Evaluation of Istituto Nazionale di Ricerca Metrologica 2011

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1 Executive summary

This report of the Scientific Evaluation Committee of INRIM for the year 2011 is its sixth report since 2006. In its first five reports, the focus was on the merging process between the former Italian metrology institutes IEN and IMGC; and indeed the 2010 report concluded that this process could considered to be successfully brought to an end. Therefore, this year’s report take a forward looking approach and makes suggestions for the future, based on the foreseen developments in society as well as on the trends that emerge from the last five years’ reports.

The findings of the Scientific Evaluation Committee for 2011 are summarised as follows:

General performance:

Measured by key figures, INRIM shows remarkable stability, in otherwise turbulent times. The positive side of this is that INRIM has not suffered from severe budget cuts that have hit both other Italian institutions and many other national metrology institutes; and it has been able to maintain its high scientific profile. The back side of this stability is that INRIM appears to develop without a clear strategic direction or focus. On the hole, INRIM seems to be driven by enthusiastic personal motives with only little guidance from management.

The above behaviour results in a situation, where INRIM continues to develop along its traditional strengths; but has difficulties in taking up modern dissemination of knowledge on a commercial basis, since it requires skills that are not present at INRIM.

The scientific evaluation committee has three general recommendations, which largely are repetitions from previous years:

- INRIM should adopt a more strategic approach to ensure that it develops in a sustainable manner in accordance with its mission.
- In order to make the strategic approach operational, INRIM should develop a common approach to the enumeration of allocation of resources, so that it matches the agreed categories of work: scientific, maintaining national standards and dissemination.
- INRIM should partner with institutions in order to have access to expertise that it does not possess satisfactorily itself. Examples are to broaden its scope of chemical metrology, and to acquire knowledge about how to set up spin-off companies.

Scientific performance:

Regarding the scientific activity for 2011, the Committee findings are summarised as follows:

The Committee appreciate that in 2011:

1) the numerousness of the scientific production was increased with respect to 2010;

2) the quality of the scientific production was higher than that of a pure NMI Institute for all the Divisions;

3) the interest of the scientific production of the Mechanics and Optics divisions was rather good.
In chapter 3.4 the committee offers seven specific suggestions that may improve the scientific performance and its documentation of INRIM.

*National Measurement Standards:*

The summary and suggestions for improvements with regard to INRIM's performance as a national metrology institute is strongly influenced by the observation that INRIM as one of the oldest and highly recognised NMIs in Europe, based on solid scientific approach to metrology and the opinion that basic and traditional metrology is not questioned by funding authorities.

During 2011 INRIM has continued its work along the traditional lines of the mission for national metrology institutes. It maintains primary standards within the traditional areas of needs of Italian society and industry, and takes part in the work of the CIPM-MRA so that its certificates are accepted all over the world.

INRIM is visibly engaged in the international organisations EURAMET and the Metre Convention, as well in associated organisations, e.g. standardization.

However, when it comes to the newer demands on NMIs, innovation and development, INRIM does not appear to engage very strongly. Its impressive scientific activity does not give noticeable rise to new calibration capabilities, nor does it give rise to tangible spin off by other means.

As INRIM's NMI-performance has been monitored by the evaluation committee for more than five years, and as the observations' have been very similar to this year's, most the recommendations given in previous evaluation reports are still valid.

*Knowledge dissemination:*

The INRIM activities of knowledge diffusion towards community and academy can be considered excellent for both quality and quantity. The visibility and proposal capability at international level of INRIM Institute in National and International activities testifies its interaction ability in several metrological sectors with the community and the scientific academy. However, the INRIM Institute should still improve the knowledge dissemination activities about International System of Units also for quantities that are for instance related to health and environment.

Whereas INRIM is strong in its interaction with academia and the general public, it is weak in commercial dissemination and innovation. An effort to acquire the necessary competences in order to reduce such weakness could be suggested to INRIM, in particular by partnering with the Incubator I3P. This is included in a step-wise guide made by the evaluation committee.

Further in Chapter 5.3 the evaluation committee offers seven specific proposal to improve INRIM’s dissemination of knowledge.

*Economic analysis*

Economic analysis correlates the quinquennial trend with the past indications of the Evaluation Committee, and with the benchmark offered by European and extra European Metrology Institutes. Key economic indices are investments, self-funding (projects, contracts and commercial income), funds to support scholarships and fellowships, as the latter should be a leverage for compensating a substantially frozen staff, and finally the income per staff, as an indication of the capability of transferring knowledge and technology. Whilst the first tri-
ennial (2007-2009) witnessed a steady growth, the year 2010 resulted into a significant economic halt, which, in the 2010 relation of the Evaluation Committee\(^1\), was interpreted as a contingent fluctuation, strictly related to economic crisis and to constraints of the regulatory body. Actually, as pointed out in the same document, the 2010 picture appears less dark by observing positive facts, like the exploit of the Europe-wide competitive research funding (+150% with respect to 2007-2009 triennial). The 2011 economic results confirm such view, since the 2011 discounted income has slightly increased with respect to 2010, demonstrating the Institute capability of reacting to an environment conjuncture. The positive picture is confirmed by a repeated exploit in the Europe-wide funding, and in general by a solid self-funding capability.

Quinquennial trend and average of INRIM with and without 2008 special fund: discounted income. (Reproduction of Figure 8 in Chapter 6.4)

Focusing on the single items of the income and expense balance, the analysis still shows negative trends and weaknesses. We refer in particular to key items like fellowships and investments, as they either have further declined (fellowships) or have remained fixed at the low 2010 value (investments). Investments that were raised in 2009 to the acceptable figure (for the European standard) of 20% fell down to about 10 % in 2010 and 2011, a value that can hardly aid a Metrology Institute to stay competitive and become a reference world-wide. The Committee is aware of the constraints impeding INRIM to put in action all of its potentialities, but modern metrology being pervasive of society and life should indicate the road map to INRIM management for breaking the straitjacket impeding Italian (metrological) research and technology to burst.

\(^1\) K. Carneiro et al., Evaluation of Istituto Nazionale di Ricerca Metrologica 2010.
2 Introduction, Method of work.

The Evaluation Committee (Comitato di Valutazione, “Committee”), established by the legislative Decree n. 38/2004, Art 10, has performed its fifth evaluation of the Istituto Nazionale di Ricerca Metrologica, INRIM, for the year 2011.

Importantly, new statutes for INRIM were issued in December 2009, and gradually implemented during 2010 and 2011. The changes were introduced simultaneously with personal changes in the positions of the president, the general director and the scientific director (now Department Coordinator). Another important change for the future work of the Evaluation Committee is the introduction of an annual external evaluation of IMRIM, since it is belonging to the family of institute operating with reference to the Ministry of Education, Universities and Research. Unfortunately, the modest steps towards a more strategic orientation of INRIM that were discussed last year have not progressed noticeably during 2011.

This report is based on the documents "Relazione consuntiva 2011” and “Risultati e Dati 2011”, as well an on-site visit during 5-7 December 2011. Here oral presentations from the four divisions of INRIM as well as a visit to the chemical laboratories. The evaluation report for 2010, as well as the progress during 2011 was discussed with senior officials of the institute (President, Department Coordinator, and four Division Responsibles). INRIM’s ”Annual Report 2011”, although published electronically in September 2012, was not available at the time of the evaluation.

Unfortunately, the reporting for 2011 by the institute and is not fully aligned with the needs of the Evaluation Committee with respect to the management of INRIM’s human resources, and therefore the analyses of how the technical personnel’s time is used on different projects and categories of work, cannot be done.

The report evaluates INRIM’s activities according to the three different facets of modern national metrology:

- Scientific work, Chapter 3
- National Measurement Standards, Chapter 4
- Dissemination of knowledge, Chapter 5.

INRIM’s economic management is evaluated under the heading:

- Economy and Resources, Chapter 6

Further, the report contains the following appendices in Chapter 7:

- Material submitted to the Evaluation committee
- List of acronyms
- Proposal for an approach to strategic management
- Summary of developments at ENEA-INMRI

In accordance with five-year approach to this year’s evaluation report, when possible Chapters 3 to 6 include trends analyses for the period 2007 –2011.

Like previously, the evaluation focuses on the activities of INRIM’s Department and its four divisions: Electromagnetism, Mechanics, Optics, and Thermodynamics.
In order to get a complete picture of the whole Italian metrology organisation the evaluation report contains a summary of the developments at the Italian Designated Institute for Ionising Radiation ENEA-INMRI. The summary is given in Appendix 7.3.

Two extraordinary items should be mentioned, since they influence this year’s report:

- In 2010 a new government evaluation agency ANVUR started its activities, and in 2011 the scientific staff has submitted material for evaluation, in accordance with the requests from ANVUR. As no results have yet been released from ANVUR the evaluation committee has made no changes to its scientific evaluation.
- Since the 2010-report gave rise to critical remarks regarding the way the chemistry activities at INRIM were treated, a special investigation has been undertaken for this activity in 2011.

Finally, the evaluation committee would like to express its gratitude for the openness exhibited by all staff of INRIM and particularly to the senior staff for frank discussions. Also the director of ENEA-INRIM is thanked for his contribution.
3 Scientific work.

During 2011, the national evaluation agency ANVUR started the evaluation of the Italian research institutes and universities for the years 2004 – 2010. INRIM, as the other institutions, was asked to submit the best products of that period, six different products per active researcher.

The Committee recognise the importance of this evaluation procedure that will complement the actual one and will help in ameliorating it: in the future the criteria up to now used and the results and conclusions up to now achieved will be merged with those of ANVUR.

As the ANVUR evaluation is still in progress, at the moment only few general considerations can be made; first the ANVUR evaluation is complementary to the actual one because it will provide an evaluation of the Institute through the evaluation of the best research products of single researchers, but will not consider the quantity and the mean quality of the research. In addition, it is not clear if and how ANVUR will consider that INRIM is a research institute with a specific metrological mission and a collection of activities different from that of a research institute. Finally, ANVUR will evaluate the Institute as a whole, but a careful evaluation also at division level is mandatory: in order to look at and to analyse the ANVUR evaluation also at division level, the evaluation results of each division shall be explicitly asked to ANVUR.

As for the products submitted to ANVUR, the Committee notes that INRIM has submitted products to five different evaluation panels (GEV in the ANVUR terminology), about 75% to the Engineering panel and 20% to Physics panel, the others to the Chemistry, Medical and Economics panels: this is in line with the large spread of different activities present at INRIM and should ensure an evaluation of the research adapted to the specific field. 63% of the 94 evaluated persons submitted ISI products; the remaining 37% submitted non ISI products. 80% of the 453 submitted products were ISI; among the non-ISI ones particular attention should be given to the “Experimental Setups” submitted (2% of the total products).

Waiting for the ANVUR evaluation, as in the previous years also for 2011 the Committee proceed in the evaluation of “research products”, documented essentially by the publications, and of overall research activities, documented by the research projects and realizations of scientific relevance, along the guidelines of the previous years.

3.1 Research Products

Table 1 reports the key numbers of the scientific research products for the Department and for the four Divisions; the detailed list of the products is in the document “Risultati e Dati 2011”.

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Table 1 Breakdown of scientific production in 2011

Table 2 shows the INRIM human resources dedicated to R&D and research contracts activities.

Table 2 Equivalent Human Resources FTE

As in the previous evaluation reports, these key numbers are used to calculate some indicators useful for evaluating the scientific activity of the Department as a whole and of the single divisions (Table 3). In order to simplify the analysis with respect to previous years, we limit to the following three indicators:

- "Numerousness of the scientific production at International level" defined as the number of publications in international journals with IF per FTE (indicator b$_2$ of the previous reports);
- "Mean quality of the scientific production" defined as the mean value of the IF of publications (indicator b$_1$ of the previous reports);
- "Presence at international level" defined as the number of papers on Conference Proceedings and communications at international conferences, seminars and meetings per FTE$^1$ (indicator c of the previous reports).

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$^1$ To avoid considering twice a “presence” at International level, only the higher between the number of Papers in Conference Proceedings and the number of Communication at International Conferences was considered.

Page 9 of 74
<table>
<thead>
<tr>
<th>Indicator/Division</th>
<th>E</th>
<th>M</th>
<th>O</th>
<th>T</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Numerousness of the International scientific production” (b, of previous reports)</td>
<td>1,2</td>
<td>0,9</td>
<td>0,9</td>
<td>0,9</td>
<td>1,0</td>
</tr>
<tr>
<td>“Mean quality of the scientific production” (b, of previous reports)</td>
<td>2,1</td>
<td>1,8</td>
<td>2,0</td>
<td>2,0</td>
<td>2,0</td>
</tr>
<tr>
<td>“Presence at international level” (c of previous reports)</td>
<td>1,3</td>
<td>1,6</td>
<td>1,0</td>
<td>0,8</td>
<td>1,2</td>
</tr>
</tbody>
</table>

Table 3 Indicators of the scientific activity referred to the total FTE

On the basis of Table 3, we underline some aspects that we consider particularly relevant for the INRIM evaluation, comparing them with the values of the previous years.

**Numerousness of the scientific production at International level**

<table>
<thead>
<tr>
<th>Division/Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>1,2</td>
<td>1,2</td>
<td>1,3</td>
<td>0,8</td>
<td>1,2</td>
<td>1,1</td>
</tr>
<tr>
<td>M</td>
<td>0,6</td>
<td>0,6</td>
<td>1,3</td>
<td>0,4</td>
<td>0,9</td>
<td>0,8</td>
</tr>
<tr>
<td>O</td>
<td>1,3</td>
<td>0,9</td>
<td>1,1</td>
<td>0,6</td>
<td>0,9</td>
<td>1,0</td>
</tr>
<tr>
<td>T</td>
<td>0,8</td>
<td>0,9</td>
<td>0,6</td>
<td>0,8</td>
<td>0,9</td>
<td>0,8</td>
</tr>
<tr>
<td>Mean Value</td>
<td>1,0</td>
<td>0,9</td>
<td>1,1</td>
<td>0,7</td>
<td>1,0</td>
<td>0,9</td>
</tr>
</tbody>
</table>

Table 4 Numerousness of the scientific production at International level

The numerousness of the scientific production at International level during 2011 was in line with that of the previous years, demonstrating that the decrease registered in 2010 was due to temporary causes; it is judged satisfactory.

**Quality of the scientific production**

<table>
<thead>
<tr>
<th>Division/Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>1,7</td>
<td>1,6</td>
<td>1,4</td>
<td>1,5</td>
<td>1,8</td>
<td>2,1</td>
<td>1,6</td>
</tr>
<tr>
<td>M</td>
<td>1,4</td>
<td>1,4</td>
<td>1,9</td>
<td>1,5</td>
<td>2,0</td>
<td>1,8</td>
<td>1,7</td>
</tr>
<tr>
<td>O</td>
<td>2,2</td>
<td>1,8</td>
<td>3,3</td>
<td>2,0</td>
<td>4,3</td>
<td>2,0</td>
<td>2,7</td>
</tr>
<tr>
<td>T</td>
<td>1,6</td>
<td>1,6</td>
<td>1,7</td>
<td>1,5</td>
<td>1,7</td>
<td>2,0</td>
<td>1,6</td>
</tr>
<tr>
<td>INRIM</td>
<td>1,7</td>
<td>1,6</td>
<td>2,1</td>
<td>1,6</td>
<td>2,4</td>
<td>2,0</td>
<td>1,9</td>
</tr>
</tbody>
</table>

Table 5 Quality of the scientific production

The Committee considers the average quality of the 2011 scientific production at INRIM level good even if rather smaller than that of 2010. At division level an increase of quality is registered by Electromagnetism and Thermodynamics, a decrease by Mechanics and Optics; such fluctuations are normal, being the relevant decrease of Optics in 2011 mainly due to the excellent performance of the previous year.

As already underlined in the previous reports many metrology journals of standard quality have IF around or slightly larger than 1.5, therefore such a value indicates a standard NMI activity. For 2011, as well as in average value for the entire evaluated period 2006-2011, all the divisions are above this min-
imum quality level, showing that the quality of the research activity is above a standard level for an Institute mainly dedicated to NMI.

However, INRIM should be also a research metrological institute, performing also R&D research. Assuming the IF of Metrologia (IF=1.688) as an indicator of a good NMI research work and that of Physical Review B (IF=3.774) as an indicator of good R&D research, the quality of the overall scientific activity should be at least between these two values. The Committee highly appreciated that all the division for 2011 reach this quality level.

At INRIM level the average quality of the overall 2006-2011 evaluated period is inside this range, so it is judged positively. At division level the same is true only for Optics; as for the other divisions, the Committee recognizes an increase of the quality with time: actions taken by the management to increase the quality of the research are giving results. The Committee strongly suggest pursuing in this direction, in order to stabilize and even ameliorate such performance.

**Presence at International level**

The Committee considers this indicator extremely important for an Institute that, for its main mission, must take part in significant international activities. In 2011 the presence at International level of Electromagnetism and Mechanics was adequate, but that of Optics and of Thermodynamics showed a remarkable decrease. In particular the value for Thermodynamics is completely unsatisfactory: it implies that only one half of the adepts attended in 2011 to International congress or workshop.

The Committee strongly recommends to the management that the presence at International Conferences, Meetings and Organisms will be maintained at least at the 2011 level for Electromagnetism and Mechanics and increased for Optics and Thermodynamics.

**Interest of the scientific production**

We now consider the Citation Impact of INRIM during the 2006-2011 period reported in Table 6.

<table>
<thead>
<tr>
<th>Division</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetism</td>
<td>4</td>
<td>2,7</td>
<td>1,5</td>
<td>1,3</td>
<td>0,1</td>
<td>0,9</td>
<td>1,8</td>
</tr>
<tr>
<td>Mechanics</td>
<td>4</td>
<td>10</td>
<td>1,8</td>
<td>1,1</td>
<td>0,1</td>
<td>3,1</td>
<td>3,4</td>
</tr>
<tr>
<td>Optics</td>
<td>16,1</td>
<td>8,4</td>
<td>11,8</td>
<td>2,5</td>
<td>0,4</td>
<td>2,2</td>
<td>6,9</td>
</tr>
<tr>
<td>Thermodynamics</td>
<td>5,1</td>
<td>4</td>
<td>2,5</td>
<td>1,4</td>
<td>0,7</td>
<td>0,7</td>
<td>2,4</td>
</tr>
<tr>
<td>INRIM</td>
<td><strong>6,4</strong></td>
<td><strong>4,7</strong></td>
<td><strong>3,6</strong></td>
<td><strong>1,5</strong></td>
<td><strong>0,3</strong></td>
<td><strong>1,4</strong></td>
<td><strong>3,0</strong></td>
</tr>
</tbody>
</table>

**Table 6: Citation impact of the scientific production**

The Citation Impact is a measure of the interest that papers rise in the scientific community; it allows to evaluate if the research topics and the results are well considered at International level. After an appropriate renormalization to
take into account the time elapsed from publication, it should be similar to the IF of the review. Assuming a paper life of two years we calculated the normalised CI values reported in Table 7: it results that both Mechanics and Optics have a scientific production with a good “interest” factor, while Electromagnetism and Thermodynamics do not.

