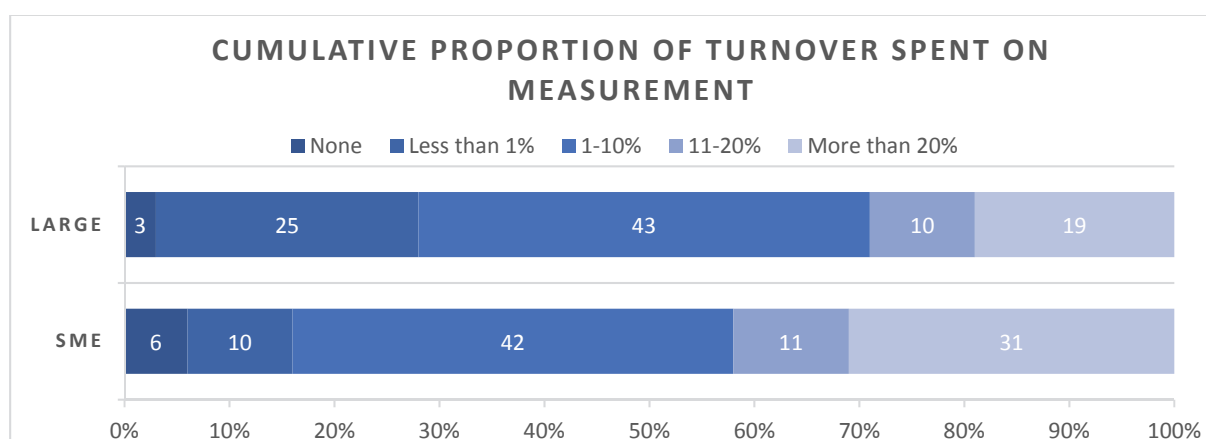


**Figure 7 - Proportion of NMS business customer's resources spent on measurement by company size<sup>23</sup>**

<sup>22</sup> Sample: n=360; Population data represents: N=1,941. These data have been tested and proven to not be independent. For details of the statistical analysis, see details of the Chi-squared testing in appendix C.

<sup>23</sup> Sample: n=349; Population data represents: N=1,884. These data have been tested and proven to not be independent. For details of the statistical analysis, see details of the Chi-squared testing in appendix C.

### 2.3.2. Allocation of measurement budgets

This section goes beyond just estimating the size of customers' measurement budgets, to consider how this money is spent and to quantify the number of employees they have in measurement related roles. These parameters give readers an understanding of the resources committed to measurement, and act as a proxy for the value of measurement for the company.

#### *Employment in measurement*

The companies were asked to quantify the number of staff that are employed at their site in total, and how many of their staff members work in a role which includes an aspect of measurement. Employment at a site was multiplied by the proportion of staff working in measurement to estimate the scale of employment in measurement related roles. These employment figures were used to calculate the proportion of staff in measurement roles at the organisation's site.

Despite this high proportion, it is likely that most of these staff only spend a fraction of their time making measurements. Nearly all respondents (95%) reported that their company has at least some members of staff working in measurement related roles. When looking at this employment among calibration labs, many reported that a large number of staff work in measurement related roles. Just under 2 in 5 (47%) employ more than half of their staff in a role which involves measurement. This is also the case for other private companies (43%).

19%

On average, companies supported by the NMS labs employ **19% of their staff in measurement related roles.**

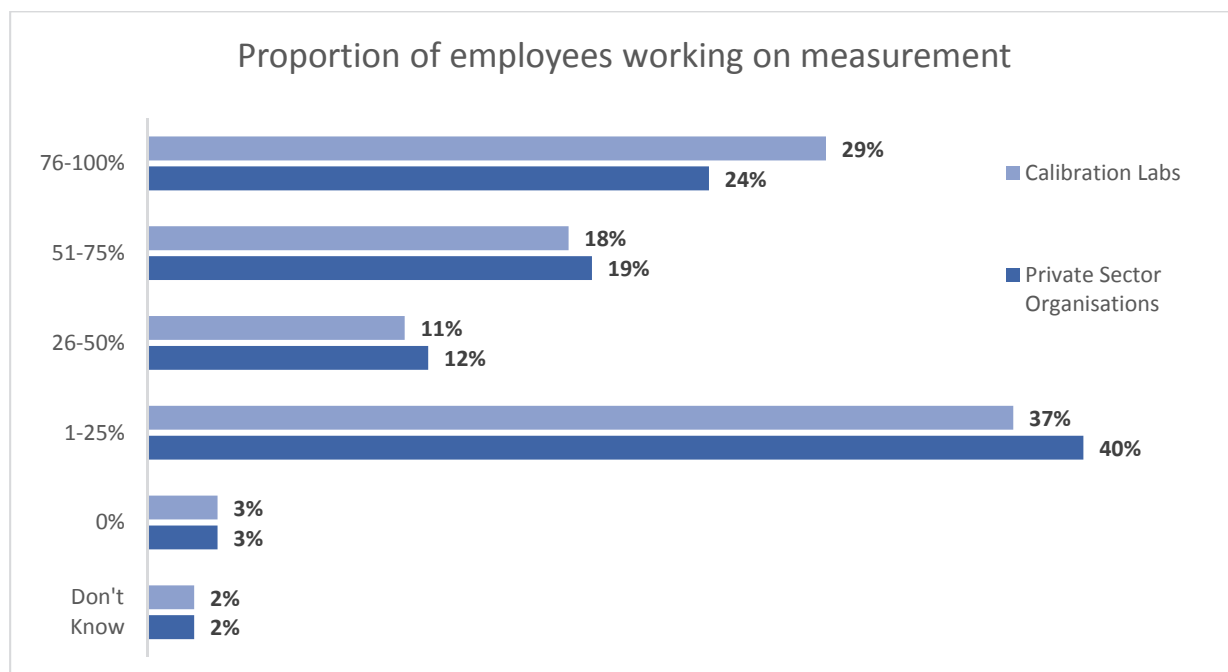


Figure 8 - Proportion of employees working on measurement split by calibration labs and other businesses<sup>24</sup>

<sup>24</sup> Prompted list, single choice, data representative of the NMS. Sample - Private sector: n=454, Population represented: N=2,646. Sample - calibration laboratories: n=98. These data have been tested and found to not be independent. For details of the statistical analysis, see details of the Chi-squared testing in the appendix.

### *How are measurement budgets spent?*

Respondents were asked how their measurement budgets were spent. On average, in-house measurement activities accounted for 54% of spending, a figure which is consistent with the large proportion of laboratories who employ a great proportion of staff in measurement related roles. A further 24% of measurement spending went on purchasing measurement services from commercial suppliers (e.g. testing labs).

The remainder of the budgets were largely invested in expanding a firm's capabilities. On average, 22% of budgets were spent on upgrading or replacing instruments and process control equipment. For comparison, annual public and private investment for the UK equates to 17% of GDP<sup>25</sup>. These investments demonstrate the significant commitment to, and value of, measurement by companies.

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<sup>25</sup> [GDP figure: Investment, The World Bank](#)

### Section findings

Each year, around 368 UK-based companies who use the NMS labs state they benefit financially through improved products and processes. They collectively receive around £539 million in annualised revenues from sales of products that respondents believe would not exist without the support they received from the NMS laboratories. This annualised estimate excludes businesses who attribute extremely large revenue benefits to the NMS laboratories.

A small number of customers enjoy exceptionally larger revenue increases. Collectively these companies attribute several hundred million pounds from sales to a product that would not have existed without support from the NMS laboratories.

It is believed that the the highly skewed distribution of benefits amongst users is part of the nature of R&D. However, the exceptionally large benefits in the upper tail of the distribution can't be annualised and are not amenable to statistical analysis. The revenue for this group of outliers is unpredictable, however, they are not errors or mistakes.

The NMS labs make their customer's innovation activities more productive by allowing them to make improvements more effectively and quickly, and reducing the risk associated with innovation.

The impact of the NMS labs is not confined to the companies working with the NMS laboratories. It often extends beyond the direct customer, through a 'spillover' effect. In total, 38% reported that impact extended beyond their organisation to their industry as a whole, or beyond.

It is important for the NMS labs to understand the impact they have on their customers and users. Impact is measured in two areas: 'innovation impact' and 'revenue impact'.

**Innovation impact** is that where support from the NMS labs enables the development and production of products and processes. There are numerous ways in which the NMS labs support companies when developing new products and processes, and this support frequently results in companies enjoying economic benefits.

**Revenue impact** is a financial figure representing the income generated by companies from the sale of products which have been improved or developed using NMS support. It also includes products sold in new markets that were accessed using support from the NMS. Revenue impact is essentially the portion of 'innovation impact' covering the benefits from product innovation.

### 2.4.1. Revenue impact

This section shows the results from the quantification of the revenue the labs create for their business customers, to allow the NMS to monitor this figure in the future. Revenue impact is an important figure as it allows the labs to understand the amount of impact they have, and the expanse of this. Data from three waves of the NMS survey have been pooled to calculate the annualised impact of the NMS laboratories on the revenue earned from sales of new products which have been sold by the companies they support.

#### *Methodology*

In order to calculate the total revenue impact that the labs have had on their surveyed users, customers who used an NMS lab to make an innovative change in the last couple of years were asked questions about the recent annual economic impact of this innovation<sup>26</sup>. This revenue impact estimate is based on income from the sale of products in three ways:

| 1                               | 2                                     | 3                                            |
|---------------------------------|---------------------------------------|----------------------------------------------|
| <i>The sale of new products</i> | <i>The sales of improved products</i> | <i>The sale of a product in a new market</i> |

The following analysis was based on making separate estimates for each component and then adding these estimates together at the end of the process, to find the revenue benefit. Only the impact on sales has been quantified because previous surveys found that respondents could not answer questions on the benefits of cost reduction through increased efficiency. In short, the benefits from process innovations are not included in what follows. This is why this section talks about 'revenue impacts' rather than the broader concept of economic benefits.

The gross benefit is the revenue from the new and improved products of which respondents are most aware. Given that the survey is directed towards staff that are best placed to talk about a firm's measurement activities, they are likely to be most aware of the sub set of new and improved products that depend on measurement in some way. That is, the gross revenue is revenue from new and improved products that depend on measurement and is not the full revenue from all the new and improved products associated with supported business.

Customers who reported that the introduction of a new product or process had been made possible with help from NMS labs were asked:

- Whether the support was essential to the success or viability of this innovation project.
- Whether similar support could have been accessed elsewhere, and whether this alternative support would have been easy or hard to obtain.

Where the support was seen by customers as essential and unavailable elsewhere, the changes they had implemented were **attributed to the NMS laboratories**. This means that it was assumed that these changes would not have been possible in the absence of support from the NMS labs.

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<sup>26</sup> In the past the NMS labs will also have supported the development of products that are more than two years old and are still being sold in their original form, although, the following analysis does not consider or record these legacy benefits.

The revenue impact reported by businesses after working with the NMS labs are thought of as coming from one of two distributions:

|                                                                                   |                                                                                                                                                |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
|  | For the vast majority of companies who work with the NMS labs, the change they will make to their products is <b>incremental</b> <sup>27</sup> |
|  | For a small number of companies working with the NMS labs, the change they introduce to their portfolio of products is <b>ground-breaking</b>  |

The type of outcome a customer gets from product innovation is uncertain, but their advance is much more likely to be incremental than it is to be ground-breaking. Metaphorically, the economic impact that companies working with the NMS can expect is random, like picking a ticket from a prize draw. Within the bucket are a large number of tickets corresponding to moderate prizes, or **incremental advances**. Alongside these common tickets there are a small number of golden tickets, where the winner wins the ‘jackpot’ or, in other terms, **achieves ground-breaking advances**.



