Evaluation of Istituto Nazionale di Ricerca Metrologica 2009

16 December 2010
Ref 9441 KC
Report no. DFM-2010-R06

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Content

1 Executive summary

This report of the Scientific Evaluation Committee of INRIM for the year 2009 is the fourth report since 2006, following the legislation for the new institution INRIM of 2004. INRIM is a merger of the former two metrology institutes of Italy, IEN and IMGC. In practice, IT started activities in 2006 on a somewhat preliminary basis, and 2007 was the first year of "normal" operation. Since 2008, the operation has been stable, and it is therefore timely to summarize the status and development in connection with the 2009 report.

In summary, the INRIM with a total staff of some 200 people has successfully followed the footsteps of its predecessors IEN and IMGC and continues to be one of Europe's leading metrology institutes, with a strong focus on science. As the core national metrology institute of Italy, INRIM serves as an almost complete institute, where only ionising radiation metrology is dealt with outside INRIM, namely by the now so-called designated institute ENEA-INMRI. INRIM has also adopted tasks in the new mission, which were neither part of IEN's nor IMGC's missions; for instance a more active role in innovation and technology transfer.

INRIM's technical activity is organised in four division of the "department". These are Electromagnetism, Mechanics, Optics, and Thermodynamics. The electromagnetism division is more than twice the size of the three other divisions. The divisions carry the combined heritage of the former institutes; and the broader scope of INRIM than of IEN and IMGC has allowed it to engage in new fields of metrology, such as nanometrology and chemistry. The management team of the department consists of the Director and four Division Heads, and it new reflects the combined new institute, with the historic separation between IEN and IMGC gradually washing out.

INRIM's scientific work continues the strong positions of its predecessors. the profile varies from division to division, with Electromagnetism and Optics being the most active in research. The Committee has analysed the scientific production in detail. It finds the quality of the scientific research, as mentioned by the so called impact factor is considered satisfactory, since it is very close to the impact factor of 1.8 for the scientific metrology journal *Metrologia.* Since 2007, the Committee has discussed *Highlights, New Ideas* and *Relevant Investments*, in order to make the choice of scientific projects more focussed and help INRIM improving its scientific performance. After three years there are signs that this is fruitful. But apart from this observation, the overall scientific production and its quality has been stable, without any clear trends.

INRIM's work as a national metrology institute has been relatively little influence by the merger between IEN and IMGC. But INRIM has played an active role in the changes that has taken place since the worldwide mutual recognition arrangement was agreed in 1999. For instance INRIM was leading the technical committee dealing with the acceptance of quality systems, which was introduced as a requirement in the arrangement. In 2006, the regional metrology organisation for Europe was transformed into the legal entity EURAMET, to cope with the challenges of the European Metrology Research Program, which was launched in its final form; and INRIM was active during the whole process. However, although there has been some developments in the portfolio of metrology services that INRIM offers, e.g. the adoption of a limited chemical cali-

bration capabilities, the Committee has suggested some means, whereby this development can be accelerated.

One of the new tasks, which required more attention at INRIM than previously, was *dissemination of knowledge;* and in the opinion of the Committee, INRIM has not reached its full potential regarding this important activity.

INRIM has a number of activities that may be considered to belong to dissemination of knowledge. It ranges from calibration services, teaching, and assistance in the accreditation of laboratories to an obligation to deal with the historic aspects of metrology. However activities, which directly promote innovation such as patents and spin off companies appear less systematic that one could wish. The Committee has analysed the numerous dissemination activities in detail and has suggested that INRIM develops a strategy for the subject, and that it seeks outside help with the competences, necessary for success, that it does not possess.

With the new status of INRIM, the need for a transparent and precise economic management system is eminent. Only, when the economy is in control, and adequate economic analysis is available for the management, can proper decisions be taken in accordance with a set strategy. Neither the economic accounting system of IEN or IMGC was amenable to this kind of analysis, and since INRIM largely inherited the accounting system of IEN the Committee has spend quite some time to retrieved the relevant economic information and to feed it back into the INRIM's planning and budgeting. This has been an iterative procedure that has not quite found its final form; but significant progress has been made.

