

# Evaluation of NRC Measurement Science and Standards

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Office of Audit and Evaluation  
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**Approval:**

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## ACRONYMS AND ABBREVIATIONS

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AAFC	Agriculture and Agri-Food Canada
AECL	Atomic Energy of Canada Limited
ASPM	Administrative Services and Property Management
BIPM	Bureau International des poids et mesures
BMS	Business Management Support
CBSA	Canada Border Services Agency
CFIA	Canadian Food Inspection Agency
CGPM	General Conference on Weights and Measures
CIPM	Comité international des poids et mesures
CLAS	Calibration Laboratory Assessment Service
CMC	Calibration and Measurement Capabilities
CNC	Cellulose nanocrystals
CNSC	Canadian Nuclear Safety Commission
CRM	Certified reference material
DFATD	Department of Foreign Affairs, Trade and Development
DFO	Department of Fisheries and Oceans
DL	Discipline Leader
DND	Department of National Defence
EAC	Evaluation Advisory Committee
EC	Environment Canada
FTE	Full-time equivalent
GDMS	Glow discharge mass spectrometry
GDP	Gross Domestic Product
GM	General Manager
GoCo	Government-owned contractor-operated
HC	Health Canada
HHT	Human Health Therapeutics
HR	Human resources
IC	Industry Canada
IEC	International Electrotechnical Commission
ILAC	International Laboratory Accreditation Cooperation
IMB	Institute for Marine Biology
INMS	Institute for National Measurement Standards
IP	Intellectual property
ISO	International Standards Organization
ITSS	Information Technology and Security Services
MC	Measurement Canada
MIS	Metrology for Industry and Society
MRA	Mutual Recognition Arrangement
MSET	Measurement Science for Emerging Technologies
MSS	Measurement Science and Standards
NINT	National Institute of Nanotechnology
NIST	National Institute of Standards and Technology
NMI	National metrology institute
NMR	Nuclear Magnetic Resonance
NPL	National Physical Laboratory
NRC	National Research Council
NRCan	Natural Resources Canada

OAE	Office of Audit and Evaluation
OAS	Organization of American States
OGD	Other government department
PMO	Project management office
PS	Public Safety Canada
QHR	Quantum Hall Resistance
RCMP	Royal Canadian Mounted Police
R&D	Research and development
RTL	Resource Team Leader
RTO	Research and technology organization
SCC	Standards Council of Canada
SEC	Senior Executive Committee
SI	Système International (international system of units)
SSNMS	Scientific Support for the National Measurement System
TC	Transport Canada
U.K.	United Kingdom
U.S.	United States



## EXECUTIVE SUMMARY

This report presents the results of the 2014-15 evaluation of the National Research Council (NRC) Measurement Science and Standards (MSS) Portfolio. MSS is Canada’s national metrology institute (NMI), conducting research and providing primary metrology services in the national interest. In this role, MSS provides traceability to the International System of Units (the SI, or metric system) for Canada and supports Canada’s participation in the Bureau international des poids et mesures (BIPM). The Portfolio hosts three programs: Metrology for Industry and Society (MIS), Measurement Science for Emerging Technologies (MSET), and Scientific Support for the National Measurement System (SSNMS). Together, MSS activities aim to improve social and economic prosperity by enabling both product and process innovation in areas where precise and reliable measurements are critical to success.

This evaluation assessed the value-for-money of the MSS Portfolio, including relevance, performance, and resource utilization, as well as the ongoing relevance and effectiveness of the assessed contribution to BIPM. It focused on the two-year period since the Portfolio was created (2012-13 to 2013-14). Where appropriate and available, the evaluation also considered earlier information relating to MSS’s predecessor institutes (i.e., 2009-10 to 2011-12). Moreover, recent developments that have occurred since April 2014 were also taken into account.

The key findings for each evaluation issue have been summarized and are presented below, along with the recommendations and management responses.

### Key Findings: Relevance

**Continued Need for Metrology and for a National Metrology Institute in Canada:** Metrology underpins the Canadian economy and society, particularly with respect to the protection of trade interests, enabling innovation and enhancing quality of life. There is a strong need to maintain a national metrology institute and to uphold Canada’s participation in BIPM, as these are vital to international trade.

As outlined in the 2009 Evaluation of the NRC Institute for National Measurement Standards, and confirmed by both internal and external interviewees, measurement infrastructure continues to be important for the protection of trade interests, enabling innovation and enhancing quality of life. The BIPM provides the structure for members of the Inter-Governmental Treaty of the Metre Convention to act in common accord on all matters relating to units of measurement. That is, participation in BIPM essentially provides members with an internationally recognized system of measurement. As a major industrialized country dependent on international trade, Canada’s continued participation in BIPM is considered vital.

There is also a continued need for other MSS activities, including calibrations and other technical services, the provision of certified reference materials, CLAS-related services, and research in emerging areas of metrology. Most industry clients interviewed as part of the evaluation felt that their needs were being met by MSS. Most clients also reported that they had no other options within Canada to address their needs, given the specific services requested or the high level of precision required.

**Meeting the Needs of Other Government Departments:** MSS plays a very specific, critical and complementary role in supporting the other core partners in Canada's national measurement system (Measurement Canada and the Standards Council of Canada) and together, the partners directly support many federal departments and agencies in meeting their specific measurement needs. Nevertheless, there may be a greater role for MSS to play with regards to disseminating knowledge and proposing opportunities to its current and potential federal government clients.

MSS is a key player in Canada's national measurement system, along with Measurement Canada (MC) and the Standards Council of Canada (SCC). The roles and responsibilities of these three core partners in serving the measurement needs of other government departments (OGDs) are, for the most part, clearly defined and differentiated.

Federal government departments and agencies typically use metrological information and services to support their objectives and missions. These are most frequently regulatory in nature. MSS revenues from OGDs have grown significantly in recent years. In 2013-14, all strategic research revenue earned by MSS was derived from projects for OGDs. This indicates the importance of measurement services and solutions provided by MSS to OGDs.

OGD representatives interviewed generally felt that MSS is adequately supporting their measurement needs. However, some revealed that they have difficulty staying up-to-date on metrology developments and the possible implications that these developments could have for their sectors. These interviewees indicated that they rely on MSS to disseminate knowledge and make them aware of possible technological challenges and opportunities for their organizations. Furthermore, some OGDs reported a lack of understanding and knowledge of the services that MSS can provide. Where this knowledge exists, it is largely dependent on individual relationships with MSS staff. This presents an opportunity for MSS, in collaboration with NRC Business Management Support (BMS), to be more proactive in identifying the potential metrology-related needs of OGDs and reaching out to potential federal government clients.

**Recommendation 1:** *In order to better support OGDs, MSS should be more deliberate in its efforts to understand the regulatory environment and be proactive in performing complementary R&D. Such efforts should take into consideration the current and future capacity of MSS staff.*

**Management Response and Proposed Actions:** Accepted. Based on MSS's current and successful projects that support the measurement needs of OGDs, the Research Director will draft a high level view of "what works". Based on this, a template will be developed to mentor and guide BMS and scientific staff to engage OGDs to identify pre-regulatory and standardization related measurement challenges.

**Alignment with Federal Roles, Responsibilities and Priorities:** MSS objectives and activities, including maintaining Canada's affiliation with BIPM, align with federal priorities and are consistent with federal roles and responsibilities.

NRC's mandate to act as Canada's national metrology institute is supported by legislation, including the *NRC Act* and the *Weights and Measures Act*. Canada's affiliation with BIPM stems from the Government of Canada's status as a State Party to the Metre Convention. By representing Canada on the international metrology stage through its affiliation with BIPM, NRC is able to more effectively and efficiently respond to its mandated responsibility for maintenance of national measurement standards.

Metrology is broadly considered to be the responsibility of government, at least to some extent, in

all major industrialized countries. Still, when it comes to the delivery and operation of an NMI, there is no definitive model. All international NMI representatives interviewed were supportive of the Canadian model and identified clear benefits associated with including the NMI as part of a country's research and technology organization (RTO).

The objectives and activities of the MSS Portfolio align with NRC's strategic outcome of providing "R&D infrastructure for an innovative and knowledge-based economy." They also align with Government of Canada priorities, particularly as these relate to supporting international trade.

## Key Findings: Performance

**Positioning and Progress toward the Achievement of Expected Outcomes:** Overall, MSS is performing well and is well-positioned to achieve expected program outcomes, despite some challenges in acquiring an optimal level of human resources.

Internal interviewees generally felt that despite aging equipment, MSS facilities and equipment are adequate to meet current program needs. As for human resources, MSS has encountered various challenges related to staffing, as well as a high level of voluntary turnover. As a result of this, current human resource levels are well below those that were planned in order to meet program needs. Services to clients have also been affected in some cases. Portfolio management is aware that current MSS human resources are not adequate and has made considerable efforts over the past year to address this risk.

**Recommendation 2:** *Given that sub-optimal human resource levels have affected client services and pose a significant risk to future portfolio performance, MSS must continue to place a strong emphasis on staffing in order to address human resource gaps. As the programs mature, resource staffing needs will need to be adjusted to ensure that the portfolio can respond in a timely and adequate manner.*

**Management Response and Proposed Actions:** Accepted. The 2015-16 MSS strategic and operating plans include a human resources (HR) hiring and succession plan developed in consultation with the MSS Directors, Discipline Leaders and Resource Team Leaders. The Research Director will steer the execution of this plan, leveraging generic competitions for multiple positions to hire cross-disciplinary resources and identify multiple candidates from a single competition. The portfolio will review and update the HR plan quarterly at the management team level.

Despite the resourcing challenges it has experienced, MSS appears to be performing well, having achieved 93% of its revenue target in 2013-14. The Portfolio is also generally making good progress in achieving key program implementation milestones. The only significant delay that was noted involves the establishment of the Biometrology group, as part of the MSET program.

Other non-financial performance indicators have been identified for the portfolio and for its hosted programs. However, this information has not been collected to date and was unavailable for the evaluation. Program Leaders pointed out that performance indicators or targets as set out in the original business plans are in many cases no longer appropriate or relevant to measure the performance of the program in the current environment.

**Recommendation 3:** *MSS should review and update the performance measurement frameworks for the Portfolio and for its hosted programs to ensure that performance indicators are relevant and targets are realistic. MSS should also clarify responsibilities for*

*collecting and reporting on performance information.*

**Management Response and Proposed Actions:** Accepted. The Program Leaders are updating implementation plans for each program. These will include updated and realistic performance indicators and targets for the programs. Further, the plans will include details on how and by whom the data will be collected, reported and reviewed. These plans will be completed by the Program Leaders, will be reviewed by the MSS management team, and will also be available for review by the office of the Vice President, Emerging Technologies.

The MSS operating plan will include updated and realistic performance indicators and targets for the portfolio, as well as details on how and by whom the data will be collected, reported and reviewed. The completion of the plan will be managed by the Director of Operations. The plan will be reviewed by the MSS management team and available for review by the office of the Vice President, Emerging Technologies.

**Impacts on Clients:** The evaluation found qualitative evidence of economic and social impacts resulting from MSS products and services. The most common direct impacts experienced by clients revolve around improved measurement knowledge and enhanced access to credible measurement services. Indirectly, MSS services have also had a positive economic impact on downstream firms that rely on MSS's unbroken chain of traceability to international standards.

The most common impacts experienced by industrial clients of MSS revolve around improved measurement knowledge and enhanced access to credible measurement services. These two impacts were cited by almost all industrial clients interviewed. Some clients also stated that improved measurement knowledge has led to improved internal processes within the company, as clients learned new testing methods, or were made aware of deficiencies in their measurement procedures.

Some industrial clients stated that MSS products or services have had an impact on their business productivity or revenue. Some also reported that MSS measurement products or services have directly enabled them to offer a new product or service. This is particularly true for clients who had licensed IP developed by MSS or its predecessor institute. Those who reported this as an impact generally highly attributed this impact to MSS, with some clients even stating that the IP was vital to the development of their products. MSS also indirectly plays a role in enabling downstream firms (i.e., clients of a CLAS and SCC-accredited laboratory) to introduce a new product or service, or to improve an existing product.

The evaluation also found some examples that demonstrate how MSS has contributed to reducing technical barriers to trade for some direct and indirect clients and has contributed to their ability to sell their products internationally. As this is an intermediate level impact for MSS, it should be noted that there are many other external factors contributing to the ability of Canadian companies to sell their products internationally.

Finally, the evaluation found some examples of cases where the work of MSS has had an impact on Canadian society, either through contributions to the health and safety of Canadians, to improvements to their quality of life, or to environmental protection.

**International Reputation for Metrology:** MSS is well perceived among its international peers and Canada's reputation as a contributor and a participant in international metrology activities has been strengthened over the past five years.

All four representatives of international NMIs who were interviewed as part of the evaluation noted that Canada's international reputation is at least as strong, if not stronger than it was five years ago. Because of this strong reputation, there is a high level of confidence, internationally, in the standards maintained by NRC.

One factor that has contributed to strengthening MSS's international reputation has been increased participation and leadership in activities of the international metrology community. Not only has Canadian representation on CIPM committees increased over the past five years, but international NMI representatives have also noticed a broader participation of MSS staff and increasingly active roles in these committees (for instance leading committees and participating in working groups).

Canada is also recognized as having made a noteworthy contribution to key metrology research developments, notably the redefinition of the kilogram. Using experiments based on the watt balance, MSS has been able to achieve the most precise determination of the Planck constant to date. As stated by one international NMI interviewee, "unequivocally, this has been a major contribution to fundamental metrology."

MSS activity levels with respect to publications and participation in international key comparisons have remained more or less consistent over the past five years.

### Key Findings: Resource Utilization

**Operational efficiency:** MSS is operationally efficient and expenditures related to the maintenance of Canada's NMI are reasonable. Efforts undertaken to improve efficiency include the implementation of matrix-based management within the Portfolio and the improvement of project management practices.

NRC corporate key performance indicators show a relatively high level of overhead efficiency and business efficiency (staff utilization). What's more, MSS expenditures appear to be reasonable when compared to expenditures of other NMIs.

International NMI representatives highlighted some benefits associated with including a country's NMI within an RTO, including access to complementary expertise, facilities and equipment. They noted that Canada's model also allows MSS to benefit from existing industrial relationships and to be more aware of leading edge industry innovations. This could potentially improve MSS's ability to anticipate future measurement needs and to deliver on standards of the future.

MSS has recently implemented a matrix structure within the Portfolio, whereby human resources have been reorganized into four teams, each led by a new Resource Team Leader. This change was made in an effort to create a more unified MSS, improve efficiency, contribute to succession planning, and reduce the administrative burden on Discipline Leaders. Internal interviewees had mixed reactions regarding the potential efficiencies gained through the reorganization, which had been introduced in April 2014 and was still relatively new at the time when internal interviews took place for the evaluation. MSS management will continue to monitor operations under the new structure and will make adjustments where and when necessary.

While resource sharing is common between MSS's three hosted programs, there have been more limited opportunities for staff to support programs hosted by other portfolios within NRC.

### Key Findings: Resource Utilization

Internal interviewees explained that this is in part due to the unique characteristics and requirements of an NMI. Interviewees also suggested that MSS resources are already heavily utilized, so there are limited opportunities for them to be deployed to other portfolios.

MSS has recently sought to improve some of its project management practices, in an effort to increase operational efficiency. The Portfolio had also identified the creation of a project management office (PMO) as one of its priorities for 2014-15. However, due to competing priorities over the past year, the PMO has not yet been established. MSS staff emphasized the need to prioritize this initiative, in order to reduce the administrative burden that is currently being assumed by research staff.

**Recommendation 4:** *MSS should prioritize the implementation of a Project Management Office within the Portfolio.*

**Management Response and Proposed Actions:** Accepted. MSS has already made significant advances in the planning and design of a project management support office for the Portfolio. The people will be trained and in the roles by June 1, 2015. The Portfolio will put in place processes for project selection, creation and launching, as well as processes for project monitoring and review, including criteria for prioritizing project reviews.



## 1. INTRODUCTION

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This report presents the results of the 2014-15 evaluation of the National Research Council (NRC) Measurement Science and Standards (MSS) Portfolio. MSS is Canada's national metrology institute (NMI), conducting research and providing primary metrology services in the national interest. In this role, MSS provides traceability to the International System of Units (the SI, or metric system) for Canada and supports Canada's participation in the Bureau international des poids et mesures (BIPM).

Following the evaluation overview presented below, Section 2 of this report provides a profile of MSS. Sections 3, 4 and 5 present the evaluation study's findings organized by broad evaluation question (relevance, performance, resource utilization) along with associated recommendations. Section 6 presents a brief conclusion drawn from the evaluation, while Section 7 lays out the management response to these recommendations and the actions that will be taken as a result.