<table>
<thead>
<tr>
<th>Division/Year</th>
<th>IF Mean Value</th>
<th>Normalized CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>1.68</td>
<td>0.95</td>
</tr>
<tr>
<td>M</td>
<td>1.67</td>
<td>1.93</td>
</tr>
<tr>
<td>O</td>
<td>2.60</td>
<td>3.63</td>
</tr>
<tr>
<td>T</td>
<td>1.68</td>
<td>1.26</td>
</tr>
<tr>
<td>INRIM Mean Value</td>
<td>1.90</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Table 7 Comparison between Impact factors and normalised Citation Impact mean values in the 2006-2011 period.

3.2 Highlights

3.2.1 2011 R&D Highlights

Table 8 reports some data on the R&D Highlights presented for 2011; the Committee first appreciate that the number of them is significant with respect to the scientific production being for all the divisions around or higher than 10%; this implies that the presented highlights are not only exceptional products but give a picture of the best products based on the overall activities. The Committee appreciates the quality of these highlights, underlining the presence of excellent products in all divisions. The CI compares well with the mean IF at INRIM level; at Division level it is significantly higher than the IF for Optics and Mechanics, demonstrating there is a significant interest of the scientific community towards investigations of these divisions. It is rather low for Electromagnetism and Thermodynamics, however the Committee assume it may be due to the still short time elapsed from the publication of the papers; this aspect will be reconsidered next year.

<table>
<thead>
<tr>
<th>R&amp;D Highlights</th>
<th>E</th>
<th>M</th>
<th>O</th>
<th>T</th>
<th>INRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Mean IF of Highlights</td>
<td>8.5</td>
<td>3.0</td>
<td>5.7</td>
<td>3.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Mean IF of 2011 products</td>
<td>2.1</td>
<td>1.8</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>CI of Highlights</td>
<td>4.8</td>
<td>13.2</td>
<td>8.5</td>
<td>1.0</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Table 8 Statistical analysis of the 2011 R&D Highlights

3.2.2 2011 NMI Highlights

Table 9 reports some data on the NMI Highlights presented for 2011; regarding these data the Committee underline that the mean IF of the NMI highlights should not be lower than the IF of Metrologia (1.688) as happens this year for Electromagnetism: the management should monitor this aspect because it may indicate a weakness of the division in developing new metrological methods. In addition the CI is rather low, significantly lower than the CI for all the divisions;

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1 The normalised CI factors are the mean of the values of Table 6 divided by two for years 2006-2010 and by one for 2011.
also this aspect should be carefully checked: a low CI implies a poor interest of the scientific community towards these studies.

<table>
<thead>
<tr>
<th>NMI Highlights</th>
<th>E</th>
<th>M</th>
<th>O</th>
<th>T</th>
<th>INRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Mean IF of Highlights</td>
<td>1,4</td>
<td>2,0</td>
<td>1,7</td>
<td>2,2</td>
<td>1,8</td>
</tr>
<tr>
<td>CI of Highlights</td>
<td>0,3</td>
<td>0,50</td>
<td>1</td>
<td>0,5</td>
<td>0,6</td>
</tr>
</tbody>
</table>

Table 9 Statistical analysis of the 2011 NMI Highlights

### 3.2.3 Evolution of the 2007-2010 Highlights

Table 10 reports an analysis on the highlights presented for the years 2007-2010; a clear division between R&D and NMI highlights was indicated only in the last two reports, therefore in the present analysis the highlights are considered all together.

<table>
<thead>
<tr>
<th>Highlights 2007-2010</th>
<th>E</th>
<th>M</th>
<th>O</th>
<th>T</th>
<th>INRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean IF of Highlights</td>
<td>2,4</td>
<td>3,1</td>
<td>9,5</td>
<td>4,5</td>
<td>4,9</td>
</tr>
<tr>
<td>Mean IF of overall production</td>
<td>1,6</td>
<td>1,7</td>
<td>2,9</td>
<td>1,6</td>
<td>1,9</td>
</tr>
<tr>
<td>Mean Citations per Highlight</td>
<td>4,3</td>
<td>9,9</td>
<td>69,1</td>
<td>15,3</td>
<td>24,4</td>
</tr>
<tr>
<td>Mean CI of Highlights</td>
<td>1,3</td>
<td>2,5</td>
<td>17,5</td>
<td>3,7</td>
<td>6,2</td>
</tr>
</tbody>
</table>

Table 10 Statistical evolution of the 2007-2010 Highlights

The quality of the highlights during these years was very good for both Optics and Thermodynamics division; it is satisfactory for Mechanics and should be ameliorated for Electromagnetic divisions. The interest of these highlights is rather good for all divisions apart for Electromagnetism.

### 3.2 Benchmarking research activity

In the evaluation report for 2010, we compared the scientific activity of INRIM with those of some other metrological Institutes around the world, we used as benchmarks. The reasons for the choice of these Institutes are given in the following table.

<table>
<thead>
<tr>
<th>Institute</th>
<th>Why benchmark?</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEM</td>
<td>Similar in size to INRIM, government institution</td>
</tr>
<tr>
<td>VSL</td>
<td>Smaller Institute</td>
</tr>
<tr>
<td>DFM</td>
<td>Small, NMI with a scientific profile</td>
</tr>
<tr>
<td>NRC</td>
<td>Similar to INRIM, part of the Canadian Research Council</td>
</tr>
<tr>
<td>METAS</td>
<td>Similar but smaller than INRIM</td>
</tr>
<tr>
<td>KRISS</td>
<td>Similar in size to INRIM, part of a Scientific Institute</td>
</tr>
<tr>
<td>LNE</td>
<td>Bigger than INRIM, part of a big Institute</td>
</tr>
</tbody>
</table>

Table 11 The seven National Metrology Institutes, used for benchmarking of INRIM’s scientific performance

In Figure 1 we report the Citation Impact of INRIM compared with those of the other Institutes; the CI refer to the overall publications 2006-2011.
Figure 1 Citation impact for INRIM and seven foreign NMIs, used for benchmarking. The period 2006 – 2011 is chosen for both citations and publications used to calculate the CI.

We note that the actual position of INRIM as a research NMI and R&D Institute is at a medium level in an International comparison. It is clear, however, that at International level similar metrological institutes have scientific performances considerably higher than those of INRIM: such performances indicate a target level to reach in the future.

3.3 Analysis of the research activity

The evaluation of the research activity follows essentially the same lines as the 2010 evaluation. As for the 2010 evaluation, the "INRIM ten year strategy document over the coming decade" is considered as a useful organizer of the research activity. According to this document, first issued in July 2010 and revised in February 2012, the strategic activities of INRIM are directed along four main lines: fundamental metrology, applied metrology, interdisciplinary metrology and emerging metrology sectors. The objectives are:

- for fundamental metrology, guarantee the foundations of the International System, by keeping the science of measurement abreast of scientific and technological progress, during a decade dominated by the reformulation of the units based on the values of the fundamental physical constants;

- for applied metrology, meet the demand for measurement technologies and dissemination of the units throughout the production system, in areas such as dimensional metrology for the aerospace sector and the metalworking and mechanical engineering industry, the “timing” for the Galileo satellite navigation system, the new harmonised measurements standards necessary in the biomedical, agro-alimentary and pharmaceutical sectors;

- for interdisciplinary metrology, contribute with reference materials and measurement technologies to the attainment of socio-economic objectives, for environment, energy, new technologies, health;

- for emerging metrology sectors, meet a growing demand in Italy for the development of metrology activities in the field of biosciences and the measurement of the quantities typical of materials engineering and communications technologies.
The first two lines are traditional in the INRIM research, and thus are easily identified in the 2011 activity, the last two are rather new lines and it is interesting to trace their growing importance.

As in previous years, the structure of the research activity of the four divisions was organized in research “programs”, which cover with a rather strict relation the metrological areas identified at the international level. Each program has its own staff of researchers, technologists and technicians, shares with the other programs of the division the responsibility of the maintenance and developments of the National Measurement Standards, and develops its own research activity. The programs have changed very little with respect to previous years, except for the Electromagnetic division that was reorganized during 2011 (however, in the following, we will refer to the previous organization, as done in the 2011 INRIM activity report).

In the next sections we will briefly recall the correspondence between “programs” and “metrological areas” and then discuss the main research projects carried on within the programs: for clarity reasons we ordered them according the funding agency, as done in the previous evaluations.

3.3.1 Programs and metrological areas

A map of the metrological areas covered by the divisions (and by the research programs within each division) is reported in table 23 of the document “Relazione Consuntiva 2011”. It is organised, to the extent feasible, in relation to the areas identified at the international level (Consultative Committees of the CIPM and EURAMET Technical Committees):

High level coverage of these areas has entailed, albeit with different degrees of intensity, various activities of a general nature, such as:

- Participation in the development of joint research projects (JRPs) within the framework of the iMERA-Plus projects.
- Participation in EURAMET activities and execution of the European Metrology Research Programme (EMRP) in particular through the production of proposals for the Industry and Environment calls.
- Participation in international (FP7), national (PRIN) and regional research programmes (with special regard to the Piedmont Region programme in support of research).
- Participation in the activities of CIPM and its Consultative Committees.
- Participation in international comparisons and in the analysis of the calibration and measuring capabilities (CMC) of member institutes, within the framework of the Mutual Recognition Arrangement (MRA) of the CIPM.
- Researcher mobility and exchange programmes with foreign metrology institutes and research centres, with production of PhD dissertations, degree theses and internships.

The first three types of activities are closely related to research projects, the fourth and fifth are related to the INRIM performance as National Metrology Institute, the last one concerns essentially the “dissemination” of the INRIM results. The separation between the three main types of activities (research, “NMI”, dissemination) is arbitrary, because they have common features and share the same finality; in this section only the research activity will be discussed, leaving the last two types to the next two sections.
We will now describe the relevant aspects of the research activity, as it emerges from the final 2011 activity report, organized, as stated above, according to the funding source.

### 3.3.2 International projects and contracts

There is a large number and variety of research projects and contracts ranging from national to international projects, involving small or large amounts of funding and personnel, based on fundamental or applicative subjects, etc. To obtain an overall view of the projects and of their relations to the programs, we grouped them according to the following categories:

- **iMERA plus projects in ERA NET VII EC Framework Program (FP7)**
- **EMRP – JRP projects**
- **other international projects**
- **PRIN 2008 and 2009**
- **national and regional projects, contracts or contributions**

#### iMERA plus projects in ERA NET VII EC Framework Program (FP7)

These projects (table 2 of the document “Relazione Consuntiva 2011”) include key metrological aspects identified in 2007 at the international level as part of the European Metrology Research Program (EMRP). The first tranche started in 2008, structured in 4 “targeted programs” (TP): SI & fundamental constants, Health, Length, Electricity; INRIM is present in 17 out of 22 projects which passed the selection, and coordinates 4 of them (in bold characters in the table). The real implementation started in 2009 and continued through 2011.

#### EMRP - JRP projects

The second and most important stage of the EMRP was formally inaugurated with the joint resolution of the European Parliament and Council (16 September 2009) on the participation of the Community (pursuant to Art. 169 of the European Treaty) in the EMRP program undertaken by 22 member states through EURAMET e. V. The overall commitment over a 7 year period of the participant countries comes to 200 M€, to which Italy contributes about 7%, with a total of 14 M€, i.e. ca. 2 M€ per year, of which about 200 k€ as an annual contribution to the “common pot” and the costs of the EMRP secretariat.

The first call, on the theme of Energy, ended on November 2, 2009. INRIM participated in the preparatory stages of the call with a proposal for 5 Potential Research Topics (PRTs), all of which were accepted to become part of the 16 Selected Research Topics (SRT) [http://www.emrponline.eu/energycall/srt.html](http://www.emrponline.eu/energycall/srt.html). INRIM participates in 7 JRPs, listed in Table 3 of the document “Relazione Consuntiva 2011”; the EU funds to be received by INRIM over a three-year period amount to ca 680 k€.

The second call, on the themes of Environment and Industry, ended in November 2010. INRIM participates in 14 JRPs, listed in table 4 of the document “Relazione Consuntiva 2011”, and coordinates 2 of them (shown in bold letters in the table). The EU funds to be received by INRIM over a three-year period amount to ca. 3000 k€.

The third call, on the themes of Health, SI and New Technologies, ended in November 2011. INRIM participates in 14 JRPs and coordinates 1 of them.
The EU funds to be received by INRIM over a three-year period amount to ca. 4920 k€.

INRIM attributes, and the Committee agree, top priority to these Joint Projects, in view of their significance in demonstrating the viability of international integration at the highest level, a significance that goes well beyond economic returns. Another key element is the high interdisciplinary content of the themes involving activities that cut across all INRIM Divisions.

Since the participation in the EMRP JRPs must be co-funded by INRIM, the prior tasks for the coming years are de facto established and it is imperative that INRIM can rely on a specific additional contribution from the MIUR to cover, at least partly, the co-funding quota requested of INRIM (14 M€ over 7 years).

**Other international projects**

Besides iMERA-EMRPs, INRIM participates in many other international projects (see table 6 of the document “Relazione Consuntiva 2011”). The participation in these projects underlines a high level presence at the international level, related to the good scientific competences and excellent facilities present in the Institute.

**3.3.3 National projects and contracts**

**PRIN 2008 and 2009**

Although not particularly relevant from the financial point of view, these projects, listed in table 7 of the document “Relazione Consuntiva”, are important because they show a good connection with the fundamental university research.

**National and regional projects, contracts or contributions**

These projects, listed in table 7 of the document “Relazione Consuntiva 2011”, arise in the context of the national or regional tenders for research and innovation and in collaboration with academic and/or industrial partners. They are very numerous: a selection of the most significant ones, which in particular takes into account the financial relevance, is listed below. The very large number of national and regional projects (mostly regional) is impressive: although the INRIM management should carefully monitor and control these external activities in order to make them functional and not conflicting to the main INRIM role, there are positive aspects as, for instance, raising funds for upgrading the lab facilities or contributing with the internal competences to solve specific environmental or industry problems.

**Projects carried on within consortia or regional innovation poles**

INRIM participates, together with other institutions, in regional innovation poles or in consortia which were established in order to be able to apply for and eventually obtain funds for specific research projects. Details on the poles and on the consortia are given in Chapter 3.3.3; a list of the project is given in table 8 of the document “Relazione Consuntiva 2011”.

**2011 Merit Projects**

The “2011 Merit Projects” complete the frame of the research projects. In 2011, thirteen “premium projects” were presented, at the national level, to obtain the so called “7% share of ordinary funds”. Of these, five projects passed the na-


tional selection in August 2012. They are particularly relevant because they testify the importance given to metrology in the national research program.

The list of the projects is given in Table 12: for each project are also reported the funds and the INRIM program of the coordinator (in brackets the other INRIM programs responsible of the different "objectives" of the project).

<table>
<thead>
<tr>
<th>Title</th>
<th>INRIM Progr</th>
<th>kC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1   Nanotechnologies for electromagnetic metrology of environment parameters</td>
<td>E8 (E2, E2, E6, E7)</td>
<td>1096</td>
</tr>
<tr>
<td>2   Measurements and models for a sustainable and efficient use of electric energy</td>
<td>E4 (E3, E7)</td>
<td>301.5</td>
</tr>
<tr>
<td>3   Beyond the classical limits of measurement</td>
<td>O4 (O3, M6)</td>
<td>1119</td>
</tr>
<tr>
<td>4   National optical link for time and frequency</td>
<td>O1 (O2)</td>
<td>1046</td>
</tr>
<tr>
<td>5   Metrology of environment parameters</td>
<td>T2 (T1,T3,T5)</td>
<td>356</td>
</tr>
</tbody>
</table>

Table 12 2011 Merit Projects

3.3.4 Summary of programs research activity

A synoptic view of the research activity of the INRIM programs is given in the following Table 13 for the four divisions. The aim of the tables is to provide a view of the profile of each program and thus, indirectly, the trend of the overall research strategy.

To clarify the evolution in time, the researches which started or became fully operative in 2011 are shown in bold letters, and the new projects approved in 2011, which will become operative only in 2012, are shown in bold-italic letters. Compared to previous years, two main features become evident:

- on one hand, the metrological research activity is progressively driven by the European Research Program, which, in the last calls, is developing rather intensively, besides the first traditional line regarding the metrological standards, the third and the fourth guidelines indicated in the “ten years strategic document”;
- on the other hand, at the national and regional level, the mechanism of the calls from the funding agencies attests the growing demand for measurement technologies and dissemination foreseen in the second guideline of the “ten years strategic document”.
A common striking feature is the large number of different projects in which a relative small number of researchers is involved. To appreciate this fact, for each program, the numbers of full time equivalent (FTE) researchers dedicated only to research and development activities (R&D) are given in column 3: they are shown separately for staff personnel working on “INRIM” research (first line), for staff working on “contracts” (second line), and for temporary personnel of different type: temporary, grants, fellowships, PhD’s (third line).