Returning now to the findings of the Committee for 2009, these may be summarised as follows:

Scientific performance:

Regarding the scientific activity for 2009, the Committee concludes: aspects:

- The quality and quantity of the scientific production is on average good for all divisions;
- The monitoring of the highlights during the last three years is satisfactory at Department level, but shows some weakness at division level;
- The number of PhD students is quite high: the Committee strongly suggests to the management to continue to support PhD students
- the start of the Nano fabrication facility and biological projects will strongly improve the research and metrological infrastructure of INRIM.

The Committee has made five specific suggestions for the improvement of INRIM's scientific activities. They are given in section 3.3.1.

The following specific actions are suggested by the evaluation Committee to improve the scientific performance and its documentation:

NMI performance:

The NMI work at INRIM appears very stable but not stagnant. There is a satisfactory dynamics within the constant overall budget.

In 2009, INRIM continued to fulfil its role as a National Metrology Institute in a way that is fully compatible with its size and the size of Italy. It is very well linked into the international network of the Meter Convention and the European regional metrology organisation EURAMET.

Work has been going on to work along the recommendation stated in the 2008 report, namely to ensure that the four divisions estimate their allocations of resources in a uniform way.

Hence the NMI work of INRIM is on a very solid ground.

Knowledge dissemination:

The activities of knowledge diffusion to 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 and with the community and the scientific academy.

As regards the knowledge dissemination to the companies, the critical aspects underlined in the previous evaluation reports are confirmed in 2009.

The Committee lists four specific challenges for INRIM's knowledge dissemination. They are listed in section 5.3.

Economic analysis

The same conclusions as in 2008 report can be iterated: overall economic analysis and benchmark 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. Management should make any effort to keep the present rank, and that has been done in 2009, as for keeping investments at the same level of 2008: one must recall 2008 income was biased by special funding.

Thematic report on benchmarking.

This year, the Committee has discussed a umber of thematic issues that has prevailed for the duration of its lifetime. This year, section 7.1 discusses the general problem of benchmarking; and it uses the Citation Impact and the KCDB for stringent comparisons between INRIM and seven other metrology institutes. It is concluded that such benchmarking may be useful for improving INRIM's strategic planning.

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 fourth evaluation of the Istituto Nazionale di Ricerca Metrologica, INRIM, for the year 2009. The report is based on the documents "Relazione consuntiva 2009" and "Risultati e Dati 2009", as well an on-site visit during 13-14 May 2010. Here oral presentations from the four divisions of INRIM as well as a visit to the laboratories of the Electromagnetic Division were given. The evaluation reports for 2006, 2007, and 2008, as well as the progress during 2009 were discussed with senior officials of the institute (Department Director, Division Heads). Owing to other pressing obligations, the President was not present during the visit; but his written remarks were available and taking into consideration.

The reporting for 2009 by the institute has been further adapted in accordance with last years discussions, easing the work of the Committee, and - hopefully – resulting into an improved usefulness of the report. During the visit it was announced that the statutes of INRIM are under consideration; and this process is foreseen to be completed by the end of 2010. this year, the Committee has decided to keep to the same structure of the report as previous years. The executive summaries of these reports are given in annexes 8.2 - 8.5.

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

- Scientific performance, Chapter 3,
- Performance as National Metrology Institute, Chapter 4, and
- Dissemination of knowledge, Chapter 5.

The economy of INRIM is analysed is analysed in Chapter 6 in a similar way to last year. Although it might be desirable to go into more detail and for instance the economy at the level of individual divisions and specific programs and projects, this is not attempted. This is because the accounting system of INRIM does not generate numbers in sufficient detail to do such analysis; and it is associated with a very time-consuming effort, to generate the data with sufficient reliability.

For the first time, Chapters 3 to 6 include a trends analysis for the period 2006 –2009.

As previously, the 2008 report has been discussed and approved by the Board of Directors of INRIM. Further, the President Professor Bava has submitted a communication to the committee chairman, in which he addresses and reflects upon the recommendations of the previous evaluation reports. In order to follow up on this fruitful dialogue, the committee has discussed to make some selected "thematic reports". The following five themes were discussed:

1. Technology transfer.
   What could INRIM do more to transform scientific successes into industrial innovation?

2. Highlights How to develop success criteria for Science, NMI work, Dissemination, and Economy

3. Benchmarking Which indicators should be used for the benchmarking against which institutes

4. Mission, strategy, and priorities Formulating mission, making strategies and setting priorities

5. Appraisal systems Which indicators should be used

However, only theme 3 is included in this year's report, in section 7

It is the intention of the Evaluation Committee to present reflections and ideas that will make it easier for INRIM's Board of Directors to address the challenges in a thematic way. A fifth theme relating to appraisal at the department, division, and personal level taking all three facets of work into account is planned for the coming year.