### 1.1 Evaluation Overview

This evaluation assessed the value-for-money of the MSS Portfolio, including relevance, performance, and resource utilization, as well as the ongoing relevance and effectiveness of the assessed contribution to BIPM. It focused on the two-year period since the Portfolio was created (2012-13 to 2013-14). Where appropriate and available, the evaluation also considered earlier information relating to MSS's predecessor institutes (i.e., 2009-10 to 2011-12). Given the focus on identifying and assessing intermediate impacts from MSS activities, earlier institute activities were considered in the assessment of client impacts, specifically in the case studies that were conducted as part of the evaluation. Moreover, recent developments that have occurred since April 2014 were also taken into account.

Evaluations are conducted at the portfolio level. The relevance and performance of the three MSS-hosted programs are examined insofar as portfolio outcomes are achieved as a result of program activities. The portfolio-hosted programs will undergo a more in-depth assessment at a later date as part of planned mid-term program reviews. It is expected that information drawn from this evaluation could contribute to these reviews.

The scope of this evaluation also includes an assessment of the ongoing relevance and effectiveness of the assessed contribution to the BIPM. The evaluation of this transfer payment was included because the payment is managed by the MSS Portfolio and MSS staff plays a significant role in supporting Canadian participation in BIPM.

This evaluation was led by an independent evaluation team from the NRC Office of Audit and Evaluation (OAE). The work of the evaluation team was supported by an Evaluation Advisory Committee (EAC), which provided advice related to the evaluation framework, approach, interpretation of findings and recommendations. These experts did not act in a decision-making capacity, but rather played an advisory role in ensuring a high-quality and useful evaluation product.

#### 1.1.1 Evaluation Rationale

The MSS Portfolio was selected for evaluation based on consultations with NRC Senior Management and the work was carried out in accordance with NRC's approved evaluation plan. As all three MSS-hosted programs were among the first to be approved through the NRC

business planning process, they were expected to have progressed further towards the achievement of their objectives than more recently approved programs. Further, the majority of MSS Portfolio resources were drawn from the former NRC Institute for National Measurement Standards (INMS), which was evaluated five years ago. As per Treasury Board's *Policy on Evaluation* (2009), all programs benefiting from any level of direct program spending must be evaluated every five years. As for the assessed contribution to the BIPM, the evaluation of this transfer payment was completed in August 2010, as part of the Evaluation of the NRC program of Class Grants to International Affiliations. Therefore, this evaluation also satisfies the requirements of the *Financial Administration Act* (section 42.1), that is, that all ongoing programs of grants and contributions be evaluated every five years.

### **1.1.2 Evaluation Design and Methodology**

The evaluation questions, outlined at the start of each section, are based on consultations with portfolio management and a review of key documents during the planning stage. Portfolio management identified specific areas of interest and information needs for the evaluation, which were incorporated into the evaluation design. The evaluation design meets management needs as well as the requirements of the 2009 Treasury Board *Policy on Evaluation*. It also takes into consideration prior evaluation evidence and places a greater emphasis and level of effort on aspects of the Portfolio that were not examined in detail in the previous evaluations.

To enhance the reliability and validity of the information and data collected, the methodology for this evaluation includes multiple lines of evidence and complementary research methods. The specific methods used in the study include:

- Internal and external document review
- Administrative and performance data review
- Semi-structured interviews
  - 23 internal interviewees (including MSS management and staff, as well as staff from NRC Human Resources and NRC Business Management Support)
  - 15 external interviewees (including client organizations, other Canadian industry stakeholders, and four heads of international NMIs)
- Case studies
  - A series of five case studies, based upon reviews of project and client documentation, as well as both internal and client interviews.
  - Three of these case studies were updates to examine the longer-term impacts of cases examined as part of the 2009 INMS Evaluation.
  - As input into one of the case studies, the evaluation team also conducted an online survey of clients of a laboratory certified through the Calibration Laboratory Assessment Service (CLAS). These end users of metrology were surveyed to examine the intermediate impacts of MSS on Canadian industry who are not direct clients of MSS.



- Social Network Analysis
  - A relationship mapping of the federal departments involved in Canada’s measurement system, including those who produce, disseminate and use measurement products and services.
  - This exercise also included interviews with 14 clients from other government departments (OGDs).

For interviews, the following scale is used in the text of the report to indicate the relative weight of the responses for each of the respondent groups.

**Table 1: Scale used when reporting on views and opinions of respondents**

All/almost all	90% or more
Many/most	At least 50% but less than 90%
Some/several	At least 25% but less than 50%
A few	At least two respondents but less than 25%

A more detailed description of the study methodology, limitations and challenges is provided in **Appendix B: Methodology**.

## 2. PROFILE OF THE MSS PORTFOLIO

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The MSS Portfolio was created on April 1, 2012, through a merger of resources drawn from the former INMS and smaller subsets of resources from five other former institutes: the Steacie Institute for Molecular Sciences; the Institute for Marine Biosciences; the Institute for Chemical Process and Environmental Technology; the Institute for Microstructural Science; and, the Institute for Information Technology.

MSS is Canada's NMI. In this role, MSS conducts research and provides primary metrology services across a broad spectrum of disciplines in support of partners in government and industry. It does this in an effort to improve social and economic prosperity by enabling both product and process innovation in areas where precise and reliable measurements are critical to success.<sup>1</sup> A full logic model, developed as part of evaluation planning, details the activities, outputs and intended outcomes of the MSS Portfolio (**Appendix A: MSS Logic Model**).

### 2.1 Support to NRC Programs

At NRC, portfolios are the business units responsible for managing people and facilities. These resources are then deployed to various programs that have been approved by NRC's Senior Executive Committee (SEC). At this time, the large majority of MSS resources are supporting MSS-hosted programs. MSS currently hosts three NRC programs, all of which were approved for implementation in June 2012:

- **Metrology for Industry and Society (MIS):** The MIS Program enables vital Canadian sectors, where high precision and credible measurement have a significant impact on market success, to better compete, conform and connect on a global stage. The program's approach includes the provision of measurement standards, including calibration services, the production of Certified Reference Materials (CRMs), glow discharge mass spectrometry (GDMS) services, and the conduct of metrology-related research. Services are delivered in the following discipline areas: chemical metrology, electrical metrology, ionizing radiation standards, mechanical metrology, electrical power measurements, frequency and time, biotoxin metrology, and photometry, radiometry and thermometry. These services aim to improve the productivity of clients in target sectors, and also to ensure that Canadian companies meet both supply chain and global market access requirements.
- **Measurement Science for Emerging Technologies (MSET):** The MSET Program is focused on identifying, developing and advancing the next generation of measurement capabilities that will be required to effectively support Canadian industry and society. This includes gaining a deeper understanding of the potential applications for new technologies and the implications of their introduction to the marketplace. The program is organized into three discipline areas: black carbon metrology, biometrology, and nanoscale metrology. Program activities include developing new measurement science standards and deploying extreme measurement capabilities.
- **Scientific Support for the National Measurement System (SSNMS):** The SSNMS Program aims to ensure that Canada's interests are well-represented internationally while also making certain all MSS-hosted programs are informed by, and can provide effective science advice to evolving national and international policy priorities. The program is focused on delivering coherent scientific advice to improve and inform national decision-

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<sup>1</sup> National Research Council Canada, *Measurement Science and Standards Strategic Plan 2014-2019*, December 2013.

making for commerce, standards development, regulation and trade agreements. This is done by establishing and strengthening relationships with federal and provincial government stakeholders, assimilating market insights and policy intelligence gathered through networking, and participation in domestic and international forums. The program also expands the number of, and the capabilities of, third-party calibration laboratories through the delivery of CLAS, which serves as a bridge between the Standards Council of Canada (SCC) and laboratories seeking accreditation to International Standards Organization (ISO) standards. SSNMS is also primarily responsible for maintaining the MSS Quality Management System.

## 2.2 International Bureau of Weights and Measures (BIPM)

Located in Sèvres, France, the BIPM is an intergovernmental organization that was created by the Metre Convention (*Convention du Mètre*). This international diplomatic treaty, signed in 1875, established a permanent financial, management and organizational structure for member governments to act in common accord on all matters relating to units of measurement.

The BIPM is financed jointly by 55 Member States which include all major industrialized countries. Canada became a Member State by acceding to the Metre Convention in 1907. As Canada's NMI, MSS represents Canada in activities related to the Metre Convention, including supporting Canada's participation in the BIPM.

The BIPM operates under the authority of the General Conference on Weights and Measures (CGPM) which acts as a governing council and is composed of delegates of the governments of Member States. Its operations are supervised by the International Committee for Weights and Measures (CIPM) which acts as a management board and is composed of 18 individuals, each with a different nationality, elected by the CGPM.

Within this framework, and in collaboration with NMIs worldwide, the BIPM fulfills its mandate of providing the basis for a single, coherent system of measurements throughout the world, traceable to the SI. This mandate is operationalized through a series of consultative committees whose members are the national metrology laboratories of the Member States, and through the BIPM's own laboratory work, which includes carrying out measurement-related research and calibrations in selected areas for some Member States, depending on the technical sophistication of their NMIs. NMIs then disseminate measurement standards through calibration services to national scientific, industrial, commercial and public sector users.

The BIPM also takes part in, and organizes, international comparisons of national measurement standards as required by the CIPM Mutual Recognition Arrangement (MRA). Signed in 1999, the CIPM MRA provides governments and other parties with a foundation for wider agreements related to international trade, commerce and regulatory affairs. This is achieved through establishing the degree of equivalence of national measurement standards maintained by the participating NMIs, and by involving mutual recognition in the calibration and measurement certificates issued by participating NMIs. NMIs of 48 Member States, three international organizations and 27 Associates of CGPM have since signed the CIPM MRA.

## 2.3 Canada's National Measurement System

Canada's national measurement system is comprised of three key players: NRC (MSS), Measurement Canada (MC), and the Standards Council of Canada (SCC). Together, these core partners in Canada's national system deliver on a framework that strengthens competitiveness, supports innovation and international trade, advances the social well-being of Canadians, and

supports new and emerging technologies. As the primary centre of reference for the accuracy, validity, and traceability to the SI, MSS anchors Canada's national measurement system and provides a fundamental technical infrastructure that supports Canadian industry and the Canadian public.

**Measurement Canada** is a Special Operating Agency of Industry Canada. It has sole jurisdiction with respect to the administration and enforcement of the *Weights and Measures Act* and the *Electricity and Gas Inspection Act*. As a result, MC is responsible for legal metrology within Canada. Legal metrology is the part of metrology that deals with trade, units and methods of measurement and measuring instruments in relation to mandatory technical and legal requirements. MC's mandate is summarized as "ensur[ing] equity and accuracy where goods and services are bought and sold on the basis of measurement, in order to contribute to a fair and competitive marketplace for Canadians."<sup>2</sup>

The **Standards Council of Canada** is a federal Crown corporation that oversees Canada's national standardization network and provides accreditation to over 400 organizations in Canada. SCC's mandate is to "promote efficient and effective voluntary standardization in Canada, where standardization is not expressly provided for by law."<sup>3</sup> As a signatory to a number of Mutual Recognition Agreements and Multilateral Agreements that assist with international acceptance of conformity assessment results, such as the International Accreditation Forum and the International Laboratory Accreditation Cooperation (ILAC), SCC is part of an international effort to form a global accreditation system. The system aims to obtain global acceptance for "one standard, one test, one certification."<sup>4</sup> Related to this, SCC is also a member of ISO and the International Electrotechnical Commission (IEC), along with other regional standards groups.

Together, these three core organizations serve the measurement needs of a number of federal government departments and agencies, as well as those of other Canadian stakeholders, including private sector calibration laboratories and industry end users.

## 2.4 MSS Organizational Structure

The General Manager (GM) of the MSS Portfolio reports to the Vice-President, Emerging Technologies, and has overall managerial accountability for the Portfolio. The GM is currently supported by three Directors (two Directors of Research and one Director of Operations) and three Program Leaders.

Recently, MSS underwent an internal restructuring whereby MSS staff was regrouped into four resource teams. Each team is headed by a Resource Team Leader (RTL) responsible for managing the human resources within their team. The RTLs report directly to one of the Directors of Research.

Discipline Leaders provide functional supervision of project staff and frequently take on the role of project managers (although this is not always the case). They report to one of the Directors of Research for issues related to human resources and to the Program Leaders for program-related deliverables.

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<sup>2</sup> Industry Canada, *Measurement Canada*, <http://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm03962.html>.

<sup>3</sup> Standards Council of Canada, *Mandate, Mission and Vision*, <https://www.scc.ca/en/about-scc/mandate-mission-vision>.

<sup>4</sup> Standards Council of Canada, *Accreditation Services Branch*, <https://www.scc.ca/en/about-scc/operations/accreditation-services>.

## 2.5 Portfolio Resources

### 2.5.1 Human Resources

MSS currently has a staff of approximately 150 employees, located primarily in Ottawa, with a smaller group in Halifax.<sup>5</sup> The current complement of staff includes 123 continuing full-time employees (FTEs), while the remainder is made up of term and short-term positions, post-retirement terms and supplementary/student positions.

### 2.5.2 Financial Resources

As the MSS Portfolio has only existed since April 1, 2012, historic financial data before that time are not available. As well, with 2012-13 being a year of transition, financial figures for that year are not considered to be typical.

For 2013-14, MSS reported total expenditures (direct and indirect) of approximately \$26.7M. Approximately 20% of these expenditures were offset by earned revenues (\$5.7M), which were derived mainly from technical services (see Table 2). Approximately \$1.3M of the Portfolio's revenue is categorized as "other revenue" (as opposed to technical services and strategic research) and comes from the sale of CRMs.

**Table 2: MSS financial data (\$)**

	2012-13	2013-14	2014-15 (Budgeted)
<b>Earned Revenues</b>			
Technical Services	4,690,617	3,464,103	3,446,200
Strategic Research	344,981	891,974	1,313,200
Other Revenue	1,195,214	1,340,153	1,200,000
<b>TOTAL EARNED REVENUES</b>	<b>6,230,811</b>	<b>5,696,230</b>	<b>5,959,400</b>
NRC Program Investment <sup>6</sup>	-	16,758,498	20,900,000
<b>TOTAL INCOME</b>	<b>6,230,811</b>	<b>22,454,728</b>	<b>26,859,400</b>
<b>Total Direct Expenditures</b>	<b>17,748,406</b>	<b>23,470,296</b>	<b>26,835,833</b>
<b>Total Indirect Expenditures</b>	<b>9,109,557</b>	<b>3,264,574</b>	<b>2,380,344</b>
Gains/Losses and other adjustments	-9,427	-30,559	-
<b>NET INCOME OR LOSS</b>	<b>-20,636,578</b>	<b>-4,310,701</b>	<b>-2,356,777</b>
<b>Total Capital Investment</b>	<b>1,899,664</b>	<b>3,270,862</b>	<b>2,770,142</b>

Source: NRC Finance Branch (Statements of Operations)

MSS direct expenditures include its annual assessed contribution to the operating budget of BIPM. Member States are expected to contribute a percentage share of BIPM's budget (referred to as a "dotation"), which is determined by a formula developed by the United Nations General Assembly based on each country's Gross Domestic Product (GDP). These funds are used by the BIPM to deliver the work program approved by the CGMP. From 2003 to 2012, there were two portions to the payment – a fixed portion that all Member States were expected to pay in full

<sup>5</sup> Human resource numbers were recorded in October 2014.

<sup>6</sup> Both the NRC Program Investment and the Net Loss are covered by NRC A-base and B-base funding.

and a supplementary portion that was discretionary and used for special projects. Over this period, Canada always agreed to pay the supplementary contribution as the projects were deemed beneficial to Canada. The majority of Member States also opted to pay the supplementary contribution.

Canada's current assessed contribution amounts to about 4% of the total BIPM dotation. Because the transfer payment is made in euros, the actual transfer payment cost is subject to currency fluctuations. Table 3 provides financial figures for Canada's contribution to the BIPM dotation for the past five years.

**Table 3: Canada's contribution to the BIPM**

Year	Base contribution (€)	Supplementary contribution (€)	Canada's assessed BIPM dotation (€)	Canada's transfer payment to BIPM (\$CAN)
2010	423,165	16,020	439,185	650,609
2011	444,909	16,581 + 249 <sup>7</sup>	461,739	620,762
2012	447,001	16,895	463,896	617,742
2013	439,199	-	439,199	594,193
2014	382,891	-	382,891	571,197

Source: BIPM and NRC Finance Branch

In addition to these assessed contributions, the administrative cost for the transfer payment is approximately \$10,000 per year. There are also noteworthy in-kind costs related to MSS staff involvement in activities related to the BIPM, including:

- Participation in meetings/events of BIPM committees;
- Participation in key comparisons required by the CIPM MRA;
- Implementation and maintenance of a Quality Management System required by the CIPM MRA; and
- Participation in the expert review of other metrology institutes.