Table 13 Summary of the programs’ research activities (Part E, M, O, T)

<table>
<thead>
<tr>
<th>Program</th>
<th>Metrol. Subfields</th>
<th>R&amp;D FTE</th>
<th>JRP’s 2010-12</th>
<th>Other International Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>INRIM - Contr. Assoc.</td>
<td>2011-13</td>
<td>2012-14</td>
</tr>
<tr>
<td>E1: Quantum devices and voltage standards</td>
<td>J.E.</td>
<td>- 3.45</td>
<td>- 0.65</td>
<td>- 3.1</td>
</tr>
<tr>
<td>E2: Metrology of electrical resistance and impedance</td>
<td>QHE, LDC, AC-V&amp;C, El.CH</td>
<td>- 2.1</td>
<td>- 1</td>
<td>- 1.7</td>
</tr>
<tr>
<td>E3a: Metrology of variable electrical quantities</td>
<td>AC-V&amp;C, RF, AC-P&amp;E</td>
<td>- 1.75</td>
<td>- 0.5</td>
<td>- 0.05</td>
</tr>
<tr>
<td>E3b: Metrology of electrical quant. at high frequencies</td>
<td>AC-V&amp;C, RF, AC-P&amp;E</td>
<td>- 1.7</td>
<td>- 0.1</td>
<td>- 0.6</td>
</tr>
<tr>
<td>E4: Mathematical models and their applications to materials and devices</td>
<td>FIELD</td>
<td>- 1.95</td>
<td>- 1.20</td>
<td>- 3.4</td>
</tr>
<tr>
<td>E5: Electromagn. fields and power systems</td>
<td>AC-P&amp;E, FIELD</td>
<td>- 1.25</td>
<td>- 1.65</td>
<td>- 0.1</td>
</tr>
<tr>
<td>E6: Nanofabrication</td>
<td>SET, BI-OAN</td>
<td>- 3.1</td>
<td>- 0.2</td>
<td>- 0.7</td>
</tr>
<tr>
<td>E7: Magnetic materials and measurements</td>
<td>MAG.M</td>
<td>- 7.75</td>
<td>- 0.35</td>
<td>- 2.4</td>
</tr>
<tr>
<td>E8: Electromagnetic properties of matter</td>
<td>MAG.M</td>
<td>- 4.8</td>
<td>- 1.25</td>
<td>- 1.6</td>
</tr>
</tbody>
</table>

Table 13 E Electromagnetic Division
<table>
<thead>
<tr>
<th>Program</th>
<th>Metrol. Subfields</th>
<th>R&amp;D FTE - INRIM - Contr. - Assoc.</th>
<th>iMERA Plus</th>
<th>JRP’s 2010-12 2011-13 2012-14 Other International Projects</th>
<th>National &amp; Regional Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1: Mass measurement</td>
<td>MASS, DENS</td>
<td>- 1.05 - 0.1 - 0</td>
<td>IND09</td>
<td>NEW04</td>
<td></td>
</tr>
<tr>
<td>M2: Dynamometry</td>
<td>FORCE, GRAV, HARD, VIBR</td>
<td>- 1.35 - 0.1 - 0.4</td>
<td>T1.J1.1</td>
<td>IND05</td>
<td></td>
</tr>
<tr>
<td>M3: Fluid mechanics</td>
<td>DENS, VISC, FLOW, PRESS</td>
<td>- 1.1 - 2.3 - 0.5</td>
<td>ENG03 IND12</td>
<td>NEW04</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M4: Mise en pratique of the metre and space technologies</td>
<td>LENG</td>
<td>- 1.1 - 1.5 - 1.7</td>
<td>T3.J3.1</td>
<td>ENV03 IND14</td>
<td>IND12</td>
</tr>
<tr>
<td>M5: Precision engineering</td>
<td>DIM.MET</td>
<td>- 2.05 - 3.45 - 3.6</td>
<td>T3.J1.1 T3.J1.4 T3.J2.2</td>
<td>NEW06</td>
<td>SOMMACK</td>
</tr>
<tr>
<td>M6: International System and fundamental constants</td>
<td>MASS, AVOG</td>
<td>- 0.75 - 0.75 - 2.5</td>
<td>T1.J1.2</td>
<td>SIB03</td>
<td>Merit Pr.3</td>
</tr>
</tbody>
</table>

**Table 13 M Mechanics Division**

<table>
<thead>
<tr>
<th>Program</th>
<th>Metrol. Subfields</th>
<th>R&amp;D FTE - INRIM - Contr. - Assoc.</th>
<th>iMERA Plus</th>
<th>JRP’s 2010-12 2011-13 2012-14 Other International Projects</th>
<th>National &amp; Regional Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1: Frequency standards</td>
<td>FR.ST</td>
<td>- 2.25 - 2.4 - 5.7</td>
<td>T1.J2.1</td>
<td>SIB02</td>
<td>SOC2 NGCAC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O2: Algorithms and timescales</td>
<td>TIME</td>
<td>- 0.55 - 1.45 - 2.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O3: Photometry and radiometry</td>
<td>PHOT</td>
<td>- 2.2 - 1.9 - 0.7</td>
<td>T1.J2.3</td>
<td>ENG05 ENV04</td>
<td></td>
</tr>
<tr>
<td>O4: Quantum optics</td>
<td>QO</td>
<td>- 1.85 - 1.3 - 3.35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 13 O Optics Division**
Program | Metrol. Subfields | R&D FTE - INRIM | iMERA Plus | JRPs’s 2010-12 2011-13 2012-14 | Other International Projects | National & Regional Projects
---|---|---|---|---|---|---
T1: Temperature and humidity: standards and new developments | CT, NCT, HUM | − 2.4  0.65  0.3 | | | CFPC-TPIC-CFPC-NMI | TMS Merit Pr.5
T2: Meas. techn. in thermometry and hygrometry | CT, NCT, HUM | − 2.05  1.85  4.5 | | | ENG05 ENV07 IND01 IND11 SIB10 | Merit Pr.5 ENERGY C HTPC MEMSEAL
T3: Physical acoustics | ACOU.PH | − 2.9  3.6  1.55 | T1.J1.4 | | ENG01 ENG03 ENG09 ENV05 SIB01 | Merit Pr.5
T4: Sound in air and ultrasound metrology | ACOU.EN | − 0.8  0.6  1.8 | T2.J07 | | HLT03 | MD
T5: Metrology of biosciences and trace substances | GAS, BI-OAN | − 1.35  0.5  7.9 | T2.J04 | | | Merit Pr.5 MICROSAT BANP HYPERSP N.T.NISO METREGEN ACTIVE
T6: Metrology in chemistry and biotechnologies | INORG, ORG, BI-OAN | − 2.35  0.5  3.4 | T2.J04 T2.J10 | | ENV01 ENV05 IND15 HLT04 SIB09 NEW02 | Table 13 T Thermodynamics Division

3.4 Suggestions for the improvement

The Committee appreciates that in 2011:

1) the numerousness of the scientific production was increased with respect to 2010;

2) the quality of the scientific production was higher than that of a NMI Institute for all the Divisions;

3) the interest of the scientific production of the Mechanics and Optics divisions was rather good.

The following specific comments and action are suggested in order to improve the scientific performance and its documentation:

1) As in the previous report, the Committee would appreciate a clearer separation of the research products between the R&D and the NMI activities, at division level. The Committee understand that this
separation is not always easy, but it is very important in order to evaluate NMI activities separately from R&D.

2) Provide in the next year a detailed report on the conclusion of the ANVUR VQR 2004-2010 evaluation procedure, both at INRIM level and at Division level.

3) As already underlined in the past years, in average the quality of the scientific production expected for an Institute involved both in NMI and R&D of the Institute was fully achieved on a permanent basis only by the Optics division; the other divisions have an average quality of the scientific production lower than this level, although improving with time: apparently, the actions taken by the management to ameliorate the scientific production are giving their results and should be continued.

4) The interest of the scientific production in general and of the “highlights” in particular is good for the Optics division and satisfactory for the Mechanics, both for the NMI and the R&D products. It appears to be rather low for the Electromagnetic and the Thermodynamics divisions; this is particularly true for the NMI highlights of the Electromagnetic division: reasons beyond this should be investigated.

5) The Committee strongly recommends to increase the presence at International Conferences, meetings and Organisms in the next years.

6) The research activity appears to be progressively driven, at the international level, by the European Research Program, and, at the national and regional levels, by the growing demand for measurement technologies and dissemination. Both aspects are positive, as they are foreseen in the guidelines of the “ten years strategic document”, but they should be accompanied by an independent guideline by of the INRIM institute itself.

7) As shown in the last table, the large number of different projects in which a relative small number of researchers is involved, indicates a great vitality of the research but might result in the risk of an excessive fragmentation, which lowers the possibility of a significant contribution on any project.
4 National Measurement Standards

The four previous reports have reported on the special tasks that are addressed at NMIs in order for them to ensure worldwide dissemination of measurements that are traceable to the SI. Brief descriptions were given of the organisations that have been established, both in Europe (EURAMET) and globally (The metre convention, often referred as BIPM). This refers to the metrological activity, which is not necessarily linked to research, however necessary at the national Metrology Institute level. These tasks have been referred to as "NMI work" but in order to underline that the key purpose is to ensure that the countries each have appropriate access to "National Measurement Standards", in this year's report they are identified as such or simply referred to as standards work.

The National Measurement Standards work may be subdivided into two tasks:

Maintenance and upgrading of national standards

This task ensures that the national standards at INRIM are international accepted as sources of measurement traceability. It involves operational maintenance, as well as successful participation in international comparisons, maintenance of an appropriate quality system, and international acceptance of the measurement capabilities (stated in terms of uncertainties) associated with calibrations that are performed. Upgrading of national standards, which does not involve new research, is also considered part of standards-work; Initial development of a new standard, including the necessary documentation in terms of calibration procedures, is possibly but not necessarily a scientific activity.

The mutual recognition arrangement, CIPM-MRA, from 1999 has established the KCDB database, where all the necessary information is available for all states and economies that have signed the CIPM-MRA.

Participation in international organisations

Further to the technical work leading to the national entries in the KCDB, an NMI takes part in the substantial work in international organisations and forums, where metrology issues are discussed.

INRIMs contributions to these standards-tasks are discussed below, followed by a analysis of its allocation of resources. Five year trends are given and benchmarks against selected foreign NMIs. When appropriate for the analysis of the total Italian national metrology, data from ENEA-IMRI is given. Finally, some conclusions are given.

4.1 Maintenance and upgrading of national standards

Appendix C of the KCDB gives the number of entries for Italy in Table 14. Each entry is “a product” or “deliverable” traceable to a national standards that INRIM maintains. The classification is made according the “metrology areas” used in the KCDB. Note that the measurement areas of the KCDB are defined like the technical fields of EURAMET, except for the fact that the EURAMET field Flow is incorporated in the metrology area Mass. In 2009 and 2010, the figures for INEA-INMRI are also given in order to give a complete picture of metrology in Italy.
Table 14 shows that, with the exception of Chemistry, Italy has activity in all metrology areas at a level that one would expect for the NMI of a big country. This is compliant with INRIM’s mission to maintain all measurement standards relevant for Italy except in Ionizing Radiation.

<table>
<thead>
<tr>
<th>Metrology Area</th>
<th>Short Division</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustics, Ultrasound and Vibration</td>
<td>AUV, T,M</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Amount of substance</td>
<td>QM, T,E</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Electricity and Magnetism</td>
<td>EM, E</td>
<td>201</td>
<td>206</td>
<td>206</td>
<td>206</td>
<td>209</td>
</tr>
<tr>
<td>Length</td>
<td>L, M</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>42</td>
</tr>
<tr>
<td>Mass and Related Quantities</td>
<td>M, M</td>
<td>105</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>Photometry and Radiometry</td>
<td>PR, O</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Thermometry</td>
<td>T, T</td>
<td>29</td>
<td>29</td>
<td>47</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Time and Frequency</td>
<td>TF, O</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Total for INRIM</td>
<td></td>
<td>465</td>
<td>473</td>
<td>491</td>
<td>494</td>
<td>498</td>
</tr>
<tr>
<td>Ionising Radiation</td>
<td>ENEA-IRMRI</td>
<td>98</td>
<td>98</td>
<td>108</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for Italy</td>
<td></td>
<td>589</td>
<td>592</td>
<td>606</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 14. Italy’s calibration measurement capabilities (CMC) for the period 2007-2011. In 2011, the global number of entries was 24477

The development of INRIMs CMCs over the five-year period 2007-2011 shows a limited but steady increase of about 2% pa. with the dominant contribution from thermometry. ENEA-IRMRI has only been monitored for three years and appears more dynamic. Over the years, Italy’s share of the total number of CMCs seems steady with about 2.5% in 2011.

In order to evaluate the Italian representation of CMCs in the 9 metrology areas relative to the total content of the KCDB appendix C, Figure 2 contains the relevant indicators. Except for Chemistry (which includes microbiology) there is an even distribution between the areas, in accordance with the mission item that INRIM “looks after everything”. However, with the limited resources that INRIM has access to in the foreseeable future, an alternative approach might be taken, namely focus more on areas, where INRIM internationally leading competences, including new areas where INRIM can make a special impact. Although this subject was discussed during the 2010 evaluation, where it was indicated that INRIM was looking into such a scenario, nothing was reported for the 2011 evaluation.
Figure 2. Italy’s representation in the CMC tables of the KCDB for the 9 metrology areas and relative to all participants. Note that in the KCDB flow is part of the mass area, and that RI is provided by ENEA-INMRI. The overall Italian participation is 2.5 %

The particular case of chemistry requires special attention as already mentioned in previous reports. It is addressed as a special report in Chapter 0.

Finally, there still appears to be any calibration work related to nano-meterology.

<table>
<thead>
<tr>
<th>Metrology Area</th>
<th>Div</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUV</td>
<td>T,M</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>QM</td>
<td>T,E</td>
<td>9</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>EM</td>
<td>E</td>
<td>46</td>
<td>46</td>
<td>49</td>
<td>52</td>
<td>53</td>
</tr>
<tr>
<td>L</td>
<td>M</td>
<td>33</td>
<td>37</td>
<td>38</td>
<td>40</td>
<td>43</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>72</td>
<td>76</td>
<td>79</td>
<td>81</td>
<td>83</td>
</tr>
<tr>
<td>PR</td>
<td>O</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>14</td>
<td>15</td>
<td>15</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>TF</td>
<td>O</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total for INRIM</td>
<td></td>
<td>190</td>
<td>201</td>
<td>208</td>
<td>222</td>
<td>233</td>
</tr>
<tr>
<td>RI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENEA-INMRI</td>
<td></td>
<td>26</td>
<td>29</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for Italy</td>
<td></td>
<td>234</td>
<td>251</td>
<td>262</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 15. Time development of comparisons that support INRIM’s CMCs in Table 14. Since 2009, the figures for INEA-INMRI are also given. In 2011, the global number of entries was some 1125.
Appendix B of the KCDB gives the number of comparisons that support INRIM’s CMCs. Table 15 gives the numbers for INRIM for 2007 – 2011 and for 2009-2011 for the whole Italian metrology organisation. The KCDB distinguish between key comparisons that concern basis quantities and supplementary comparisons that deal with "non-basic" and special quantities. Comparisons are divided into CIPM-comparisons, covering selected NMI’s worldwide and regional comparisons, which are normally linked to a CIPM-comparison by having some duplicate participant, in order to document global equivalence for a measurement quantity. For the purpose of this evaluation, only the total number of comparisons is considered.

It should be noted that the comparisons mentioned in Table 15 for a given year are “active” in their support to a given set of CMCs. But they have not necessarily required technical activity in that year. Typical comparisons run for several years and have a validity of around 10 years. “Inactive” comparisons are also kept in KCDB for historic reasons; but they are not included in Table 15.

Non-compliances that affect the validity of CMCs have resulted in the temporary removal of some 225 CMC’s from appendix C for 10 countries. This has not involved Italy.

Table 15 shows that the participation in Comparisons is well developed in Italy and demonstrates a steady increase; in 2011 Italy took part in 2.3%. However, the increase in comparisons in appendix B with no associated increase in CMC entries in appendix Cs indicates that Italy is using more and more resources to document every CMC.

4.2 Participation in international organisations

Below, INRIM’s participation in the work under the Meter Convention and in EURAMET is described in Section 4.2.1, whereas its participation in standardization bodies and related organisations is describe in Section 4.2.2, since INRIM’s work in such organisations are metrology related. It should be mentioned that INRIM participates in the work of the legal metrology organisations OIML but does not participate in the work of WELMEC.

Participation in other forums is described in Chapter 5.

4.2.1 Metrology organisations

The Meter Convention is an international treaty organisation, signed in 1875 by 18 states and by the end of 2011 encompassed some 84 states. It is ruled by the ‘18 member Comité International des Poids et Mesures, CIPM, elected at the quadrennial general conference. CIPM elects its president and supervises the BIPM. The CIPM MRA has been signed by the representatives of 83 institutes – from 50 Member States, 34 Associates of the CGPM, and 3 international organizations – and covers a further 138 institutes designated by the signatory bodies. CIPM currently has 10 Consultative Committees with participation of the leading institutes within the technical fields that the CCs represent.

During 2011 INRIM maintained its traditional high activity in the CIPM and its consultative committees. There are only few changes with respect to 2011. It currently takes part in the work of all CCs, except the consultative committee for units, CCU. Italy provides the president of CCL.
Also in EURAMET, INRIM has maintained the high activity of previous years in the committee structure. It chairs the Technical Committee for Metrology in Chemistry. The European Metrology Research Programme, EMRP, is now running in its fourth year. This activity is described in Chapter 3.3.2.

4.2.2 Standardization, Scientific and Technical Committees

The standardization activity is very similar to previous years, and particularly pursued at INRIM by participating in national organisations (e.g. AICQ and AC-CREDIA) and international standardization committees (e.g. ISO, IEC, IUPAC, CIE, CEN, IAU, ITU-R, etc.); and INRIM coordinates several of these committees. The participation to metrological and accreditations organisms, beyond scientific and technical organisms, also represents a particularly qualified and significant activity. The participation to numerous international and national scientific and technical organisms was also kept activated. Such aspects demonstrate the good relationships of INRIM with national and international institutions, with the collaboration in standardization activities and in the definition of measurement and test protocols.

4.3 Allocation of resources to national standards

The general issue of allocation of resources has been treated in detail in previous evaluation report, and is necessary for INRIM to be able to manage personal and economic resources of projects. Although each division has done some analysis of its resource allocation, no common approach has been taken; therefore the necessary analyses cannot be done. Figure 3 gives a very preliminary view of the situation.

<table>
<thead>
<tr>
<th>INRIM: 206 FTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INRIM R&amp;D</td>
</tr>
<tr>
<td>Contract R&amp;D</td>
</tr>
<tr>
<td>National Standards</td>
</tr>
<tr>
<td>Calibration and Test</td>
</tr>
<tr>
<td>Support to Accreditation</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

Figure 3. Preliminary resource allocation for INRIM. It can only be used a indicative of the real situation.

Figure 3 shows the data communicated to the evaluation committee for the total allocation of resources in terms of FTE units for 2011. The classification is: INRIM R&D, Contract R&D, National Measurement Standards, Calibration and Tests, Support to Accreditation and Other activities. This classification is similar but not identical to the categorisations used in this evaluation report. Further it
is not consistent between divisions. Whereas the three first categories can be unambiguously mapped in the Science (Chapter 3) and National Measurement Standards; and the two subsequent categories can be included in Dissemination (Chapter 5); but “Other activities” remains ill-defined and is perceived differently by the four heads of divisions.

The issue is what is meant by the FTE unit. Therefore, the following should be clarified:

- A typical European employee works some 1600 hours per year, when vacation time has been subtracted.
- Out of the 1600 annual hours, a fraction is “non-productive”. It incorporates sickness, in service training, and other non-technical elements of a working day.
- The number of hours in a year that is devoted to specific technical activities forms the unit FTE. It is typically between 1200 and 1300 hours annually. The FTE should be registered by category, which may be at the individual project level. The evaluation committee has subdivided FTE-time in three coarse categories: Science, National Standards Work, and Dissemination of Knowledge.

Only when INRIM has developed a time registration system that allows an analysis of the time spent on each of the three categories, can a sensible analysis of its resource allocation be performed; and it necessitates the registration of non-productive time.

### 4.4 Benchmarking

As only little development occurred during the recent years in the key figures in INRIM’s work as a NMI, there is little to add to the analysis provided by the evaluation committee in previous reports.

INRIM continues to be an NMI which fulfils its duties in much the way that it has always done. In order to address the requirements for NMI-operation in the future, INRIM will have to address its management in a new light, both at the strategic governance level as well as the level of daily management.

### 4.5 Summary and suggestions for improvement

The summary and suggestions for improvements with regard to INRIM’s performance as a national metrology institute is strongly influenced by the observation that INRIM as one of the oldest and highly recognised NMIs in Europe, based on solid scientific approach to metrology and the opinion that basic and traditional metrology is not questioned by funding authorities.

#### 4.5.1 Summary of the 2011 status

During 2011 INRIM has continued its work along the traditional lines of the mission for national metrology institutes. It maintains primary standards within the traditional areas of needs of Italian society and industry, and takes part in the work of the CIPM-MRA so that its certificates are accepted all over the world.

INRIM is visibly engaged in the international organisations EURAMET and the Metre Convention, as well in associated organisations, e.g. standardization.
However, when it comes to the newer demands on NMIs, innovation and development, INRIM does not appear to engage very strongly. Its impressive scientific activity does not give noticeable rise to new calibration capabilities, nor does it give rise to tangible spin off by other means.