Like previously, the evaluation focuses on the activities of INRIM's Department and its four divisions: Electromagnetism, Mechanics, Optics, and Thermodynamics. The accreditation of calibration laboratories, which has a special position at INRIM is assessed as part of knowledge dissemination. The Administration, which was addressed in the 2006 report is given no further analysis; but the stated challenges for the administration are still considered relevant.

In order to get a complete picture of the whole Italian metrology organisation the Committee invited presentations from the Italian Designated Institute for Ionising Radiation ENEA-INMRI. Although is it is certainly useful to get such a holistic view of the metrology organisation, it is outside the scope of this report to report on the activities of ENEA-INMRI in general; but in section 4, data for ENEA-INMRIare included[1]

Benchmarking is used when appropriate and possible, and often the German and Danish Metrology Institutes, Physikalish-Technische Bundesanstalt (PTB) and Danish Fundamental Metrology (DFM) respectively, have been used. In section 7.1 a number of National metrology institutes are proposed as relevant benchmark candidates, with the aim of reaching a better benchmark reference for the evaluation of INRIM.

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 and interesting discussions.

[1] Note that ENEA-INRIM has the same status as INRIM as a National Primary Institute, recognized by Italian law. However, due to the rules of the CIPM-MRA ENEA-INMRI is listed in the KCDB Appendix A as a designated institute.

3 Scientific performance.

The scientific performance of INRIM shows, from a general and qualitative point of view, similar aspects to that of the previous year. In the present report we have evaluated not only the "research products", which are documented essentially by the publications, but also the overall research activity, in terms of projects and realizations of scientific relevance.

3.1 Research Products

Table 1 reports the key numbers of the scientific research products for the Department and for the four Divisions; Table 2 shows the INRIM human resources employed in Scientific Research activities.

Table 1 Breakdown of scientific production in 2009

Product	E	M	O	T	Depart.	TOT
Books	3	0	0	2	0	**5**
Paper on ISI Journal (IF ≥ 1.6)	73	28	31	16	0	**148**
Other papers and chapters in Books	11	2	2	12	1	**28**
Papers in Conference Proceedings	34	31	31	35	1	**132**
Technical Reports	23	30	18	12	5	**88**
Communications at International Conferences	59	26	32	16	1	**134**
Communications at National Conferences	21	10	12	1	0	**44**
Total	**224**	**127**	**126**	**94**	**8**	**579**

Table 2 Equivalent Human Resources[1]

Division	E	M	O	T	Department Total
R&S INRIM	42,6	9,5	14,8	19,9	**86,8**
R&S Contract	13,4	11,8	12,9	7,1	**45,2**
Total	**56,0**	**21,3**	**27,7**	**27,0**	**132,0**

On the basis of these key numbers, as already done in the previous evaluation reports, we calculated the following indicators to evaluate the scientific activity of the Department as a whole and of the single divisions.

Indicator a_1 "Numerousness of the global production", defined as the number of products per FTE;

[1] From Chart n. of "Result and Resources"

Indicator a_2 "Numerousness of the scientific production", defined as the number of publication in journals, conference proceedings or books with or without IF per FTE, i.e. the Technical reports as well as the Communications at conferences are not considered.

Indicator b_1 "Mean quality of the scientific production" defined as the mean value of the IF;

Indicator b_2 "Numerousness of the scientific production at International level" defined as the number of publications in international journals with IF per FTE;

Indicator c "Presence at international level" defined as the number of papers on Conference Proceedings and communications at international conferences, seminars and meetings per FTE. 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.