Costs related to these activities are generally attributable to the SSNMS Program, and have been estimated in the past at approximately \$1.5 million per year.<sup>8</sup>

### 2.5.3 Physical Resources

The Portfolio currently holds capital assets valued at approximately \$13M (book value). These include a wide range of facilities, including nuclear magnetic resonance (NMR), radiometry, thermometry and spectrophotometry facilities, dimensional laboratories, time equipment and facilities, and a three-dimensional imaging laboratory, among others.

## 2.6 Profile of MSS Clients

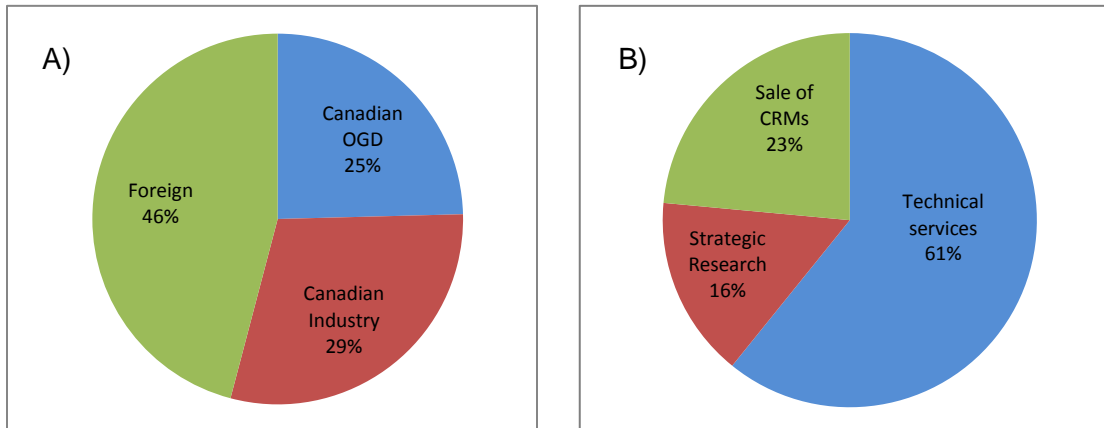
As shown in Figure 1 A, on the following page, almost half of MSS revenue in 2013-14 came from foreign sources and over half of this amount was for the sale of CRMs. Another 29% of revenue came from Canadian industry sources and the final 25% came from OGDs.

<sup>7</sup> The 2011 supplementary amount includes an additional 249 € adjustment to the previous year's supplementary amount.

<sup>8</sup> National Research Council Canada, *Performance Measurement Strategy for the Class Grants to International Affiliations: Bureau International des Poids et Mesures (BIPM)*, April, 2011.

It is important to highlight that, due to the nature of MSS’s business, the majority of revenue is derived from technical services (61%) and from the sale of CRMs (23%). Sixteen percent (16%) of revenue in 2013-14 came from strategic research projects (see Figure 1 B). These were exclusively with OGD clients. Technical services, such as calibrations and the sale of CRMs generally represent relatively low contract values. As a result, the composition of MSS clients is highly fragmented. For 2013-14, only 89 of MSS’s 842 clients (11%) had projects valued over \$10,000, and only 11 (1%) had projects valued at over \$100,000.

**Figure 1: MSS sources of revenue, by client type (A) and by contract type (B) (2013-14)**



Source: SIGMA

### 3. RELEVANCE

The relevance of the MSS Portfolio was examined from the perspectives of: Canada's need for a national metrology institute (section 3.1); its role in meeting the metrology-related needs of other government departments (section 3.2); and, its alignment with federal roles, responsibilities and priorities (section 3.3).

#### 3.1 The Need for Metrology and a National Metrology Institute in Canada

**Evaluation Question 1: What is Canada's need for metrology in general and a national metrology institute specifically?**

**Assessment:** Metrology underpins the Canadian economy and society, particularly with respect to the protection of trade interests, enabling innovation and enhancing quality of life. There is a strong need to maintain a national metrology institute and to uphold Canada's participation in BIPM as these are vital to international trade.

##### 3.1.1 Importance of Metrology to the Canadian Economy and Society

**Key Finding 1:** Measurement infrastructure is important for the protection of trade interests, enabling innovation and enhancing quality of life.

It has frequently been stated that metrology underpins most key components of our economy and society. The importance and need for metrology, and for international coordination of metrology, was outlined in the 2009 evaluation of INMS. The evaluation report details the role of metrology, as a public good, and explains how it responds to three needs of Canadian government and industry:

- Metrology **protects trade interests** by providing confidence in the measurement system and by contributing to the reduction of measurement-related technical barriers to trade. In particular, the CIPM MRA was established to enable the mutual recognition of national measurement standards and of calibration and measurement certificates issued by NMIs. This provides users with reliable quantitative information on the comparability of national metrology services and provides the technical basis for wider agreements negotiated for international trade, commerce and regulatory affairs. The importance of the agreement is evidenced by the fact that in 2012, over 90% of world trade in merchandise exports was between CIPM MRA participant nations.<sup>9</sup>
- Metrology **enables innovation** by ensuring reproducible manufacturing processes. To remain competitive, Canada must ensure that its industrial sector is able to keep up with an accelerating pace of technology development. By meeting ever-increasing requirements for accuracy and precision in standards and measurements needed for manufacturing and other segments of the economy, metrology provides the basis on which innovation can take place.
- Metrology **contributes to the quality of life of Canadians**. Improvement of quality of life is highly served by reliable, traceable and more accurate measurements, particularly in areas such as health care, food safety and nutritional content, environmental and pollution control, and forensics and security.

<sup>9</sup> Based on data from the World Trade Organization (WTO), *International Trade Statistics 2013*, p. 84.



Internal and external interviewees agreed that these needs still exist, and some noted that they continue to gain importance, particularly for a country dependent on international trade such as Canada. Interviews with the heads of some international NMIs also revealed that international cooperation in metrology is growing increasingly important as it relates to shared information around new or changing metrology needs and developing common strategies to address global challenges, such as climate change.

### 3.1.2 Importance of Canadian Participation in BIPM

**Key Finding 2:** *As a major industrialized country dependent on international trade, Canada's continued participation in BIPM is considered vital.*

The Inter-Governmental Treaty of the Metre Convention aims to establish and maintain a unique, long-term and stable global measurement system which defines measurement units and measurement standards. Created through this treaty, BIPM provides the structure for members to act in common accord on all matters relating to units of measurement. Along with the CIPM and its scientific Consultative Committees, BIPM is in charge of disseminating traceability, facilitating international cooperation, organizing comparisons, representing the global metrological community, and liaising with other inter-governmental and international organizations with an interest in metrology. As of July 2014, 56 states (including all major industrialized countries) were members of the Metre Convention and another 41 states were associates of the CGPM. All international NMI interviewees were in agreement that an international body for the coordination of metrology activities is essential. They also agreed that BIPM and CIPM currently fulfill this role and are effective.

All of the international NMI interviewees stressed the importance for major industrialized countries to maintain a strong national metrology system and supported the need for Canada to maintain its own NMI. They also felt that there would be severe consequences if Canada (or any other industrialized country) chose not to participate in BIPM and CIPM, as such a situation would imply that Canada would essentially be withdrawing from the Metre Treaty. In the words of one interviewee, "to do so would mean that Canada would no longer have an internationally recognized system of measurement." This would have repercussions, for example on international trade and on foreign investments (i.e., Canada could no longer be part of the CIPM MRA and there would be diminished confidence in the amount of traded goods and in the quality of industrial production within the country). As noted by one NMI interviewee, "international trade relies more and more on internationally accepted conformity testing and mutually recognized measurements, making trade crucially dependent on metrology."

Having an NMI and participating in BIPM and CIPM is also a question of sovereignty for Canada. The international metrology community is very cooperative and it may be possible for a country to purchase some measurements or calibration services from other international NMIs (i.e., it is not necessary for every country to do everything for itself, particularly in areas where there is not a high demand from industry). However, one international NMI interviewee noted that such situations generally work best when they involve an equitable exchange of services and most indicated that oversight of primary legal standards is something that should be sovereign to a particular country. Interviewees also raised other consequences related to sovereignty:

*"Overall, it is characteristic for a developed industrialized country to have a well-functioning metrology system and it is viewed as an undesirable situation to purchase metrology from another country to a large extent."*

- International NMI interviewee

- **More difficulty acquiring services that fit the needs of the country.** NMIs must be able to respond to specific challenges or new opportunities being faced by their country's industries. Without an NMI in the country, industry would always be waiting for other countries to make those developments first. All activities requiring traceability to the SI system of units would necessarily need to rely on the willingness and capability of foreign institutes to provide the services.
- **Lack of input to metrology decisions.** Through the Metre convention, the international community agrees to common definitions and realizations of units for global use. The ability to contribute to, and influence, the process of standards development in areas of Canadian interest can lead to a market advantage for Canadian industry. Without an NMI, a country would be excluded from this discussion.
- **Knowledge transfer to industry would be difficult to arrange.** There is a need for expertise and understanding of metrology as it relates to the local infrastructure. Many companies do not understand what measurement could do for them; therefore it is the role of the NMI to present this to them.

### 3.1.3 Continued Need for Other MSS Services

**Key Finding 3:** *In addition to MSS activities related to supporting Canada's participation in BIPM, there is also a continued need for other services, including calibrations and other technical services, the provision of CRMs, CLAS-related services, and research in emerging areas of metrology.*

#### *Calibrations and other technical services*

Canada currently maintains 614 internationally recognized Calibration and Measurement Capabilities (CMCs). This is up from 594 CMCs reported in 2010 and places Canada in eleventh place in a global ranking of number of CMCs. MSS determines which capabilities are maintained based on industry demand and ensures that services can be accessed elsewhere (for example, from other NMIs) if the need is not large enough to require a domestic capacity.

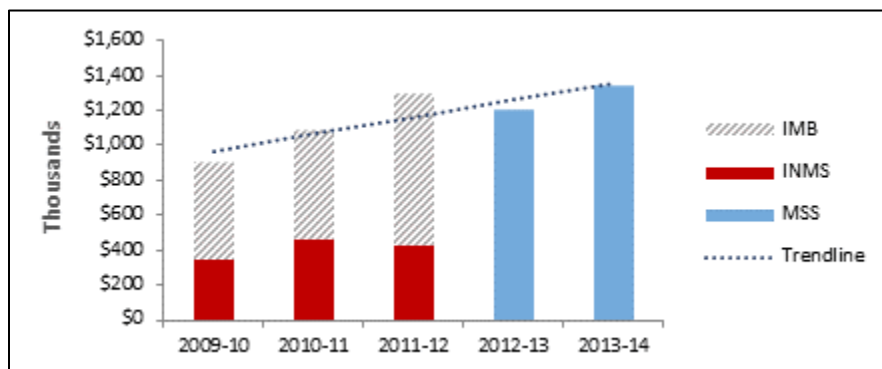
Over the last five years, MSS has completed about 5,000 technical service agreements per year, primarily with industry and government clients. Although project data shows a slight decrease year over year in the number of agreements, MSS interviewees have indicated that this reflects a natural and desirable evolution, as calibration capabilities are disseminated to second-level calibration laboratories and more clients acquire services from these laboratories (in cases where a lower precision is acceptable).

#### *Sale of certified reference materials*

CRMs are materials used by laboratories as a control or standard to check the measurement precision and calibration of analytical instruments. The goal is to ensure the accurate measurement of a given compound by relating it to a national or international standard (a concept known as traceability). NRC provides CRMs for environmental, biotoxin, food, nutritional supplement and stable isotopic analysis. Over the years, this program has grown in scope and today NRC is internationally recognized as a producer of a variety of inorganic and organic CRMs. Figure 2, on the following page, shows increasing NRC revenues from sales of goods and information products, which indicate a generally growing demand for CRMs. It is important to note that this analysis includes CRM revenue generated by the former Institute for

Marine Biology (IMB) between 2009-10 and 2011-12, since these parts of IMB were later aligned with the MSS Portfolio as part of the 2012 transformation of NRC.

**Figure 2: Revenue from sales of goods and information products (2009-10 to 2013-14)**



Source: NRC Finance Branch

### *Services related to CLAS certifications*

Accreditation is the process of validating and recognizing the competence of an organization to manage and perform activities in a specified subject or area of expertise. In Canada, the accreditation of calibration laboratories is the shared responsibility of SCC and NRC. Through the delivery of the Program for the Accreditation of Laboratories, SCC has the responsibility of receiving and approving applications from calibration laboratories seeking accreditation to the ISO/IEC 17025 standard.<sup>10</sup> To obtain this accreditation, calibration laboratories must meet certain internationally recognized requirements. NRC, through CLAS, is responsible for assessing whether a laboratory conforms to these requirements. Receipt of a CLAS certificate from NRC is a requirement for a calibration laboratory to receive SCC accreditation.

As members of ILAC, NRC and SCC assist calibration laboratories to have their accreditation recognized and accepted internationally. Outside of Canada, other accreditation bodies (also members of ILAC) exist that can provide accreditation to Canadian calibration laboratories. Accreditation obtained in the United States (U.S.), for example, is recognized as equivalent to accreditation obtained in Canada and vice versa. Therefore Canadian calibration laboratories have many options for obtaining accreditation.

As of March 2014, there were 35 Canadian calibration laboratories accredited in Canada, through CLAS. This is less than 40% of all accredited Canadian calibration laboratories. The majority of accredited Canadian calibration laboratories have sought accreditation in the U.S. A 2014 CLAS Market Research Analysis report produced by MSS also noted increasing withdrawals from the program in recent years (due, in part, to some laboratories ceasing activities and others seeking accreditation elsewhere). CLAS clients interviewed as part of this evaluation identified some frustrations with the CLAS and SCC accreditation system, which may be prompting some accredited laboratories to withdraw from the CLAS program and, in some cases, to seek accreditation elsewhere. Frustrations noted include higher costs, longer timelines, and additional requirements for accreditation, as compared to similar U.S. accreditation bodies.

<sup>10</sup> The ISO/IEC 17025 is an internationally accepted standard that seeks to enhance product quality by formally recognizing the competence of testing and calibration laboratories in producing consistent, valid results.

Despite these frustrations and the decline in accreditations certified by CLAS, the clients who were interviewed indicated that there is value in the superior level of quality associated with the CLAS program and that is why it is important for them to continue to choose accreditation in Canada. They also noted that the existence of a Canadian accreditation system ensures that specific requirements of Canadian industry stakeholders are heard and taken into account by international trading partners, especially in regulated areas such as product safety, electricity and gas. Both SCC and NRC are currently investigating ways to better market the program and to demonstrate the added benefits of CLAS, where these can be of value to Canadian calibration laboratories.

#### *Research in emerging areas of metrology*

MSS research in emerging areas of metrology is driven by the need to sustain performance of measurement standards at a level that supports users and is able to stay ahead of their requirements. A need for more coordinated efforts in this area was raised in the 2009 evaluation of INMS. This issue has been addressed, in large part, through the merger with other NRC institutes/groups and the creation of the MSET program.

NRC's emerging areas of research appear to be well aligned with the priorities of the international metrology community. The fields of nanometrology, biometrology and environmental metrology came up repeatedly in documentation and in interviews with the heads of international NMIs as being important areas of emerging metrological research that are being pursued by other NMIs. As well, MSET's ability to secure co-investments by other government departments (primarily Natural Resources Canada, or NRCan, and Transport Canada) in strategic research projects demonstrates that these projects are in line with national priorities.

#### **3.1.4 Ability to Meet Industry Needs**

**Key Finding 4:** *MSS is meeting the needs of Canadian industry and, in most cases, these needs could not be addressed as adequately in the absence of MSS.*

Most industry clients interviewed as part of this evaluation, including those who were interviewed in the context of a case study, felt that their needs were being met by MSS. These included clients who had accessed a range of MSS services such as CLAS certifications, collaborative research, CRMs, licensing of intellectual property (IP), calibrations and other technical services. Most clients also reported that they had no other options within Canada to address their needs, given the specific services requested or the high level of precision required. The few that did have other options within Canada chose to work with NRC either because of its reputation and role as Canada's NMI or because of a history of involvement and satisfaction with the services provided.