### 4.5.2 Suggestions for improvements

As INRIM’s NMI-performance has been monitored by the evaluation committee for more than five years, and as the observations’ have been very similar to this year’s, most the recommendations given in previous evaluation reports are still valid.

In consequence, the evaluation committee suggests that in order to ensure sustainable operations of INRIM as a national metrology, the following initiatives are taken:

1. INRIM strengthens its rudimentary approach to strategic governance. This is needed to give the staff sufficient guidelines to continue it work and break new frontiers along well thought-out directions.
2. INRIM improves in management system, in order to enable it to manage its human and financial resources in an accountable way.
The economic and social impact of the scientific activities on the evaluation of knowledge dissemination represents a crucial aspect. In order to promote the development of the Italian system components (scientific knowledge transfer, exploitation and diffusion), the INRIM legislative decree n. 38/2004 explicitly deals with scientific and technologic competences’ diffusion and transfer. In particular, these activities include: i) knowledge and technology transfer to science, industry and society; ii) development of the calibration laboratories network (since 2010 in cooperation with Accredia - DT); iii) high level scientific and technical services; iv) technical standardization cooperation; v) education and training; vi) technical support to legal, health and environmental metrology (in term of measurement method and traceability).

In the following sections the above-mentioned different topics are specifically treated, by focusing the results obtained in the year 2011. With the aim of comparing the consistency of planned actions in the triennial plan with obtained results, the INRIM dissemination policy and strategies (toward internal division, other NMI, the scientific community, the industry and society) are briefly reported in Table 16.

<table>
<thead>
<tr>
<th></th>
<th>Knowledge Improvement</th>
<th>Competence Improvement</th>
<th>Efficiency in resources use improvement</th>
<th>INRIM brand improvement</th>
<th>Competitiveness Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal (INRIM-Division)</strong></td>
<td>Continuous updating (ICT, quality, safety and security, ..)</td>
<td>Internal training</td>
<td>Cooperation between divisions and programs</td>
<td>n.a.</td>
<td>Standard and CMC Improvement</td>
</tr>
<tr>
<td><strong>Other NMI</strong></td>
<td>Bilateral and multilateral Agreements</td>
<td>Foreign researchers and researchers abroad</td>
<td>International cooperation with other NMI</td>
<td>Leadership in international projects and committees</td>
<td>Support of new NMI</td>
</tr>
<tr>
<td><strong>Companies</strong></td>
<td>Research contract</td>
<td>Personal detachment</td>
<td>Metrological services (accreditation, calibration, test)</td>
<td>Press on technical journals and magazines</td>
<td>Patents and licenses; Spin-off</td>
</tr>
<tr>
<td><strong>Scientific community</strong></td>
<td>International Conference, Standardization Committee</td>
<td>Theses (doctorate, I and II level)</td>
<td>Cooperation with Universities and Research Institutes</td>
<td>Congress Organization and Sponsorship</td>
<td>Common Researche Plataforms</td>
</tr>
<tr>
<td><strong>Society</strong></td>
<td>Information and Education (environment, safety, legal metrology, ..)</td>
<td>External Training</td>
<td>Cooperation with regional institutions and associations</td>
<td>Radio and Television interviews</td>
<td>Common Laboratories</td>
</tr>
</tbody>
</table>

Table 16 - Dissemination policy and strategies
5.1 Dissemination of know-how to the companies

Knowledge dissemination to private and public companies was carried out by INRIM Institute with different activities as reported in Table 17.

<table>
<thead>
<tr>
<th>Description</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research programs and contracts: active in the year</td>
<td>65</td>
<td>77(82)*</td>
<td>70</td>
<td>89</td>
<td>99</td>
</tr>
<tr>
<td>Research programs and contracts: signed in the year</td>
<td>26</td>
<td>21(39)*</td>
<td>21</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Research programs and contracts: total income (k€)</td>
<td>1425</td>
<td>(4148)*</td>
<td>2847,2</td>
<td>(2264)*</td>
<td>2751</td>
</tr>
<tr>
<td>Regione Piemonte</td>
<td>567,4</td>
<td>538,9</td>
<td>1327,3</td>
<td>309,4</td>
<td>614,0</td>
</tr>
<tr>
<td>European Community</td>
<td>187,0</td>
<td>688,9</td>
<td>319,0</td>
<td>999,8</td>
<td>1189</td>
</tr>
<tr>
<td>Industrial Companies</td>
<td>449,3</td>
<td>463,6</td>
<td>973,1</td>
<td>747,7</td>
<td>284,1</td>
</tr>
<tr>
<td>Other public</td>
<td>199,1</td>
<td>647,9</td>
<td>227,8</td>
<td>(207,2)*</td>
<td>663,3</td>
</tr>
<tr>
<td>Patents filed in Italy and requests for European patents</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Extension of patents abroad</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Calibration procedures in force</td>
<td>242</td>
<td>238</td>
<td>229</td>
<td>231</td>
<td>239</td>
</tr>
<tr>
<td>Testing procedures in force</td>
<td>30</td>
<td>9</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>No. of calibration certificates, test reports and other doc.</td>
<td>1916</td>
<td>1857</td>
<td>1641</td>
<td>1621</td>
<td>1778</td>
</tr>
<tr>
<td>Income from calibration and testing activities (k€)</td>
<td>1853</td>
<td>1868</td>
<td>1690</td>
<td>1693</td>
<td>1803</td>
</tr>
<tr>
<td>Laboratory accreditation activities: number of laboratories</td>
<td>177</td>
<td>177</td>
<td>175</td>
<td>164</td>
<td>159</td>
</tr>
<tr>
<td>Laboratory accreditation activities: income (k€)</td>
<td>800</td>
<td>1175</td>
<td>745</td>
<td>592</td>
<td>878</td>
</tr>
<tr>
<td>Designed instruments and devices:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electromagnetism Division</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Mechanics Division</td>
<td>1</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Optics Division</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Thermodynamics Division</td>
<td>3</td>
<td>-</td>
<td>4</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>5</td>
<td>12</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Outstanding realized instruments, devices and software:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electromagnetism Division</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Mechanics Division</td>
<td>10</td>
<td>13</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Optics Division</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Thermodynamics Division</td>
<td>10</td>
<td>24</td>
<td>13</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>54</td>
<td>40</td>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 17 Knowledge transfer – other product applications**

Note * - Some data have been updated with respect to previous evaluation report
Administration and Scientific Councils (in the reports of 10.07.08-All. p.to 8 and of 29.06.09-All. p.to 3) recently underlined that “the technology transfer and the support to industries, services and society innovation (calibration, measurement and testing; patents and licenses; training researchers and technicians; dissemination of scientific culture and technical standards) is an INRIM priority”. Nevertheless the 2009-11 three-year plan includes only generic actions in sustaining technology transfer and innovation support to industries. Furthermore, the mechanisms to promote and support the knowledge dissemination are not adequately detailed, with particular reference to human and financial resources.

As a consequence, direct and indirect impact of INRIM researches on the productive system is not adequately evaluated by INRIM itself. In particular: i) no analysis regarding the applications of INRIM patents or applied researches are available; ii) no statistics about advantages induced by CMC’s capabilities, standards and knowledge improvement on national productive system are carried out.

Finally, it is not clear how the knowledge dissemination results are evaluated in relation to: i) Divisions’ funding; ii) human resources assignments; iii) researchers career progressions. So the knowledge dissemination activities seem to be a consequence of the researchers sensibility instead of the result of a careful planning.

5.1.1 Patents and licenses.

Also in the 2011 INRIM was not very active in the patents and licenses field. Only 2 new patents have been granted in 2011 and none existing patent has been extended as European patent. In particular, the patents granted in 2011 are reported in the following Table 18.

None patent has been mentioned in the INRIM Highlights 2011 and submitted to Evaluation Committee, although several researches presented to the evaluation committee could be patented or, however, successfully applied in industrial field. This aspect highlights both the limited industrial fallen back of the INRIM research knowledge and the INRIM limited interaction ability with the industrial system.

<table>
<thead>
<tr>
<th>Div</th>
<th>Typology</th>
<th>Title</th>
<th>Patentees</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>Industrial – Italian National Patent</td>
<td>Procedimento per la taratura di reti di sensori wireless e relativo sistema</td>
<td>Inventors: D. Smorgon, V. Femicola</td>
<td>Patent No. TO2011A000503 Filed: 08.06.2011</td>
</tr>
</tbody>
</table>

Table 18 INRIM Patents
Patent benchmarking is used with the aim of reaching a better reference for the evaluation of INRIM. In fact by comparing the INRIM experience with analogous Italian (e.g. INO-CNR, ENEA) and European (e.g. PTB) institutes, it is possible to notice that:

- INRIM patent number for year and person (approximately 1 for every 50 unit of staff) is comparable with the one of other institutes (about 1 for every 30 unit of staff for INO-CNR and 1 for every 400 units of staff for the PTB);


Finally the impact of patents on the INRIM is not systematically estimated and actually only few Patents seem to be used by private companies.

Modern product development relies on a closer collaboration between knowledge centres and private entrepreneurs, but this connection is not well established at INRIM.

5.1.2 Calibration and test report

The reliability of measurement instrument represents a fundamental prerequisite for all quality systems and all measurements results should be traceable to the SI. In Italy most of the calibrations are traceable with INRIM Institute. So the INRIM calibration activity in 2011 issued about 1.628 calibration certificates and other metrological services. In particular, details of such activities are reported in the following Table 19.

After the decreased number of calibration observed in the last years, in the 2011 number of calibrations and tests increased with exception of thermal Division.

In the 2011 the human resources dedicated to the calibration and test activity are about 22,4 FTE units (corresponding to 11% of whole personal) and 3,25 FTE units of support to SAL. So the pro-capita report number is about 70 reports a year per person; this index appears high in term of productivity.
5.1.3 Accreditation services

Since the mid-1970’s, laboratory accreditation in Europe has maintained close relations with the respective national NMI, and in several cases calibration accreditation has been operated as part of an NMI. On December 2009 an Italian Governmental law assigned to ACCREDIA the role of unique National Accreditation Body, in compliance with EU Regulation 765/2008. So since 1st January 2010 SIT, as operational unit of COPA SCrl, has ceased to be one of the signatories of the EA-MLA and ILAC-MRA agreements for calibration laboratories. On 1st July 2011 INRIM signed an agreement with ACCREDIA and the calibration Department of ACCREDIA became operative from that date.

The Accreditation Service Laboratory (SAL) Department operates in compliance with ISO/IEC 17011 and EA and ILAC regulations. As a consequence, ACCREDIA
has employed the competencies of INRIM, with particular reference to SAL, and INRIM has thus maintained the function of primary metrological institute as assigned by law no. 273 of 11th August 1991 regarding the recognition of calibration Centres. INRIM has so undertaken the task of assessing technical and operational conformity.

Actually, calibration laboratories accredited with INRIM technical support according to the standard ISO/CEN 17025 are 159 with an overall number of sectors about equal to 680. Details of these activities are reported in Table 20. Through accreditation of laboratories, INRIM potentially can disseminate its high technical knowledge to the industrial practitioners of metrology.

Furthermore in the last years the Institute attention on safety, security and environmental field has significantly increased as shown by the accreditation on the chemical quantities (with 6 accredited laboratories), the environmental comfort (with 21 accredited laboratories on acoustic and photometric quantities), cronotachograph and speed meters (with 2 accredited laboratories).

<table>
<thead>
<tr>
<th>Description</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accredited Calibration Laboratories</td>
<td>177</td>
<td>177</td>
<td>175</td>
<td>164</td>
<td>159*</td>
</tr>
<tr>
<td>New accredited Laboratories</td>
<td>10</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Extensions</td>
<td>24</td>
<td>24</td>
<td>23</td>
<td>8</td>
<td>39</td>
</tr>
<tr>
<td>Renewals</td>
<td>44</td>
<td>18</td>
<td>55</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Surveillances</td>
<td>88</td>
<td>87</td>
<td>57</td>
<td>104</td>
<td>84</td>
</tr>
<tr>
<td>Inter-comparisons (bilateral / multilateral)</td>
<td>92</td>
<td>110</td>
<td>123</td>
<td>68</td>
<td>70</td>
</tr>
<tr>
<td>Technical guides</td>
<td>2</td>
<td>n.d.</td>
<td>1</td>
<td>3</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

Nota * Accredited Laboratories by ACCREDIA-DT with INRIM technical support

Table 20 INRIM Accreditation Activities

5.1.4 Scientific metrological services

About 1-2% of INRIM total budget comes from technical and research activities involving private companies. Furthermore in 2011 this quantity was reduced respect to the last year. On the other hand about 23% comes from self-funding: in particular in the 2011 about k€ 614 comes from projects and contracts financed by Piedmont Regional Authority for research projects funding, k€ 1189,7 for research contracts with EC, k€ 663,3 for research activities submitted to other Public Bodies, k€ 284,1 for research activities involving private companies, k€ 1803,1 for consulting, calibrations, equipment tests and other activities, k€ 877,6 for laboratory accreditation. It is important to underline that in the last 5 years public and private contract number (see Table 17 and Table 28) is increased significantly and doubled with respect to 2007.

As shown in Table 21, in the 2011 all divisions have been active in proposition of new research contracts. In particular, the INRIM drew up 33 new research contracts, so in the same year more than 99 research contracts were active. Among these, particularly interesting are:

- the numerous EMRP, ESA-Galileo and iMera-Plus European contracts testifying the excellent scientific value of all INRIM Division;
- the cooperation of all INRIM Division with the Piemonte Regional Authority for the realization of some research poles (innovation Mecha-
tronics and Advanced production systems poles), Proplast (innovation, research and technology transfer in plastic sector);
- the cooperation with the bank Foundation (Compagnia di San Paolo) for the realization of a NanoFab Laboratory (with particular reference to Thermodynamic and Optic divisions).

Also in the 2011 (such as in 2010) the industrial applied research contracts number and the funding amount seem to be poor compared to the ones of base public research (European, National and Regional). In the Committee opinion, such results could be again due to the severe economic crisis instead of the INRIM inability, even though this trend must be carefully monitored.

<table>
<thead>
<tr>
<th>Div</th>
<th>European</th>
<th>National</th>
<th>Regional</th>
<th>Industrial</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>N</td>
<td>A</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>E</td>
<td>16</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>M</td>
<td>12</td>
<td>3</td>
<td>1</td>
<td>0</td>
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<td>O</td>
<td>10</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>T</td>
<td>15</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Tot</td>
<td>53</td>
<td>15</td>
<td>13</td>
<td>8</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 21 New (N) and Active (A) Contracts in the 2011

5.1.5 Spin-off and technical personnel detachment

Even though many researchers declare to be ready to start working on the spin-off project as soon as regulation will be available, no spin-off activities have been carried out in 2007-2011 and no procedures at the moment are available at INRIM to promote spin-off activities.

Since others institutions in Torino and in Piemonte have faced the issue of promoting spin offs within professors, researchers and students, like Politecnico di Torino Incubator I3P, a systematic collaboration and reciprocal connection could be a start without being a new center of costs. These kind of external cooperation could also be a valid support for those INRIM researchers that are searching for new environments where apply their studies.

As regards the people mobility, in the last years personal detachments toward private companies are very poor. On the contrary, the ability of both moving INRIM researchers and receiving foreign researchers from other NMI is very interesting.

5.2 Dissemination in society and scientific community

As regards the scientific knowledge dissemination, the INRIM Institute pursues such aim with several activities: i) participation to the Standardization, Scientific and Technical Committees; ii) education and training; iii) diffusion of competences to the community (scientific or not); iv) giving support to legal, health and environmental metrology. Some details related to the first three activities are given in section 4.2.2.
INRIM has also active 32 framework agreements with other national and international institutes and universities. In addition to various agreements for internships, training courses and doctoral programs, in 2011 INRIM signed the following new collaboration agreements (3 international and 2 national ones):

- Department of Biomedical Sciences and Human Oncology of the Medical School of the University of Turin: collaboration agreement in the areas relating to the development of new systems and materials for applications in the biomedical sciences, orthodontics and gnathology;
- Ștefan Cel Mare University of Suceava – USV - (Romania): scientific collaboration agreement;
- Università degli Studi di Napoli Federico II: scientific collaboration agreement;
- Instituto Nacional de Metrologia, Normalização e Qualidade Industrial (INMETRO) del Brasile: Specific Agreement su “Amplification of Primary Force Standardization in Brazil: a Project to develop a Low Force Primary Standard Machine from 10 N to 1000 N”;
- Bayerisches Zentrum für Angewandte Energieforschung e.V. (ZAE BAYERN) - Würzburg (Germania) Memorandum of Understanding (MoU): scientific and technologic cooperation in thermometry field.

5.2.1 Education and Training.

Training constitutes an integral part of the activities of INRIM, as it appears from INRIM Reports. It is also noteworthy that “education and training” is one key element of INRIM’s vision. The very fruitful relations with different Polytechnics and Universities (e.g. the Politecnico di Torino e Milano, Università di Torino, Roma “La Sapienza”, Napoli “Federico II”, Pisa, Cassino, etc.), together with dedication grants for thesis work at INRIM, ensures a high concentration of graduate work at INRIM.

As shown in Table 22, in 2011, 20 first level degree theses, 12 master degree thesis and 6 PhD thesis have been discussed.

<table>
<thead>
<tr>
<th>Description</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-year PhD programmes activated in the year</td>
<td>10</td>
<td>7</td>
<td>11</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Dissertations completed during the year (PhD)</td>
<td>6</td>
<td>5</td>
<td>11</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Dissertations completed during the year (Level 2)</td>
<td>11</td>
<td>17</td>
<td>14</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Dissertations completed during the year (Level 1)</td>
<td>20</td>
<td>24</td>
<td>19</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>Foreign researchers at INRIM (man-months)</td>
<td>10</td>
<td>10</td>
<td>54</td>
<td>37,5</td>
<td>31</td>
</tr>
<tr>
<td>INRIM researchers abroad (man-months)</td>
<td>35</td>
<td>10</td>
<td>18</td>
<td>8,5</td>
<td>35,2</td>
</tr>
<tr>
<td>INRIM seminars by internal experts</td>
<td>15</td>
<td>4</td>
<td>6</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>INRIM seminars by external experts</td>
<td>29</td>
<td>29</td>
<td>44</td>
<td>29</td>
<td>41</td>
</tr>
</tbody>
</table>

Table 22 Knowledge transfer/ training

Also, training in all its facets is part of INRIM activities. Courses for industrial technicians and teachers, workshops and seminars, summers schools that are
organized in collaboration with other bodies, indicate the substantial effort that INRIM puts into training. In 2011 a large number of lessons have been held by lecturers in Universities (about 533 hours in graduate courses are made with INRIM participation) and cultural associations and third level courses. Also, INRIM widely participated to activity of several bodies and associations involved in knowledge diffusion and/or education activities (e.g: AICQ, ANCQ, CMM Club Italia, EMIT-LAS, Istituto Tagliacarne, ecc.)