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

Indicator / Division	E	M	O	T	Mean Value
a_1: "Numerousness of the global production"	4,0	6,0	4,6	3,5	4,5
a_2: "Numerousness of the scientific production"	2,2	2,9	2,3	2,4	2,5
b_1: "Mean quality of the scientific production"	1,6	1,6	1,9	1,5	1,7
b_2: "Numerousness of the scientific production at International level"	1,3	1,3	1,1	0,6	1,1

On the basis of this table, we underline some aspects that we consider particularly relevant for the INRIM evaluation, also comparing the 2009 values with those of the previous years.

Indicators a_1 *and* a_2*: "Numerousness of the global and of the scientific production"*:

Table 4

Indicator / Division	E	M	O	T	Mean Value
a_1: Global production 2009	4,0	6,0	4,6	3,5	4,5
a_1: Global production 2008	3,5	5,3	4,4	4,3	4,4
a_1: Global production 2007	3,5	4,5	6,9	4,1	4,8
a_2: Scientific production 2009	2,2	2,9	2,3	2,4	2,5
a_2: Scientific production 2008	2,0	1,7	2,0	2,9	2,2
a_2: Scientific production 2007	2,0	2,3	3,1	2,4	2,5

The mean values of the Global and of the Scientific products/year/adept (indicators a_1 and a_2) are similar in the three years here considered, the small variations being physiological in research; they confirm that the Institute has been quite active in many different scientific fields, without substantial variations during the three years.

Quality of the scientific production

Table 5

Indicator / Division	E	M	O	T	Mean Value
b_1: Mean quality of the scientific production 2009	1,6	1,6	1,9	1,5	1,6
b_1: Mean quality of the scientific production 2008	1,4	1,8	3,3	1,7	2,1
b_1: Mean quality of the scientific production 2007	1,4	1,3	1,8	1,5	1,5

As already noted in the previous reports many metrology journals of quality have IF around or slightly larger than 1.5; therefore a good average scientific production of a metrological Institute as INRIM is should have such IF. We note that for 2009 all the divisions are at or above this quality level. Moreover the level has been rather stable in the three years here considered; in fact the rather high value for Optical Division in 2008 was due to an exceptional publication in Science.

As already stated in the 2008 Evaluation Report, the Committee believes that the mean value of the IF of the publications is not enough to properly judge the quality and the interest of the scientific products, but at least also the Citation Index, should be considered. In order to make this feasible for the whole scientific production, the Committee needs to have the publication list of the last three years (2007-2009) reporting also the numbers of citations of each paper.

Numerousness of the scientific production at International level:

Table 6

Indicator / Division	E	M	O	T	Mean Value
b_2: Scientific production 2009	1,3	1,3	1,1	0,59	1,07
b_2: Scientific production 2008	1,2	0,56	0,86	0,89	0,88
b_2: Scientific production 2007	1,2	0,60	1,3	0,80	0,98

The mean value of the indicator b_2 for 2009 is higher than those of the previous years and shows that the number of outcomes of the INRIM scientific activity of good quality at International level is quantitatively increasing. The Committee hopes that such a higher value will be confirmed in the next years.

At the Division level, the Committee much appreciates the good performance of Mechanics that doubles the number of products at the International level; the Committee will monitor in the next years the decrease of the scientific production of the Thermodynamics division.

Presence at international level [1]

Table 7

Indicator / Division	E	M	O	T	Mean Value
c: "Presence at international level" 2009	1,1	1,5	1,2	1,3	1,2
c: "Presence at international level" 2008	1,1	1,9	1,7	1,1	1,4
c: "Presence at international level" 2007	1,1	1,4	2,4	1,5	1,5

The indicator c is extremely important for an Institute that, for its main mission, must take part in significant international activities. This figure, in average slightly smaller than that of previous years, is anyway judged adequate at Department and at Division level; the Committee strongly recommend that the presence at International Conferences, meetings and Organisms will be maintained also for the next years at these levels, even if the foreseen financial difficulties will be confirmed.