In general, internal interviewees felt that current client needs (e.g., those in traditional client segments) are well understood. Research staff maintains close communications with clients and key external stakeholders in order to keep abreast of current and future needs. As well, attendance at conferences, trade shows and science meetings, and participation in intra- and intergovernmental meetings help to ensure that MSS staff are positioned to address stakeholder needs. Some internal interviewees did note that it can be more challenging to anticipate future needs and to identify areas for new opportunities in non-traditional markets. One of the main challenges noted in terms of business development within the Portfolio is the fact that MSS works across all industries, as opposed to one defined market. In response to this, MSS has undertaken the development of "mini business plans" for each of its 12 metrology disciplines. These mini plans provide a view of market size and growth for the capabilities. Seven of these plans have been produced to date and MSS expects to complete the remaining five over the next year.

## 3.2 Meeting the Needs of Other Government Departments

### **Evaluation Question 2: What are the metrology-related needs of other government departments and what role should the MSS Portfolio be playing to support them?**

**Assessment:** Measurement needs of OGDs are diverse, but OGDs rely on MSS specifically for calibration and testing, measurement standards/traceability, and scientific and technical expertise. MSS plays a very specific, critical and complementary role in supporting the other core partners in Canada's national measurement system (Measurement Canada and the Standards Council of Canada) and together, the partners directly support many federal departments and agencies in meeting their specific measurement needs. Nevertheless, there may be a greater role for MSS to play with regards to disseminating knowledge and proposing opportunities to its current and potential federal government clients.

### **3.2.1 Supporting the Core Partners in Canada's National Measurement System**

**Key Finding 5:** MSS plays a very specific, critical and complementary role in supporting the core partners in Canada's National Measurement System.

As described in section 2.3, MSS is a key player in Canada's national measurement system, together with Measurement Canada (MC) and SCC. Together, these three core organizations serve the measurement needs of a number of federal government departments and agencies.

The social network analysis that was conducted as part of this evaluation indicates that the roles and responsibilities of the core partners in Canada's national measurement system are, for the most part, clearly defined and differentiated. In addition, MSS appears to be playing an important role in complementing the responsibilities of the other core partners. MSS, as Canada's NMI, is the definitive domestic source for scientific metrology information, as well as an exclusive domestic source of calibration and measurement services that are directly traceable to the SI.<sup>11</sup> Given these two pivotal roles, MSS is an important "anchor" within Canada's national measurement system.

Measurement Canada relies on the activities and presence of MSS because it is legally required by the *Weights and Measures Act* and *Electricity and Gas Measurement Act* to have their measurement traceable to the SI and to calibrate and certify their measurement reference standards (including local standards) with NRC. Beyond this legal reliance, MC also makes use of MSS's scientific expertise to assess the scientific validity and credibility of their commerce-based weights and measures. Taken together, this reliance on MSS affords MC the opportunity to effectively deliver upon its public good goal of ensuring fairness in the marketplace, which in turn facilitates trade and cooperation.

Through the delivery of CLAS, MSS supports SCC by conducting third party assessments of calibration laboratories seeking (or renewing) accreditation to the ISO/IEC 17025 standard, to ensure that they meet internationally recognized standards. This involvement stems from an Agreement of Collaboration between SCC and NRC, originally signed in 1988. With its close ties to international standards organizations, as well as NMIs of other industrialized countries, MSS is able to ensure that Canada's laboratory accreditation system is compatible with the accreditation systems of Canada's major trading partners. In addition to providing calibration laboratory assessments, MSS also acts as an advisor to SCC, providing expertise in scientific

<sup>11</sup> The one exception to this is traceability for natural gas flow, which is not offered by MSS, but rather by a private company, TransCanada Calibrations.

metrology as well as assistance in generating scientific evidence and interpreting complex technical details. This advisory role ensures that SCC is sufficiently informed and able to best represent the interests of Canadian industry in international forums.

**3.2.2 Supporting the Needs of Other Federal Government Users of Metrology**

**Key Finding 6:** *MSS plays a central role in meeting the measurement and metrology-related needs of other government departments and agencies.*

Interviews conducted as part of the social network analysis revealed that the general measurement needs of OGDs are diverse, but generally include:

- Regulatory development, policy, domestic and international standards;
- Calibration;
- Research and development (R&D);
- Detection of public safety threats; and
- Testing and monitoring for safety.

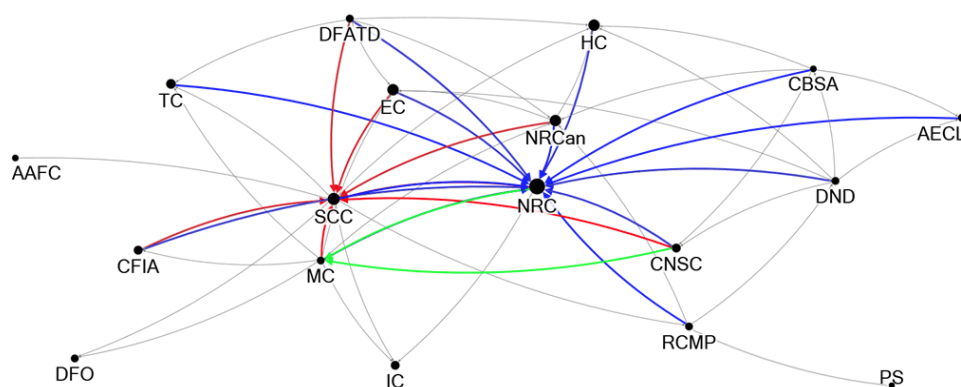
Table 4 provides a relatively complete, but not exclusive list of the federal departments and agencies that make use of Canada’s national measurement system in fulfilling their mandates. The table also identifies those departments and agencies that specifically rely on the measurement products or services provided by MSS. The central role played by MSS is made evident by the fact that most users of the system are also users of MSS products and services.

**Table 4: OGD users of Canada’s national measurement system and of MSS products and services**

Department or agency	Users of Canada’s national measurement system	Users of MSS products and services
Agriculture and Agri-Food Canada (AAFC)	✓	
Atomic Energy of Canada Limited (AECL)	✓	✓
Canada Border Services Agency (CBSA)	✓	✓
Canadian Food Inspection Agency (CFIA)	✓	✓
Canadian Nuclear Safety Commission (CNSC)	✓	✓
Department of Foreign Affairs, Trade and Development (DFATD)	✓	✓
Department of Fisheries and Oceans (DFO)	✓	
Department of National Defence (DND)	✓	✓
Environment Canada (EC)	✓	✓
Health Canada (HC)	✓	✓
Industry Canada (IC)	✓	✓
Natural Resources Canada (NRCan)	✓	✓
Public Safety (PS)	✓	
Royal Canadian Mounted Police (RCMP)	✓	✓
Transport Canada (TC)	✓	✓

One way of measuring the relationship of the parties within Canada's national measurement system and the support they provide to OGDs is to map their connectedness according to social network theory. Social network analysis utilizes a set of metrics to describe the characteristics of a network in terms of the density and pattern of connections within. Figure 3 provides a representation of the influence and position of the various federal government parties in Canada's national measurement system. Within the network diagram, the size of the dots is relative to that organization's centrality within the system. The relatively large size of NRC's dot and its central position within the network indicates that the other organizations most frequently cited NRC/MSS as a strong connection for their measurement and metrology needs. Further confirmation of MSS's strong role is provided by the positive comments of interviewees who were almost universally positive about MSS's ability to understand and meet their needs.

**Figure 3: Position and influence of federal players in Canada's national measurement system**<sup>12</sup>



Source: Social Network Analysis conducted by Capacity Research & Resonance Inc.

**Key Finding 7:** *Although MSS adequately supports the measurement needs of OGDs, there may be a greater role for MSS to play with regard to disseminating knowledge and proposing opportunities to its current and potential federal government clients.*

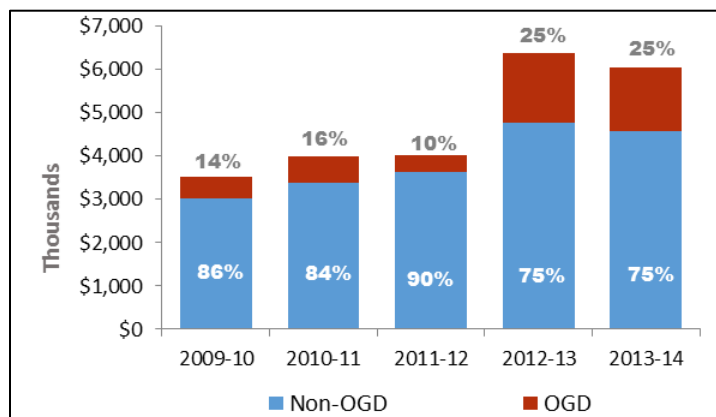
As users of Canada's national measurement system, federal government departments and agencies typically use metrological information and services to support their objectives and missions. These objectives and missions are most frequently regulatory in nature. As demonstrated in Figure 4 (on the following page), the amount of revenue MSS has received from OGDs has grown significantly in recent years. It is also worth noting that in 2013-14, all strategic research revenue earned by MSS was derived from projects for OGDs. This indicates the importance of measurement services and solutions provided by MSS to OGDs.

Although OGD representatives interviewed as part of the social network analysis generally felt that MSS is adequately supporting their measurement needs, some revealed that they have difficulty staying up-to-date on metrology developments and the possible implications that these developments could have for their sectors. These interviewees indicated that they rely on MSS to disseminate knowledge and make them aware of possible technological challenges and opportunities for their organizations. Furthermore, some OGDs reported a lack of understanding and knowledge of the services that MSS can provide. Where this knowledge exists, it is largely

<sup>12</sup> It is worth noting that interviews were not conducted with AAFC, DFO and PS. This may partly explain their relative isolation from the other organizations.

dependent on individual relationships with MSS staff. This presents an opportunity for MSS, in collaboration with NRC Business Management Support (BMS), to be more proactive in identifying the potential metrology-related needs of OGDs and reaching out to potential federal government clients. Other NMIs, such as the United Kingdom’s (U.K.) National Physical Laboratory (NPL), have been proactively playing this role.<sup>13</sup>

**Figure 4: MSS revenues<sup>14</sup> from OGD clients as compared to revenues from other clients**



Source: SIGMA

**Recommendation 1:** In order to better support OGDs, MSS should be more deliberate in its efforts to understand the regulatory environment and be proactive in performing complementary R&D. Such efforts should take into consideration the current and future capacity of MSS staff.

### 3.3 Alignment with Federal Roles, Responsibilities and Priorities

**Evaluation Question 3: Are the objectives and activities of the MSS Portfolio aligned with federal roles, responsibilities and priorities?**

**Assessment:** Yes. MSS objectives and activities, including maintaining Canada’s affiliation with the BIPM, align with federal priorities and are consistent with federal roles and responsibilities.

#### 3.3.1 Alignment with Federal Roles and Responsibilities

**Key Finding 8:** NRC’s mandate to act as Canada’s national metrology institute is supported by legislation and as a federal government organization, this role is appropriate.

The rationale for NRC’s role stems from subsection 5 (1) (c) of the *NRC Act*, which states that the Council may “undertake, assist or promote scientific and industrial research...”, including, under subsection 5 (1) (c) (iv), “the investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time, heat, light, electricity, magnetism and other forms of energy, and the investigation and determination of physical constants and the fundamental properties of matter.” The *Weights and Measures Act*, subsections 12 (1) and 12 (2) also identify NRC’s role with respect to reference standards for legal trade within Canada.

<sup>13</sup> Quentin Maxwell-Jackson, *Getting better value from public sector research establishments: Appendices* (2011), 28.

<sup>14</sup> Revenue presented in this graph includes IP revenue.



Canada's affiliation with the BIPM stems from the Government of Canada's status as a State Party to the Metre Convention. By representing Canada on the international metrology stage through its affiliation with the BIPM, NRC is able to more effectively and efficiently respond to its mandated responsibility for maintenance of national measurement standards.

Based on documentation reviewed and on interviews with heads of international NMIs, it appears that metrology is broadly considered to be the responsibility of government, at least to some extent, in all major industrialized countries. International NMI representatives pointed to the fact that metrology responds to broad national objectives (i.e., supporting national and international standards, supporting effective regulations at a national and international level). In addition, its nature as a public good does not make it a viable option for the private sector since measurement standards must be equally available to all parties who need metrology services. Finally, market failure also justifies governmental intervention in metrology. That is, the maintenance of measurement standards and the provision of primary measurement services are viewed as being an unattractive business model, where it is difficult for private firms to recoup their investments. Where there is a strong business rationale (for instance, in the provision of second-tier and third-tier calibration services), private enterprise has established a strong industry.

Although all of the NMI representatives interviewed agreed that the maintenance of a country's NMI is ultimately a federal government responsibility, they also commented that when it comes to the delivery and operation of the NMI, "there is no definitive model." Some countries, such as Australia and Mexico, combine legal and scientific metrology under one organization (frequently the country's Department of Industry, or equivalent). Others follow a similar model as Canada, whereby the NMI is included within the country's research and technology organization (RTO) – examples include Japan and Singapore. In the U.K., NPL is currently transitioning from a government-owned contractor-operated (GoCo) model to a government company in partnership with two universities.<sup>15</sup> Despite the different models that exist, all NMI representatives were supportive of the Canadian model. They identified clear benefits associated with including the NMI as part of an RTO, such as the ability to leverage cutting-edge expertise and industrial relationships (more detail on some of these benefits is provided in section 5.1.2). In addition, some NMIs that are not housed within an RTO are taking steps to forge a closer relationship with the research sector (NPL is an example of this).

### **3.3.2 Alignment with NRC and Federal Priorities**

**Key Finding 9:** *The objectives and activities of the Portfolio align with NRC strategic outcomes.*

The MSS Portfolio supports the National Science and Technology Infrastructure program activity of NRC's Program Alignment Architecture. As per the logic model presented in Appendix A, MSS seeks to inform and improve Canada's measurement infrastructure, which enables industry to capitalize on market opportunities involving emerging technologies and to compete, conform and connect on a global stage. This is directly aligned with NRC's strategic outcome of providing "R&D infrastructure for an innovative and knowledge-based economy." Collaborative projects in areas such as security, energy and health also demonstrate alignment with the critical issues included as part of the NRC strategy.

It is also worth noting that, at a corporate level, mechanisms have been put in place to ensure that portfolio activities align with NRC priorities. The most significant of these mechanisms is a business planning process whereby the work of MSS, like that of all other NRC portfolios, must

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<sup>15</sup> National Physical Laboratory, <http://www.npl.co.uk/news/brian-bowsher-to-retire-from-npl>.

fall within the scope of NRC programs. Programs are approved by NRC's Senior Executive Committee (SEC) following a rigorous stage gate process. The fact that all three MSS-hosted programs have been approved for implementation by NRC's SEC demonstrates their alignment with NRC's new strategic direction and stated goals.

At a portfolio level, MSS has also implemented a stage gate approach for the development, review and approval of projects by the leadership team. This approach helps to ensure that individual projects link back to portfolio goals and objectives.

**Key Finding 10:** *The objectives and activities of the MSS Portfolio, including maintaining Canada's affiliation with the BIPM, align with Government of Canada priorities.*

Much of the documentation reviewed as part of this evaluation describes how measurement science underpins the economic and social development of a country at all levels. Therefore, it can be said that overall, metrology aligns with government priorities. One clear example of this is the role MSS plays in demonstrating traceability to the SI, and thereby supporting international trade. Adherence to BIPM, specifically, represents Canada's share of the budget for a global program of metrology activities that are intended to demonstrate equivalence of national measurement standards of the NMIs across all trading nations. This equivalence reduces measurement-related technical barriers to trade, improving access to global markets and contributing to the competitiveness of Canadian industry. Through its involvement in the CGPM, the CIPM and its consultative committees, MSS has effective channels in place allowing it to influence BIPM activities in support of their alignment with Canadian priorities.

MSS research and other activities also play a role in supporting the policy and regulatory objectives of other government departments in areas such as health, the environment, natural resources, safety and security. This is demonstrated by the strategic research projects in which OGDs are willing to co-invest, as was the case for the cellulosic nanomaterials project for NRCan (see the text box below, which presents information drawn from one of the evaluation case studies). In addition to such strategic research projects, MSS has been called upon to provide measurement advice to the Department of Foreign Affairs, Trade and Development Canada during the negotiation of several trade agreements. MSS representatives also participate in various international forums, where they provide measurement-related expertise and help to ensure that Canada's trade interests are being upheld. Recent examples include delegations to ISO and IEC meetings and working groups, as well as co-chairing of an Organization of American States (OAS) Working Group on National Quality Infrastructure.