It is also interesting to notice cultural events assimilated by INRIM Institute to technical training activities. To such purpose, several seminars within internal and external professional courses have been held. A further activity is represented by the international mobility, with 17 foreign researchers guests nearby the INRIM in 2011 and 10 INRIM researchers guests nearby other foreign metrology institutes.

5.2.2 Dissemination to scientific community and civil society

Among the expected diffusion activities, particularly interesting are the numerous cultural activities proposed by INRIM, such as:

- Torino 150° Unità d’Italia: Conferences on “Passato presente e futuro della scienza delle misure”
- guided tours (organized in the “Settimana della Cultura Scientifica e Tecnologica” promoted by MIUR) and multimedial aids for the high school students (“Crescere in città”, promoted by Città di Torino);
- Information conferences as the public events for the diffusion of scientific topics, such as “Il tempo della scienza” (also available at the web address http://www.inrim.it/events/tempo_scienza_11.shtml);
- scientific conferences and seminars held at INRIM by both internal scholars and external institutions;

Furthermore, the organization and the participation in several scientific congresses and workshops are also notable:

- National Congress on “Scienza e beni Culturali: Misure, datazioni, analisi: esperienze a confronto per lo studio, la diagnostica e la conservazione del patrimonio artistico, archeologico e culturale”;
- Workshop “Quantum Information at Laser Phys 2011”;
- Workshop “Single Photon 2011”; 
- Technical meetings (e.g. JRP IND-12; Nanotrace iMERA-Plus JRP “UL-QHE”, TVF - Review Meeting, EURAMET - Technical Committee on Electricity and Magnetism, EURAMET TC Mass and Related Quantities, Annual meeting, InTeRSeC 21, InTeRSeC 22: ENV07 – MeteoMet Kick off Meeting, Galileo TVF - FAR meeting, NANO TRACE, JCGM WG1 meeting, IMERA REGENMED, METEOMET, etc.).

Between the dissemination activities carried out in 2011 the numerous external relations and library are a very interesting and appreciable; in the Committee’s
opinion such activities can improve the diffusion of "INRIM" brand in the society and the culture of traceability.

5.2.3 Support for legal, health and environmental metrology.

In legal, health and environment fields the society needs correct procedure measurement and reliable calibration facilities. Then INRIM provides some tasks regulated by law, in fact in most of these areas the INRIM is the authority named to measurement traceability. INRIM drew up a formal agreement with National Research bodies for health ISS (National Health Institute) and for environment ISPRA (National Institute for the Protection of the Environment Research). Furthermore, the INRIM cooperates with MiSE (Economic Development Ministry) to make available measuring techniques and procedures for both the protection of the consumers in commercial exchange and the protection of the population health and of the environment.

Also in 2011 the INRIM has developed research projects, measurement procedures and specific traceability of measuring instruments in the fields of:

- Legal metrology: in this field INRIM cooperates continuously with: i) MISE Ministry for developing standards and laws in legal metrology; ii) legal metrological services of CCIAA for standard calibration activities; iii) Tagliacarne Institute for personal training in legal metrological field;
- Health and environmental metrology (in cooperation with University of Turin, ISS and ISPRA): in such field the INRIM Institute has carried out research activities aimed to the improvement of the measurement equipment and techniques, test campaigns for energy and environmental measurements and realization of standards for traceability (e.g. traceability of ozone measurements);

5.3 Conclusions and suggestions

The INRIM activities of knowledge diffusion towards community and academy can be considered excellent for both quality and quantity. The visibility and proposal capability at international level of INRIM Institute in National and International activities testifies its interaction ability in several metrological sectors with the community and the scientific academy.

In the last years significant efforts have reduced the gap between the health, legal and environment metrology and the scientific metrology in terms of national metrological traceability. However, the INRIM Institute should still improve the knowledge dissemination activities about International System of Units also for such quantities.

As regards the knowledge dissemination to the companies, the critical aspects underlined in the previous evaluation reports are confirmed in 2011. So we can affirm that the industrial knowledge transfer activity does not appear to represent a priority activity at INRIM. Such activity depends on the researchers’ sensitivity instead of being the consequence of the Institute strategy. As a consequence, there is a gap between capabilities and results, in terms of patents and
spin-off. This problem is certainly shared by the entire national scientific community, but it broadens the scope rather than reduce it.

In order to reduce this gap it is necessary to set up a policy and to take measures able to boost patent activity and application of research activity. Then the INRIM should develop a range of programs: i) to manage a specific consultancies programs toward industry and stakeholders; ii) to plan knowledge transfer into all research programs to ensure the right impact; iii) to improve the access to INRIM's expertise, laboratories and equipment; iv) to maintain a Knowledge Transfer Networks; v) to improve the knowledge transfer by means of the new media communication; vii) to evaluate all research results in terms of patentability or know-how for innovation; viii) to evaluate the industrial knowledge transfers effectiveness (paying particular attention to the patents); ix) to establish a researcher's career progression and a personal appraisal in order to clarify the evaluation of knowledge dissemination activities.

In the last year several actions are carried out to diffuse the INRIM image with specific marketing actions to better promote the "INRIM" brand in the industry and not only in the scientific community, such as Radio and Television interview and several publication on magazine.

As concluding remarks, the challenges with respect to INRIM's manifold dissemination activities still appear to be:

1. to maintain the excellence in the knowledge diffusion results toward the community and the academy, widening the traditional metrology also to the new chemical, health and environmental fields;
2. to keep participating to Regione Piemonte innovation poles, to European Joint Project and to continue the investments in the health, energy and environmental know-how and apparatus';
3. to improve the industrial diffusion activities planning in term of: specific consultancies of industry and stakeholders; programs to ensure the right impact; a full access to INRIM's expertise, laboratories and equipment; the use of a specific network;
4. to establish a systematic overview of its dissemination of knowledge and results and to bring them in line with the mission of the institute. This could be formulated in a policy document, traduced in strategic actions with appropriate human and economic resources and, finally, periodically verified;
5. to introduce a specific hour accounting method for the dissemination activity similarly to other activities (e.g research, calibration, ...);
6. to implement a specific staff and office for the coordination and the promotion of the industrial knowledge dissemination; this activity could be also carried out in cooperation directly with industrial stakeholder or with a transfer technology specialist;
7. to define and promote a specific regulation about spin-off activities in INRIM in order also to allow young researchers to create an enterprise. A systematic collaboration with Incubator I3P, as mentioned in Chapter 5.1.5 is suggested as a useful instrument to support outbound dissemination within INRIM and to promote INRIM brand and image in the local and national industrial environment.
6 Economy and Resources

6.1 Introduction and rationale

Institute-wide economic figures are reported from the ‘Annual report 2011’ \(^1\), and compared with similar figures of two European Metrology Institutes, the Danish Fundamental Metrology (DFM),\(^2\) much smaller than INRIM (DFM staff is about 10% of INRIM), and the German PTB,\(^3\) larger than INRIM (INRIM staff is less than 15% of PTB), and with an extra-European institute, the Korean Research Institute of Standard and Science (KRISS)\(^4\). A few budget figures are also available from BSMI (the Bureau of Standards, Metrology and Inspection of the Republic of China, Taiwan\(^5\)). Having the Institute reached the fifth life year, quinquennial trends are reported and analyzed. After a significant improvement both in self-funding and investments in the first three years of life (2007 to 2009) – in agreement with the guidelines that were traced out in the past evaluations - the year 2010 showed variegate results mixing decline and development, that have combined into a decrease of the total income with respect to years 2008 and 2009. The 2010 decline looks in the average halted and partly recovered in the year 2011, mainly thanks to Institute self-funding capability that has turned back to the values of 2008 and 2009, though discounted by the national inflation rate.

That the reasons of the 2010 decline, as reported in the Institute Annual Report 2010, should be referred to ‘the decline of the revenues from services to the private sector, because of the economic crisis …’ can be hardly negated, as the same decline affected more or less all the benchmark Institutes in the same year, and tends to persist in the year 2011 (see Figure 2). What looks positive is the prompt answer of INRIM that has been capable of turning self-funding to the 2009 values notwithstanding a significant reduction of the industrial research contracts: the latter reduction is a warning that the 2010 economic conjuncture still persists. However, as the Evaluation Committee already pointed out in the 2010 relation, INRIM fluctuations cannot be uniquely referred to external conditions but also to internal organization and policies. For instance, may the large reduction of industrial research contracts be correlated to project funding increase, as the latter allows more research freedom and science?

Passing to the low investment rate (10% of the income) and its stagnation, INRIM management has confirmed that it has been imposed by the uncertainty about future regulatory body restrictions. To the purpose, the 2011 balance reports, as the 2010 report did, a positive surplus which is carried over to the next year and further increases the accumulated surplus to about 4,25 ME. It should be a policy of the INRIM management to direct such surplus to investments when more favourable and predictable conditions will occur. What stands without explanation is the decline of the fellowships funding, which is likely to

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2 DFM, Annual report 2011 (in Danish), and personal communication by K. Carneiro.
3 PTB, Zahlen und Fakten (Figures and facts), 2011, part of the 2011 Annual Report.
5 MOEA, 2011 Annual report of BSMI.
affect labor flexibility and investment that are already penalized by a staff reduction.

In summary, the 2010 decline may be interpreted as a contingent fluctuation, but its reason cannot be deemed as passed away, though economic results have been partly recovered in 2011. Figure 8 clearly indicates INRIM economic status, as the 2010 and 2011 discounted incomes remain well below a 5-year average. Comparison with the usual benchmark Institutes, namely DFM and PTB, but also with extra-European Institutes (KRISS and BSMI), shows a similar stagnation, indicating the world-wide economic crisis as a common conjuncture. Remarkable of INRIM is the recovery capability by self-funding also in the presence of low investment rates, if compared to European and Asian benchmark institutes. This fact indicates the Institute potentialities, but they need investments in people and plants to express at a world class level. The same perception was captured during a short visit to INRIM laboratories and their motivated staff.

6.2 Overall assessment and benchmark

6.2.1 Key economic figures

Table 23 compares 2011 INRIM income and expenses to DFM, PTB and KRISS figures. The operating result, if positive (surplus), is treated as an expenditure in the next financial year. If negative (deficit), it is treated as an item of the current year income. In this manner total income and expenditures come to balance. PTB income has been forcibly estimated as it is missing in the 2011 report, in the form which is available from the Internet.

The last rows of Table 23 give details of the origin of the operating result as a difference between surpluses.

Remarks to Table 23 are the following:

1) Differently than 2010, INRIM rate of non-institutional income (row 0.5) approaches DFM (23% versus 29%, 19% versus 28% in 2010), and diverges from the steady 15% of PTB. Such a recovery from 2010 decline is ascribed to a steady increase of European competitive funds and to the calibration and test income that has turned back to the peak value of 2008. Clouds concerning difficulties because of changes in the accreditation organization can be kept as dissipated. The positive, undeniable fact, is the capability of INRIM of keeping the self-funding quota around 20%. In the absence of a specific study/plan/rule indicating which should be the expected quota for a Metrology Institute like INRIM, values close to 20% should be retained adequate. The wish is that 2011 recovery will be not a fluctuation but a steady phenomenon.

2) Comparison with the Korean Metrology institute looks at first sight unfavorable to INRIM, but whereas the great part of INRIM self funding comes from competitive Europe-wide projects, the same cannot apply to the national institute of a country as South Korea. In fact INRIM commercial funding looks higher than KRISS. A rather discrepant figure is that of investments, but KRISS figure should be treated with some caution as no details are available.

3) For what concerns expenditures, INRIM and PTB percentages look very similar, except for the investments that have been greatly reduced from the 19% of 2009 to the 11% of 2010 and 2011. As a comparison, PTB has kept the invest-
Investment rate is a key issue raised in all the past evaluations.

Table 23 EXTENDS OVER SEVERAL PAGES

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>INRIM</th>
<th></th>
<th>DFM</th>
<th></th>
<th>PTB</th>
<th></th>
<th>KRISS (***</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Value [ME]</td>
<td>%</td>
<td>Value [ME]</td>
<td>%</td>
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<td>%</td>
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<td>Institutional funding (+)</td>
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<td>77</td>
<td>1,88</td>
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<td>85</td>
<td>58,3</td>
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<td>Income from commercial activities (++)</td>
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<td>60</td>
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<td>55</td>
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<td>7,89</td>
<td>29</td>
<td>0,48</td>
<td>17</td>
<td>34,3</td>
<td>21</td>
<td>5,1</td>
<td>6</td>
</tr>
<tr>
<td>1.3</td>
<td>Investments/depreciation</td>
<td>2,95</td>
<td>11</td>
<td>0,21</td>
<td>8</td>
<td>38,5</td>
<td>23</td>
<td>54,2</td>
<td>65</td>
</tr>
<tr>
<td>1.4</td>
<td>Direct costs</td>
<td>NA</td>
<td></td>
<td>0,29</td>
<td>11</td>
<td>2,2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.5</td>
<td>Operating result (surplus)</td>
<td>1,50</td>
<td>5</td>
<td>0,13</td>
<td>4</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Total</td>
<td>27,40</td>
<td>100</td>
<td>2,76</td>
<td>100</td>
<td>165,8</td>
<td>100</td>
<td>83,1</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Accumulated surplus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Carried over from previous year</td>
<td>4,76</td>
<td>1,79</td>
<td>NA</td>
<td></td>
<td>NA</td>
<td></td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Surplus (deficit) of the year</td>
<td>0,64</td>
<td>0,13</td>
<td>NA</td>
<td></td>
<td>NA</td>
<td></td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>Carried over to the next year</td>
<td>6,26</td>
<td>1,92</td>
<td>NA</td>
<td></td>
<td>NA</td>
<td></td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>
(+) It consists of Ministry (MIUR) funding, referring to permanent and temporary staff, as well as grants and scholarships.

(++) It includes income from calibration and test activities, as well as ‘other receipts’ (altre entrate)

(*) Estimated as it is missing in the 2011 PTB report.

(*) They include both permanent and temporary staff.

(**) Caution must be paid toward KRISS figures, since no balance is provided (only the budget of expenditures). Moreover, a rather relevant item of the budget (54%), referred to as R&D, is not clear if it consists of mere investments or it should include other costs. However, the former interpretation looks the more acceptable, since the reported personnel costs are proportional to INRIM ones. Data have been converted in MEuros from USD, 1 USD = .77 Euros (January 2012). Investments include constructions.

| Table 23 Key economic figures for INRIM, DFM, PTB and KRISS 2011 |

In summary the key points are:

1) Positive: INRIM significant capability of self-funding (23 % of the total income) higher than PTB but significantly lower than DFM and KRISS.

2) Negative: IMRIM low investment rate (11% of the expenses) much lower than PTB (23%). INRIM looks restrained by future uncertainty, which may explain the consistent surplus carried to 2012 (+36% with respect to 2010).

3) Warning: rather different percentages emerge in Table 23 for what concerns operating costs. For instance, INRIM operating costs showed a significant, but unexplained, increase in 2011, reaching the peak of the quinquennial.

6.2.2 Economic trend

The quinquennal trend 2007 to 2011 is reported in Table 24. Table 25 shows the same trend for the benchmark Institutes. The time profile of the discounted income for all the Institutes is plotted in Figure 4. Values have been scaled to obtain comparable figures. Figure 5 compares INRIM to the European benchmark Institutes: PTB and DFM. Tables and Figures employ the same items and data of Table 23 Table 24 and Table 25 have been enriched with the compound inflation rate from 2008 to 2011 and the corresponding discounted incomes. Only European Institutes have partly recovered the decline of 2010.
Figure 4– Quinquennial trend of INRIM and benchmark Institutes: discounted income.
<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>2007 values</th>
<th>2008 values</th>
<th>2009 values</th>
<th>2010 values</th>
<th>2011 values</th>
<th>5 year average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INRIM (Italy)</td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
<td>2010</td>
<td>2011</td>
<td>Value [ME]</td>
</tr>
<tr>
<td>0</td>
<td>Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>Institutional funding</td>
<td>19,95</td>
<td>20,5</td>
<td>21,1</td>
<td>21,11</td>
<td>21,11</td>
<td>20,75</td>
</tr>
<tr>
<td>0.2</td>
<td>Research contracts/projects</td>
<td>1,4</td>
<td>4,25</td>
<td>2,85</td>
<td>2,15</td>
<td>2,75</td>
<td>2,68</td>
</tr>
<tr>
<td>0.3</td>
<td>Income from commercial activities (calibration, test,</td>
<td>3,4</td>
<td>3,65</td>
<td>3,05</td>
<td>2,94</td>
<td>3,54</td>
<td>3,32</td>
</tr>
<tr>
<td></td>
<td>accreditation, others)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>Total INRIM</td>
<td>24,76</td>
<td>28,4</td>
<td>27</td>
<td>26,20</td>
<td>27,40</td>
<td>26,75</td>
</tr>
<tr>
<td>0.5</td>
<td>Compound inflation rate (Italy)</td>
<td>1</td>
<td>1,035</td>
<td>1,043</td>
<td>1,06</td>
<td>1,09</td>
<td>1,09</td>
</tr>
<tr>
<td>0.6</td>
<td>Discounted funding</td>
<td>19,95</td>
<td>19,8</td>
<td>20,2</td>
<td>19,9</td>
<td>19,4</td>
<td>19,85</td>
</tr>
<tr>
<td>0.7</td>
<td>Discounted self-funding</td>
<td>4.81</td>
<td>7,6</td>
<td>5,7</td>
<td>4,8</td>
<td>5,8</td>
<td>5,7</td>
</tr>
<tr>
<td>0.8</td>
<td>Discounted total (2007 as a basis)</td>
<td>24,76</td>
<td>27,4(25,6+)</td>
<td>25,9</td>
<td>24,7</td>
<td>25,1</td>
<td>25,58</td>
</tr>
<tr>
<td>1</td>
<td>Expenses (balanced)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Personnel costs</td>
<td>15,29</td>
<td>14,9</td>
<td>15,75</td>
<td>16,36</td>
<td>15,06</td>
<td>15,47</td>
</tr>
<tr>
<td>1.2</td>
<td>Other operating costs</td>
<td>6,05</td>
<td>6,9</td>
<td>7,3</td>
<td>6,26</td>
<td>7,89</td>
<td>6,88</td>
</tr>
<tr>
<td>1.3</td>
<td>Investments/depreciation</td>
<td>2,24</td>
<td>5,6</td>
<td>5,35</td>
<td>2,94</td>
<td>2,95</td>
<td>3,81</td>
</tr>
<tr>
<td>1.5</td>
<td>Operating result</td>
<td>1,18</td>
<td>1</td>
<td>-1,4</td>
<td>0,64</td>
<td>1,50</td>
<td>0,58</td>
</tr>
<tr>
<td>1.4</td>
<td>Total INRIM (balanced)</td>
<td>24,76</td>
<td>28,4</td>
<td>27</td>
<td>26,20</td>
<td>27,40</td>
<td>26,75</td>
</tr>
<tr>
<td>1.5</td>
<td>Total INRIM (actual expenses)</td>
<td>23,58</td>
<td>27,4</td>
<td>28,4</td>
<td>25,56</td>
<td>25,90</td>
<td></td>
</tr>
</tbody>
</table>