3.1.1 R&D Highlights

Table 8 List of the R&D 2009 "highlights"

Division	Product	Reference	IF	CI
E	Local thermal bistability in MgB2 microwave coplanar resonators: opposite jumpwise response to weak-link switching and to vortex avalanches	Applied Physics Letters **94**, 52505 (2009)	3.726	0
E	Experimental and numerical characterization of an electrode matrix cell for electrochemical measurements	Sensors and Actuators **B 138**, 326 (2009)	3.12	0
E	Non linear Magnetization dynamics in nanosystems	Elsevier Publisher, Oxford 2009	--	--
M	Observation of a bent crystal lattice by X-ray interferometry	Optic Express **17**, 11172 (2009)	3.880	1
M	Compact imaging spectrometer combining Fourier transform spectroscopy with a Fabry-Perot interferometer	Optic Express **17**, 8319 (2009)	3.880	0
O	Measurements of sub-shot-noise spatial correlations without background subtraction	Physical Review Letters **102**, 213602 (2009)	7.180	6
O	Chirped biphotons and their compression in optical fibres	Physical Review Letters **103**, 193602 (2009)	7.180	1
T	Thermodynamic properties of acetone calculated from accurate experimental speed of sound measurements at low temperature and high pressure	Journal of Chemical Thermodynamics **41**, 506 (2009)	1.876	0

In Table 9 we report for these highlights, both at Division level and at INRIM level, some numbers useful to analyse them, namely the number of the high-

[1] The values of indicator c for 2007 and 2008 have been recalculated using the same criteria used for 2009.

lights both as a total and normalized to the number of programmes and to the number of adepts, the mean impact factor and the mean citation index.

Table 9 Statistical analysis of the R&D "highlights"

Highlights	E	M	O	T	INRIM
Number	3	2	2	1	8
Number/Programme	0,37	0,40	0,50	0,25	0,36
Number/Adept	0,054	0,094	0,072	0,037	0,061
Mean IF	3,42	3,88	7,18	1,88	3,85
Mean CI	0	0,50	3,50	0	1

First the Committee notices that there are no common selection criteria for the highlights among Divisions; this makes it difficult to judge the highlights in a proper way and to compare them with those of the previous years. The Committee suggests for the future to use one of the following criteria: present a number of highlights equal to a fixed fraction (10% for instance) of the number of adepts of the Division; consider as highlights the publications that have an Impact Factor higher than the mean value of the Division plus 2σ; define for each Division a threshold for the Impact Factor above which publications are considered as highlights. The Committee noted also that all the Divisions, apart Optics, published papers with Impact factor comparable and even higher than those presented as highlights and would like to understand the reason why these papers were not considered as highlights.

For the present evaluation report the Committee underlines that the mean Impact Factor of these highlights (3.85) is similar to that of 2008 and is significantly higher than the mean IF of the overall scientific production (1.6); this is true both for the Department and for all Divisions apart Thermodynamics whose highlight IF is only slightly higher than the mean quality of the scientific production. The Committee underline that all the chosen highlights, which are surely among the best papers published in 2009 by INRIM, are of relevant quality at the International level. The mean number of citations is still small compared with the mean Impact Factor, but this may be due to the short time elapsed after the publication; therefore this aspect should be considered in the next evaluation report.

As for the number of highlights, the mean value is rather smaller than half the number of the programs: this is considered un-satisfactory; the same consideration holds also for the number of highlights per adept.

3.1.2 Evolution of the R&D 2008 Highlights

We note the increase in the mean value of the citations for all Divisions; it is rather small and not significant for Electromagnetic and Mechanics Divisions but really significant for Optics and Thermodynamics; all Division have at least one highlight with a CI significantly higher than the IF. In particular we underline that the paper "Frequency ratio of Al+ and Hg+ single ion optical clocks: metrology at the 17th decimal place" Science 319 (2008), 1808-1812 has a number of citations about 7 times the IF of the prestigious review Science.

In the next report the Committee will have at disposal a Citation Indices for a long enough period to make a proper statistical analysis and subsequent considerations.

Table 10 reports the 2008 R&D highlights presented in the 2008 report, with the upgraded number of citations; table 11 reports the upgraded mean values of the citation indices together with the mean Impact Factors.

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In the next report the Committee will have at disposal a Citation Indices for a long enough period to make a proper statistical analysis and subsequent considerations.