**Strategic research project for NRCan: Development of standards for cellulosic nanomaterials**

In 2013, MSS worked with NRCan to advance Canada's lead in the global pursuit to commercialize cellulose nanocrystals (CNC), a new nanomaterial extracted from wood fibre. With its unique qualities (renewable, non-toxic, biodegradable, lightweight and five times stronger than steel), CNC has the potential to lead to a number of product improvements or innovations. As part of this project, MSS conducted research and characterization work necessary to obtain approval from ISO to lead the development of an international standard for CNC. The success of this project brings Canada one step closer to developing an accepted international standard that will prevent technical barriers to trade and will allow Canadian industry to lead the way in the international sale of CNC. MSS expertise and representation at ISO was considered "crucial" by the client in achieving this first critical milestone.

## 4. PERFORMANCE

The evaluation assessed the performance of MSS in terms of a) the extent to which the Portfolio has positioned itself to achieve expected program outcomes (section 4.1); b) the impact it has had on clients (section 4.2); and c) the extent to which it has increased Canada's presence and reputation for metrology on the international stage (section 4.3).

### 4.1 Positioning and Progress toward the Achievement of Expected Outcomes

**Evaluation Question 4: To what extent has MSS positioned itself to achieve expected program outcomes? What have been the barriers and facilitating factors?**

**Assessment:** Overall, MSS is performing well and is well-positioned to achieve expected program outcomes, despite some challenges in acquiring an optimal level of human resources.

#### 4.1.1 Resource Availability

**Key Finding 11:** MSS facilities and equipment are adequate to meet current program needs.

Internal interviewees generally felt that despite aging equipment, MSS facilities are adequate to meet current program needs. The Portfolio has invested in some of the major capital infrastructure and facilities required by programs. However, there are a few outstanding major capital investment items that have not yet been approved. Interviewees explained that this is due, in part, to a shift in priorities, meaning that some of the equipment originally identified in the business plans is no longer required. Although MSS staff did not raise the adequacy of facilities and equipment as an area of concern in the near term, the suite of MSS capital assets is almost 80% amortized, which signals that MSS may need to invest in the replacement of some of its capital assets over the next few years.

**Key Finding 12:** Current human resources levels are not optimal, which represents a significant risk to the Portfolio's ability to deliver on program plans.

MSS maintains highly skilled and specialized staff, which is vital to its continued success. Human resource requirements for MSS's three hosted programs were identified in program business and implementation plans. However, internal interviewees described various challenges that have prevented the Portfolio from acquiring the planned number of human resources. Out of 32 positions that MSS had intended to staff by 2014-15 in order to meet the needs of its three hosted programs, MSS has to date staffed only 15 long-term and continuing positions. In some cases, students and term employees have also been brought in to fill some resource gaps. Some of the challenges identified by interviewees include: a temporary corporate moratorium on hiring, limited succession planning, limited support from NRC Human Resources (HR) Branch in the first years of the Portfolio, and difficulty finding and attracting qualified candidates. Most recently, complications resulting from the 2014 cyber intrusion at NRC have also hampered MSS's efforts to staff permanent positions.

Staffing challenges have been further exacerbated by a high level of voluntary turnover within the Portfolio. For 2013-14, the voluntary turnover rate was 7.3%,<sup>16</sup> as compared to an NRC

<sup>16</sup> The rate of voluntary departures is corporately defined as the proportion of employees who leave NRC voluntarily divided by the total number of employees. Departures can be the result of retirements, employees changing employers, returning to school, etc.

average of 4.7%. Consequently, while MSS successfully hired 15 new full-time employees over the last two years, it also lost 15 employees over this same time period.

MSS also faces a serious risk associated with the high number of personnel eligible for retirement. Although high retirement eligibility is a common risk across NRC, it is of particular concern to MSS. Data obtained from MSS indicates that approximately 14% of MSS staff (20 continuing full-time employees) are currently eligible for retirement and this proportion will increase to approximately 27% (34 employees) as of June 2015. This is significantly higher than the projected 13% of overall NRC staff who will be eligible for retirement at that time. Internal interviewees commented that so far, MSS has relied on the goodwill of its employees and has been fortunate in that many have chosen to continue working at MSS despite their retirement eligibility.

Portfolio management is well aware that current MSS human resources are not adequate and has made considerable efforts over the past year to address this risk. A Human Resources Generalist from another area of NRC has now been assigned to the Portfolio. A detailed hiring plan is in place and is being executed, and a comprehensive succession plan, identifying critical positions, future human resource requirements, and career development opportunities for MSS staff, is currently being developed. Although most internal interviewees had raised human resource challenges as being an issue of concern within the Portfolio, many also mentioned that the Portfolio has made good progress with recent hires and many were optimistic that the situation is now improving.

**Key Finding 13:** *Despite a high level of client satisfaction overall, sub-optimal human resource levels have affected services to clients.*

Internal interviewees generally were of the opinion that any negative impacts associated with sub-optimal resource levels were limited to internal projects and other aspects of portfolio operations (e.g., training new staff, performing equipment upgrades and customizations, and business development). However, despite a high level of client satisfaction overall, the evaluation found that clients have also felt some impacts on the timeliness of service delivery.

Most clients interviewed were very positive about their interactions with MSS, expressing great appreciation for the expertise of MSS staff and for the quality of the service they received. This was also true for case study clients, many of whom stated that the success of their specific projects was very much attributable to the services or products they received from MSS. Still, several clients commented that they had experienced issues with the timeliness of service delivery and almost half of these clients specifically attributed these issues to staff turnover or a lack of personnel within the Portfolio. One client has also been affected by the discontinuation of some services, following the unanticipated departure of key staff.

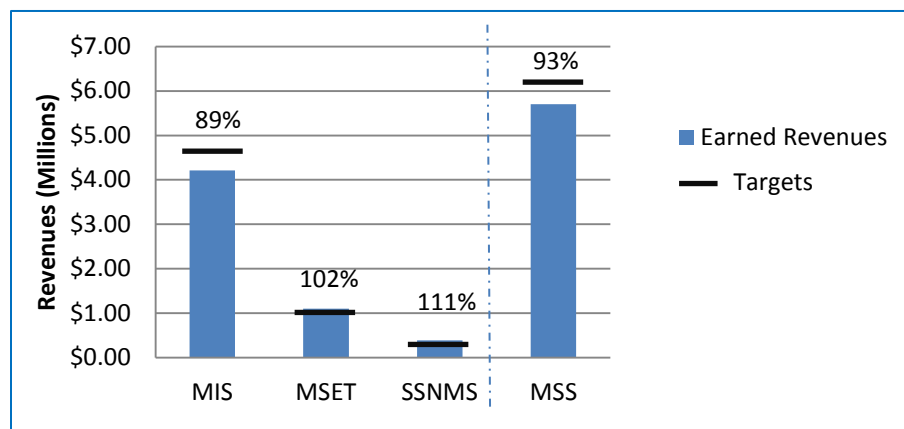
**Recommendation 2:** Given that sub-optimal human resource levels have affected client services and pose a significant risk to future portfolio performance, MSS must continue to place a strong emphasis on staffing in order to address human resource gaps. As the programs mature, resource staffing needs will need to be adjusted to ensure that the portfolio can respond in a timely and adequate manner.

#### **4.1.2 Progress toward Expected Outcomes**

**Key Finding 14:** *Overall, MSS has performed well and is making good progress in achieving its objectives, despite the resourcing challenges it has experienced.*

From a revenue perspective, MSS is performing well, having achieved 93% of its revenue target in 2013-14 (see figure 5, on the following page). Moreover, 21% of portfolio expenditures were offset by earned revenue. Based on senior level interviews, this level of revenue generation is in line with management expectations.

**Figure 5: Percentage of revenue targets met (2013-14)**



Source: NRC Finance Branch

Despite some delays, MSS is also making good progress in achieving key program implementation milestones. These milestones, originally identified in program implementation plans, are managed by the three programs using corporate systems. Data provided by the Program Leaders indicates that both SSNMS and MIS have achieved all implementation milestones to date and are on track to achieve future milestones. While the MSET program has also successfully achieved most implementation milestones, it has experienced some delays establishing a full team for the Biometrology group. The target of fully establishing and launching this group by the second quarter of 2013-14 has not been met, primarily due to the staffing challenges previously discussed in section 4.1.1. Regardless of the delay, there is some progress being made, as a Discipline Leader has been hired, staffing needs for the group have been identified, and the program is exploring options to access expertise from other NRC portfolios to help fill some of the resource gaps.

Finally, as good indicators of strong performance, it is also worth highlighting a few examples of notable project-level accomplishments achieved by the Portfolio:

- The introduction of ten new measurement services, including MSET's first environmental calibration service which, since 2013-14 has generated approximately \$100,000 in revenue for MSS;
- Internationally recognized contributions to the redefinition of the kilogram using watt balance (further details of this are provided in section 4.3.2);
- Contributions to an important update of the American Association of Physicists in Medicine protocol to determine the output of radiation machines used in North America to treat cancer;
- An extensive review of MSS's Quality Management System and an update of the Quality Manual, both of which reflect new practices and structures that were put in place following the transformation of NRC from an institute-based organization to an RTO; and
- The implementation of a "Virtual Store", which has facilitated access to measurement products and services, by allowing clients to order online (it is expected that the Virtual

Store will be expanded in the current fiscal year to include all of MSS's standard calibration services).

#### 4.1.3 Performance Measurement

**Key Finding 15:** *There was limited non-financial performance data available to assess program and portfolio performance.*

The program business plans outline a set of performance measures, with targets, which were to be used to monitor program implementation. A similar list of portfolio-level indicators was included in the 2014-15 MSS Operating Plan. However, non-financial performance information has not been collected and was unavailable for the evaluation. Program Leaders pointed out that performance indicators or targets as set out in the original business plans are in many cases no longer appropriate or relevant to measure the performance of the program in the current environment. As well, the documents do not identify who is responsible for collecting and reporting on performance information and portfolio staff admitted to not having a formal mechanism to track the achievement of operational targets or objectives.

**Recommendation 3:** MSS should review and update the performance measurement frameworks for the Portfolio and for its hosted programs to ensure that performance indicators are relevant and targets are realistic. MSS should also clarify responsibilities for collecting and reporting on performance information.

## 4.2 Impacts on Clients

**Evaluation Question 5:** *What has been the impact of MSS on its clients and other Canadians?*

**Assessment:** *The evaluation found qualitative evidence of economic and social impacts resulting from MSS products and services. The most common direct impacts experienced by clients revolve around improved measurement knowledge and enhanced access to credible measurement services. Indirectly, MSS services have also had a positive economic impact on non-direct clients who rely on MSS's unbroken chain of traceability to international standards.*

Although the MSS Portfolio has only been in existence for a little over two years, many of the services delivered by MSS, as Canada's NMI, do not differ from the services delivered by the former INMS. Therefore it was possible, through the use of qualitative methods (i.e. mostly interviews and case studies), to collect evidence of economic and social impacts experienced by clients.

This section presents six categories of impacts:

- Improving measurement knowledge
- Enhancing access to credible measurement services
- Improving business productivity or revenue for clients
- Enabling product innovation
- Reducing technical barriers to trade to enable clients to sell products internationally
- Social impacts

Cases where MSS services have had a direct impact on clients are described, as well as cases where MSS may be having an indirect impact on non-clients through an unbroken chain of

traceability. Potential impacts on non-direct clients were assessed primarily through the short survey of Ulrich Metrology's clients.

**Key Finding 16:** *The most common impacts experienced by industrial clients of MSS revolve around improved measurement knowledge and enhanced access to credible measurement services.*

#### **4.2.1 Improving Measurement Knowledge**

Consistent with the findings of the 2009 Evaluation of INMS, the current evaluation found that, as a result of their interactions with MSS, clients are benefiting from knowledge gained about measurement and its challenges. This was one of the most frequently cited impacts, as it was noted by almost all interviewees and also came up in four of the five case studies. It also appears to be among the impacts clients found to be most beneficial. Almost all industrial clients interviewed directly attributed their improved knowledge of measurement to the services they accessed from MSS. Some clients explicitly stated that this improved knowledge has led to improved internal processes within the company, as clients learned new testing methods, or were made aware of deficiencies in their measurement procedures. Although there were various examples provided, the case study of MSS's relationship with Ulrich Metrology Inc. clearly demonstrated this impact.

- **Ulrich Metrology Inc.:** This Canadian calibration laboratory is a CLAS client of MSS. Company representatives stated that the CLAS certification process itself has provided the company with an opportunity to receive feedback and advice on their calibration techniques and ultimately improve their quality management systems. As explained by Ulrich Metrology representatives, if the company is not following the latest procedures and standards or the most appropriate techniques to calibrate an instrument, they must learn to do so in order to receive the CLAS certification. Company representatives added that the learning process has been facilitated by the willingness of NRC staff to answer questions and provide feedback when they can.

It is reasonable to expect that other CLAS clients of MSS would have experienced similar impacts. In addition, other types of clients also reported having gained improved measurement knowledge, as examples emerged from interviews and from three other case studies.

#### **4.2.2 Enhancing Access to Credible Measurement Services**

Almost all industrial clients interviewed stated that MSS has provided them with measurement services that are trusted, credible, and more easily accessible than would otherwise be possible. Because MSS focuses on providing measurement services not provided by others, MSS enhances access to services for Canadian companies who otherwise would have to seek these services internationally. Both interviews and case studies revealed that MSS has helped some industry clients meet standard and regulatory requirements within their field of work. One example of this, drawn from the case studies, is provided below.

- **“Company X”:** MSS directly assisted an unnamed Canadian company in meeting regulatory requirements to sell their selenium products in Canada and internationally. Because selenium is a controlled product in terms of dosing, regulatory bodies required accurate measurements so that proper dosage and consumer safety could be ensured. Unfortunately, at the time, there were no international standards for this organic form of selenium. MSS helped the company understand the characterization of selenium-enriched yeast so that it could be differentiated from other forms of selenium, and thus,



properly measured. MSS also developed a CRM for selenium-enriched yeast that was used as a reliable and credible standard by the company. This helped the company produce consistent and credible results and allowed them to meet the regulatory requirements to sell their products on the market. According to a company representative, NRC's role in developing this CRM was unique in Canada and vital to the company's success with yeast-based selenium products. In addition, what started out as a competitive edge for the company in 2005 is now considered an industry standard for all.

Two other case studies (the QuantOhm project with Measurements International Ltd. and the cellulosic nanomaterials project for NRCan) also provided examples to support MSS's contributions to enhancing credible measurement service in Canada.

#### **4.2.3 Improving Business Productivity or Revenue for Clients**

Some industrial clients (particularly CLAS clients and those who have accessed electrical power measurement services) stated that MSS products or services have had an impact on their business productivity or revenue. The case study of MSS's relationship with Ulrich Metrology revealed that by providing extensions to a calibration laboratory's scope of accreditation, MSS enables CLAS clients to offer new accredited service lines. Specifically for Ulrich Metrology, being able to offer more accredited services has allowed them to compete for more contracts, including multi-service projects, and increase their customer base. This, in turn, has enabled Ulrich Metrology to generate more revenue. Furthermore, the CLAS certificate serves as proof that their systems have passed a rigorous inspection and helps Ulrich Metrology avoid duplicative audits of their quality management systems, which are sometimes requested by their clients. This saves the company time and money. Although the extent of the impact may not be as strong for more recent CLAS clients of MSS or for laboratories with a smaller scope of accreditation, this example provides evidence that demonstrates how MSS contributes to improving business productivity for some clients.

Two other case studies (the QuantOhm project with Measurements International Ltd. and the VMC++ project) also revealed examples of this impact of MSS. Attribution of improved client productivity to products/services offered by MSS was relatively high, with client interviewees giving an average attribution rating of 3.9 out of 5.

#### **4.2.4 Enabling Product Innovation**

Some industrial clients reported that MSS measurement products or services have directly enabled them to offer a new product or service. The case studies also provided multiple examples of this impact, particularly for clients who had licensed IP developed by MSS or its predecessor institute. Those who reported this as an impact generally highly attributed this impact to MSS, with some clients even stating that the IP was vital to the development of their products. The examples below present information drawn from some of the evaluation case studies and illustrate MSS's contributions:

- **Measurements International Ltd.:** This is a Canadian company specializing in the design, development, calibration, and manufacturing of electrical metrology instrumentation and measurements. Under a licensing agreement, MSS provided samples of the Quantum Hall Resistance (QHR) standard that were used by this company to create a new electrical measurement product. The product, called the QuantOhm, was a notable accomplishment in this field, as it was the first to provide a low cost and sufficiently accurate solution for measuring resistance values with direct



traceability to international standards. Without it, potential clients would have very limited access to precise QHR measurements. Since 2002, MSS has been providing the company with QHR samples that continue to be critical to the traceability and functioning of the system.