(+) without the special funding of 1.87 MEuros

Table 24 INRIM, economic trend from 2007 to 2011
<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>2007 values</th>
<th>2008 values</th>
<th>2009 values</th>
<th>2010 values</th>
<th>2011 values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6</td>
<td>DFM (+)</td>
<td>Country population 5.5 million units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total DFM (balanced)</td>
<td>2,22</td>
<td>2,30</td>
<td>2,51</td>
<td>2,58</td>
<td>2,76</td>
</tr>
<tr>
<td>1.63</td>
<td>Compounded inflation rate (Denmark)</td>
<td>1</td>
<td>1,036</td>
<td>1,047</td>
<td>1,07</td>
<td>1,10</td>
</tr>
<tr>
<td>1.64</td>
<td>Discounted total (2007 as a basis)</td>
<td>2,22</td>
<td>2,22</td>
<td>2,40</td>
<td>2,41</td>
<td>2,51</td>
</tr>
<tr>
<td></td>
<td>PTB (Germany)</td>
<td>Country population 8 2 million units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>Total PTB (balanced)</td>
<td>132,9</td>
<td>141,2</td>
<td>163</td>
<td>158,3</td>
<td>165,8</td>
</tr>
<tr>
<td>1.71</td>
<td>Compounded inflation rate (Germany)</td>
<td>1</td>
<td>1,028</td>
<td>1,03</td>
<td>1,042</td>
<td>1,068</td>
</tr>
<tr>
<td>1.72</td>
<td>Discounted total (2007 as a basis)</td>
<td>132,9</td>
<td>137,4</td>
<td>158</td>
<td>151,9</td>
<td>155,2</td>
</tr>
<tr>
<td></td>
<td>KRISS (South Korea,++)</td>
<td>Country population 49 Million units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>Total KRISS (expenditures)</td>
<td>NA</td>
<td>NA</td>
<td>83,2</td>
<td>85,0</td>
<td>83,1</td>
</tr>
<tr>
<td>1.81</td>
<td>Compounded inflation rate (2007 basis)</td>
<td>1</td>
<td>1,041</td>
<td>1,071</td>
<td>1,108</td>
<td>1,149</td>
</tr>
<tr>
<td>1.82</td>
<td>Discounted total (2007 as a basis)</td>
<td>NA</td>
<td>NA</td>
<td>77,3</td>
<td>76,7</td>
<td>72,3</td>
</tr>
<tr>
<td></td>
<td>BSMI (Taiwan ++++)</td>
<td>Country population 23 Million units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td>Total BSMI (expenditures)</td>
<td>54,5</td>
<td>58,6</td>
<td>62,6</td>
<td>61,5</td>
<td>61.7</td>
</tr>
<tr>
<td>1.91</td>
<td>Compounded inflation rate (2007 basis)</td>
<td>1</td>
<td>1,035</td>
<td>1,026</td>
<td>1,036</td>
<td>1,050</td>
</tr>
<tr>
<td>1.92</td>
<td>Discounted total (2007 as a basis)</td>
<td>54,5</td>
<td>56,6</td>
<td>60,7</td>
<td>59,0</td>
<td>58,7</td>
</tr>
</tbody>
</table>

(+ DFM data in ME, from data in DKK (1 DKK =0.1345 Euros, January 2012)

(++ KRISS data in ME, from data in USD (1 USD =0.77 Euros, January 2012)

(+++) BSMI data in ME, from data in Taiwan dollars (1 Taiwan dollar=0.025 Euros, January 2012)

Table 25 Economic trend of the benchmark Institutes from 2007 to 2011.
Remarks to Figure 4, Figure 5, Table 24 and Table 25 are the following:

1) The economic trends of INRIM, DFM, PTB, KRISS and BSMI during the quinquennial 2007 to 2011 show similarities and discrepancies. Subtracting the special funding of 1,87 MEuros obtained in 2008, INRIM income steadily increased from 2007 to 2009, also on a discounted basis, which positive result was already remarked in the past evaluation reports, and it was interpreted as a solid basis for future achievements. The positive trend halted in the 2010, like most of the benchmark Institutes (except DFM). The INRIM negative result was interpreted as due to the economic crisis and the consequent restrictions of the regulatory body (a similar interpretation might apply as well to benchmark Institutes except DFM). The INRIM negative result was interpreted as due to the economic crisis and the consequent restrictions of the regulatory body (a similar interpretation might apply as well to benchmark Institutes except DFM). The 2010 Evaluation Report wrote "INRIM stays in the middle and the past triennial (2007-2009) trend showed potentialities for supplying shortage of institutional funding. The hope is that the 2010 decline could be recovered during current and next years.". We may say that such hopes stood on a solid basis.

2) Analysis of the different items shows that institutional funding has remained rather constant (if cleared of the inflation rate), whereas self-funding significantly increased during 2008 and 2009, but during 2010 it declined to the 2007 values (if cleared of the inflation rate). Remarkably, in 2011 it turned back to the 2008 and 2009 values (subtracting the 2008 special funding). The four items contributing to self-funding are detailed in the next section. The 2010 Evaluation Report wrote "What must be remarked ... is the continuous decrease of the commercial income (calibration and test), though not so high as in the
2009, partly due to economic conjuncture and to changes of accreditation bodies.” In 2011 calibration and test income turned back to 2009 values, what looks a positive result, and shows that calibration and test activity is a solid asset of the Institute.

In summary the key points are

1) Positive but short term: the net (discounted) 2011 income has increased with respect to 2010 value, but the 2008 values are still far. In fact, the 2011 income stays well below the 5-year average of Figure 8.

2) Positive but short term: research and commercial funds (self-funding as a total) have recovered the 2009 and 2008 values.

3) Negative: investment rates remains at the 2010 level.

4) 5-year trend: INRIM income looks fluctuating, which contrasts the steadily increase of DFM and PTB. PTB income showed a decline in 2010 but after a sharp increase in 2009.

6.2.3 Self-funding

A better insight may be obtained splitting self-funding into different items, which is done in Table 26, Figure 6 and Figure 7. To better assess the quinquennial trend, the special funding of 1,87 Meuro awarded to INRIM in 2008, has been taken as a separate item, as in the past evaluation reports. The reader should notice that the latter must be included in the self-funding total, in the case INRIM economic trend is projected over longer terms, for instance when computing 5-year averages.

![Discounted figures](image)

Figure 6– Trend of INRIM discounted self-funding, investment (without special funding) and fellowships.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Self-funding source (research)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>Regione Piemonte</td>
<td>567</td>
<td>539</td>
<td>1327</td>
<td>309</td>
<td>614</td>
</tr>
<tr>
<td>0.2</td>
<td>European Community</td>
<td>187</td>
<td>689</td>
<td>319</td>
<td>1000</td>
<td>1190</td>
</tr>
<tr>
<td>0.3</td>
<td>Other public bodies</td>
<td>199</td>
<td>648</td>
<td>228</td>
<td>90</td>
<td>663</td>
</tr>
<tr>
<td>0.4</td>
<td>Research contracts</td>
<td>449</td>
<td>464</td>
<td>973</td>
<td>748</td>
<td>284</td>
</tr>
<tr>
<td>1</td>
<td>Total - research</td>
<td>1402</td>
<td>2340</td>
<td>2847</td>
<td>2147</td>
<td>2751</td>
</tr>
<tr>
<td>1.1</td>
<td>Discounted total research</td>
<td>1402</td>
<td>2260</td>
<td>2730</td>
<td>2025</td>
<td>2524</td>
</tr>
<tr>
<td>2</td>
<td>Calibration, test and accreditation</td>
<td>2653</td>
<td>3043</td>
<td>2436</td>
<td>2284</td>
<td>2681</td>
</tr>
<tr>
<td>3</td>
<td>Others</td>
<td>746</td>
<td>542</td>
<td>611</td>
<td>652</td>
<td>858</td>
</tr>
<tr>
<td>4</td>
<td>Total self-funding-commercial</td>
<td>3399</td>
<td>3585</td>
<td>3047</td>
<td>2936</td>
<td>3539</td>
</tr>
<tr>
<td>4.1</td>
<td>Discounted commercial</td>
<td>3399</td>
<td>3464</td>
<td>2921</td>
<td>2770</td>
<td>3247</td>
</tr>
<tr>
<td>5</td>
<td>Total self-funding</td>
<td>4801</td>
<td>5925</td>
<td>5894</td>
<td>5083</td>
<td>6290</td>
</tr>
<tr>
<td>5.1</td>
<td>Discounted self-funding</td>
<td>4801</td>
<td>5724</td>
<td>5651</td>
<td>4795</td>
<td>5770</td>
</tr>
<tr>
<td>6</td>
<td>Self/institutional funding [%]</td>
<td>24</td>
<td>29</td>
<td>28</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>2008 special funding</td>
<td>NA</td>
<td>1870</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>8</td>
<td>Personnel costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1</td>
<td>Permanent/temporary personnel + travel</td>
<td>14203</td>
<td>13204</td>
<td>14143</td>
<td>14866</td>
<td>14147</td>
</tr>
<tr>
<td>8.2</td>
<td>Research grants, scholarships</td>
<td>1083</td>
<td>1673</td>
<td>1601</td>
<td>1490</td>
<td>905</td>
</tr>
<tr>
<td>9</td>
<td>Total</td>
<td>15286</td>
<td>14877</td>
<td>15744</td>
<td>16356</td>
<td>15051</td>
</tr>
<tr>
<td>9.1</td>
<td>Discounted Personnel costs</td>
<td>15286</td>
<td>14374</td>
<td>15095</td>
<td>15430</td>
<td>13808</td>
</tr>
<tr>
<td>10</td>
<td>Investments (without the 2008 special fund-</td>
<td>1588</td>
<td>2833</td>
<td>4672</td>
<td>2940</td>
<td>2953</td>
</tr>
<tr>
<td>10.1</td>
<td>Discounted investments</td>
<td>1588</td>
<td>2737</td>
<td>4479</td>
<td>2773</td>
<td>2709</td>
</tr>
<tr>
<td>11</td>
<td>Compound inflation rate (Italy)</td>
<td>1,035</td>
<td>1,043</td>
<td>1,06</td>
<td>1,09</td>
<td></td>
</tr>
</tbody>
</table>

Table 26 INRIM self-funding, personnel costs and investments (details)
Remarks to Table 26, Figure 7 and Figure 8 are the following:

1) In the quinquennial 2007 to 2010 INRIM management made a significant effort of investment in agreement with Evaluation Committee suggestions. The acme occurred in 2009 when the investment rate of PTB was paired (about 20% of the total expenses). The positive trend underwent a stoppage in 2010, which was justified by a declining self-funding and the need to withstand expected reduction of institutional funding. Notwithstanding such difficulties, the 2010 discounted investments were kept close to the 2008 value, thus higher than 2007, which must be recognized as a reasonable policy. The same policy has been pursued in 2011, by keeping investments at the same level of 2010. May the Committee observe that in front of a steady institutional funding, the personnel cost has decreased of about 1200 kEuro from 2010 to 2011, thus creating premises for an investment increase at least in 2012? As matter of fact, the 2011 surplus of about 1500 kEuro pretty corresponds to personnel cost decrease.

2) A second leverage in the hands of INRIM management is the ensemble of research grants and scholarships (briefly fellowships). The 2007 to 2008 remarkable increase (+50%) did not repeat both in 2009 and in 2010, although the 2010 figure looks still higher than 2007. At first sight, the situation has become even worse in 2011 since the undiscounted value of 905 kEuro is lower than the 2007 amount! The 2010 evaluation report wrote "The picture looks at first sight aggravated by the INRIM labour being substantially frozen both in terms of man power and of costs. While the policy of a frozen labour is imposed by sluggish national regulations, the parallel decline of research grants and scholarships looks unclear, ...". Such a remark remains valid: the total number of fellowships and scholarships in 2010 differed from 2009 just by one unit, they increased of 3 units (about 10%) in 2011. Ph. D. students diminished of 1 unit. In summary, as for the 2010 findings, the flexible leverage of fellowships and scholarships has remained invariant, in the face of a staff reduction (per-
manent and temporary) of 4 units. A comparison with PTB (and with the other Institutes) is not immediate, because of difficulties in comparing personnel categories. A tentative is offered by Table 27. INRIM Ph. D. students are reported but not included in the total personnel, as they are not mentioned among PTB personnel categories. Four main differences emerge from Table 27: (i) The trainees category at PTB, which includes laboratory technicians under traineeship (an INRIM equivalent cannot be found in INRIM reports), (ii) the higher percentage of the temporary staff at PTB, (iii) the PTB category of personnel financed by third parties, (iv) the lower percentage of PTB civil servants with respect to researchers and technologists at INRIM. The first and fourth items looks in some way correlated, and testify the PTB care toward laboratory technicians.

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>INRIM 2010</th>
<th>INRIM 2011</th>
<th>PTB 2010</th>
<th>PTB 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Total personnel (excluding INRIM Ph.D. students)</td>
<td>261</td>
<td>260</td>
<td>1890</td>
<td>1925</td>
</tr>
<tr>
<td>0.1</td>
<td>Permanent staff</td>
<td>212</td>
<td>206 (79%)</td>
<td>1332</td>
<td>1314 (68%)</td>
</tr>
<tr>
<td>0.2</td>
<td>Temporary staff</td>
<td>16</td>
<td>18 (7%)</td>
<td>230</td>
<td>264 (14%)</td>
</tr>
<tr>
<td>0.3</td>
<td>INRIM Fellowships</td>
<td>33</td>
<td>36 (14%)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>0.4</td>
<td>PTB personnel financed by third parties</td>
<td>NA</td>
<td>NA</td>
<td>194</td>
<td>216 (11%)</td>
</tr>
<tr>
<td>0.5</td>
<td>PTB trainees</td>
<td>NA</td>
<td>NA</td>
<td>134</td>
<td>131 (7%)</td>
</tr>
<tr>
<td>0.6</td>
<td>INRIM Ph.D. students</td>
<td>29</td>
<td>28</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td><strong>Permanent staff subdivision</strong></td>
<td><strong>212</strong></td>
<td><strong>206</strong></td>
<td><strong>1332</strong></td>
<td><strong>1314</strong></td>
</tr>
<tr>
<td>1.1</td>
<td>Researchers and technologists (PTB civil servants)</td>
<td>96</td>
<td>94 (46%)</td>
<td>537</td>
<td>535 (40%)</td>
</tr>
<tr>
<td>1.2</td>
<td>Technicians and administrative staff (PTB employees)</td>
<td>116</td>
<td>112 (54%)</td>
<td>795</td>
<td>779 (60%)</td>
</tr>
</tbody>
</table>

**Table 27 INRIM and PTB personnel categories**

3) A third remark concerns the fluctuation of industrial contracts, that after a peak in 2009 (+67% with respect to the 5 year average of 584 kEuro) and a limited decrease in 2010 has fallen down in 2011 to a very low amount, 284 kEuro, less than the 50% of the 5-year average, and close to the 10% of the total research income in 2011. Fluctuations of the competitive research funding may be reasonable, less of research contracts with industry. One reason may be a delayed effect of the economic conjuncture, to be better verified in 2012. Things looks less severe by combining industrial and public body contracts, as they sum up to 947 kEuro, higher than the 2010 value and above the threshold of 850 kEuro fixed in the 2010 evaluation report.
4) Last but not least, the further increase of the European research projects corroborate the assessment of INRIM potentialities and flexibility, as it was capable of compensating a reduction of the regional funding and of keeping the total discounted self-funding at the 2008 level. 2011 self-funding looks slightly higher than the 5-year average, and corresponds to the following acceptable percentages: self/institutional funding equal to 30%, self-funding/income equal to 23%.

In summary the key points are:

1) Positive: regional and competitive European funding has recovered the 2009 values.
2) Positive: calibration, test and accreditation income has recovered the 2008 values.
3) Negative: significant decrease of industrial research contracts, but compensated by contracts with public bodies.
4) Negative: reduction of personnel cost (staff and fellowships) that has not been directed to investment because of uncertainty on the Institutional funding.
5) Negative: continuous decrease of fellowship expenses, less than the 60% of the 2008-2009 values.

6.2.4. Income-per-staff index

Table 28 reports the income-per-staff index as derived from Table 26 and the permanent/temporary staff amount.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Total personnel</td>
<td>225</td>
<td>224</td>
<td>20</td>
<td>1578</td>
<td>388</td>
<td>890</td>
</tr>
<tr>
<td>1</td>
<td>Total discounted income (basis:2007)</td>
<td>25,58</td>
<td>25,1</td>
<td>2,51</td>
<td>155,2</td>
<td>72,3</td>
<td>58,7</td>
</tr>
<tr>
<td>2</td>
<td>Project income</td>
<td>2,68</td>
<td>2,75</td>
<td>0,45</td>
<td>12,1</td>
<td>16,3</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>Commercial income</td>
<td>3,32</td>
<td>3,54</td>
<td>0,37</td>
<td>13,2</td>
<td>8,5</td>
<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>Key indices [kE/staff unit]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>Total income per staff (discounted)</td>
<td>114</td>
<td>112</td>
<td>125,5</td>
<td>98</td>
<td>186</td>
<td>66</td>
</tr>
<tr>
<td>4.2</td>
<td>Project income per staff</td>
<td>12</td>
<td>12</td>
<td>22,5</td>
<td>8</td>
<td>42</td>
<td>NA</td>
</tr>
<tr>
<td>4.3</td>
<td>Commercial income per staff</td>
<td>15</td>
<td>16</td>
<td>18.5</td>
<td>8.4</td>
<td>22</td>
<td>NA</td>
</tr>
</tbody>
</table>

Table 28 Income per staff index for INRIM in 2011

Remarks to Table 28 are the following:

1) During the five years from 2007 to 2011, the project income per staff has approached the commercial income per staff, and the 2011 results lie close to the 5-year average line. As mentioned in the past evaluation, this fact should be kept as a positive result, since income from calibration and test was historically one of the most solid INRIM assets, comparable if not better to other worldwide metrology institutes, close to DFM and KRISS, and doubling the PTB value (row 4.3 of Table 28). Though the balance is partly due to a reduction of...
calibration and test income in 2009 and 2010, it shows INRIM quick and effective effort in diversifying self-funding sources and, more significant, in shortening the path from basic to applied research.

2) Past expectations about the INRIM capability of approaching the performance of a small and aggressive institute as DFM, are confirmed by comparing the total income-per-staff in Table 28. The latter has been discounted by the national inflation index for comparison with the 5-year average of the INRIM income (row 4.1 in Table 28). The INRIM 5-year average looks pretty close to DFM 2011 value (114 versus 125 kEuro/staff unit), a significant performance taking account of the continuous increase of the discounted DFM income and of the steady (actually decreasing on a discounted basis) institutional funding received by INRIM. Besides the wish that the actual 5-year trend could continue, the Committee iterates INRIM to address a pair of policies: a) to reinforce nationwide knowledge transfer, becoming the proposer of systematic ventures with industry consortia; b) to reinforce/improve its position Europe-wide, through a better blend of regional and European projects; a hint would be to take advantage of the regional funds to the purpose. No feedback looks available to judge about the former policy, except the large decrease of industrial contracts in 2011. The latter policy seems having been put in action as the European funds awarded to INRIM in 2010 and 2011 prove.