Every company who works with the NMS labs has a chance of picking a golden ticket in the draw, however this chance is unknown. Those who pull out a normal prize are treated as having impact in a normal range, which is annualised, added to that of the other ‘normal’ ticket winners, and reported as part of the total revenue impact.

The huge prizes received by the golden ticket winners are classified as ‘outliers’. This is because although they are not errors, they are too infrequent and random to generate a predictable annualised figure. No attempt is made to gross up or annualise these benefits, as the distribution from which these extreme values are drawn has not been characterised. Consequently, the large benefits received by these winners are treated separately and reported as a raw number. The occurrence of ‘jackpot winners’, who enjoy considerably greater revenue benefits, is common for the returns on R&D projects, where innovation can occasionally create very considerable benefits for a single company. There is no reason to believe the ‘golden ticket’ winners overlap from one year to the next.

### The sample and the population

Data from the 2018 survey was boosted by data from previous survey waves to reduce the uncertainty around estimates of gross impact. Data from the customer surveys undertaken in 2012 and 2015 were aggregated with the 2018 sample. Collection of this data throughout the waves did not differ methodologically, meaning that this amalgamation did not distort the analysis. In each case, the changes occurred two or three years before the survey was conducted and the revenue estimates relate to the year before the survey was conducted. For example, for the 2018 survey, the changes occurred during 2014-2017.

<sup>27</sup> “Incremental” innovation is that which creates small improvements in products, services and other ways in which businesses do business.

The presence of impact data from 2012 and 2015 means that an adjustment of data is necessary to make the values comparable to the data from 2018. This was done by using inflators to convert ‘nominal’ values to ‘real’ values, where the base-year is 2017. In this analysis, the following inflators were used<sup>28</sup>:

- For data collected in 2012 from the previous years, impact values were inflated by a factor of 1.10635
- For data collected in 2015 from the previous years, impact values were inflated by a factor of 1.05147

Customers who could not provide a value were given the option to provide a banded estimate. This analysis rests on the assumption that the scale of a firm’s impact, and their likelihood to respond to the impact questions, are not correlated. That is, that customers failing to quantify their achieved impacts are assumed not to be significantly different from customers providing a response. For this reason, missing values were not replaced but the weights of those that gave a response were adjusted to account for non-responses.

The objective is to estimate the aggregate revenue benefit that would be attributed to the support of the NMS labs if all their users were surveyed every year. Because the sample represents a fraction of the population, the results for the sample need to be grossed up. The weightings were calculated using the following formula:

$$\frac{\text{Sample per strata (n)}}{\text{Population per strata (N)}} = \text{Weighting Factor}$$

There were differing non-response rates across segments, and values were re-weighted to account for non-responses or missing values. Weighting factors of firms who gave a value were rescaled in line with the response rate for their strata.

$$\frac{\text{Old weight for segment}}{\text{Response rate weigh of Segment}} = \text{New Weight for Segment}$$

The pooled sample used for the impact analysis contained 1,528 observations from the three waves of the NMS survey. After adjusting for weighting and stratification, the corresponding population contained over nine thousand users.

### Identification of outliers

The distribution for the sales of new products was found to be highly skewed; meaning that for most businesses, the income from the sales of new products was modest, but some businesses earned very significant income from sales of their new products. The objective of the following analysis is to separate the predictable annualised benefit going to hundreds of businesses each year from exceptionally large, one-off benefits enjoyed by one or two businesses. The exceptionally large revenue benefits are not predictable and an annualised figure for such benefits isn’t meaningful. To

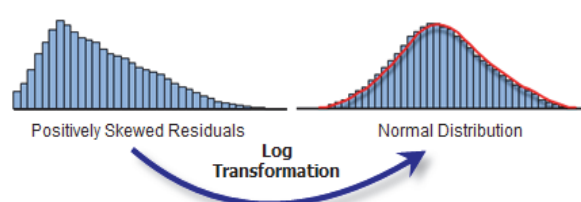
<sup>28</sup> GDP deflators measure the change in prices for all goods and services in an economy. As nominal GDP itself rises and falls, it doesn’t account for the effect of inflation. The deflator shows the extent of price changes on GDP by first establishing a base year and comparing current prices to the base year’s prices. This shows how much the change in GDP was down to changes in the price level. Using deflators allows comparisons of real economic activity from 2 different years to be made.

separate ‘usual’ benefits from ‘exceptional’ benefits, it’s necessary to have criteria for distinguishing large benefits from exceptional benefits.

The standard statistical techniques for identifying outliers assumes that the random variable under consideration has a normal (or ‘bell shaped’) distribution. However, the distribution for the revenue benefits is highly skewed. Consequently, a logarithmic transformation<sup>29</sup> was used to reduce a positive skew in the distribution of revenue benefits. Indeed, it was found that the distribution of these revenue benefits is approximately log-normal, meaning that the logged values have a bell-shaped distribution; which enabled outliers among the logged values to be identified using a criterion known as Tukey’s fences.

Following Tukey’s rule, outliers were defined as values which are more than 1.5 times the interquartile range.<sup>30</sup> Tukey’s fences are only meaningful when applied to data that has been drawn from a population that has an approximately normal distribution. Consequently, the log transformation was used to create a new variable with this convenient distribution.

**Figure 9 - Explanation of log normality**



## Results

It was found that each year, around 1,225 companies gain financial impact within the ‘normal’ range. These collectively created a **total annual revenue impact of £1.4 billion before accounting for attribution**. The total impact can be seen broken down into the three components which make up ‘total revenue impact’.

|                                 | Total annualised revenue impact for those with benefits in the ‘normal range’<br>Weighted: (n=1,528, N=9,661) | 95% confidence interval <sup>31</sup> |
|---------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Sales of new products (£m)      | 687                                                                                                           | 330 – 1,050                           |
| Sales of improved products (£m) | 470                                                                                                           | 190 – 740                             |
| Sales in new markets (£m)       | 258                                                                                                           | 150 – 360                             |
| <b>Total (£m)</b>               | <b>1,415</b>                                                                                                  | <b>991 – 1,839</b>                    |

**Table 4 - Total gross revenue impact of new and improved products by our customers (before attribution) per annum**

<sup>29</sup> Transforming a random variable, X, by taking its logarithm,  $\ln(X)$ , sometimes makes it possible to employ a standard statistical analysis of the transformed variable. See image of a log transformation sourced from: <https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-statistics-toolbox/what-they-don-t-tell-you-about-regression-analysis.htm>

<sup>30</sup> The lower fence is given by Quartile 1 minus 1.5 times the Interquartile-Range. The upper fence is given by Quartile 3 plus 1.5 times the Interquartile-Range.

<sup>31</sup> When the data was analysed, confidence intervals were estimated to create a range of possible values that would have a 95% chance of containing the population parameter of interest. In this case, the parameter is the annualised revenue impact for incremental product innovations.

This headline figure is considerable but does not account for attribution, that is, some customers believe that some of these revenue benefits would have occurred without the support of the NMS labs. Consequently, a second impact figure has been calculated, which accounts for attribution. After removing the impact figures which were not attributed to the NMS labs, the score is necessarily lower.

**19% of the NMS lab's innovation-active customers from the private sector, who made an innovative change, attribute the success of that change to the support they received from the NMS labs.**

**When accounting for attribution, the annual revenue impact is £539 million.**

These results show 38% of the total gross impact is estimated to be attributed to the support received by the NMS labs. This finding is considerable and shows that the NMS labs contribute to a significant proportion of income for its customers.

There was further found to be varying levels of attribution across the three impact components. The largest proportion of this revenue comes from the sales of new products (42% of all sales of new products), highlighting the value of the labs in supporting its users in developing these. Sales in new markets appear least likely to be attributed (29% of all sales in new markets), however these calculations have a large uncertainty, meaning this is not a definitive finding.

|                                 | Total annualised revenue impact for those with benefits in the 'normal range'<br>Weighted: (n=1,528, N=9,661) | 95% confidence interval | % of gross impact that is attributed to the NMS |
|---------------------------------|---------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------|
| Sales of new products (£m)      | 288                                                                                                           | 23 – 553                | 42%                                             |
| Sales of improved products (£m) | 175                                                                                                           | 77 – 274                | 37%                                             |
| Sales in new markets (£m)       | 75                                                                                                            | 32 – 119                | 29%                                             |
| <b>Total (£m)</b>               | <b>539</b>                                                                                                    | <b>277 - 801</b>        | <b>38%</b>                                      |

**Table 5 - Total attributed revenue impact of the NMS laboratories per annum**

From these figures, the outliers, or 'jackpot winners', have been removed because these benefits can't be annualised. Among just the outliers, the annual impact across the three-year period averaged £2.3 billion before attribution. When accounting for attribution, the revenue impact enjoyed by the 'jackpot winners' amounted to an annual benefit of around £300 million.



The NMS labs acknowledge that the attributed revenue benefits appear large. Whilst it is believed that users' benefits are considerable, the result is likely to be an overestimate due to the self-reported nature of the underlying survey data. Of course, these reservations do not affect the gross benefits; but it does affect the reliability of attempts to estimate the portion of the gross benefit that is attributable to the NMS labs. That is, respondents are explicitly being asked to speculate about the counterfactual outcome and this is known to be problematic methodologically.

### 2.4.2. Innovation impact

Respondents were asked about the impact of the NMS labs on innovation at their site. This was designed to identify how support from the laboratories helps the development and introduction of new products and processes, and to identify how far this impact extends in the sector.

#### **The NMS laboratories support customers to make improvements effectively and quickly**

- **7 in 10 (69%)** of the private company representatives, whose site had made an innovative change, reported that the NMS labs helped their site make improvements more effectively than would have been possible otherwise.

This could represent the productivity benefits afforded by waste reduction due to process innovation, allowing products to be made more efficiently and reducing scrap-rates. For example, reducing material loss in a manufacturing process allows companies to save on production costs, making them better prepared when launching a product on the market.

- **6 in 10 (59%)** believed that the support of an NMS lab had enabled their team to make improvements more quickly than would have been possible otherwise.

The support of the NMS labs allows companies to innovate in a more-timely manner by supporting technology advancements and R&D projects. These interventions assist such companies during the time-crucial period of product creation, before it's launched on the market, thereby allowing these companies to enjoy the benefits of commercialisation earlier.

#### **The NMS labs help their users to innovate by reducing the risks associated with innovation**

- **7 in 10 (70%)** reported that the NMS lab they used helped their site to reduce the risks associated with innovation.

The NMS labs equip companies, such as manufacturers, to take-on what would otherwise be excessively risky projects. The NMS labs allow their customers to undertake product and process innovations whilst removing some of the risk of going down blind alleys.

Verbatim feedback from users suggests that by collaborating with a team of scientific experts at the NMS labs, these users have greater confidence in their own products. Moreover, it shows that this confidence is extended to others, who have greater assurance that such a product is reliable by virtue of its inventor's association with the reputation of the NMS labs. These factors enable private sector organisations to continue their innovation drive.