- **“Company Y”**: MSS successfully developed and licensed a source code called VMC++ to an unnamed Canadian radiotherapy company. VMC++, a type of calculation engine, was used by this company in 2001 to develop a new treatment-planning system that is used on cancer patients prior to radiation therapy to help reduce collateral damage to healthy cells. The challenge at the time was that the simulation methods available were either fast but not accurate or accurate but not as fast as other methods. This new system allowed clinicians, for the first time, to run radiotherapy simulations in a way that were as accurate as the most accurate methods and fast enough to make it convenient for clinical settings. Independent reviews of this treatment planning system reveal that no other calculation engine has been developed that has the combined speed and accuracy of VMC++. As such, positive reviews of the source code continue to have a positive effect on sales by the multinational company who holds the license today.

Indirectly, MSS may also have played a role in enabling downstream firms to introduce a new product/service or to improve an existing product. The evidence comes from the survey conducted of clients of Ulrich Metrology, a CLAS and SCC-accredited laboratory. Of survey respondents who cited an impact, 27% (n=25) stated that they had experienced an improved ability to introduce a new product/service or improve an existing product as a direct result of calibration services they received from Ulrich Metrology.<sup>17</sup> MSS plays a role by providing calibration services (traceability) and CLAS certification to Ulrich Metrology that enables the company to provide these calibration services to their clients.

#### **4.2.5 Reducing Technical Barriers to Trade and Improving the Ability of Clients to Sell Products Internationally**

MSS has contributed to reducing technical barriers to trade for some direct and indirect clients and has contributed to their ability to sell their products internationally. As this is an intermediate level impact for MSS, there are many external factors contributing to the ability of Canadian companies to sell their products internationally. Nevertheless, the evaluation found some examples that clearly demonstrate MSS’s contributions in this area. The following case presents one of these examples:

- **Natural Resources Canada** (for more information, see the text box in section 3.3.2): The case study on MSS’s collaboration with NRCan illustrates how MSS played an important role in reducing technical barriers to trade associated with the commercialization of cellulose nanocrystals (CNC), a material produced by the Canadian forest industry. MSS’s contributions have led to sustained progress in NRCan’s goal of supporting the development of international standards for CNC and thus ensuring access to international markets.

Two other case studies provide examples of how MSS has helped to improve the ability of clients to sell products internationally. These include the case studies of the selenium-enriched yeast project (“Company X”) and of the QuantOhm project with Measurements International Ltd.

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<sup>17</sup> Although the survey generated 249 responses, only 93 reported experiencing any impact resulting from having their instruments calibrated or repaired by Ulrich Metrology. Percentages are based on 93 total responses.

MSS has also played a role in enabling downstream firms to sell their products internationally. The survey of Ulrich Metrology's clients revealed that clients of Ulrich Metrology are also experiencing this impact. Twenty-four percent (24%) of survey respondents who experienced an impact (n=22) stated that they have experienced an improved ability to sell their products/services in global markets as a result of accessing calibration services from Ulrich Metrology. Some of these clients even stated that the services provided by Ulrich Metrology specifically helped them to overcome technical barriers to trade by helping them meet the regulatory requirements or standards in other markets. This impact can be traced back to services offered by MSS to Ulrich Metrology, as this company relies on MSS for CLAS certification and calibration of gauge blocks with traceability to internationally accepted standards, both of which are essential in delivering services to their clients.

#### **4.2.6 Social Impacts**

**Key Finding 17:** *The evaluation found some examples of cases where the work of MSS has had an impact on Canadian society, either through contributions to the health and safety of Canadians, to improvements to their quality of life, or to environmental protection.*

##### *Health and safety*

The production of CRMs and the delivery of calibration services with direct traceability to internationally recognized standards are two ways that MSS is contributing to positive impacts on the health and safety of Canadians, both directly and indirectly.

- **“Company X”:** As demonstrated in the case study on the production of the CRM for selenium enriched yeast, the work of MSS allowed companies and regulatory bodies around the world to understand the levels at which the substance could become toxic and to set an international standard to accurately measure this type of selenium. The CRM allows companies to produce selenium enriched products (such as nutritional supplements and animal feed) that are beneficial and safe for human consumption.

MSS also contributes to ensuring consumer safety by enabling clients to produce better quality products. For example, MSS delivers CLAS and calibration services that provide an unbroken chain of traceability to international standards to enable manufacturers to produce reliable products. As was evidenced in the case study on Ulrich Metrology, important industries, such as aerospace or medical device manufacturers, rely on CLAS laboratories to ensure that the equipment they use to do their tests and measurements are trusted and reliable to produce accurate measurements. Instruments that are properly calibrated will give accurate readings that will limit the danger of producing defective products. The better the quality, the more reliable the product is, the safer the product may be to consumers. MSS's impacts are wide, as the survey of Ulrich Metrology clients revealed that this was an impact experienced by 72% of their clients who reported impacts.

##### *Quality of life*

When asked about social impacts, a few internal interviewees brought up the work MSS has undertaken in the field of radiation therapy, where accurate radiation dosage is critical to the quality of life of cancer patients and positive treatment outcomes. Evidence from the case study on the development and licensing of VMC++ supported these opinions and provided a specific example of this impact.

- **“Company Y”:** The VMC++ calculation engine has been used by an unnamed client to develop a faster and more accurate treatment planning system. This has contributed to enhancing the quality of life of cancer patients, who can now receive more accurate and faster radiation treatment while reducing collateral damage. As the system is used in about 489 sites around the world, many cancer patients are benefiting from this technology.

### *Environmental protection*

MSS has also recently started offering technical services in the area of black carbon metrology, including calibration of black carbon mass measurement instruments (introduced in 2013-14). Services offered by this group are focused on helping government and industry to improve the uncertainty associated with the measurement of black carbon, a key contributor to global warming. Clients include federal regulators, manufacturers of black carbon mass measurement instruments, manufacturers of aviation and energy gas turbine engines and manufacturers of heavy/light duty vehicles.

### **4.3 International Reputation for Metrology**

**Evaluation Question 6: To what extent has MSS increased Canada’s presence and reputation for metrology on the international stage?**

**Assessment:** MSS is well perceived among its international peers and Canada’s reputation as a contributor and a participant in international metrology activities has been strengthened over the past five years.

**Key Finding 18:** Canada has a strong reputation as a contributor and a participant in international activities.

All four representatives of international NMIs who were interviewed as part of the evaluation noted that Canada’s international reputation is at least as strong, if not stronger than it was five years ago. Because of this strong reputation, there is a high level of confidence, internationally, in the standards maintained by NRC. As well, three of the four NMI representatives explicitly commented on the fact that Canada “punches slightly above its weight” in terms of influence. The views of these interviewees are consistent with findings from the 2009 INMS evaluation, where metrology experts viewed the institute favourably when compared to other NMIs.

*“Canada has historically always played a significant role, but still, there has been an improvement in recent years.”*

International NMI interviewee

International NMI interviewees identified factors which have contributed to strengthening MSS’s international reputation. The most significant of these include: a) increased participation and leadership in activities of the international metrology community; and b) contributions to key metrology research, notably, the role Canada has played in the redefinition of the kilogram. Sustained levels of activity in terms of publications and participation in international key comparison studies also indicate that Canada’s reputation is at least as good as it was five years ago.

### 4.3.1 Increased Participation and Leadership in International Metrology Activities

Over the past five years, MSS has increased its participation in activities of the international metrology community, including participation in CIPM committees. Table 5 presents Canada's participation in these committees, which include the CIPM and its Consultative Committees, as well as other high profile committees, such as conference-related committees.

**Table 5: Canadian participation on CIPM committees**

	2009	2014 <sup>18</sup>
# of Canadian representatives on committees	31	59
# of chairing/leading roles	4	6
# of unique individuals involved in international committees	16	30
# of committees with Canadian representation	26	44

One NMI representative remarked that he has noticed a broader participation of MSS staff as it appears that NRC is sending a greater diversity of individuals, including some more junior staff, to attend international activities. This is seen as being positive, as it will contribute to succession planning and will help to sustain Canada's reputation in metrology. MSS Management confirmed that the Portfolio is purposely sending people to participate in international committees earlier in their careers, as this can be a valuable learning opportunity for them.

NMI representatives also commented that the nature of Canada's participation on international committees has improved over the past five years. They commented that Canadian representatives are playing an increasingly active role, for instance leading committees and participating in working groups, as opposed to simply attending meetings. As stated by one NMI representative, "overall, the impact of Canada's participation is now likely higher than what it was five years ago."

### 4.3.2 Contributions to Key Metrology Research

Canada is recognized as having made a noteworthy contribution to key metrology research developments. With respect to fundamental metrology, all four NMI representatives noted that a major ongoing initiative of the international metrology community is the redefinition of many base units, based on fundamental quantum standards. They also all commented that Canada is participating very actively in this, and has played a particularly significant role in the redefinition of the kilogram. Using experiments based on the watt balance, MSS has been able to achieve the most precise determination of the Planck constant to date (see the text box below). As stated by one international NMI interviewee, "unequivocally, this has been a major contribution to fundamental metrology."

#### **Redefinition of the kilogram using the watt balance**

Of the seven base units within the SI (meter, kilogram, second, kelvin, ampere, mole and candela), the kilogram is currently the only unit still defined by a physical artefact – a lump of platinum-iridium held in a vault near Paris. Over time, as atoms accrete or fall off this particular kilogram, its mass changes.

<sup>18</sup> The 2014 numbers include participation by the former Director General of INMS. Despite the fact that he is no longer an NRC employee, he sits on these committees as Canada's representatives and engages closely with MSS to ensure that his participation reflects the views of the organization.

Metrologists are thus aiming to redefine the kilogram on the basis of something more stable, such as Planck's constant, which relates the frequency of a photon to its energy.<sup>19</sup> The watt balance relates electrical power to mechanical power. This allows for very accurate measurements of Planck's constant in terms of the SI units of mass, length and time. The SI units of length and time are already fixed in terms of fundamental and atomic constants. If the value of Planck's constant is fixed, then the watt balance provides a method of measuring mass.<sup>20</sup>

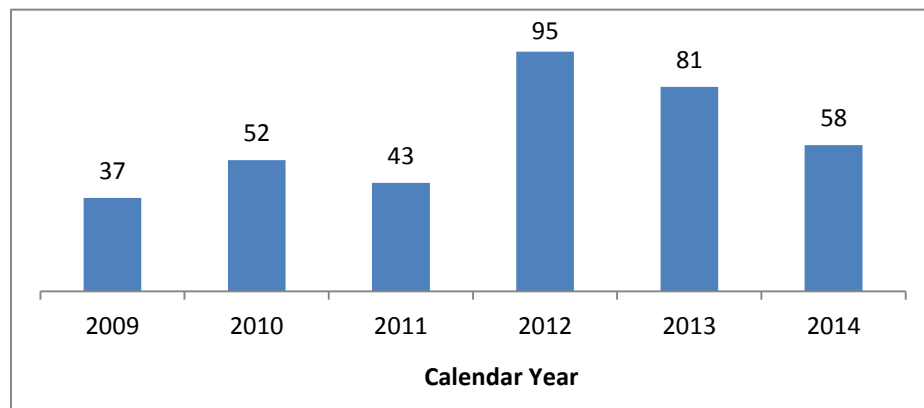
NRC acquired its watt balance device from the United Kingdom's National Physical Laboratory (NPL) in 2009. In 2012, researchers from MSS were the first to report results with a relative standard uncertainty below  $2 \times 10^{-8}$ , which remains the most precise determination of the Planck constant to date.<sup>21</sup> Other watt balance experiments are being undertaken in the U.S. National Institute of Standards and Technology (NIST), the Swiss Federal Office of Metrology in Berne, the International Bureau of Weights and Measures (BIPM) near Paris and Laboratoire national de métrologie et d'essais in Trappes, France.<sup>22</sup>

### 4.3.3 Publication Levels

**Key Finding 19:** *MSS activity levels with respect to publications and participation in international key comparisons have remained more or less consistent over the past five years.*

MSS has maintained a high level of publications in recent years (see Figure 6). Although many NRC portfolios no longer track the number of scientific publications they produce, this remains a corporately reported performance indicator for MSS because its reputation as an NMI is highly dependent on the credibility and reputation of staff. This notion was supported by some of the international NMI representatives interviewed, who stated that an NMI's level of publications can be indicative of a strong reputation in metrology.

**Figure 6: Number of publications with an affiliation to MSS**



Source: NRC Publications Archive

<sup>19</sup> Nicola Jones, "Canada assumes weighty mantle," *Nature* 460 (August 2009): 1070.

<sup>20</sup> NPL, *One step closer to a new kilogram*, <http://www.npl.co.uk/news/one-step-closer-to-a-new-kilogram> (April 16, 2012).

<sup>21</sup> Ian A. Robinson, "Watt and joule balances," *Metrologia* 51 (April 2014).

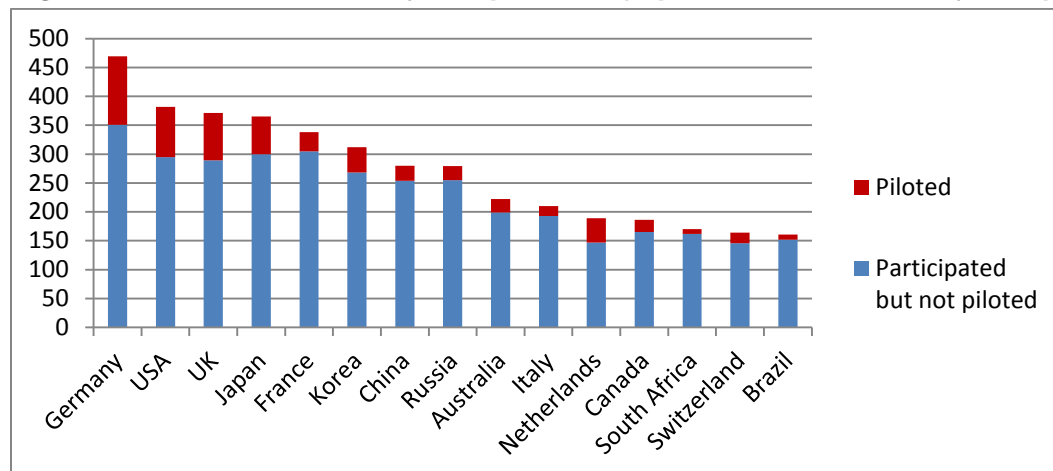
<sup>22</sup> Wikipedia, *Watt balance*, [http://en.wikipedia.org/wiki/Watt\\_balance](http://en.wikipedia.org/wiki/Watt_balance).

### 4.3.4 Participation in Key Comparisons

As Canada’s NMI, MSS participates in international key comparison studies that aim to establish comparability between NMIs and that are a significant component of the CIPM Mutual Recognition Agreement. CIPM key comparisons, of international scope, are carried out by those participants having the highest level of skills in the measurement involved and are restricted to laboratories of CIPM Member States. The CIPM key comparisons deliver "the reference value" for the chosen key quantity and underpin the development of the Calibration and Measurement Capabilities (CMCs).

According to the information presented by BIPM, Canada has participated in a total of 186 key comparisons and has served as the pilot laboratory for approximately 11% of these (as of May 2014). Compared to other nations, Canada ranks twelfth in the world for total number of key comparison exercises conducted to date, and ranks seventh in percentage of key comparisons piloted (see Figure 7). It is fair to say that Canada has piloted a relatively large proportion of the key comparisons in which it has participated. Although some countries, such as France, China, Russia, Australia and Italy have participated in more key comparisons, they have piloted 10% or less of these. The data for Canada is relatively consistent with data from 2010, when Canada was ranked twelfth in number of key comparisons conducted and also twelfth in percentage of key comparisons piloted (11%).

**Figure 7: Total number of key comparisons (top 15 nations as of May 2014)**



## 5. RESOURCE UTILIZATION

### 5.1 Operational Efficiency

**Evaluation Question 7: How efficiently are operations being conducted and could there be improvements made to the efficiency of the MSS Portfolio?**

**Assessment:** MSS is operationally efficient and expenditures related to the maintenance of Canada's NMI are reasonable. Efforts undertaken to improve efficiency include the implementation of matrix-based management within the Portfolio and the improvement of project management practices.

#### 5.1.1 Financial Indicators

**Key Finding 20:** Corporate key performance indicators show a relatively high level of overhead efficiency and business efficiency.