3) The income per staff of the Korean and Taiwan Institutes look as outliers with respect to European figures which settle around 115 kEuros/staff. The Korean index is about 50% higher than the European average index. KRISS has a staff which is close to double the INRIM staff (South Korea population is lower than Italy), and an income which is close to be three times! KRISS is just a metrology institute with some science branches as INRIM and PTB. The numerous staff of the Taiwan institute may be related to inspection activities of the institute (Bureau of Standards, Metrology and Inspection is the brand name). Whichever be the underlying policies, they confirm intense concern and devotion to metrology of such countries.

6.3 Conclusions and recommendations

INRIM potentialities emerge from uneasy conditions, since the year 2011 has witnessed a prompt and significant recovery from the 2010 decline, a recovery which looks still weak but is expected to repeat the 2007-2009 positive trend. As a matter of fact, INRIM looks to have wisely navigated in the past years among different rocks:

1) regional fund fluctuations were recovered by competitive European funding,
2) calibration, test and accreditation income although fluctuating because of the economic conjuncture remains a solid asset of the Institute as the 2001 recovery witnesses,
3) the frozen staff (net personnel cost decreasing from 2007 on) was complemented with fellowships and scholarships, but unfortunately the latter dropped in 2010 and still in 2011.

The same conclusions as in the past reports can be iterated: the overall economic analysis and benchmarks are ranking INRIM as a rather effective research organization for what concerns both self-funding and investments, a pair of concerns that were in the past deemed being weak by Committee. Manage-
ment should make any effort to keep and improve the present rank. Today, the rank can be quantified in a robust way by computing quinquennial averages.

Special attention should be deserved to foster INRIM potentialities, to increase investments and fellowships, as both declined in 2010 and 2011, to keep a steady position in the Europe-wide funding. The Committee is aware of the difficulties in pursuing these objectives, but the self-funding shift to European projects indicates INRIM potentialities and flexibility.

For the second time, a limited but significant comparison has been made with extra-European metrology Institutes, specifically South-Korean and Taiwan. The relevant financial data, though limited and affected by uncertainty, enlighten the strong attention and care devoted to metrology by such countries. Nothing comes from nothing; more than 50% of the Korean Institute income looks investment! Last but not least, metrology should be kept as a sensible observatory of technology attention and advancement, because of being pervasive and diffusive in every activity and moment of life (think of health and legal metrology how they can support every-day life!). Investment shortage and careless can only lead to a progressive know-how and wealth decrease, and worse in the midst of a technological circumstance full of opportunities!

6.4 Executive summary

Economic analysis aims to correlate the quinquennial trend with the past indications of the Evaluation Committee, and with the benchmark offered by European and extra European Metrology Institutes. Key economic indices are investments, self-funding (projects, contracts and commercial income), funds to support scholarships and fellowships, as the latter is a leverage for compensating a practically frozen staff, and finally the income per staff, as an indication of the capability of transferring knowledge and technology. Whilst the first triennial (2007-2009) witnessed a steady growth (if the 2008 income is removed of a special fund, see Figure 8), the year 2010 resulted into a significant economic halt, which, in the 2010 relation of the Evaluation Committee\(^1\), was interpreted as contingent, and strictly related to economic crisis and to constraints of the regulatory body. Actually, as pointed out in the same document, the 2010 picture appears less dark by observing some positive facts, like the exploit of the Europe-wide competitive research funding (+150% with respect to 2007-2009 triennial). The 2011 economic results confirm such view, since the 2011 discounted income in Figure 6 has slightly increased with respect to 2010, demonstrating the Institute capability of reacting to an environment conjuncture. The positive picture is confirmed by a repeated exploit in the Europe-wide funding, and in general by the self-funding capability.

\(^1\) K. Carneiro et al., Evaluation of Istituto Nazionale di Ricerca Metrologica 2010.
Figure 8– Quinquennial trend and average of INRIM with and without 2008 special fund: discounted income.

Focusing on the single items of the income and expense balance, the picture still shows negative trends and weaknesses, the same that have been pointed out in the past assessments. We refer in particular to key items like fellowships and investments, as they either have further declined (fellowships) or have remained fixed at the low 2010 value (investments). Investments that were raised in 2009 to the acceptable figure (for the European standard) of 20% have fallen down to about 10% in 2010 and 2011, a value that can hardly aid a Metrology Institute to stay competitive and become a reference world-wide. The Committee is aware of the constraints impeding INRIM to put in action all of its potentialities, but modern metrology being pervasive of society and life should indicate the road map to INRIM management for breaking the straitjacket impeding Italian (metrological) research and technology to burst.
7 Annexes

7.1 Material submitted to the Evaluation Committee

A. Risultati e Dati 2011
B. Relazione consuntiva 2011
C. Supplementary documentation in connection with the on-site visit 5-7 September 2012.
### 7.2 List of acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCREDIA</td>
<td>Italian Accreditation Body</td>
</tr>
<tr>
<td>AICQ</td>
<td>Associazione Italiana Cultura qualità</td>
</tr>
<tr>
<td>ANVUR</td>
<td>Agenzia Nazionale per la Valutazione dell'Università e della Ricerca (National Agency for the evaluation of the University and the Research)</td>
</tr>
<tr>
<td>BIPM</td>
<td>Bureau International des Poids et Mesures (Sèvres, France)</td>
</tr>
<tr>
<td>BSMI</td>
<td>Bureau of Standards, Metrology and Inspection of the Republic of China, Taiwan</td>
</tr>
<tr>
<td>CC</td>
<td>Consultative Committee of the CIPM</td>
</tr>
<tr>
<td>CCIAA</td>
<td>Italian Commerce Body for Industry and Handicraft</td>
</tr>
<tr>
<td>CEM</td>
<td>Centro Español de Metrologia</td>
</tr>
<tr>
<td>CEN</td>
<td>European Committee for Standardisation, Centre Européenne de Normalisation</td>
</tr>
<tr>
<td>CII</td>
<td>Citation Impact. Citations of a single paper, or a group of papers e.g. from an institution. CI is defined specifically, defined by year(s) of publication and of citation.</td>
</tr>
<tr>
<td>CIE</td>
<td>INTERNATIONAL COMMISSION ON ILLUMINATION</td>
</tr>
<tr>
<td>CIPM</td>
<td>International Committee for Weights and Measures (Metre Convention)</td>
</tr>
<tr>
<td>CIPM-MRA</td>
<td>Mutual Recognition Arrangement of the CIPM from 1999</td>
</tr>
<tr>
<td>CIVR</td>
<td>Committee for the Evaluation of Research (Italy)</td>
</tr>
<tr>
<td>CMC</td>
<td>Calibration measurement capabilities (Entry in KCDB appendix C)</td>
</tr>
<tr>
<td>DFM</td>
<td>Danish Fundamental Metrology Ltd (Danish metrology institute)</td>
</tr>
<tr>
<td>E</td>
<td>Electromagnetism division of INRIM</td>
</tr>
<tr>
<td>EA</td>
<td>European co-operation for Accreditation</td>
</tr>
<tr>
<td>EA - MLA</td>
<td>EA Multilateral Agreement</td>
</tr>
<tr>
<td>EMRP</td>
<td>European Metrology Research Programme</td>
</tr>
<tr>
<td>ENEA-INMRI</td>
<td>Italian Designated Institute for Ionising Radiation</td>
</tr>
<tr>
<td>EURAMET</td>
<td>European Association of Metrology Institutes</td>
</tr>
<tr>
<td>FTE</td>
<td>Full Time Equivalent (corresponding to the workload of one full-time employed person)</td>
</tr>
<tr>
<td>GEV</td>
<td>Gruppo di Esperti della Valutazione (Panels of the National Evaluation Agency)</td>
</tr>
<tr>
<td>IAU</td>
<td>International Astronomical Union</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Committee</td>
</tr>
<tr>
<td>IF</td>
<td>Impact Factor of a scientific journal (average number of citations from an article in the journal)</td>
</tr>
<tr>
<td>ILAC</td>
<td>International Laboratory Accreditation Cooperation</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>ILAC - MRA</td>
<td>ILAC Mutual Recognition Arrangement</td>
</tr>
<tr>
<td>IMERA</td>
<td>Implementing the Metrology European Research Area</td>
</tr>
<tr>
<td>INRIM</td>
<td>Istituto Nazionale di Ricerca Metrologica</td>
</tr>
<tr>
<td>ISI</td>
<td>International Statistical Institute</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standardization Organization</td>
</tr>
<tr>
<td>ISPRA</td>
<td>Italian Institute for the Protection of the Environment Research</td>
</tr>
<tr>
<td>ISS</td>
<td>Italian Health Institute</td>
</tr>
<tr>
<td>ITU-R</td>
<td>Formerly CCIR. It with the standardization of wireless communication.</td>
</tr>
<tr>
<td>IUPAC</td>
<td>International Union of Pure and Applied Chemistry</td>
</tr>
<tr>
<td>JRP</td>
<td>Joint Research Project of the EMRP</td>
</tr>
<tr>
<td>KC</td>
<td>Key Comparison (Entry in KCDB Appendix B)</td>
</tr>
<tr>
<td>KCDB</td>
<td>Key Comparison Database of the CIPM-MRA</td>
</tr>
<tr>
<td>KRISS</td>
<td>Korean Institute of Standards and Science</td>
</tr>
<tr>
<td>LNE</td>
<td>Laboratoire National de Métrologie et d'Essais</td>
</tr>
<tr>
<td>M</td>
<td>Mechanics division of INRIM</td>
</tr>
<tr>
<td>METAS</td>
<td>The Federal Office of Metrology</td>
</tr>
<tr>
<td>MIUR</td>
<td>Ministero dell'Istruzione, dell'Università e della Ricerca (Italian Ministry of Education, University and Research)</td>
</tr>
<tr>
<td>NMI</td>
<td>National Metrology Institute</td>
</tr>
<tr>
<td>NRC</td>
<td>National Research Council</td>
</tr>
<tr>
<td>O</td>
<td>Optics division of INRIM</td>
</tr>
<tr>
<td>PRIN</td>
<td>Progetto di Ricerca di Interesse Nazionale (Research projects founded by the Ministry)</td>
</tr>
<tr>
<td>PRT</td>
<td>Potential Research Topics</td>
</tr>
<tr>
<td>PTB</td>
<td>Physikalisch Technische Bundesanstalt (German metrology institute)</td>
</tr>
<tr>
<td>SC</td>
<td>Supplementary Comparison (Entry in KCDB Appendix B)</td>
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<td>SRC</td>
<td>Selected Research Topics</td>
</tr>
<tr>
<td>T</td>
<td>Thermodynamics division of INRIM</td>
</tr>
<tr>
<td>TP</td>
<td>Target Programme</td>
</tr>
<tr>
<td>VSL</td>
<td>Dutch Metrology Institute</td>
</tr>
</tbody>
</table>
7.3 Summary of developments at ENEA-INMRI for 2011

This section was written by Pierino De Felice, Antonio Guerra and Maria Pia Toni

In order to get a complete picture of the whole Italian metrology organisation, a summary of the developments carried out in 2010-2011 at the National Institute of Ionising Radiation Metrology of ENEA (ENEA-INMRI), that is the Italian Designated Institute for Ionising Radiation, is reported in this Appendix.

The ENEA-INMRI programmes were focused, as in the past, on maintaining and developing the national standards for ionising radiation measurements and on activities in the field of standardisation and quality assurance in ionising radiation measurements as well as in the dissemination of relevant physical units.

These programmes are carried out along the following lines:

- Protection level dosimetry standards;
- Therapy level and industrial radiation processing dosimetry standards;
- Radionuclide activity standards;
- Neutron measurement standards.

The national standards (with their main characteristics) maintained by ENEA-INMRI are described in http://www.inmri.enea.it/. The list of international comparisons for validation of the Italian standards is reported in http://kcdb.bipm.org. (See section 4.1)

The programmes in standardization on radiation measurement aim at objectives such as:

- improving procedures for practical dosimetry at therapy and protection levels;
- supporting preparation of radiotherapy dosimetry protocols for national radiotherapy centres in the framework of their Quality Assurance programmes;
- implementing measurement quality programmes for the "National Radionuclide Activity Surveillance Network" - some tens laboratories in the Country - reporting to the local administrative authorities and the Ministry of the Environment.

A calibration service is performed at ENEA-INMRI for ionising radiation measuring instruments used in medical, industrial and radiation protection applications. Large part of calibrations is however carried out by the Italian network of secondary standard calibration laboratories. These are accredited by the Italian accreditation body (ACCREDIA) and their standards are in majority of cases traceable to the ENEA-INMRI primary standards.

A total number of 98 calibration and measurement capabilities (CMCs) were registered, at the end of 2010, by ENEA-INMRI and internationally recognised in the frame of the MRA. The CMCs are included in Table 14 (see Section 4.1) and distributed on the technical activities according to Table 29.

Extensive restructuring work in 2 of the 4 Institute buildings, as requested by the Italian authority for radiological protection, was completed. Renewed laboratories are now fully available for the Institute experimental activities.
A summary of the main developments in specific projects and activities is reported hereafter.

### 7.3.1 Development of national standards and comparisons

#### BIPM-ENEA comparisons on x-rays air-kerma standards

Remarkable improvement were recently made on the ENEA-INMRI low-energy, medium-energy, mammography x-ray and 137Cs air-kerma standards following extensive laboratory restructuring, calculation and refinement of relevant correction factors. New comparisons with BIPM were carried out or are ongoing for validation and periodical confirmation of degree of equivalence. A technical report was jointly published with BIPM colleagues.

#### Low dose rate brachytherapy absorbed-dose-to-water standard

A new low-dose-rate (LDR) brachytherapy (BT) absorbed-dose-to-water standard was developed in the frame of the EMRP project "Brachytherapy", to measure the absorbed dose to water at 1 cm from the sources (D_{w,1 cm}) due to 125I LDR sealed BT sources used in clinical radiotherapy treatments. The standard consists of a large-angle, variable volume ionization chamber. Monte Carlo (determination of correction and conversion factors) and 3D boundary element calculations (determination of electric field inside the chamber in collaboration with INRIM) were used in both design and characterization phases of the standard development. Preliminary comparison among the project partners allowed satisfactory validation of the standard. The standard allows a significant reduction of the uncertainty of D_{w,1 cm} from 5.0% (previous D_{w,1 cm} determination based on international measurement protocols) to 2.3%. The ENEA-INMRI, along with other project partners, are promoting an updating of these measurement protocols based on the new standards developed. A joint paper with INRIM colleague was submitted for publication in Metrologia.

#### High dose rate brachytherapy absorbed-dose-to-water standard

A new high-dose-rate (HDR) brachytherapy (BT) absorbed-dose-to-water standard was developed in the frame of the EMRP project "Brachytherapy", to measure the absorbed dose to water at 1 cm from the sources (D_{w,1 cm}) due to 192Ir HDR sealed BT sources used in clinical radiotherapy treatments. The standard consists of a graphite calorimeter of annular shape (dose to graphite) and of a conversion procedure (dose to water) by means of Monte Carlo calculations. Optimisation of calorimeter design was made by Monte Carlo simulation and Finite Element Method heat transfer calculation. Preliminary comparison among the project partners allowed satisfactory validation of the standard. The standard allows a significant reduction of the uncertainty of D_{w,1 cm} from 5.0% (previous D_{w,1 cm} determination based on international measurement protocols) to 1.4%. As for LDR standards, new measurement protocols will be available for

<table>
<thead>
<tr>
<th>Technical activities</th>
<th>Number of CMCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dosimetry standards</td>
<td>76</td>
</tr>
<tr>
<td>Radionuclide activity standards</td>
<td>13</td>
</tr>
<tr>
<td>Neutron measurement standards</td>
<td>09</td>
</tr>
</tbody>
</table>

Table 29 Details of the CMCs from ENEA-INMRI.
the national and international medical community. A paper was submitted for publication in Metrologia.

Therapy level absorbed-dose-to-water standard

Following recent improvement in characterization of the therapy-level absorbed-dose-to-water standard, made by Monte Carlo simulation, a new comparison with BIPM was carried out and extensive data evaluation was needed. A paper and technical report were jointly published with BIPM colleagues.

New absorbed dose to water standard at $^{60}$Co radiation-processing dose levels

A new absorbed dose to water standard at $^{60}$Co radiation-processing dose levels was developed based on graphite calorimetry, ferrous sulphate and dichromate dosimetry. It was also validated participating in the CCRI(I)-S2 supplementary comparison with good results.

Standardisation of $^{64}$Cu

A $^{64}$Cu primary standard was developed by using two absolute measurement techniques: the 4πγ integral counting method, based on a well-type NaI(Tl) 5” x 5” detector, and the 4πβ Liquid Scintillation Spectrometry Method with $^3$H-Standard Efficiency Tracing (CIEMAT/NIST method). A number of ENEA-INMRI secondary standards were calibrated, using the new primary standard and a comparison was started in the frame of the BIPM/SIR.

Standardisation of $^{177}$Lu

The 4πγ and CIEMAT/NIST methods were also applied for $^{177}$Lu standardization in the frame of a BIPM key comparison, piloted by NIST (USA). Particular effort was devoted to identification and quantification of $^{177m}$Lu radionuclide impurity. A special algorithm, developed at ENEA-INMRI, was successfully applied to this purpose. The ENEA-INMRI result was in good agreement with the key comparison reference value.

Standardisation of $^{131}$I

A solution of $^{131}$I was standardised by three different absolute methods: 4πγ integral counting, CIEMAT/NIST and TDCR, the latter based on an Hidex 300SL Liquid Scintillation Counting system (metrological version), recently introduced at ENEA-INMRI.

Standardisation of $^{63}$Ni

Sealed ampoules of $^{63}$Ni solution were sent to CIEMAT (ES) and BIPM in the frame of the Extended SIR (ESIR) project for pure β-emitters. The solutions were standardized at ENEA-INMRI by CIEMAT/NIST and TDCR methods. Comparison results were discussed at the ESIR meeting at BIPM in June 2011.

Improvement of standards for $^{222}$Rn metrology

The experimental systems available for radon metrology were complemented by a new device for production of air atmospheres with negligible radon concentration, needed to determine the instrument reading corresponding to a zero signal. This new device will make it possible to perform linearity tests for a large variety of active radon monitors used, in particular, for low-level measurements.

Participation in National and International Organizations

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Participation in working groups and collaboration with metrological and standardisation organisations were guaranteed: BIPM, INRIM, ICRM, IAEA, EA, EURAMET, ISO, IEC, UNI, ACCREDIA, UKAS. P. De Felice continued in his office as ICRM President.

7.3.2 Standardisation and quality assurance in ionising radiation measurement

Participation in EMRP Research Projects

The ENEA-INMRI is actively involved in a number EMRP European Projects (3 years duration) as reported in Table 30. For project iMera-Plus JRP T2.J06, the ENEA-INMRI acted as Project coordinator.

<table>
<thead>
<tr>
<th>Call</th>
<th>Title</th>
<th>Value (k€)</th>
<th>EC contribution (k€)</th>
<th>Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td></td>
<td>3144</td>
<td>1272</td>
<td></td>
</tr>
</tbody>
</table>

Table 30 ENEA-INMRI’s participation in EMRP projects

Various scientific collaborations were also started with a number of national partners (hospitals, nuclear new-built developers, environmental laboratories) to involve them in metrological research taking advantage of their expertise in relevant applications and maximising the project impact to the external end-users.