*"[Working with the NMS] allowed us to show that we had been externally audited by an internationally recognised facility."*

*"... by pinning NMS's reputation to our measurements, we are able to back up the claims we are making. We can say we are making these measurements and they work."*

**The impact of an advance is not confined to the site or even the company working with an NMS laboratory. It often extends beyond the NMS labs' direct users to their customers and perhaps to their competitors.**

- 38% of the innovation-reporting organisations said its impact reached beyond their company.

Private sector organisations who had innovated were asked if their change, facilitated by working with the NMS labs, benefited other organisations or individuals outside of their organisation. 38% confirmed that this was the case.

The results show a large prevalence of spill-overs among the innovations that occur with support from the NMS labs. Companies supplying R&D services, or operating in the chemical or pharmaceutical industries, were more likely than users from other industries to achieve transformational<sup>32</sup> innovations with spill-overs that benefited their partners, suppliers, or customers. For these special companies, innovations are sometimes adopted across the sector, with the potential to transform the market.

The scale of an advance seems to have affected the likelihood of spill-overs being seen. Those who reported a breakthrough or transformational innovations had significantly **higher self-reported spill-over effects** than those who reported incremental innovations. This is expected as breakthrough and transformational innovation leads to radical shifts in technology and advances that would be new to market. This led to those who aren't directly benefitting from a new product to gain some form of benefit due to the scale of change; because the technology on which this new product was based is later incorporated into products that they do use.

Furthermore, analyses were conducted using the groupings of customers by their industry. The results show that users from within the 'Professional, Scientific, and Technical Activities' grouping<sup>33</sup> were significantly more likely to report the presence of spill-overs than users from the other industry groupings. This is logical as the work conducted at these firms probably has a stronger connect to specialised R&D activities. Hence, innovation activities within the 'Professional, Scientific, and Technical Activities' grouping have a higher propensity to generate breakthrough or transformational innovations than the innovation activities taking place in many other industry groupings; which are less likely to invest in ambitious, early-stage research projects due to the risks involved. Also, companies in the 'Professional, Scientific, and Technical Activities' grouping are often set-up to operate as professional intermediaries, who disseminate knowledge to their customers as part of their core business model.

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<sup>32</sup> "Transformational" innovation was defined as that which can create a new industry and/or transform the way we live and work.

<sup>33</sup> High skill service firms, such as architects and R&D firms.

## 2.5. Satisfaction with the NMS laboratories

The NMS monitors customer satisfaction to understand how customers view their working relationship with the NMS labs. It enables the NMS labs to reflect on their practice and ensure they continue to deliver value for their users.

### Section findings

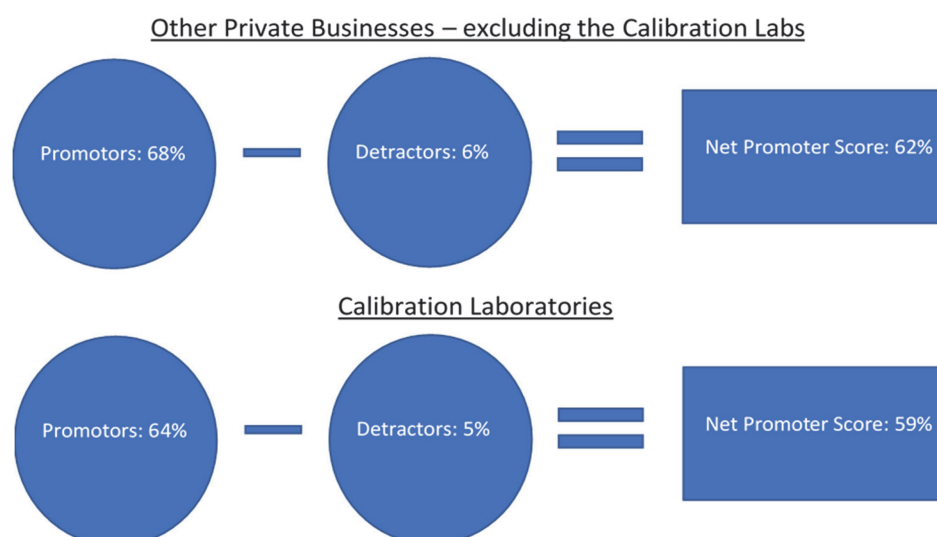
The NMS labs enjoy a high level of customer satisfaction, with a 'very good' net promoter score of 62 among private companies and 59 among the calibration laboratories.

Notable areas of satisfaction include value-for-money, quality, reputation, staff flexibility, and working relationships.

To measure satisfaction, customers were asked how likely they were to recommend the NMS lab that they worked with to a colleague or other organisation. Based on these results, a 'net promoter score' (NPS) was calculated to represent customers' experience and satisfaction with the NMS labs' products and services<sup>34</sup>.

The overall net promoter score (NPS) given to the NMS labs by private companies was in the range that is considered to be 'very good'. The score was 59 among calibration laboratories, and 62 among other private sector organisations. When comparing these scores to those of other high-profile organisations, it was found that Amazon has a similar NPS of 61, whilst Google has an NPS of 50, highlighting the reasonably strong performance of the NMS labs.

**Figure 10 - NPS among private sector organisations**



<sup>34</sup> Customers were asked on a scale of 0-10 how likely they are to recommend the NMS laboratories to a colleague or other organisation. Customers were classified as 'promoters' if they selected 9 or 10, 'passives' if they selected 7 or 8, and 'detractors' if they selected 6 or under. The NPS was calculated by subtracting the percentage of detractors from the percentage of promoters.

The results for calibration labs and other private companies were compared using confidence intervals and determined not to be significantly different as the intervals overlapped. For details on the analysis, see the appendix.

Specifically, in their qualitative feedback, the areas in which customers expressed satisfaction were:

### 1. Value for money

Good value-for-money is defined as paying a reasonable price for some intended benefit. Value for money is partly dependent on a user's willingness-to-pay and so it is considered differently by customers whose use of services and requirements differ. Consequently, customers who did not pay for services, and thus did not consider value-for-money, were excluded from these calculations. This was also the case for those who had to use an NMS lab due to a lack of alternatives, as these may represent distressed sales where it's difficult to make comparisons to other providers.

For those who paid for services, more than four fifths (81%) felt the NMS labs offered good value for money. Generally, this was based on the high quality of service and the reputation of the NMS. A smaller proportion of calibration customers said that NMS services represented good value-for-money than customers who paid for any service, signifying that satisfaction is lower among calibration customers. However, many of these calibration customers are obliged to routinely use this service compared to companies who use the NMS labs to overcome a specific measurement problem. This makes value for money difficult to assess and compare between different types of customer, as some have alternatives, whereas others have no choices but to use the NMS labs.

*"Because our standard is traceable through them and we are accredited as a result of that it is a big plus in gaining new business for us" [Private sector – industry]*

*"It's valuable to us as it is about being part of a proficient test that demonstrates we are good at our job which is good for our customers to know and therefore good for business" [Private sector – industry]*

### 2. Quality of the product/service they received



Respondents from private companies said the service they received met their business' needs, and many felt these services are delivered to a high standard.

*"They have enabled us to actually overcome some major issues that would have stopped the development of our product" [Private sector industry]*

*"[The NMS] Facilities are very good, high standards and location was a key point." [Calibration lab]*

### 3. Reputation of the NMS labs



The good reputation of the NMS labs was quoted by many respondents as a key benefit of their service. Some business users said that working with an NMS lab had given third-parties confidence in the competence and quality standards of their business; because the NMS labs are thought to be discriminating in their choice of collaborators and have an established reputation for the quality of their science. Hence, companies felt that working and engaging with the NMS labs strengthened the reputation of their own organisation. This allows companies to overcome barriers by giving others confidence in their work and raising their profile.

The reputation and credibility of the NMS labs amongst businesses is important as many respondents reported that interest in NMS's services is spread by word of mouth; and that they started collaborating with the NMS labs after receiving a recommendation to do so from a colleague.

*"It is a good organisation to be associated with... It brings a lot of kudos in the industry if we can say we have worked with NMS" [Private sector - industry]*

#### 4. Working relationship with the NMS laboratory staff



Respondents reported that the relationship their site has with NMS scientists is highly valued by their team. They felt that the NMS scientists build strong relationships with their customers and provide support in a variety of ways. This level of engagement was crucial for some customers to enable them to bring successful innovations to market.

*“We have worked with them for years and they come on site, so they know our equipment and requirements. We have a good working relationship with the staff there.” [Private sector - industry]*

There was also some acknowledgement that NMS scientists acquire a strong understanding of their customers’ business needs. Many of these customers felt the scientists they work with have a solid understanding of their organisation as a whole. This helps to strengthen relationships and leads to a more personalised service with better outcomes for customers. For those working on collaborative projects, some felt that the NMS staff have become part of their own team.

#### 5. Flexibility



According to some customers, NMS staff have a dynamic way of working that is seen as highly accommodating. This was particularly prevalent among companies who had been working with the NMS for a long period of time.

*“The instructor asked questions on what I do and tailored his examples to my work.” [Private sector - industry]*



*NPL's SMART Chamber*

### 3. The academic sector

#### Headline findings

The NMS labs have worked with nearly 1,000 academics from across the UK. This work predominately takes the form of partnerships on specific research projects.

The NMS labs have worked with around 3% of UK-based academics in the biological, mathematical and physical sciences, engineering and technology, from a third of the UK's universities (31%).

Alongside partnerships, academics predominantly use free services, such as best-practice guides and conferences. The amount of interaction that academics have with the NMS labs is probably price sensitive.

Most academics (78%) use the NMS labs because of their high scientific standards and unique technical expertise. More than two thirds (68%) use them to improve their strategy and research direction, providing evidence of how the NMS labs helps academics to realise their vision.

Academics cannot quantify the impact of working with an NMS lab, however, three quarters of respondents (74%) rated the impact of NMS research as 'good' or 'very good'.

The impact of the NMS on many academics is substantial, as 34% said that the benefit they achieved could not have occurred without the support of the labs. This largely reflects the nature of collaborative R&D where project solutions are co-created.

Half (51%) said collaborating with the NMS labs helps them reach milestones quicker, and the same proportion reported working with the NMS reduces the risk that the research would not achieve the intended outcome (48%).

Academics are highly satisfied with the NMS labs, awarding a world-leading NPS score of 74.

Notable areas of satisfaction include the cost and quality of the NMS services, as well as the scientific reputation of the NMS labs.



For the first time, academics who use NMS labs' products and services have been surveyed. This section will display results from the part of the 2018 NMS customer survey that was undertaken by academics. It will begin by outlining the reach of the NMS labs in the academic sector by assessing the profile of users, their metrology needs, and benchmark this against that of the total population. This section will also report the impact that the NMS labs make in the sector and will summarise the customer service scores awarded by academics.

The NMS labs have worked with over 1,000 academics on diverse scientific topics, collaborating with universities from across the UK. In total, 183 academics were interviewed from 51 universities, which amounts to around 18% of the labs' academic userbase. Respondents provided information on a personal level representing their own view, and results were not grossed up.



### 3.1. Demographic profile of academics using the NMS labs and the reach into this sector

#### 3.1.1. Customer profile and reach

##### **The NMS labs have worked with many academics**

Nearly 1,000 academics have used the NMS labs' services or collaborated with NMS scientists. The Higher Education Statistics Agency (HESA), estimate that between 2017 and 2018, around 34,000 academics worked in the areas of biological, mathematical and physical sciences, engineering and technology<sup>35</sup>. NMS engagement represents approximately 3% of this population of which around 18% of the existing userbase took part in the customer survey.