Corporately, NRC tracks a number of key performance indicators, some of which monitor portfolio overhead efficiency and business efficiency. The overhead efficiency indicator calculates indirect costs (that is, any costs that are not directly charged against a project) as a percentage of total expenditures. For 2013-14, MSS's indirect expenditures represented 12.2% of total expenditures, which was the second lowest ratio of all NRC portfolios and well below the NRC target of 32%. From a business efficiency perspective, 92% of MSS's labour expenses were recovered by NRC programs. This ratio indicates a high utilization of MSS human resources as, again, MSS has the second highest ratio among all NRC portfolios.

For facility utilization, the implementation of NRC's facility management model is still in its infancy, making currently reported facility utilization rates incomparable and unreliable.<sup>23</sup> Documents suggest that some MSS facilities such as the Co-60 laboratory and the x-ray laboratory are used at close to capacity, while others are more sporadically used due to their metrological requirements. As NRC has recently appointed an executive level research facilities champion to drive improvements of the management framework and MSS has recently started to implement a more rigorous method of facility costing and assessing utilization, it is expected that more representative capacity and resource use data will be available for management use and for the next evaluation.

#### 5.1.2 Comparison with Other NMIs

**Key Finding 21:** MSS expenditures appear to be reasonable when compared to expenditures of other NMIs.

MSS expenditures (direct and indirect) over the past two years amounted to approximately \$26.8 million per year. Of this amount, about 21% was offset by earned revenues. A 2013 study by the Australian National Measurement Institute compared government spending (per capital and as a proportion of GDP) by several commonwealth countries on primary measurement standards through their respective national metrology institutes. Based on this study, the level of government expenditures allocated to the maintenance of Canada's national NMI appears to be reasonable.

<sup>23</sup> National Research Council Canada, *Audit of Research Facilities Management*, September, 2014.

As noted in section 3.3.1, all NMI representatives interviewed were supportive of the Canadian NMI model and felt that there are benefits associated with including the NMI within an RTO. Some of the benefits suggested by NMI representatives include access to complementary expertise, facilities and equipment. They noted that Canada's model also allows MSS to benefit from existing industrial relationships and to be more aware of leading edge industry innovations. This could potentially improve MSS's ability to anticipate future measurement needs and to deliver on standards of the future. One disadvantage that was noted by NMI representatives is that being part of NRC (or any other large organization) limits MSS's autonomy, and it may therefore be subject to broader organizational priorities.

### 5.1.3 Matrix-Based Management

**Key Finding 22:** *MSS has implemented matrix management within the Portfolio in an effort to make the most efficient use of existing resources.*

In line with the matrix management approach instituted at NRC, MSS has recently implemented its own matrix structure whereby portfolio human resources have been reorganized into four teams, each led by a new Resource Team Leader (RTL). Prior to this change, human resources were organized by discipline, and reported to a Discipline Leader (DL). The RTLs now have a supervisory role and are responsible for HR-related matters, including staffing, HR allocation across the Portfolio, time entry approvals, performance planning and assessment and the coordination of promotion cases. The role of the DLs is now to provide functional supervision of project staff and to make sure that projects are delivered, milestones are met and programs are achieving their goals. This change was made in an effort to:

- **Create a more unified MSS.** Prior to this reorganization, organizational structures very much still resembled the old structures under INMS and staff identified strongly with the disciplines they belonged to. As noted by one internal interviewee, "the change from the institute model to the program model was not clear to people on the ground." Separating the program and project management from the resource ownership was seen as a way to break down silos and encourage a cultural change, and potentially broaden cross-disciplinary collaboration.
- **Improve efficiency.** It is expected that the new matrix structure will help to reduce redundancy within MSS and will lead to greater resource sharing (especially for Technical Officers, who are not necessarily as specialized in one particular discipline).
- **Contribute to succession planning.** The RTL positions will provide additional leadership opportunities within the Portfolio and therefore act as a developmental training ground for more junior staff.
- **Reduce the administrative burden on DLs.** Prior to this change DLs spent a large proportion of their time on administrative aspects. Given that some of this work has now been taken on by RTLs, DLs have more time to focus on project delivery and outreach to clients.

Internal interviewees had mixed reactions regarding the reorganization, which had been introduced in April 2014 and was still relatively new at the time when internal interviews took place for the evaluation. For some interviewees, the change is expected to have a positive effect on portfolio efficiency (these interviewees frequently referred to some of the potential benefits listed above). Others pointed to potential inefficiencies due to the fact that DLs are still



responsible for the functional supervision of staff working on their projects, but are no longer responsible for approving time and evaluating performance. Despite these mixed reactions, most interviewees recognized that any change of this magnitude involves an initial adjustment period and that it may be too early to make a definitive assessment at this time. Meanwhile, MSS management has indicated that they will continue to monitor operations under the new structure and will make adjustments where and when necessary to ensure efficiencies.

**Key Finding 23:** *There is significant cross-resourcing between MSS-hosted programs but cross-resourcing with programs hosted by other NRC portfolios is limited.*

Data indicates that complementary use of competencies and facilities between MSS-hosted programs is common. As illustrated in Table 6, as of October 2014, 49% of MSS personnel were resourced to open projects in at least two different MSS-hosted programs. The highest rate of cross-resourcing occurs between the SSNMS and the MIS programs. This is because staff who are responsible for delivering specialized technical services to clients in a particular discipline also participate in international activities (e.g. committees) related to the maintenance of standards in that discipline. Although cross-resourcing between MSET and the other two MSS-hosted programs is more limited, there are some cases where this has been successful. One example is the aforementioned strategic research project for Natural Resources Canada (see the text box in section 3.3.2), which sought to develop standards for cellulosic nanomaterials. The project was managed through the SSNMS program, but support was provided by the MSET program (in Nanoscale Measurement) as well as by certain disciplines within the MIS program (Chemical Metrology, and Photography, Radiometry and Thermometry).

**Table 6: MSS cross-program human resource utilization (data as of October 2014)**

Programs	Number of Individuals Cross Resourced	Percentage of Individuals Cross Resourced
MIS and MSET	12	6%
MSET and SSNMS	13	7%
SSNMS and MIS	71	37%
At least two programs	94	49%

While the cross-program use of resources is common within MSS, there have been more limited opportunities for staff to support programs hosted by other portfolios within NRC. In 2013-14, approximately 91% of MSS’s labour workforce supported MSS-hosted programs, whereas only approximately 1% worked on programs hosted by other NRC portfolios. Internal interviewees explained that this is in part due to the unique characteristics and requirements of an NMI. For example, equipment and facilities used for metrology have to meet a very stringent level of precision that is not required of other portfolios. Interviewees also suggested that MSS resources are already heavily utilized, so there are limited opportunities for them to be deployed to other portfolios. Nevertheless, there are cases where MSS-hosted programs have utilized expertise available in other portfolios (and vice-versa). For example, an MSET project in the area of nanoscale measurement is being led by a resource from the National Institute of Nanotechnology (NINT), a program under the Security and Disruptive Technologies Portfolio. More recently, MSET has also started working with the Human Health Therapeutics (HHT) Portfolio to identify opportunities to address emerging measurement needs in biotechnology. Conversely, MIS recently contributed to a project led by the Information and Communications

Technologies Portfolio and has provided sophisticated NMR measurement capabilities to the Construction Portfolio.

#### **5.1.4 Project management**

**Key Finding 24:** *MSS project management practices are being improved, although the Portfolio has not yet established a Project Management Office, as it had intended to do in 2014-15.*

MSS has recently sought to improve some of its project management practices, in an effort to increase operational efficiency. Some of the initiatives mentioned by interviewees include improved resource tracking, better costing of facilities, and more consistent pricing of the services offered. Program Leaders also noted that they have recently begun the process of breaking down what they call “omnibus” projects into more mid-sized projects with targeted deliverables, in order to better track resources and results. Although some internal interviewees were not convinced that these changes have yet had an actual impact on portfolio efficiency, others felt that there has been an improvement in that they now have a better awareness of project costs and are being held accountable for the use of resources.

MSS had also identified the creation of a project management office (PMO) as one of its priorities for 2014-15. However, due to competing priorities over the past year, the PMO has not yet been established. MSS staff emphasized the need to prioritize this initiative, in order to reduce the administrative burden that is currently being assumed by research staff. The creation of a PMO was also identified as a best practice in the recent evaluation of the HHT Portfolio. At HHT, the PMO not only takes the lead on performing administrative tasks and meeting reporting requirements, but also aims to improve client communications by offering a “one window approach.”

**Recommendation 4:** MSS should prioritize the implementation of a Project Management Office within the Portfolio.

#### **5.1.5 Interactions with common services**

Almost half of internal interviewees pointed to cases where improved interactions with common services would have a positive impact on portfolio efficiency, although the examples provided were varied. Some of these include:

- Improved processes for contract approvals (e.g. moving from a paper-based system to an electronic approval system);
- Improved coordination and communication with NRC Administrative Services and Property Management (ASPM) (e.g. for planned power shutdowns);
- Better understanding by Information Technology and Security Services (ITSS) of the Portfolio’s specialized information technology and computing requirements;
- More efficient processes for posting CRMs to the Virtual Store; and
- Additional support around IP management.

## 6. CONCLUSION

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NRC plays a central role within Canada's national measurement system. The activities undertaken by MSS, including those related to maintaining Canada's affiliation with the BIPM, are fundamental to the Canadian economy and society. MSS's mandate to provide a public good makes it unique among NRC's portfolios. Internationally, many different models exist for the delivery of a country's NMI but the evaluation found that the rationale for housing Canada's NMI within its RTO is well supported.

The evaluation also found that MSS is operating efficiently and effectively. It has had an impact, not only on direct clients, but also indirectly on industry players who benefit from traceability to the SI. As well, MSS has strengthened Canada's reputation within the international metrology community. Finally, MSS appears to be on track to achieve intended program outcomes, particularly if it is successful in addressing some of the human resource risks it currently faces.

## 7. MANAGEMENT RESPONSE

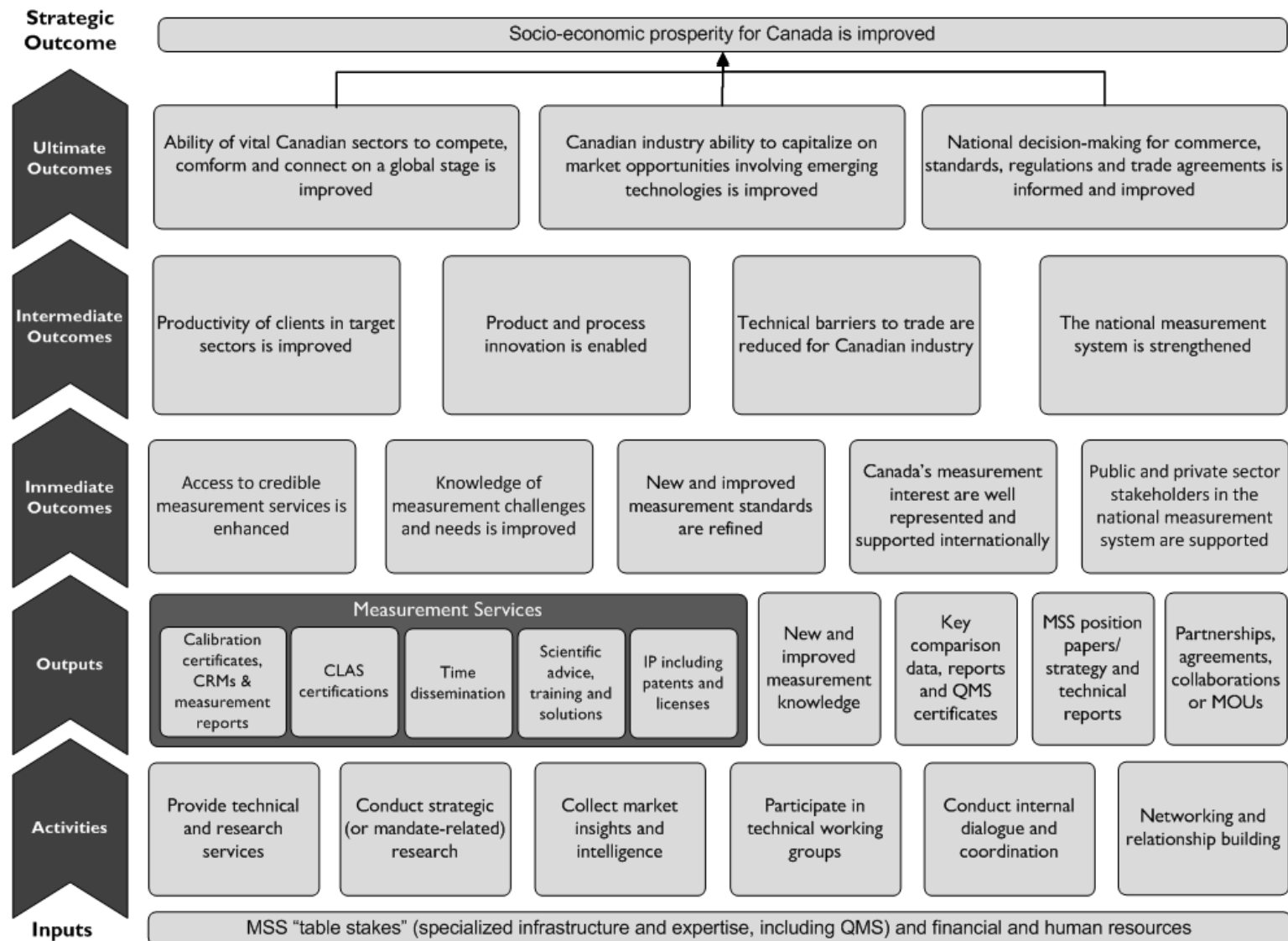
Recommendation	Response and Planned Action(s)	Proposed Person(s) Responsible	Timelines	Measure(s) of Achievement
<p><b>Recommendation 1:</b>                      In order to better meet the needs of OGDs, MSS should aim to further enhance the role it plays in understanding the regulatory environment and being proactive in performing complementary R&amp;D. Such efforts should of course be made, while taking into consideration the current and future capacity of MSS staff.</p>	<p><b>Recommendation accepted.</b>                      Based on MSS’s current and successful projects that support the measurement needs of OGDs, the Research Director will draft a high level view of “what works” (by the end of Q1). Based on this, a template will be developed to mentor and guide BMS and scientific staff to engage OGDs to identify pre-regulatory and standardization related measurement challenges (by the end of Q2).</p>	<p>Research Director</p> <p>Supported by:                      Research Director                      Program Leaders                      Discipline Leaders</p>	<p>End of FY16 Q1</p> <p>End of FY16 Q2</p>	<p>Overview document created</p> <p>Template for understanding measurement needs of OGD is developed and used by BMS and scientific staff.</p>

Recommendation	Response and Planned Action(s)	Proposed Person(s) Responsible	Timelines	Measure(s) of Achievement
<p><b>Recommendation 2:</b> Given that sub-optimal human resource levels have affected client services and pose a significant risk to future portfolio performance, MSS must continue to place a strong emphasis on staffing in order to address human resource gaps. As the programs mature, resource staffing needs will need to be adjusted to ensure that the portfolio can respond in a timely and adequate manner.</p>	<p><b>Recommendation accepted.</b> The 2015-16 MSS strategic and operating plans include an HR hiring and succession plan developed in consultation with the Directors, Discipline Leaders and Resource Team Leaders. The Research Director will steer the execution of this plan, leveraging generic competitions for multiple positions to hire cross-disciplinary resources and identify multiple candidates from a single competition. The portfolio will review and update the HR plan quarterly at the management team level.</p>	<p>Research Director</p> <p>Supported by: Research Director Human Resource Generalist Resource Team Leaders</p>	<p>Quarterly</p> <p>End of FY16 Q2</p> <p>End of FY16</p>	<p>Review of progress and updating of the hiring plan</p> <p>Succession plan completed and approved</p> <p>Staffing actions for 2015-16 (as per hiring plan) have been executed.</p>

Recommendation	Response and Planned Action(s)	Proposed Person(s) Responsible	Timelines	Measure(s) of Achievement
<p><b>Recommendation 3:</b> MSS should review and update the performance measurement frameworks for the Portfolio and for its hosted programs to ensure that performance indicators are relevant and targets are realistic. MSS should also clarify responsibilities for collecting and reporting on performance information.</p>	<p><b>Recommendation accepted.</b> The Program Leaders are updating implementation plans for each program. These will include updated and realistic performance indicators and targets for the programs. Further, the plans will include details on how and by whom the data will be collected, reported and reviewed. These plans will be completed by the Program Leaders, will be reviewed by the MSS management team by May 29, 2015, and will also be available for review by the office of the Vice-President, Emerging Technologies.</p> <p>The MSS operating plan will include updated and realistic performance indicators and targets for the portfolio, as well as details on how and by whom the data will be collected, reported and reviewed. The completion of the plan will be managed by the Director of Operations. The plan will be reviewed by the MSS management team by June 12, 2015 and available for review by the office of the Vice-President, Emerging Technologies.</p>	<p>General Manager</p> <p>Supported by: Research Directors Director Operations Program Leaders</p>	<p>May 29</p> <p>June 12</p> <p>End of FY16 Q2</p>	<p>Updated program implementation plans, with performance indicators and targets</p> <p>Updated portfolio performance indicators and targets included in MSS operating plan.</p> <p>Dashboards are created and used for monitoring and reporting on program and portfolio performance indicators and targets.</p>

Recommendation	Response and Planned Action(s)	Proposed Person(s) Responsible	Timelines	Measure(s) of Achievement
<p><b>Recommendation 4:</b> MSS should prioritize the implementation of a Project Management Office within the Portfolio.</p>	<p><b>Recommendation accepted.</b> MSS has already made significant advances in the planning and design of a project management support office for the Portfolio.</p> <p>The people will be trained and in the roles by June 1, 2015.</p> <p>The processes for project selection, creation and launching will be in place by the end of FY16 Q1.</p> <p>The processes for project monitoring and review will be in place by the end of FY16 Q2, including criteria for prioritizing project reviews.</p>	<p>Director Operations</p> <p>Supported by: Research Directors Program Leaders</p>	<p>Jun 1 2015</p> <p>End of FY16 Q1</p> <p>End of FY16 Q2</p>	<p>Project office staffed and personnel trained</p> <p>Project initiation processes in place</p> <p>Project monitoring processes in place</p>

## APPENDIX A: MSS LOGIC MODEL





## APPENDIX B: METHODOLOGY

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The evaluation of MSS was led by an independent evaluation team from the NRC Office of Audit and Evaluation (OAE). This appendix presents the detailed evaluation methodology used by the evaluation team and includes a discussion on the evaluation rationale, the scope, the design and methods, as well as the challenges and limitations encountered.