Table 10 List of the published 2008 "highlights"

Division & program	Product	Reference	IF	CI
E1	"Superconducting MgB_2 nanobridges and meanders obtained by an electron beam lithography based technique on different substrates"	Supercond. Sci. technol. 21 (2008), 034006	1,847	0
E3	"On coaxial microcalorimeter calibration"	Applied Optics 43 (2008), 239-244	0,822	2
E4	Dynamic modelling and experimental analysis of terfenol-d rods for magnetostrictive actuators	J. of Applied Physics 103, (2008) 07F121-3	2,201	1
E5	"Perturbing effects of the probe support on the calibration of electric field meters"	The European Physical Journal – Applied Physics 42, (2008) 345-350	0,822	1
E6	"Experimental observation of glassy dynamics driven by gas adsorption on porous silicon"	Journal of Physics – Condensed Matter 20, (2008) 385207 – 385211	1,9	0
E7	"A Peltier cell calorimeter for the direct measurement of the isothermal entropy change in magnetic materials"	Review of Scientific Instruments 79, (2008), 063907	1,738	4
E8	"Magnetization processes in sputtered FeSiB thin films"	Phys. Rev. B77, (2008) 2144041/11	3,322	4
M1	"Silicon lattice parameter measurement by centimeter X-ray interferometry"	Optics Express 16 (2008), 16877-16888	3,880	6
M5	Multiple reflection Michelson intereferometer with picometer resolution	Optics Express 16 (2008), 21558-21563	3,880	3
O1	Frequency ratio of Al^+ and Hg^+ single ion optical clocks: metrology at the 17^{th} decimal place	Science 319 (2008),1808-1812	28	190
O4	Experimental test of nonclassicality for a single particle	Optics Express 16 (2008), 11750-11758	3,880	7
T1	Primary gas thermometry by means of laser absorption spectroscopy: determination of the Boltzmann constant	Phys. Rev. Lett. 100 (2008) 2008001 – 4	7,13	10
T5	New melanic pigments in the human brain that accumulate in aging and block environmental toxic metals	Proc. Of the National Academy of Sciences 105 (2008) 17567-17572	10,22	7

Table 11 Mean value of the IF and CI for 2008 R&D Highlights (values in parenthesis are excluding the publication in Science)

Highlights	E	M	O	T	INRIM
Mean IF	1,81	3,88	15,94 (3,88)	8,68	5,04 (3,47)
Mean CI actual report	1,5	4,5	98 (7)	8,50	16,80 (3,21)
Mean CI 2008 report	1,29	3,50	65 (5)	2,50	14,10 (2,17)

3.1.3 Evolution of the 2007 R&D Highlights

The R&D highlights presented in 2007 were 8; 3 from Electromagnetic, 2 from Mechanics, 2 from Optics and 2 from Thermodynamics. For these highlights in table 12 we report the Impact Factors, the total number of citations obtained up to now and the number per year (we considered three years elapsed from the publication time to the time of preparation of the actual report).

Table 12 Statistical analysis of 2007 published "highlights"

2007 Highlights	IF	Total CI	CI / year
E1	2,37	1	0,33
E2	3,72	2	0,67
E3	3,72	6	2,00
M	2,36	20	6,67
O1	7,13	75	25,00
O2	3,71	3	1,00
T1	3,13	15	5,00
T2	7,13	12	4,00

Three papers, one of Mechanics, one of Optics and one of Thermodynamics, have a number of citations per year considerably higher than the impact factor: these papers have to be considered as real scientific highlights, because they caused a significant interest in the scientific community. For the Department as a whole, this performance is judged positively. At the Division level, the Committee notes that the Electromagnetic division did not produce in 2007 papers judged enough interesting by the scientific community. This kind of analysis will be repeated in the next evaluation reports, to monitor such results and to average fluctuations in the quality of the scientific production, that surely are present.

3.2 Analysis of the research activity

To evaluate the research activity we took into account, as already done for the 2008 evaluation, the overall framework in which the divisions were involved in 2009, both at the international and at the national level.

The activity of each division is organized in research "*programs*", which have changed very little with respect to previous years. Each program has its own staff of researchers, technologists and technicians and develops two principal types of research activities:

- "*institutional research projects*", strictly related to the INRIM metrological mission and carried on mainly with internal INRIM funds

- *"other research projects or contracts"* with national or international funding agencies.

Besides, a program may be responsible for reproducing certain units of measurement, maintaining the related standards, participating in the Mutual Recognition Arrangement (MRA) of the CIPM, etc., in order to comply with INRIM role as National Metrology Institute ("*NMI role*"): these activities will be discussed in detail in the next section.