The NMS lab's academic users and partners generally work in the physical science disciplines. It is estimated that there are 13,500 academics working in these disciplines<sup>36</sup>, meaning the labs collectively work with around 7% of these strongly relevant academics.

**The NMS labs work with 1,000 academics**

#### *Location*

##### **The NMS labs have worked with a third of universities in the UK**

Alongside the individual relationship, the reach of the NMS labs is large across the number and location of universities in the UK. It is notable that the interviewed academics were associated with 51 different universities, representing 31% of the 164 higher education institutes in existence during the period 2017-18<sup>37</sup>. The NMS labs have worked with academics from 23 of the 24 Russell Group Universities, exemplifying the high standard of research to which they contribute.

Not all of the UK's academic institutes have academic staff or students who conduct research which may benefit from collaboration with the NMS labs. However, it is not easy to calculate this reach among only universities with relevant academics due to a lack of adequately detailed data on their research. It is believed that if this were possible, the degree of uptake among relevant academics would be significantly higher than that calculated using all universities.

**These academics represent 51 universities**

<sup>35</sup> <https://www.hesa.ac.uk/data-and-analysis/staff/areas>

<sup>36</sup> <https://www.hesa.ac.uk/data-and-analysis/staff/areas>

<sup>37</sup> <https://www.hesa.ac.uk/support/providers>

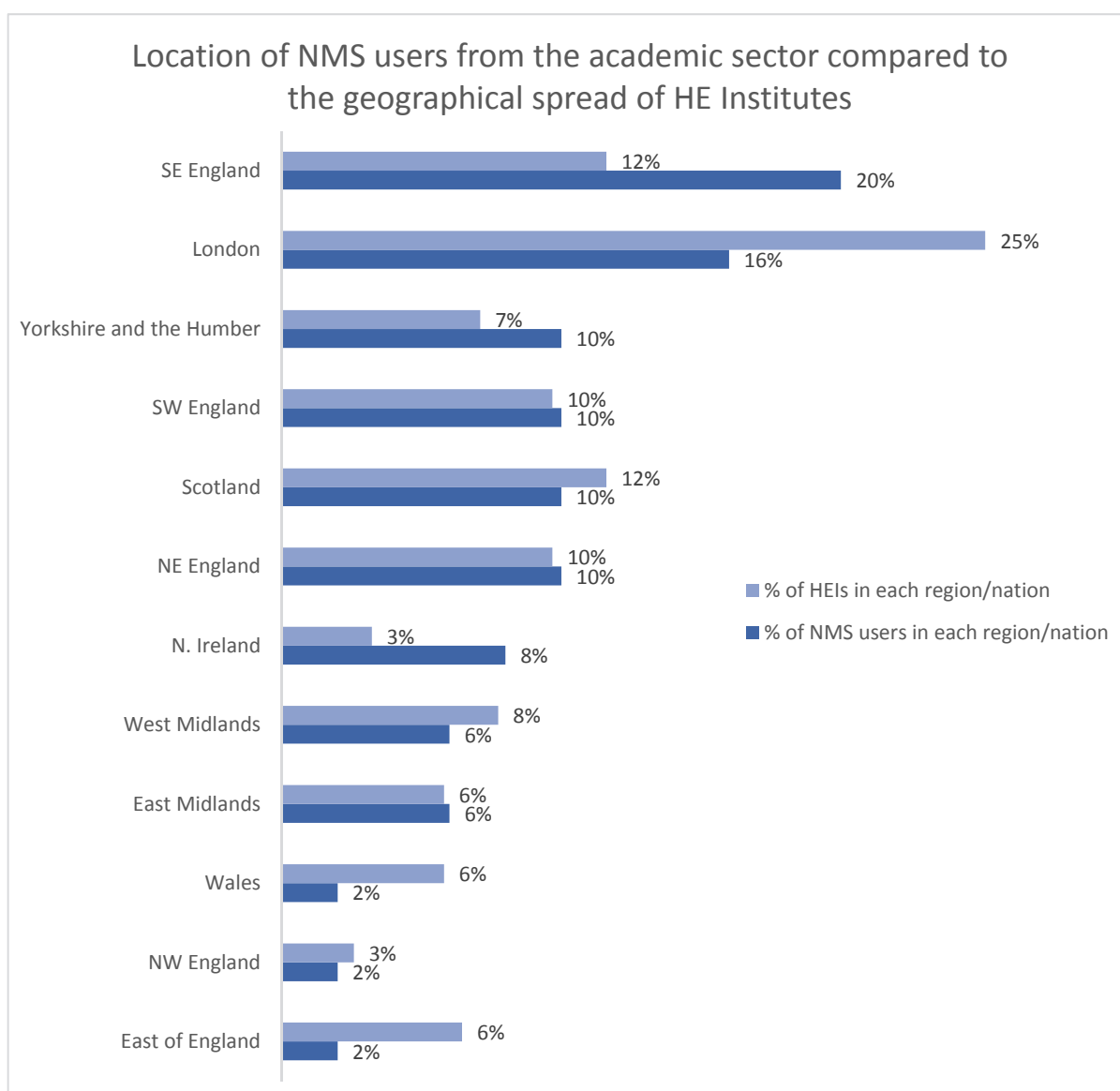


**Figure 11 - Proportion of NMS lab customers in each of the UK regions and nations, compared to the geographical spread of Higher Education Institutes (HEIs) in the UK<sup>38</sup>**

The regional distribution of academic staff or students who work with the NMS labs generally tracks the proportion of the UK's higher education institutes (HEIs) that are based in each region or nation of the UK. This suggests that in terms of collaboration with academics, the NMS labs have a good and proportionate reach across most regions of the UK. Despite this proportionate spread of academic collaborators, there is a cluster of academic users in the South East of England, where 20% of the academic customer-base is located. This is a large proportion considering that just 12% of the UK's universities are sited in the South East. This apparent clustering suggests the NMS labs may find it easier to work with academic users located in close proximity to NPL and NML at LGC, who are based in Greater London. Indeed, this is supported by the finding that the second largest regional user-base is London (16% of all users), however this proportion is smaller than the proportion of universities which are based in the region (25%), suggesting the reach could be increased in the capital.

<sup>38</sup> Data on NMS from customer survey. Data on HEIs from <https://www.hesa.ac.uk/support/providers>. Sample -NMS: n=51, HEIs: n=164.

### 3.1.2. Customer's needs and challenges

Academics who were surveyed by the NMS have a wide range of measurement needs. These customers often require multiple types measurements due to the nature of their exploratory and innovative work.

Many of the academics surveyed reported that they undertake more than one type of measurement in their research. The most common technical areas are 'materials', 'engineering', and 'dimensional'. Comparatively, more academics reported that they undertake optical, quantum and time measurements (44%) than occurs among the private sector users (32%), probably reflecting that this group of users undertake more blue-skies research than that which is undertaken by businesses during their near-to-market product development work.

The majority of academic respondents reported they work in collaboration with NMS scientists, often in R&D partnerships that are funded by grants, or they use free services, such as best-practice guides and conferences. Few academics reported that they use the other services on offer, particularly paid-for services, as most academic users are price sensitive.



### 3.2. Impact

It is important for the NMS to understand the impact that it has in the academic sector. Academics benefit from the NMS by collaborating with its scientists and using the laboratories' resources, such as best practice guides and attending conferences.

The NMS survey found that academic customers predominantly use the NMS labs for project-based collaboration and training services. Academics generally undertake 'blue-skies' research, meaning academic collaboration with the labs does not produce things like sales which can be economically quantified. None of the academic respondents were able to create an impact figure which could be attributed to the outcomes of working with the NMS labs, however, respondents were able to report the impact the laboratories made on a personal level and what this meant for their department or project.

**Three quarters of respondents (74%) rated the impact of NMS research as 'good' or 'very good'**

*"What I obtained [from the NMS labs] is the most precious and traceable measurement which can be used as a benchmark for everything else - they are what I compare everything against. They are a baseline in a sense" (Academic)*

*"[the NMS lab] Helps us to advance in a field we wouldn't be able to go into by ourselves without collaboration with NMS" (Academic)*

Notably, **34% of academics attributed the benefits they received as a result of working with the NMS** directly to the labs, such as a project breakthrough or finalisation. This high figure likely represents the nature of collaborative R&D, as these academics work in close partnership with NMS scientists to co-create solutions.



More than two thirds (68%) of academics said they work with the NMS labs to improve their **strategy and research direction**, outlining how the laboratories help their academic collaborators to realise their vision. It also highlights that it is important for academics to collaborate with measurement specialists early in their projects to improve their research strategy.



Half (51%) said that collaborating with the NMS labs helps them to **reach milestones quicker**, representing how access to the NMS facilities and expertise sometimes leads to solutions more quickly than undertaking research without support. The same proportion reported that working with the NMS labs reduces the risk that the research would not achieve its intended outcome (48%).

### 3.3. Satisfaction with the NMS laboratories

The NMS labs monitor customers' satisfaction to understand how users view their partnership with the labs. It enables the NMS labs to reflect upon their practice and continue to deliver for their users. To measure satisfaction, academic users were asked if they would recommend the NMS laboratory they worked with to a colleague or other organisation. Based on these results, a 'net promoter score' (NPS) was calculated to represent customer experience and satisfaction.

The NPS awarded to the NMS labs by academics is in the range of scores that is considered to be **'World Leading'**, at 74.

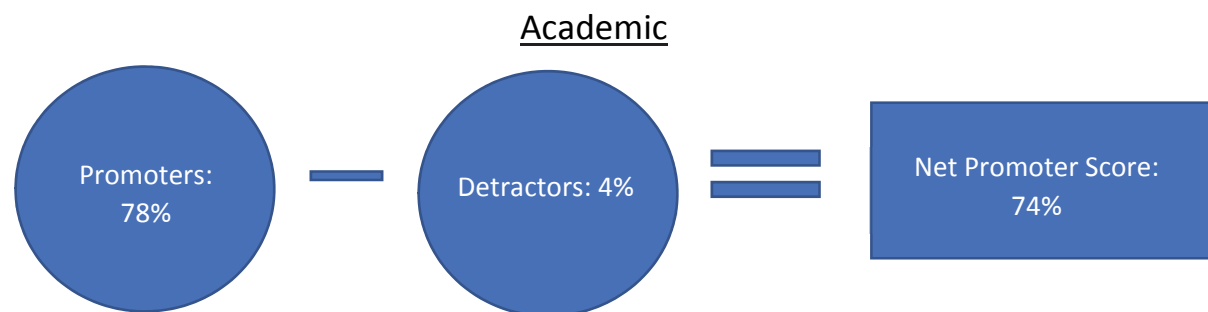


**Figure 12 - NPS among academics**

The world leading NPS shows that customers in the academic sector are advocates of the NMS labs. Indeed, the great reputation of the laboratories appears to be a driver for these customers. There is a large amount of referral within the sector; the customer survey illustrated that 25% of the academics first heard of the NMS labs through a colleague in their discipline.

When asked, there were multiple reasons why academics said they worked with the laboratories.

- 4 in 5 (78%) academics said that they work with an NMS lab because of its unique technical expertise, exemplifying the scientific excellence of the NMS laboratories.
- 60% said that they collaborate with the NMS because they feel the scientists are easy to work with, signifying the good working relationship between NMS staff and their customers.
- A large number also cited the reputation of the NMS and access to high quality equipment.