### Evaluation Rationale

The timing of the evaluation of the MSS Portfolio was based on consultations with NRC Senior Management and the work was carried out in accordance with NRC's approved evaluation plan. As all three MSS-hosted programs were among the first to be approved through the NRC business planning process, they were expected to have progressed further towards the achievement of their objectives than more recently approved programs. Further, the majority of MSS portfolio resources were drawn from the former NRC Institute for National Measurement Standards (INMS), which was evaluated five years ago. As per Treasury Board's *Policy on Evaluation* (2009), all programs benefiting from any level of direct program spending must be evaluated every five years. As for the assessed contribution to the BIPM, this transfer payment was evaluated in August 2010, as part of the Evaluation of the NRC program of Class Grants to International Affiliations. Therefore, this evaluation also satisfies the requirements of the *Financial Administration Act* (section 42.1), that is, that all ongoing programs of grants and contributions be evaluated every five years.

### Evaluation Scope

This evaluation assessed the value-for-money of MSS, including relevance, performance, and resource utilization. It focused on the two-year period since the Portfolio was created (2012-13 to 2013-14). Where appropriate and available, the evaluation also considered earlier information relating to MSS's predecessor institutes (i.e., 2009-10 to 2011-12). Given the focus on identifying and assessing intermediate impacts from MSS activities, earlier institute activities were considered in the assessment of client impacts, specifically in the case studies that were conducted as part of the evaluation. Moreover, recent developments that have occurred since April 2014 were also taken into account.

The scope of this evaluation also includes an assessment of the ongoing relevance and effectiveness of the assessed contribution to the BIPM. The evaluation of this transfer payment was included because the payment is managed by the MSS Portfolio and MSS staff plays a significant role in supporting Canadian participation in BIPM.

### Evaluation Design and Methodology

The questions to be addressed through the evaluation were developed following consultations with portfolio management and the Vice-President, Emerging Technologies, who identified specific areas of interest and information needs. These were incorporated into the evaluation design, which also meets the requirements of the Treasury Board Policy on Evaluation.

The approach used for the evaluation was commensurate with the level of program risk, which was assessed as low during an assessment conducted as part of the planning phase. Methods were also selected in light of other relevant studies or reviews being undertaken by the program. For instance, because MSS was planning to contract out a partial cost-benefit analysis study in 2015 to determine the economic and long-term benefits for Canada of investing in an NMI, these elements were excluded from the evaluation. As well, the evaluation design took into

consideration the fact that thorough evaluations of INMS and of the assessed contribution to BIPM had been completed in 2009 and 2010, respectively. Therefore, the current evaluation places more emphasis on aspects of the Portfolio that were not previously evaluated (e.g. MSS's role in meeting the needs of OGDs) and took a more calibrated approach for issues that had been previously examined (e.g. the need for and relevance of an NMI).

To maximize the possibility of generating useful, valid and relevant evaluation findings, a mixed methods approach was used. This allowed for the convergence of results across lines of evidence and for a more thorough understanding of the Portfolio and of the issues it faces, given that these issues were explored from different perspectives. Both qualitative and quantitative methods were used and included:

- Internal and external document review;
- Administrative and performance data review;
- Semi-structured interviews;
- Social Network Analysis; and
- Five case studies, one of which included a survey of a CLAS-certified laboratory's clients.

A discussion of the approach used for each of these methods is provided in the following paragraphs.

#### *Internal and External Document Review*

Internal and external documents were reviewed, synthesized and integrated into the evaluation to provide context and history, and to complement other lines of evidence in assessing relevance and performance. Internal documents reviewed included strategic, business, and operational plans for the portfolio and the three programs, special studies, performance reports, presentations, audit reports, evaluation reports, intranet articles, and any other document identified by portfolio management and staff. In addition, external documentation was also reviewed by the evaluation team, such as publicly available information from other NMIs, BIPM, and CIPM. A selected list of the documents reviewed can be found in **Appendix C**.

#### *Administrative and Performance Data Review*

Administrative and performance data for 2009-10 through 2013-14 were reviewed to provide information on resourcing, program outputs and activity levels, financial performance, and operational efficiency. These data contributed to the analysis of program need, achievement of expected outcomes, and resource utilization. To the extent possible, administrative data was drawn from corporate systems and from corporately prepared reports (e.g. reports prepared by Finance Branch and Planning and Reporting Services). Output and performance data was also provided by MSS staff and some activity data was available through the BIPM website.

#### *Semi-Structured Interviews*

Semi-structured interviews were conducted with portfolio stakeholders to collect information such as personal experiences, opinions, and expert knowledge. This information was used to complement other lines of evidence and to contextualize quantitative information. Interviews were also conducted to inform the development of case studies and the Social Network Analysis. However, these will be described along with the respective method which they informed, and thus, are not included in the following numbers and descriptions.

In total, 38 MSS stakeholders were interviewed, including 23 internal stakeholders (MSS management and staff, HR Branch staff and BMS staff) and 16 external stakeholders. The breakdown by interviewee type is provided in Table 7. External stakeholders included: nine active clients of MSS (defined as those who had had a project with NRC in the past three years); two other Canadian stakeholders (including one calibration laboratory that is not a client of MSS and an organization that specializes in providing training in laboratory quality systems); and representatives from four other NMIs around the world. In selecting potential client interviewees, an attempt was made to include many of MSS's top revenue-generating clients. The selection of other interviewees reflects the information needs of the evaluation and was informed by suggestions made by MSS management during the evaluation planning phase.

**Table 7: Stakeholders interviewed**

Interviewee Category	Interviewee Type	# of Individuals Interviewed
<b>Internal</b>	MSS portfolio management and staff, as well as portfolio support staff from HR Branch and BMS	23
<b>External</b>	MSS portfolio clients	9
	Other Canadian industry stakeholders	2
	Representatives from international NMIs	4
<b>TOTAL</b>		<b>38</b>

Interviews with internal stakeholders were conducted mostly in person, while interviews with external stakeholders were all conducted by telephone. Interview guides were developed to align questions with the information requirements as identified in the evaluation framework. This process ensured that the information requested would yield relevant information in support of evaluation judgement criteria and indicators.

All interviewees received the interview guide in advance of the interview. In some cases, interviewees elected to provide their comments in writing to the evaluation team, either following the interview or instead of participating in an interview. The majority of interviews were individual. However, two group interviews were conducted with some Discipline Leaders for reasons of efficiency and to provide a richer discussion.

### *Social Network Analysis*

Social Network Analysis was used as a method to develop a "system map" of the federal government departments involved in Canada's national measurement system. An external consultant was hired to carry out this method. The objective of the social network analysis was to provide evidence in response to the following evaluation question: What are the metrology-related needs of other government departments and what role should the MSS Portfolio be playing to support them? Specifically, this method helped to differentiate the roles played by federal government departments that are key contributors to Canada's national measurement system from those that are dependent on the system (e.g., regulatory bodies). It also helped to

clarify the role that MSS plays in supporting the system and other stakeholders' awareness of that role.

As a first step, OAE developed an initial list of the key players in Canada's national measurement system, based on information and documentation provided by MSS management and staff. The list was provided to the consultant, who then completed the following tasks:

- Conducted interviews with MSS staff to develop a better understanding of Canada's national measurement system, key players, their respective roles, and their connections to one another. These internal consultations established MSS's connections in metrology and measurement within the federal government and established a framework for measuring the strength of MSS's relationship with other key players. From these interviews, a list of key external contacts was generated.
- Conducted interviews with key external contacts, including with representatives from Measurement Canada and the Standards Council of Canada, who are partners of MSS in the core group that make up Canada's national measurement system. These interviews established measures of connectivity within the core group and from their positions outward to other government departments and agencies.
- Conducted interviews with the contacts from other federal departments outside of the core group.

A representative from OAE accompanied the consultant to some of the interviews. In all cases, the interviews gathered information on the existence and strength of ties between federal departments and agencies in metrology and measurement, as well as the awareness among interviewees of MSS's roles and responsibilities within the national measurement system. In addition, interviewees also commented on the existence of barriers, disconnects and best practices used by federal government departments and agencies to conduct their business in metrology and measurement. Upon the completion of the data collection and analysis, a "system map" was produced depicting the network of key federal government players in Canada's national measurement system. The specific methodology used by the consultant to collect and analyze the data, as well as several variations of the system map can be found in the report produced by the consultant entitled *Social Network Analysis: Metrology* (19 August 2014).

### *Case Studies*

OAE undertook the development of five case studies. This case study methodology had the following objectives:

- To gain better understanding of the types of projects and activities being conducted by the MSS Portfolio;
- To determine how client needs have been met through these projects;
- To identify the social and/or economic impacts of MSS's involvement with these clients;
- To identify other beneficiaries of MSS products and services and the impact traceable back to MSS; and
- To identify examples in support of key findings from other lines of evidence.

The case studies were selected in collaboration with MSS management and included clients involved with all three MSS-hosted programs in some capacity. The case studies also included three projects previously selected for case study in support of the 2009 INMS Evaluation. This gave the current evaluation a unique opportunity to assess, in the current context, additional

and longer-term economic and social impacts of MSS products and services beyond the immediate impacts revealed by the 2009 evaluation. Finally, the decision to include specific clients/projects for case study was influenced by the need to have representation of different client types (including industry, OGD clients and CLAS clients). The final selection of case study clients is listed in Table 8.

**Table 8: Representation of case study clients within the MSS-hosted programs**

Case Study Client Selected	Project Name	Program		
		MIS	MSET	SSNMS
Natural Resources Canada	Development of standards for cellulosic nanomaterials ( <i>new</i> )		✓ (Characterization)	✓ (Advisory services)
Ulrich Metrology Inc.	All services accessed from MSS ( <i>new</i> )	✓ (Calibrations)		✓ (CLAS)
“Company X”	Development of a CRM for Selenium-Enriched Yeast (SELM-1) ( <i>also selected for case study during the 2009 evaluation</i> )	✓ (Research Services, Characterization, CRM)		
“Company Y”	Monte Carlo Electron Radiotherapy Dose Calculation Project (VMC++) ( <i>also selected for case study during the 2009 evaluation</i> )	✓ (IP)		
Measurements International Ltd.	QuantOhm Project ( <i>also selected for case study during the 2009 evaluation</i> )	✓ (IP, Technical and Research Services)		

Four of the five case studies focused on the impacts generated from one specific project conducted by MSS over a specific period of time. In contrast, the case study on Ulrich Metrology Inc. was specifically designed with a wider scope to cover the broader interactions between MSS and the client, including all services offered to this client since becoming a client of MSS. As result, this more detailed case study used more research methods to gather the evidence.

The case studies were developed using a common template and information was collected through reviews of project documentation, available external documentation (e.g., newspaper articles discussing the project or its impacts), and interviews with both MSS project staff and external client representatives. The case study on Ulrich Metrology also included a brief online survey of Ulrich Metrology’s clients. The details of the survey methodology are described below. Once data was collected, analyzed, and summarized, drafts were shared with internal and external interviewees for factual validation.

*Survey of Ulrich Metrology’s Clients*

A short survey targeting Ulrich Metrology’s clients was designed and administered by OAE to support the case study on Ulrich Metrology. The main purpose of the survey was to identify the impacts of the services provided to Ulrich Metrology’s clients that could be traced back to the

services provided by MSS. In addition, a few client satisfaction questions were added to the survey at the request of Ulrich Metrology, the results of which will be used by the client for internal purposes.

The survey was electronically administered and delivered via Fluid Survey software with the assistance of the NRC Communications Branch. The survey included a total of 14 questions. A link to the web-based survey was sent to over 900 email addresses from a client list provided by Ulrich Metrology. An appropriate response rate was achieved, with 249 respondents completing the survey, yielding a 90% confidence in the results (with a confidence interval of +/-5%).

The survey was delivered in accordance with policies on public opinion research and laws regarding privacy of information. Information was anonymously collected, unless the survey participant voluntarily provided identifying information (e.g. company name, company size, etc.). Survey questions were designed and piloted by OAE and vetted by representatives from MSS, Ulrich Metrology, and the NRC Communications Branch.

Once the survey was complete, the survey data was exported from Fluid Survey by NRC Communications Branch and sent to OAE for analysis. The analysis of survey responses was discussed with a representative from Ulrich Metrology during an interview to provide context to the responses.

### Challenges and Limitations

Various limitations and challenges were experienced in conducting the evaluation of MSS that need to be taken into consideration when interpreting the findings. The challenges and limitations in the current evaluation are not unique. Rather, they are common in most evaluations conducted within the federal government. In order to alleviate the effects of the limitations and challenges on the evaluation findings, various mitigation strategies have been used. The main challenges experienced by OAE as part of the project include the following:

- **Interviews as a primary line of evidence and potential response bias of client interviewees:** Interview evidence is based on personal perceptions of a select group of interviewees. Because client interviewees were selected based upon a list of the top revenue-generating clients of MSS, and in collaboration with MSS management, this could bias interviewees towards those who have a more positive view MSS. As a mitigation strategy, interview results were verified against findings from other lines of evidence. Clients were also encouraged to provide feedback that would help NRC to improve the program and were reminded about the anonymity of their responses. In the end, clients were very open with their responses and provided well-balanced feedback on the MSS services and products they accessed and at times specifically supported their opinions with hard evidence.
- **Case studies are not representative of the experiences of all MSS clients:** Case studies were selected based on recommendations from MSS staff and represent the experiences of five specific clients of MSS. Therefore, these projects are not intended to be representative of the views of all MSS clients or of the impacts of MSS on all clients. As a mitigation strategy, the case studies were used primarily as examples to illustrate findings from other lines of evidence. When specific themes from case studies emerged, they were confirmed via other lines of evidence before being specifically discussed in the report.

- **Recent portfolio implementation:** Because the MSS Portfolio and its hosted programs were only implemented in 2012-13, there is limited information on impacts that are specifically attributable to the MSS Portfolio. However many of the outputs and impacts of MSS build on the work conducted by the former institute (INMS). Because the new portfolio structure did not change the mandate of MSS as Canada's NMI, nor the services and products offered to industry, impacts of the former institute could be generalized to MSS.
- **Attribution to MSS:** As is the case with many programs, attribution of impacts specifically to MSS is difficult due to the many external contributing factors that influence the success of industrial clients. Where possible, the evaluation made efforts to discuss how MSS may be contributing to impacts while considering other factors that may have also played a role.

## APPENDIX C: SELECTION OF DOCUMENTS REVIEWED

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