Characterization of a CVD-diamond-detectors

Research activity related to radiotherapy dosimetry was carried out in the framework of the iMera-Plus JRP T2.J07 "External beam cancer therapy". In particular, a CVD diamond detector prototype fabricated at the laboratories of Rome University "Tor Vergata" was tested for use as transfer standard dosimeter in radiotherapy photon beams. Measurements were performed in $^{60}$Co and in
6 MV and 10 MV photon beams available at S. Filippo Neri hospital in Rome. The detectors showed fast dynamic response, linear response with dose and dose rate, signal repeatability of 0.03% (k = 1) and signal long term reproducibility (months) better than 0.5% (k = 1). The energy and field size dependence of the detector response in radiotherapy photon beams was determined by Monte Carlo simulations. These results allow the use of diamond detectors for traceable absorbed dose to water measurements in photon beams, beyond the use as dosimeter for relative measurements.

Calculations of stopping power ratios in radiotherapy photon beams
Photon beams produced by a Clinac DHX Varian accelerator (S. Filippo Neri hospital) were simulated, using BEAMnrc Monte Carlo code, for various field sizes and followed by EGSnrc/SPRZnrc calculation of water–air stopping power ratios. The characteristics of the useful 6 MV and 10 MV photon beams were obtained by simulation taking into account information provided by the manufacturer (shape, dimension and materials) for various accelerator components. A maximum variation of -0.4% was found between stopping power ratios for reference (10 cm x 10 cm) and smallest (1cm x 1 cm) field size.

New beam quality specifiers
Studies of new beam quality specifiers and reference conditions, suitable for absorbed dose to water measurements in photon beams with small field size, were performed. Thanks to these new beam parameters it will be possible to improve the characterisation of photon beams and reduce the uncertainty of the absorbed dose to patients in radiotherapy with small fields such as Intensity Modulated Radiotherapy (IMRT), helical Tomotherapy and Cyberknife radiosurgery.

Dosimetry for high-dose-per-pulse electron beams
A new calibration service was established to allow in-situ calibration of intraoperative radiotherapy (IORT) beams. Specific dosimetric parameters for IORT accelerators were determined by electron beams Monte Carlo simulation. The new calibration service is based on ferrous sulphate reference dosimeters produced at ENEA-INMRI and it will allow accurate determination (u_c=1.6%) of absorbed dose in IORT accelerator beams overcoming the problem of accurate determination of recombination correction factor when using ionization chambers.

Development of a direct traceability chain for LDR and HDR BT sources in terms of absorbed dose
Portable well-type ionisation chambers were calibrated with uncertainty lower than 2.5%, using the new developed brachytherapy primary standards. The chambers will be used as transfer standards for calibration of LDR (125I) or HDR (192Ir) sources for BT treatment at hospitals. This new service was tested and found very effective in a collaboration with the Sant'Andrea hospital in Rome.

Development of a transfer standard for short-lived radionuclides
A new portable well-type ionisation chamber was calibrated with uncertainty lower than 2% by the ENEA-INMRI, using the new developed 64Cu primary standard. The new chamber can be used as a transfer standard and carried to hospitals or to 64Cu production centres for calibration of the local instrumentation.

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Comparison on coincidence-summing corrections in gamma-ray spectrometry

The ENEA-INMRI participated in the comparison on coincidence-summing corrections organized by the Gamma-Spectrometry Working Group of the International Committee for Radionuclide Metrology (ICRM). The comparison was performed in two phases, considering point-and volume-sources respectively. The ENEA-INMRI applied six different correction methods, ranging from semi-empirical simplified procedures, use of different dedicated computer codes or full Monte Carlo simulations.

Cooperation with the International Atomic Energy Agency (IAEA)

Collaboration with the International Atomic Energy Agency (IAEA) was established in the frame of the Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) Quality Assurance programme. In particular, the cooperation regarded development of new Reference Materials for measurements of air born radioactivity (simulated air filters) and soil from oil field (IAEA Reference Material #448).

Quality Assurance programme for the national radioactivity surveillance network

The scientific collaboration with the Institute for Environmental Protection and Research (ISPRA) continued in the field of the QA programme for the national environmental radioactivity surveillance network.

7.3.3 Calibration and accreditation activities

Collaboration with ACCREDIA

Technical support for accreditation of calibration laboratories was continuously provided to ACCREDIA (Italian Accreditation Body) on the base of a formal agreement between ENEA-INMRI and ACCREDIA.

To this regard, the following tasks are envisaged:

- participate in the “Comitato Settoriale di Accreditamento, Dipartimento Laboratori di Taratura”;
- provide office of Technical Secretariat of Ionising Radiation Sector of the “Dipartimento per Accreditamento dei Laboratori di Taratura”;
- provide assessors for ionising radiation calibration laboratories evaluations;
- organize comparison with ionising radiation calibration laboratories.

In this frame nine bilateral comparisons, a new assessment and three full reassessments of ionising radiation accredited calibration laboratories were carried out in 2010-2011.

Calibration service for therapy and radiation protection level dosimetry

Calibrations of protection-level and diagnostic dosimeters, traceable to the air kerma standards for low/medium x rays and $^{60}$Co gamma rays, were carried out for national end-users. Calibrations of therapy-level, and industrial-level dosimeters, traceable to the absorbed-dose-to-water ($D_w$) standard presently operating at the $^{60}$Co gamma ray quality were made mainly for hospitals. Calibrations in terms of $D_w$ at low and medium energy x rays were also provided, with traceability to the air-kerma standards.

Calibration service for radionuclide and neutron metrology
Standard sources of different radionuclides, prepared in different geometries (point-like, Marinelli beakers, filters, etc.) and calibrated with uncertainties 2-3% (k=1), were supplied to national end-users for calibration purposes.

Contamination monitors were calibrated according to ISO standards at mainly $^{241}$Am, $^{90}$Sr and $^{14}$C reference radiations.

Extensive calibration of short-lived radionuclides measuring systems (radionuclide calibrators), radon monitors and neutron measuring instruments was provided to fulfil the growing request from Nuclear Medicine Departments, Environmental laboratories and Radiation protection services in the Country.

7.3.4 Teaching, reporting and internal organisation

Teaching activities

Many teaching activities were carried out by different staff members in high education courses (Italian Universities, Research Laboratories, Regional Agencies for Environmental Protection) on ionising radiation measurement for medical and environmental applications.

Publication

During 2010-2011 a number of about 50 publications were issued including peer-reviewed articles in journals, conference proceedings and technical reports.

Implementation of the quality system

A new Quality Manager was appointed in 2011 in replacement of retired staff member. The ENEA-INMRI Quality System is presently self-declared. A QS peer review was agreed, within the TC-Q committee EURAMET Project 1123, to be performed in the second half of 2012.

Staff

The ENEA-INMRI staff in 2011 includes 14 scientists, 7 technicians and 1 administrative secretary for a total of 22 permanent positions. Students, fellows, guests from different national and international Institutes collaborate with ENEA-INMRI under various mobility schemes.
7.4 Chemistry at INRIM

7.4.1 Reason for a deeper analysis of Chemistry

Last year’s report contained some critical remarks to the way Metrology in Chemistry is conducted at INRIM. These remarks caused Ms Michela Sega to write a letter to the president of INRIM, professor Carpinteri, where complains about the seemingly unfair evaluation of the chemical activities, and point out an error in assigning herself to the wrong group. This is particularly relevant, since her chairmanship of the EURAMET-TCQM in the report was taken as given credit to the bio-analysis group instead of the chemical groups, where she rightfully belongs.

The most important statements from the 2010 report are the following:

“The particular case of chemistry requires special attention as already mentioned in previous reports. The activity is quite limited, but extends over four different fields: Gases, electrolytic conductivity, metals and alloys, and bio-analysis.

Combined with the fact that there have been no new CMCs during the last three years, it is therefore difficult to see how chemical metrology in general will reach a satisfactory level at INRIM. The exception is bio-analysis, where a group of about 12 people has been established and seem to have reached a sustainable situation, both from the point of view of both science and standards.”

And:

“Also in EURAMET, INRIM has maintained the high activity of previous years in the committee structure. It now chairs the Technical Committee for Metrology in Chemistry with a staff member from the biotechnology group; this supports the statement above that this group seem to have the greatest potential in the chemical area of INRIM.”

It may further be relevant to show the following figure from the 2010 report, where the number of chemical measurement capabilities are categorised as “general”, “ionising radiation” and “chemistry” for a number of countries, since it exposes Italy as being anomalous with a very modest chemical activity.
Ms. Sega also points out that her TC-chairmanship started in June 2010 and should therefore not be mentioned in the evaluation report for 2010.

The evaluation committee would like to thank Ms Sega for her critical remarks and specifically apologise for the wrong assignment given to her. It will to the outmost to repeat such errors in the future; and since from 2011 the INRIM reporting is much more specific about the personal assignments than previously, this should indeed be possible.

The evaluation committee also admits that the time span of previous evaluation reports is not stringently related to the calendar year. It is therefore recommended that this deficiency be remedied from this year’s report.

Regarding the fairness of the report on chemical activities at INRIM, and in particular the Promotion of the bio analysis group as being the most successful of INRIM’s chemical activities, the opinion of the evaluations committee has not changed. In this respect it should be noted that the chairmanship was said to support the view; but the view was not dependant on it.

Finally, the evaluation committee would like to add that its criticism it not against any of the individual scientist that are involved in chemical metrology at INRIM. It is a systemic criticism, noting that:

- Chemical metrology in Italy is small compared to similar countries
- Chemical metrology at INRIM covers four metrology categories (gases, electrochemistry, inorganic, bio-analysis; they are distributed over four programs (E2, E6, T5, T6) and two divisions (E,T).
- That chemical metrology appears sub-critical and in consequence not satisfactory.

Whereas the conclusions of the evaluation committee do not change as a result of Ms Sega’s letter, the committee finds it justified to make a full evaluation of Chemical metrology at INRIM based on the criteria that have been applied to the four divisions.

### 7.4.2 Science

An attempt to analyse the scientific activity within chemical metrology is stalled by the lack of designation of chemistry to the scientific work described in Chapter 3. As the scientific products are not tagged according to the divisional structure of INRIM, it is not possible to give a unique “chemical” tag to them. One exception is the fact that 5% of the “scientific products” that INRIM has declared to the ANVUR have been sent to the Chemical, Medical and Economic panel.

However, the impression is that the chemical topics that INRIM has chosen is in general founded upon sound scientific knowledge and discussed both in the relevant literature and at conferences. But the impact of chemical metrology, both within INRIM and in the broader scientific community suffers from its fragmented organisation.

Because of these difficulties in identifying chemical metrology in the scientific work at INRIM, it is difficult to conclude about its quality. However, the impression from Chapter 3 is that the scientific quality within the chemical area corresponds to the average for INRIM.

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7.4.1 Standards

When it comes to maintenance of measurement standards within chemical metrology, the KCDB provides a clear structure which compensates for the entangled organisation the field has at INRIM. Table 31 to Table 34 show the CMCs that are registered for Italy in KCDB appendix C under “Amount of Substance”. Separate tables are made for each of the four “service categories” of the KCDB, where Italy is active. The data from KCDB Appendix C have been supplemented with the relevant INRIM work program and with the supporting comparisons from Appendix B. In some cases, comparisons have been performed, without specific relation to a CMC, registered in appendix C.

Further to the registration of CMCs, INRIM takes active part in the relevant chemical metrology committees, both in EURAMET and CIPM.
<table>
<thead>
<tr>
<th>Service identifier</th>
<th>Subcategory</th>
<th>Matrix</th>
<th>Measurand</th>
<th>From</th>
<th>To</th>
<th>Unit</th>
<th>INRIM program</th>
<th>Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/08/01</td>
<td>Environmental</td>
<td>N₂</td>
<td>CO₂</td>
<td>100</td>
<td>1000</td>
<td>µmol/mol</td>
<td>T6</td>
<td>CCQM- K74(^1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Amount of substance fraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EUROMET.QM- K3(^2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EUROMET.QM- S1(^3)</td>
</tr>
<tr>
<td>M/08/01</td>
<td>Synthetic air</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T6</td>
<td>CCQM- K52(^4)</td>
</tr>
<tr>
<td>L/08/01</td>
<td>Purified air</td>
<td>O₃</td>
<td></td>
<td>0</td>
<td>1000</td>
<td>µmol/mol</td>
<td>T5</td>
<td>BIPM.QM- K1(^5)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T5</td>
<td>EUROMET.QM- S3(^6)</td>
</tr>
</tbody>
</table>

Table 31 Category 3: Gasses; INRIM: 3 CMCs

---

\(^1\) Nitrogen dioxide (NO\(_₂\)) in Nitrogen (N\(_₂\)) 2009 - 2010
\(^2\) Automotive emission gases 2000
\(^3\) Comparison of multi-component vehicle emission standards 2005
\(^4\) Carbon dioxide (CO\(_₂\)) in Air 2006
\(^5\) Ozone at ambient level 2007
\(^6\) VOCs in air 2007 - 2008
<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Matrix</th>
<th>Quantity</th>
<th>From</th>
<th>To</th>
<th>Unit</th>
<th>INRIM program</th>
<th>Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric conductivity</td>
<td>aqueous</td>
<td>Electrical conductivity</td>
<td>0.005</td>
<td>0.01</td>
<td>S/m</td>
<td>E2</td>
<td>CCQM- K92¹</td>
</tr>
<tr>
<td>Electric conductivity</td>
<td>aqueous</td>
<td>Electrical conductivity</td>
<td>0.01</td>
<td>2</td>
<td>S/m</td>
<td>E2</td>
<td>CCQM- K36.b² CCQM- K92³ CCQM- K105⁴</td>
</tr>
</tbody>
</table>

Table 32 Category 7: Electrolytic conductivity; INRIM: 2 CMCs

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Matrix</th>
<th>Measurand</th>
<th>From</th>
<th>To</th>
<th>Unit</th>
<th>INRIM program</th>
<th>Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>aluminium alloy</td>
<td>Fe</td>
<td>500</td>
<td>10000</td>
<td>mg/kg</td>
<td>T6</td>
<td>CCQM- K42⁵</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cr</td>
<td>200</td>
<td>2000</td>
<td>mg/kg</td>
<td>T6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mn</td>
<td>100</td>
<td>2000</td>
<td>mg/kg</td>
<td>T6</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CCQM- K56⁶ CCQM- K89⁷</td>
</tr>
</tbody>
</table>

Table 33 Category 8: Metals and Metallic Alloys; INRIM: 3 CMCs

¹ Measurement of electrolytic conductivity 2005
² Measurement of electrolytic conductivity 2005
³ Measurement of electrolytic conductivity 2011
⁴ Conductivity of aqueous salt solution 2012
⁵ Key comparison in Amount of Substance, Inorganics
⁶ Trace elements (calcium, iron, zinc and copper) in whole fat soybean powder 2007
⁷ Trace and essential elements in Herba Ecliptae 2010 - 2011
<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Matrix</th>
<th>Measurand</th>
<th>From</th>
<th>To</th>
<th>Unit</th>
<th>INRIM program</th>
<th>Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tissue</td>
<td>Fish tissue</td>
<td>As</td>
<td>3</td>
<td>10</td>
<td>mg/kg</td>
<td>T6</td>
<td>CCQM- K31</td>
</tr>
</tbody>
</table>
| Tissue      | Fish tissue | Se        | 1    | 10  | mg/kg  | T6            | CCQM- K43\(^1\)  
|             |            |           |      |     |        |               | CCQM- K49\(^2\)  |
| Other       |            |           |      |     |        |               | CCQM- K102   |

Table 34 Category 10: biological fluids and materials; INRIM: 2 CMCs,

\(^1\) Arsenic in shellfish 2002 - 2003
\(^2\) Organo-mercury in salmon fish 2005
\(^3\) Toxic and essential elements in bovine liver 2006
7.4.2 Dissemination

Traditionally, the primary dissemination activity of an NMI is to perform traceable calibrations for clients; and the result of this activity for INRIM in 2011 is shown in Table 35. Here is seen that only three out of 10 CMCs are used in connection with measurement services at INRIM, and two service categories are does not seem to be used at all.

During the visit, the Evaluation Committee found that there is little motivation for INRIM staff to deliver measurement services that are demanded by clients and other end users. For instance in electrochemistry, INRIM provides only calibrations of instruments, whereas certification of reference solutions is much more popular. Except for ozone, a stumbling block for giving the clients their desired services was mentioned to be the fact that a separate standard, namely ISO Guide 34, is the basis for accreditation, instead of the usual ISO 17025.

For comparison, Danish Fundamental Metrology, DFM, has diversified its services to include both calibrations of instruments and verifications of reference solutions. In 2011 DFM issued some 150 certificates within electrolytic conductivity, compared to INRIM’s 10.

<table>
<thead>
<tr>
<th>Service category</th>
<th>Type</th>
<th>Certificates</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Gases</td>
<td>CO₂ in nitrogen and synthetic air</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Ozone in purified air</td>
<td>13</td>
</tr>
<tr>
<td>7 Electrolytic conductivity</td>
<td>Electrolytic conductivity</td>
<td>10</td>
</tr>
<tr>
<td>8 Metal and metal alloys</td>
<td>Fe, Cr and Mn in aluminium alloys</td>
<td>0</td>
</tr>
<tr>
<td>10 Biological fluids and materials</td>
<td>As, Se in meat or fish tissue</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 35 Certificates issued in connection with “chemical CMCs” in 2011

Alternative dissemination activities such as direct support to the accreditation process and collaboration with industry and support to laboratory accreditation are reported in connection with the maintenance of chemical activities at INRIM; and also appearances at national conferences may be seen as a way of dissemination. Indeed, from the analysis in Chapter 5 it is clear that chemistry does contribute to INRIMS’s dissemination of knowledge.

7.4.3 Economy and resources

It is not possible to separate in any detail the economy and resources that is related to chemical metrology at INRIM, because of its cross-divisional organisation. Therefore, only indirect estimates can be made, such as the following:

The maintenance of chemical measurement standards (or reference materials) gives rise to relatively little dissemination activity, compared with other metrology areas at INRIM; and more than half the standards do not appear to give traceability at all. For total INRIM about 500 CMCs give rise to some 1600 measurement certificates, i.e. 3.2 certificates per CMC. The corresponding number for chemistry is 2.3 certificates per CMC.

Moreover, chemical CMCs at INRIM require significantly more support from comparisons from key and supplementary comparisons. The factor CMC per
comparison, which has the overall value of 2.2 for INRIM, is 0.6 for the chemical area. This subject was discussed in detail in the report for 2010.

7.4.4 Conclusions

The above analysis, which treats chemical metrology as a virtual division in INRIM, indicates that this field is characterised by the following:

- It consists of a number of small activities, which each in their own right have a reasonable technical level and scientific background.
- The visible dissemination of knowledge related to each activity is very limited.
- The activities do not have a balance between the costs of their maintenance and their usefulness (in terms of commercial activity or other benefits to society) that one would expect at National Metrology Institute.
- In combination, the activities appear un-coordinated and fragile.