*"[The laboratory has] strong measurement capabilities which are outstanding and world-leading. I believe this NMS is one of the greatest research institutions" [Academic]*

*"They are amongst the most careful researchers in what they do. Everything they do is well documented and clear. They also publish in high profile journals" [Academic]*

Specifically, in their qualitative feedback the areas academic customers expressed satisfaction in were:

### 1. Value for money



Among those who paid to access resources, nearly three quarters (72%) reported that they were satisfied with the value-for-money of the services they used. This was particularly evident when they considered the NMS' reputation, as many felt they were receiving value for money due to the rigour of the service and its reputation. Others worked with the NMS labs on projects using grant funding, and consequently couldn't comment on value for money.

*"For the training, the costs were quite small and I got a qualification from it." [Academic]*

### 2. Quality of service



The majority of academics surveyed (86%) rated the research quality of the NMS labs as 'good' or 'very good'. Research standards, care, traceability and clarity were all key positives.

*"[I have] Been consistently impressed with the professional rigour that goes into the outputs, like the fact checking and the analysis is all to a very high standard" [Academic]*

### 3. Reputation of the NMS



Many academics reported that after working with the NMS labs their work was viewed as rigorous and of high technical standard by others in the field. Some said working with the labs gave third parties confidence in their work because of the labs' reputation for the high quality of their science and the technical abilities of their staff.

*"If you say some work has been done by NMS it is not questioned" [Academic]*

## 4. NHS trusts and medical research centres

### Headline findings

This is the first time a survey of the lab's healthcare users has been undertaken. The process identified the need for more effective methods of data collection in this sector, as many of the lab's users were not contacted to take part as a result of how their partnership with the labs is classified on the databases.

It is believed that this survey represents less than 30% of the total number of healthcare users currently in NML at LGC's database. Consequently, the users captured in the survey are largely customers of NPL, and in light of this the results should be considered to broadly only reflect NPL's userbase.

The majority of the interviewed users are medical physicists who work with ionising radiation, using the NPL for calibration services and reference materials to assure accurate doses of ionising radiation are delivered to patients. This calibration work is part of routine quality assurance and is a requirement for ionising radiation operators.

The labs work with clinicians and medical physicists from healthcare charities, trusts and the NHS. They have worked with at least 4% of medical physicists in England.

Healthcare customers are very innovation active. Nearly all (91%) of healthcare respondents said their department has made an innovative change in the last 3 years.

Measurement is crucial to the lab's healthcare users. Almost all respondents (90%) said they use measurement to 'ensure operational health and safety' and 80% use measurement to plan and deliver treatment.

Measurement also creates economic benefits for the NHS. 2 in 5 (39%) said they use measurement to avoid the undertaking of unnecessary treatment, and 1 in 5 (20%) said they use it to make treatment less costly.

The impact of measurement on cost efficiency, and the role of the NMS labs in providing this, is widely acknowledged by users. A substantial proportion (60%) use the NMS labs to realise efficiency benefits; either to avoid unnecessary treatments or to make treatment cheaper. A third (32%) say the change they made by working with an NMS lab actually went on to create increased cost efficiency, highlighting the potential of this benefit mechanism.

4 in 5 (82%) healthcare professionals said working with the NMS labs has created better safety and quality of healthcare. Half said this working relationship has improved recovery for their patients (52%).

The impact of the NMS labs goes beyond it's direct users. 30% of customers reported the advance had a national impact. However, just 4% of those who reported innovation attribute this to the NMS labs.

Healthcare respondents cannot quantify the impact of working with the NMS labs in financial terms, however, three quarters of respondents (74%) rated the impact of NMS research as 'good' or 'very good'.

Respondents from the healthcare sector are highly satisfied with the NMS labs, awarding a world-leading NPS score of 72. Notable areas of satisfaction include the quality of products and services and the working relationship they have with the laboratories.

In the UK, spending on healthcare accounted for 9.6% of GDP in 2017<sup>39</sup>. This section will discuss results from the 2018 NMS customer survey undertaken by healthcare professionals.

For the first time representatives from healthcare trusts and the NHS who use the NMS laboratories' products and services have been surveyed. The survey's recruitment process identified the need for more effective methods of data processing and collection in this sector, as many of the lab's users were not contacted to take part as a result of how their partnership with the labs is classified on the databases. This largely reflects the nature of the relationships between the NMS labs and their healthcare customers, as these are frequently partnerships or associations undertaking collaborative R&D, and consequently not registered as traditional commercial customers, as takes place for private sector business customers.

It is believed that this survey represents less than 30% of the total number of healthcare users currently in NML at LGC's database. Consequently, the users captured in the survey are largely customers of NPL, and in light of this the results should be considered to broadly only reflect NPL's userbase. Moreover, since carrying out the survey NML at LGC has implemented new processes for data collection, which has led to a 50% increase in stakeholder numbers. This will ensure that in the next round of the customer survey, the results will be more reflective of the full customer base.



*NPL's Linear Particle Accelerator (LINAC)*

<sup>39</sup> [Healthcare expenditure, ONS UK Health Accounts: 2017](#)

#### 4.1. Demographic profile of healthcare professionals using the NMS laboratories and reach in the sector

Between 2014 and 2017, the NMS laboratories have worked with more than 350 individuals from healthcare organisations, including hospitals, NHS trusts and medical research charities. 125 healthcare professionals were interviewed, from 55 healthcare organisations, including 49 hospitals or NHS trusts and 6 other healthcare organisations. This sample represents around 36% of healthcare professionals known to be working with the NMS labs. Respondents provided information on a personal level, representing their own view, and the results were not grossed up.

##### 4.1.1. Customer profile and reach

#### **The NMS labs have worked with at least 4% of medical physicists in England**

Based on data from the surveyed sample, the NMS labs work with individuals from NHS trusts, hospitals and medical research charities. These individuals work in a variety of roles including as medical physicists, clinicians, and heads of department. 350 individuals from these organisations have worked with the NMS, many of which are repeat customers, whose medical work involves the use of ionising radiation. Many of the customers that work in ionising radiation use NPL for calibration to assure accurate dosing. Alongside this direct support, the NMS labs also indirectly support healthcare by supporting pharmaceutical companies and medical instrument manufacturers.

In 2019 there were 2,704 individuals working as medical physicists in England<sup>40</sup>, a figure which is taken to represent the number of employees during the period covered by the survey. In the customer survey, 116 of the 125 respondents were involved with radiology in some form, accounting for 93% of the sample. When applying this proportion to the population of medical physicists working in England, it is estimated that the NMS works with at least 4% of medical physicists<sup>41</sup>. It is believed that this estimate would increase if the sample were to include the full span of users across the labs.

##### *Location*

#### **The NMS labs have worked with around half of teaching hospitals in the UK**

In the UK there are 228 NHS authorities and trusts<sup>42</sup>, of which at least 41 are teaching hospitals<sup>43</sup>, representing around 15% of all hospitals. The NMS labs have a wide reach among teaching hospitals; often working in these hospitals to support staff and deliver training courses. Of the 49 hospitals with respondents in the customer survey, 19 were teaching hospitals (35% of the labs' userbase), suggesting the laboratories work with around half of all teaching hospitals in the UK. Again, it is believed this figure would rise if it included the full range of customers using NML at LGC.

When assessing how this reach spans across the UK, it can be seen that the number of hospitals who work with the NMS labs remains disproportionately lower in Scotland (where they work with three of 206 hospitals) and Wales (where they work with three out of 106 hospitals) when comparing the geographical distribution of hospitals across the UK. However, Wales has just



<sup>40</sup> <https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics/june-2019#resources>

<sup>41</sup> Of the 116 customers who work in medical physics, just 16 were not from England and figures of employment in medical physics are not available in the devolved nations. The number of staff working outside England were subtracted to create the estimate of reach in England, and this was not extended to the devolved nations.

<sup>42</sup> <https://www.nhs.uk/ServiceDirectories/Pages/NHSTrustListing.aspx>

<sup>43</sup> <https://www.universityhospitals.org.uk/>

three radiotherapy centres<sup>44</sup>, whilst there are just five in Scotland, as well as a satellite unit<sup>45</sup>. When considering the sample in this survey, who in-large work in ionising radiation, it is likely that these users represent these specialist centres.

Conversely, the NMS has a large reach in London, where 24% of the hospitals who use the NMS labs are based, but just 12% of all UK hospitals are based. This is likely due to the proximity of these hospitals to NPL and LGC; or because a third (34%) of hospitals in London are teaching hospitals<sup>46</sup>.

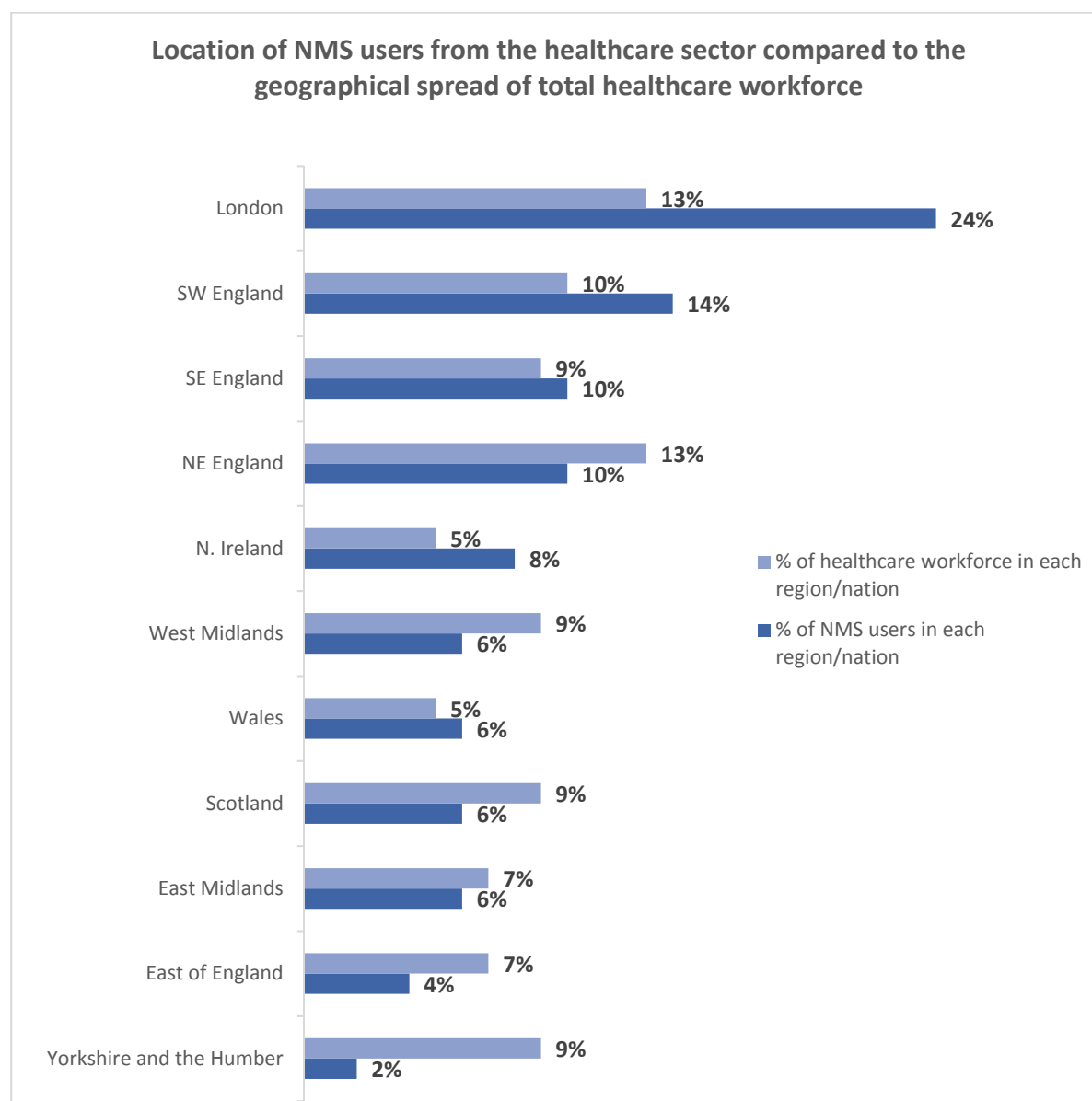


**Figure 13 - Proportion of hospitals with staff that work with the NMS labs, in each of the UK's regions and nations, compared to the geographical spread of the healthcare workforce in the UK<sup>47</sup>**

<sup>44</sup> <https://gov.wales/sites/default/files/publications/2019-10/radiotherapy-equipment-needs-and-workforce-implications-2006-2016-update-report-to-2020.pdf>

<sup>45</sup> [https://www.cancerresearchuk.org/sites/default/files/where\\_next\\_for\\_cancer\\_services\\_in\\_scotland\\_june\\_2017\\_-\\_full\\_report.pdf](https://www.cancerresearchuk.org/sites/default/files/where_next_for_cancer_services_in_scotland_june_2017_-_full_report.pdf)

<sup>46</sup> <https://www.universityhospitals.org.uk/who-we-are/>

<sup>47</sup> Workforce data from <https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics/june-2019#resources> (England), <https://gov.wales/sites/default/files/statistics-and-research/2019-03/staff-directly-employed-by-the-nhs-30-september-2018-167.pdf> (Wales), <https://www.isdscotland.org/Health-Topics/Workforce/Publications/2018-06-05/2018->

### Customer's needs and challenges

When considering the reasons for which the sampled healthcare customers use measurement, it was found that almost all the respondents use measurement to create benefits for customers in one form or another. 90% said they use measurement to 'ensure operational health and safety'. A similar proportion (80%) use measurement to plan and deliver treatment, and half (46%) use it to detect disease. It should be considered that the large majority of these sampled customers work in the field of ionising radiation, where they are required to use calibration services to certify the doses of radiation delivered to patients undergoing radiotherapy. Consequently, these needs span from the necessity of calibration for patient safety.

Moreover, many users require measurement for efficiency reasons. In the UK, spending on healthcare accounted for 9.6% of GDP in 2017<sup>48</sup>. For the first time, the role of measurement on cost efficiency has been surveyed. Notably, nearly half (43%) of customers said they use measurement to improve efficiency and enable cost savings<sup>49</sup>. 2 in 5 (39%) said they use measurement to avoid the undertaking of unnecessary treatment, and 1 in 5 (20%) said they use measurement to make treatment less costly. These findings suggest that measurement has the potential to create practical economic benefits through boosting the efficiency of the NHS.

#### Healthcare organisations use measurement for a range of reasons:

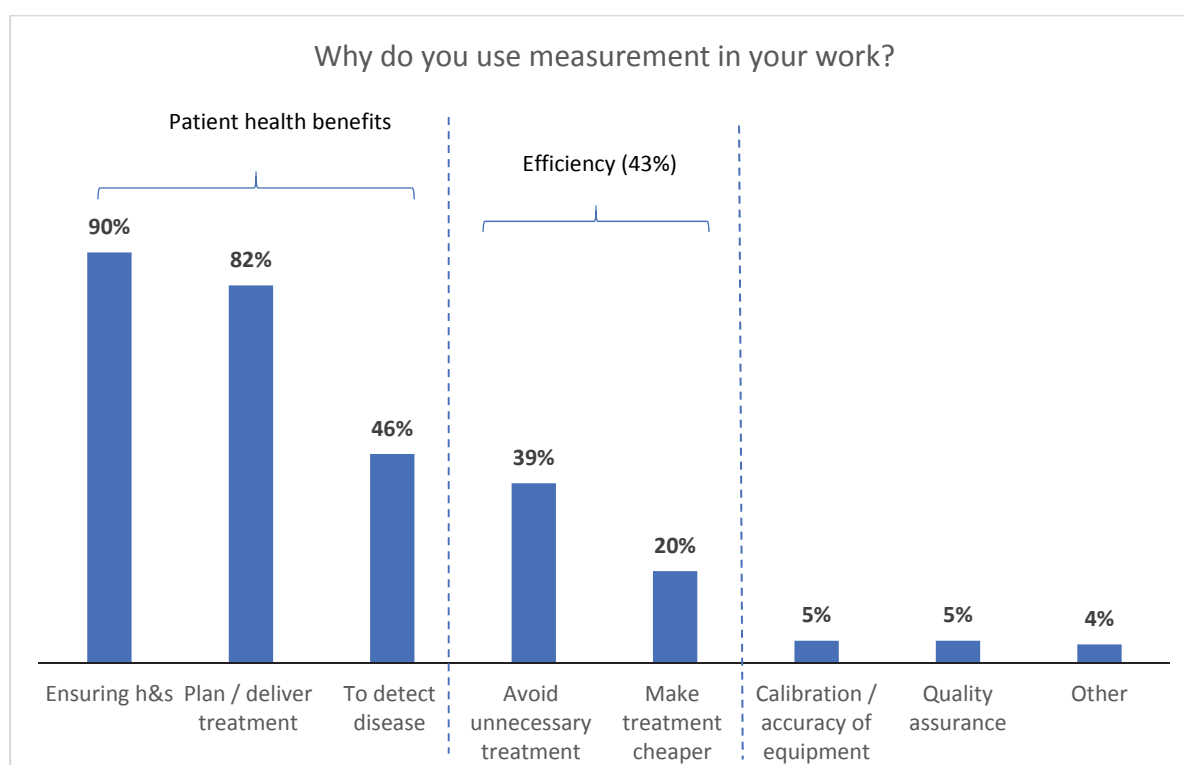


Figure 14 - Reasons NMS lab customers in healthcare use measurement<sup>50</sup>

06-05-Workforce-Report.pdf (Scotland), and <https://www.health-ni.gov.uk/sites/default/files/publications/health/hscwb-key-facts-june-2019.pdf>

(Northern Ireland). Hospitals NMS users represent sample size (n) = 49, Workforce population (N) = 1,519,052

<sup>48</sup> Healthcare expenditure, ONS UK Health Accounts: 2017

<sup>49</sup> Calculated by aggregating those who said they use measurement to avoid unnecessary treatment and those who said they use it to make treatment cheaper.

<sup>50</sup> Prompted list, multiple choice. NMS sample: n=125

User's measurement needs dictate and drive the NMS services they use. Consequently, it is important to undertake a comprehensive customer market analysis and segmentation to understand the key motivations of users, and how this influences their use of the labs. As discussed, many of the healthcare customers of NML at LGC undertake collaborative R&D, and consequently were not considered as customers and invited to participate in the survey. Consequently, a full user segmentation was not possible in this round of analysis, due to the missing data. However, it is possible to provide an overview of the way the sampled customers use the labs; a group which largely represent NPL healthcare users.

The large majority of NPL's healthcare customers use the labs' calibration services to calibrate and assure the transmissions from ionising radiation machines. Indeed, in this sample around 90% of healthcare customers said they had paid for calibration services. This concentration of use is the consequence of regulation, as it is a requirement for those working with ionising radiation to have calibration directly from NPL, and to use the services as routine assurance of quality standards.

Whilst the data shows a concentration of users in radioactivity, seen as a consequence of this regulation, recent changes in diagnostics and medical devices regulation<sup>51</sup> have increased the need for traceable methods and materials within other areas of healthcare. This is necessitating closer engagement of other healthcare professionals with the NMS going forward, as these laboratories understand the requirements and adopt best practice. Consequently, there will be a greater reach of the NMS labs in other areas of healthcare in the coming years.

Alongside this, the NMS labs sometimes collaborate with teaching hospitals on the provision of training services, and many of the healthcare customers reported that they make use of these free services to train staff so that they can deliver services involving the use of ionising radiation. Of the 49 hospitals with respondents, 19 were teaching hospitals (35%), highlighting the large number of training facilities that use NMS resources.

When considering pay-for services, it becomes clear that healthcare users may be price sensitive. Aside from calibration services, just 6% of customers in the healthcare sector only paid for the other NMS products and services, compared to 49% of the private sector users.

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<sup>51</sup> (Regulation (EU) 2017/746, Regulation (EU) 2017/745)

## 4.2. Impact

It is important for the NMS to understand the impact it has on the healthcare sector so it can understand the extent to which it helps the sector to protect lives.

The survey results provide a clear picture on the impact the NMS labs have on healthcare customers who use the NMS labs for calibration services associated with the measurement of ionising radiation, as well as those who use them for training services. As consequence of the limited sample, the impact of the NMS labs cannot be defined in its entirety. Moreover, impact cannot be quantified in terms of the revenue generated from the selling of new products and services, as is possible in the private sector. Despite being unable to give a financial impact figure which could be attributed to the outcomes from working with the NMS laboratories, respondents were able to report the impact that working with the labs has made on a personal level and what this meant for their organisation. Respondents were asked if they made any of the following changes between 2014 and 2017:

- Introduced a new, or improved a treatment
- Introduced a new, or improved a diagnostic technique
- Improved their measurement capability
- Changed their calibration or traceability process

To gauge attribution, respondents were next asked if this change was positively or negatively impacted by support from the NMS labs, and the extent to which this support made an impact on the change. The survey data shows that the innovative changes which the healthcare organisations make, as a result of the support of the NMS, has had impacts in a range of areas:



6 in 10 said the change they have made by working with the NMS labs directly helps save lives. That is, 60% said the scheme **increased survival of their patients**.



The same proportion (61%) reported that the change **enhanced quality of life** for citizens.



More than 4 in 5 (82%) healthcare professionals, who used an NMS lab, said the change they made has **created better safety and quality of healthcare**.



Half said the change has **improved recovery** for their patients (52%).

The labs also had an impact on the **efficiency** with which healthcare is delivered. The impact of measurement on cost efficiency, and the role of the NMS labs in facilitating this, is widely acknowledged by users. Half (48%) of customers said that better measurement would result in greater cost efficiency in their department, showing there is awareness among customers of the potential benefits that measurement can provide. In practice, 20% of the NMS labs healthcare customers state they use measurement to make treatments cheaper, and when combined, a substantial proportion (43%) directly use the NMS labs to realise efficiency benefits; either to avoid unnecessary treatments or to make treatment cheaper. When considering if the benefits of measurement were realised in practice, a third (32%) said the change they made by working with an NMS lab actually went on to create increased cost efficiency, highlighting the potential of this benefit mechanism.

Alike to the businesses who work with the NMS, sampled healthcare professionals who use the NMS labs are very innovation active. Nearly all (91%) of healthcare respondents said their organisation has made an innovative change in the last 3 years, predominantly concerning advances involving the use of ionising radiation. Of these, two thirds (66%) made incremental innovations<sup>52</sup>, and nearly all (89%) of healthcare professionals said that the advancements made by their collaboration with the NMS labs affected their job day to day and the way their department operates.

For others, the impact had a greater effect and spill-over beyond their own use. Nearly 2 in 10 had breakthrough innovations<sup>53</sup> (17%) and 8% had transformational innovations<sup>54</sup>. 20% said the advance they made had an impact for the sector and 30% felt it went beyond this to create a national impact. In practice, nearly 70% introduced a new treatment or improved an existing treatment, with over 40% improving a measurement capability.

Despite these high figures, this impact cannot often be attributed to the NMS laboratories. Only 4% of the 114 who reported an innovation attributed this to support from the NMS labs, compared to the 34% of academics and 19% of users from the private sector who attribute the impact they achieve to the labs. Although most respondents said these innovations would have developed regardless, more than 3 in 5 (63%) agreed that the NMS labs provided support that sped up the process<sup>55</sup>, and that this support would have been difficult to find elsewhere. This suggests that the NMS acts as an innovation catalyst in this field of healthcare.

This survey focuses on direct users of the NMS. Among healthcare users, a direct relationship with the NMS is observed where traceability is a regulatory requirement, such as in the case of radiology. However, a significant proportion of healthcare users are indirect, with a fan-out effect similar to calibration laboratories. Whilst this was not measured in this survey, it creates significant impact and should not be overlooked. An example that demonstrates this is the work done by NML at LGC on improving measurements for a kidney disease biomarker. NML directly interacts with international associations, such as IFCC<sup>56</sup>, NKDEP<sup>57</sup>, EC4<sup>58</sup>, JCTLM<sup>59</sup>, and National Measurement Institutes such as NIST in the USA. This work impacts on all major assay suppliers as well as reference, clinical and quality assurance laboratories performing the measurements.

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<sup>52</sup> "Incremental" innovation is that which creates small improvements in products, services and other ways in which businesses do business.

<sup>53</sup> "Breakthrough" innovation is that which provides customers or users demonstrably new products/services.

<sup>54</sup> "Transformational" innovation was defined as that which can create a new industry and/or transform the way we live and work.

<sup>55</sup> Calculated as the proportion of those who agree, or strongly agree, that support from the NMS labs enabled them to make improvements quicker than would have otherwise been possible, excluding those who reported that support from the NMS labs didn't effect the process or product being discussed.

<sup>56</sup> International Federation of Clinical Chemistry and Laboratory Medicine

<sup>57</sup> National Kidney Disease Education Program

<sup>58</sup> European Communities Confederation of Clinical Chemistry

<sup>59</sup> Joint Committee for Traceability in Laboratory Medicine

### 4.3. Satisfaction with the NMS laboratories

The NMS tracks customers' satisfaction to understand how users view their partnership with the laboratories. It enables the NMS to reflect upon its practice and thereby continue to deliver for its users. To gauge satisfaction, healthcare staff were asked if they would recommend the NMS laboratory that they worked with to a colleague or other organisation. Based on these results, a 'net promoter score' (NPS) was calculated to represent customers' experience and their degree of satisfaction.

The sampled customers of the NMS labs appear to be highly satisfied in multiple areas. The NPS awarded by healthcare customers is 72, a score which is considered to be **'World Leading'**.

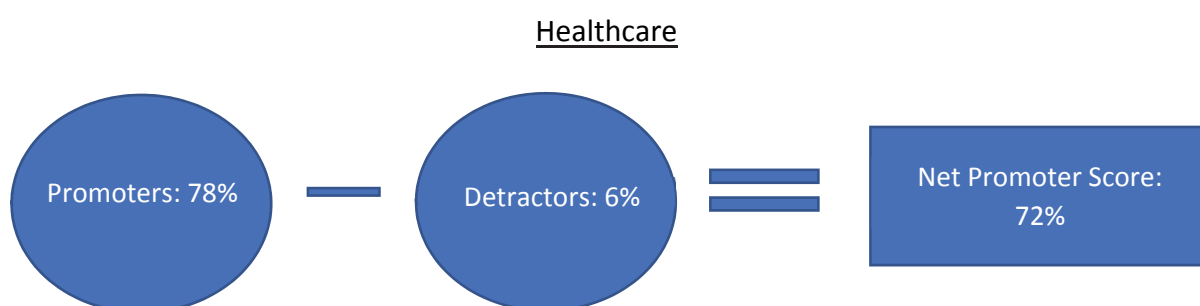


**Figure 15 - NPS among healthcare professionals**

When respondents were asked how they first heard of the NMS, the most common response from healthcare professionals was that their organisation had a pre-existing relationship with the NMS (30%). This suggests that the NMS has an opportunity to reach beyond its existing users to engage and attract a new customer base.

Specifically, in their qualitative feedback, the areas in which customers expressed satisfaction were:

#### 1. Quality of service



The accuracy of the service provided by the NMS laboratories means most customers are satisfied with the quality. For those collaborating and attending courses, many felt these were of a high standard and cutting-edge.

*"[You] can always trust the advice. Always very thought-provoking. Always very interactive and collaborative" (Healthcare)*

*"They are scientifically accurate and reliable. By an institute that is globally recognised" (Healthcare)*

#### 2. Working relationship



Many healthcare professionals said they value their relationship with the NMS, and that NMS scientists provide tailored support that meets their needs.

*"We have access to discussion with physicists who have a good understanding of what we do" (Healthcare)*

*"We just have a long and fruitful relationship. They provide a service we need." (Healthcare)*



## 5. Learnings, areas to develop and opportunities

The customer survey results provide the opportunity to review the NMS through assessing the impact it creates along with customer satisfaction.

### 5.1. Areas to be improved

The survey revealed a number of areas where customers felt service could be improved.



**The NMS laboratories should improve the timeliness of some services and manage expectations on timings.**

11%<sup>60</sup> of all users reported the NMS lab had not met their deadline. This issue was concentrated in calibration services, where many felt improvements could be made. Delays in calibration outputs could be the result of the work needing to be undertaken in batches because of having to assemble apparatus, or due to the volume of demand exceeding capacity at peak times of the year.

To address this, there is scope for the NMS labs to better communicate the process of bundling calibration jobs to manage expectations, such as informing customers about the process and setting deadlines for the submission of instruments. The labs could also consider creating express services for calibrations needed on a tight deadline.



**The NMS laboratories should improve their engagement and customer service when dealing with calibration customers.**

Calibration laboratories are the segment that appears most dissatisfied with their use of the NMS and sometimes cite high costs. These users are most likely to have a wholly commercial relationship with the NMS labs; and it is this segment where engagement with the NMS is a routine requirement.

To address this, the NMS could better engage with this segment and try to ensure services are timely.



**The NMS scientists should continue to build relationships and support partners from companies who use gas, flow and acoustic services.**

When representatives from businesses who create products were asked what could be improved, those who use gas, flow and acoustic measurement services felt they could be supported more closely by scientists.

<sup>60</sup> 95% CI [~8.05%, 15.5%]

## 5.2. Areas for development and opportunities

Alongside the issues raised by customers directly, analysis of the results enabled the identification of a number of areas where the NMS labs can develop its analysis and services in future.

### 1. Improving the survey process and sampling

2018 was the first year in which customers and users from academia and the healthcare sector were interviewed. This raised a number of issues surrounding data storing and sampling, particularly among healthcare users. As many of the users from these sectors work with the labs as collaborators and partners on R&D projects, they have historically not been registered as customers in databases. This has resulted in the absence of these customers in the survey, as they were not invited to participate when sampling due to their exclusion from the customer list of potentially interviewees provided to Winning Moves. This sampling error has now been realised, and since carrying out the survey NML at LGC has implemented new processes for data collection, which has led to a 50% increase in stakeholder numbers, who will be contacted in the next round of evaluation. This will result in a more representative sample, providing a better understanding of the customer's and their views.

### 2. Improving the NMS customer database and future evaluation

As discussed, the survey has identified that there is a need to improve the management of the NMS databases. There is no central database of users, and each lab maintains their own customer database. In future, customer analyses would benefit from each laboratory maintaining a well-structured database which follows a uniform format, which can then be combined and compared. This would deliver several benefits for the NMS, such as assisting future analysis of where the NMS creates impact. The challenge is to find a way to do this in a way that respects the commercial interest of the NMS labs and is compatible with customer confidentiality. The realisation that this database requires improvement will be used as evidence of the need to undertake further analyses and be considered when creating the next customer survey, anticipated to be in 2021.

### 3. Future areas for analysis

In the future there is a need to undertake a broader evaluation of the benefits going to the NMS labs' customers, particularly of the benefits going to customers in the academic and healthcare sectors. Currently, there are no estimates of the scale of these impacts, to support the existing qualitative findings on how and why the NMS labs have an influence in these sectors.

### 4. Broadening the services of the NMS labs

Some customers explicitly expressed a wish for the return of discontinued products and 'new' types of measurement services, such as high voltage and high current calibration and testing services. This gap in provision was also present in the measurement of biological materials. By broadening the scope of the NMS labs to include new types of measurement, the NMS would increase its customer base, as well as benefitting the economy through the inevitable fan-out that providing these services would create.

## 5. Improving awareness of the NMS and increasing uptake of its services

When asked about the range of products and services that the NMS labs offer, customer awareness of each product or service is greater than 70%, however, just 45% of those interviewed could recall the full range of services on offer. This suggests there is an opportunity for the NMS to better communicate what it offers to potential customers.

When it comes to the uptake of services, use of calibration services was high amongst those companies who have worked with the NMS for more than 25 years (77%). However, fewer than 3 in 10 (27%) organisations who have worked with an NMS laboratory for less than 5 years use calibration services. This suggests calibration could be better advertised to newer partners, however this could come from rational decision making, whereby customers use the service of competitors (e.g. commercial calibration laboratories) due to its lower price, convenient location, or a lack of need for the high accuracy provided by the NMS.

## 6. Attracting new customers

The survey revealed multiple ways in which the NMS could attract new customers and retain their current users. This includes understanding the competition in the market and remaining ahead of future needs with regard to technical capabilities.

When responding to the survey, many customers provided multiple comparisons between the NMS laboratories and its competitors in the calibration sector. When considering cost and pricing, it would appear that competitors are less expensive than the NMS labs. However, the NMS maintains precision and accuracy underpinned by the SI units, meaning that customers who need the most accurate calibration are required to use the NMS. The NMS should consider this price difference when thinking about customer attraction and retention.

There was a need by private companies for the NMS to stay in-line with or ahead of the market. Remaining at the forefront of the market would continue to attract and retain customers. The need for this was expressed by private companies, many of whom develop products and attend training courses, and would consequently benefit from the NMS if expertise and training sessions are cutting-edge or ahead of current market needs.

*“I guess [NMS laboratories should be] including new technology or new processes which are ahead of the market” [Private sector]*

## Appendix

### A. About the labs

#### **The National Physical Laboratory (NPL)**

NPL is the UK's National Measurement Institute. At its core, NPL maintains the UK's units of measurement. It works to ensure that measurement in the UK is consistent with the global common system of measurement units.

Alongside this core role, NPL conducts research into fundamental metrology and develops primary standards, as well as new instrumentation. It further works in partnership with a number of grant providers, such as Innovate UK, to offer grant funded collaborative R&D projects, to provide measurement support to a mixture of firms and research organisations. Lastly, NPL undertakes a number of commercial activities, such as supplying commercial calibration, testing, and training services to firms, hospitals, and universities.



NPL has laboratories in South West London, where more than 800 scientific and technical staff are based, as well as sites across the UK, in Surrey, Huddersfield, Glasgow and Cambridge. NPL's legal status and ownership has changed over time; but NPL is now wholly owned by the UK government and receives more than 80% of all the NMS funding.

NPL was founded in the early 19<sup>th</sup> century to bring scientific knowledge to bear practically upon industrial and commercial life. Historically, NPL focused on developing the national measurement standards that are used in applied physics and engineering; but over recent decades, NPL also built-up capabilities to support the digital technologies and the life sciences.

#### **The National Measurement Laboratory at NML (NML at LGC)**

The NML at LGC is a private company which receives significant public funding to sustain and advance the nationally beneficial work it performs for the NMS.



The NML is the UK's designated institute for chemical and bio-measurements and is also responsible for the UK Government Chemist, a statutory role as arbiter in legal disputes about chemical analysis and advisor to the government in the field of chemical measurement. The NML is hosted at LGC, and itself was once a government laboratory, but LGC is now a leading international life sciences measurement and testing company.

## The National Engineering Laboratory (NEL)



The NEL is a private company which receives significant public funding to sustain and advance the nationally beneficial work it performs for the NMS.

The NEL is the UK's designated institute for flow and density measurement. It is based in Glasgow and is a world-class provider for flow measurements to the energy, oil and gas industry sectors and to government.

### B. Key terms and concepts

#### *Accreditation*

Accreditation is the process that ensures organisations which provide certification have the means to do so. UKAS (United Kingdom Accreditation Service) is the UK's National Accreditation Body. It is responsible for determining, in the public interest, the technical competence and integrity of organisations, such as those offering certification services.

#### *Calibration*

Calibration is the comparison of an instrument against a reference or standard, to find any errors in the instrument readings. In some cases, calibration identifies a relationship linking the input and output of an instrument. For example, calibration of a resistance thermometer could relate its output (in ohms) to an input temperature (in degrees Celsius or kelvin). The outcome of a calibration is typically a certificate reporting instrument errors (or corrections to be applied), and the uncertainties in these.

#### *Certification*

Certification is a written assurance by a third party confirming that a specific product or service conforms to the requirements outlined in a standard. The notified bodies examine user's products to ensure they meet the criteria and provide certification. Certification markings can be placed on items to indicate their conformity, such as the European 'CE' markings.

#### *Company size*

In this report, private companies are classified into size groups based on the number of staff they employ. Companies are classified as 'large' if they have 250 or more employees. Small or medium-sized enterprises (SMEs) are organisations with 249 or fewer employees. Within this, medium sized organisations are defined as those with 50-249 employees and small sized organisations includes all those with fewer than 50 staff members. When small organisations are broken down further, micro-enterprises are those with 10 staff or fewer.

#### *Concentration*

Concentration is discussed in this report in relation to user's location. Concentration refers to the number of organisations in a specific industry who are based in a geographic region or nation, as a proportion of the total number of organisations in the industry across the UK as a whole. This is compared to the proportion of NMS users; which is defined as the number of users from a specific industry who are based in a geographic region or nation as a proportion of the total number of customers in the NMS has in the industry.

### *Fan-out*

In the context of metrology, the ‘fan-out’ refers to the transmission of traceable calibrations across the UK through the work of the commercial calibration laboratories. That is, there is an unbroken chain of calibrations, spreading through the economy. Fan-out originates with the core NMS labs, who hold the primary measurement standards for the UK. The core NMS labs certify the working standards of commercial calibration laboratories, who then in-turn calibrate the instruments of other companies.

### *Forms of innovation*

Innovation is broken down into categories which define the importance of the innovation. Innovation is defined as “**Transformational**” when it can create a new industry and/or transform the way we live and work. It is defined as “**Breakthrough**” when it provides customers or users with demonstrably new products/services. Lastly, it is defined as “**Incremental**” when it creates small improvements in goods, services, or other ways in which businesses operate.

### *Knowledge Transfer (KT)*

Knowledge transfer is the sharing of knowledge and information between individuals and companies. Within the NMS, this is done through active and passive modes:

**Active knowledge transfer (two-way flow of information)** occurs when the NMS works with its users to co-create solutions. In this instance, knowledge is shared and combined, and the output is jointly generated, operating outside of a teacher-learner model.

**Passive knowledge transfer (one-way broadcast)** occurs when individuals and companies attend events and courses, access best practice guides, and purchase consulting. In this capacity, knowledge is disseminated from the NMS, acting as the teacher, to the user, acting as the learner, allowing them to reproduce outcomes using the newly acquired knowledge.

### *Metrology and measurement*

Metrology is the science of measurement. Measurement is important as it is only when we can measure something that scientists can study it and engineers can improve it. In its simplest form, measurement is the quantitative comparison of something against a reference. A measurement result is expressed as a number, or value, together with one or more units of measurement. When a measured value is given along with its one or more units, this tells us the dimension (such as mass or length or time) and the scale of the measured value.

### *Standards*

Product standards are technical documents specifying the performance and characteristics of products. They form the technical basis of a system of certification and accreditation that provides purchasers with confidence in the products they buy and use. Many types of technical standards exist, such as performance or interface standards. For example, EU directives require the certification of goods that are sold in the Common Market (‘CE’ marking) to ensure they conform to the EU’s quality and safety standards. Businesses also adhere to voluntary product standards that are written and developed by industry representatives with the support of bodies, such as, the British Standards Institute (BSI) and the International Organisation for Standardisation (ISO).

Measurement protocols are often incorporated into product standards to explain how they should be applied in practice. That is, for a standard to be effective, there needs to be an agreed method for determining whether or not an item conforms to its requirements.

### *The International System of Units (the SI units)*

The International System of Units, known as the SI, is a globally agreed system of measurements. The SI has units for every type of measurement, with seven 'base units' at the heart of structure. This system underpins the consistency of measurement, whether a metre or a second, and ensures these remain comparable and consistent worldwide. These standards are maintained by National Metrology Institutes (NMIs) around the world. The National Physical Laboratory (NPL) is the UK's NMI and maintains the country's SI units.

### *Traceability*

Traceability refers to the unbroken chain of calibrations that begins at a national standards body like NPL. Any organisation can achieve traceability through the correct use of a traceably calibrated instrument. When this is done, the instruments calibrated would go on to calibrate the instruments of their own customers. This would lead to fan-out, with traceable measurements spreading across the market.

## C. Detailed methodology of statistical analysis

In the analysis of the customer survey data, chi-squared and t-tests we used. This section details the rationale for using these analyses.

### *Chi-Squared test*

The chi-square test was run on data collected from the survey to check for statistical independence. Independence is where one event conveys no information about the other, meaning that the occurrence of one event doesn't affect the probability of the occurrence of the other event. If data is found to be independent, then in practice, a story cannot be told between the data being tested as the results are not related. This provides value as it allows the understanding of driver or influence of the customer survey results, such as if a finding is driven by satisfaction of a service, rather than being influenced by a separate variable.

### *T-test*

T-tests were run on data from the survey to check for statistical significance, defined as when a result is very unlikely to have occurred given the default position, known as the null hypothesis. In the case of the *t*-test being run in the document (Welch's *t*-test), the null hypothesis is that the two populations have equal means. If this were so, then it would be assumed that there was no variation between the two populations, preventing a conclusion to be drawn between them.

In practice, this is a useful tool to assess whether two results differ from each other significantly and that if the group of respondents were interviewed again, the results would remain different.

Unlike most *t*-tests, Welch's test doesn't require equal variance of samples. Furthermore, population proportions were used in order to test two sections of the sample against one another to find significance between them. *T*-tests require 3 main data values; the difference in means, the standard deviation for each group and the number of data values of each group. With these, you would produce 2 values; the *t* value and the degrees of freedom. Using either the *p* value and significance level or the *t*-distribution table, a decision to reject or fail to reject the null can be reached.

### *Confidence Intervals*

Confidence intervals are an estimate that proposes a range of potential values for an unknown parameter. This interval is assumed with a level of confidence. A 95% confidence interval would indicate that there is a 95% chance that the correct value lies within the potential values. When two

values' confidence intervals overlap, significance can be rejected, meaning a story cannot be told about the differences between the two values.

#### D. SIC code groupings

This report used 2007 Standard Industrial Classification (SIC) codes to contextualise information from the customer survey that relates to private sector organisations. This annex explains how groups of potentially relevant firms have been defined based on their SIC codes. For the purposes of this analysis, 'relevance' means that the firms in these SIC codes have some propensity to directly use the NMS labs.

The details of how the industry groupings were defined and generated are as follows:

| Industry groupings                                | SIC code groupings                                                                                                                                                                                                                                          | SIC code numbers |
|---------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Manufacturing (Low to high level)                 | Section C - Manufacturing                                                                                                                                                                                                                                   | 10--33           |
| Other production                                  | Section A - Agriculture, forestry and fishing; Section B - Mining and quarrying; Section D - Electricity, gas, steam and air conditioning supply; Section E - Water supply; sewerage, waste management and remediation activities; Section F - Construction | 01-09, 35-43     |
| Retail and Distribution                           | Section G - Wholesale and retail trade; repair of motor vehicles and motorcycles; Section H - Transportation and storage; Section I - Accommodation and food service activities                                                                             | 45--56           |
| Information and Communication                     | Section J - Information and communication                                                                                                                                                                                                                   | 58--63           |
| Other business services                           | Section K - Financial and insurance activities; Section L - Real estate activities; Section N - Administrative and support service activities                                                                                                               | 64-68, 77-82     |
| Professional, scientific and technical activities | Section M - Professional, scientific and technical activities                                                                                                                                                                                               | 69--75           |
| Unknown                                           | Section T - Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use; Unknown                                                                                                             | 97-98, Unknown   |

"Relevant" firms were defined by using the SIC sections. Sections B-F were included as relevant due to the strong relationship that the NMS labs have with firms within this groups. The NMS works closely with firms within *Manufacturing* industries, as well as those within the Oil & Gas industry that largely make up the UK's *Mining and Extraction* industries. Perhaps to a lesser extent, Construction and Utilities also work directly with the NMS labs. Lastly, firms within Section A, *Agriculture, forestry and fishing*, were omitted as there is little scope for direct involvement with firms within this group.

Codes 49-51 were included due to the NMS labs' role in supporting transportation and distribution, be that by land, air, water or via pipelines. It is unlikely that firms involved in retail, postal and courier services, or warehousing would work directly with the NMS labs in a meaningful way.

Neither would those firms working in *Accommodation and food service activities*, as there is little (if any) overlap between their industry and the work of the NMS labs.

60-63 were included due to the relationship the NMS has in supporting broadcasters and the telecommunication infrastructure that supports them. For example, the NMS labs have done work relating to 4G in the past and work to support 5G is now being conducted. The firms involved in publishing and production, though they require the infrastructure, aren't likely to directly benefit from the work conducted by the NMS labs.

Assessing the *Professional, scientific and technical activities* section, only sic codes 71 (architectural and engineering activities; technical testing and analysis), 72 (scientific R&D) and 74 (other professional, scientific and technical activities) can be classed as relevant, because of the obvious overlap with the scientific activities of the NMS labs. However, legal, accounting and head office services have little to gain from working directly with the NMS labs.

## Contact details

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