The breakdown of the full time equivalent researchers and technologists (FTE) dedicated to the different types of activities is shown in Figure 9 and Table 36 (see appendix 8.6) for INRIM as a whole and for each division.

Relevant differences exist between divisions in the percentage of activity dedicated to the research compared with that dedicated to the "NMI role": more than ¾ of the activity of Electromagnetic and Optics divisions is dedicated to research, while the fraction is significantly smaller for the Thermodynamics division and for the Mechanics division. These numbers imply that a complete judgment of the activity of the Divisions, particularly for the Mechanics and Thermodynamics divisions, must consider also the activities related to the NMI role, which will be analysed in section 4.

We will now describe the relevant aspects of the research activity, as it emerges from the final 2009 activity report, divided, for clarity reasons, into a general subsection which summarizes the overall research activity of the "programs" and a specific subsection which contains a detailed description of "projects" and "contracts". With respect to the final 2008 activity report, in the final 2009 report the description of the activities is organized in a much clearer and more uniform way at the division level: for each program, are quoted the most relevant research results obtained in 2009, with a specific comment on their impact (a selection of them is given in the "highlights" described at the department level), as well as the status of each "project" carried on by the "program" (in particular, for the projects which are a continuation of 2008 activities, information is provided on the results obtained compared with the expectations). Together with the detailed information provided, for each type of project, in the "Results and data" report, this allows to obtain a complete view of the research activity and to appreciate the supporting scientific and financial effort.

3.2.1 Institutional INRIM research projects

Table 13: Metrological subfields and programs

Field	short	Sub-field	Progr.
DC & Q. metrology	J.E.	Josephson effect and DC voltage	E1
	QHE	Quantum Hall effect and DC resistance	E2
	SET	Single electron tunnelling	E6
	L.DC	Low DC current	E2
Low frequency	AC-V&C	AC/DC transfer, AC voltage and current, impedance	E2, E3
Radiofr. & Microw.	RF	RF power, scattering parameters, RF impedance	E3
Power and energy	AC-P&E	AC power and energy	E3, E5
	FIELD	Electric and magnetic fields (incl. high voltage/high current tests)	E4, E5
	MAG.	Magnetic measurements and properties	E7, E8
Mass & related quantities	MASS	Mass standards	M1
	AVOG	Avogadro Constant	M1
	DENS	Density and volume	M1, M3
	VISC	Viscosity	M3
	FLOW	Fluid flow	M3
	FORC	Force	M2
	PRES	Pressure (high and low)	M3
	GRAV	Gravimetry	M2
	HARD	Hardness	M2
	VIBR	Vibration	M2
Length	LENG	Basic length	M4
	DIM.M.	Dimensional metrology	M5
Time and Frequency	FR.ST	Frequency standards	O1
	TIME	Time scale	O2
Photometry & Radiometry	PHOT	Photometry and radiometry	O3, E1
	QO	Quantum optics	O4
Optical standards & diss.	TIME PHOT	Optical standard maintenance & dissemination	O5
Temperature	C-T.	Contact temperature meas.	T1, T2
	NC-T	Non-contact temperature meas.	T1, T2
Humidity	HUM	Humidity	T1, T2
Acoustics	PH AC	Physical acoustics	T3
	AC EN	Acoustic engineering	T4
Amount of substance	GAS	Gas	T5
	EL.CH	Electrochemistry	E2
	INOR	Inorganic	T5
	ORG	Organic	T5
	BIOAN	Bioanalysis	T5, E6

INRIM has defined its own "metrological sectors", which are close, but not coincident with the international sectors, and has structured them into sub-fields. The sub-fields and their association with the programs are shown in the following table (short titles are introduced for easier reference in the analysis): they provide the general frame for all the activities of the divisions, both for those

related to the "NMI role" that will be discussed in section 4, and for the research activities that we discuss in the present section.

Table 14: Research activity of the programs (two parts)

First part

Program	Metrol. subfields	Highlights of research on measurement standards and fundamental constants	Other research highlights	students	
				2nd level degree	Ph.D.
E1	J.E.	Arrays of Josephson junctions for the programmable voltage standard			2
E2	QHE, LDC, AC-V&C, El.CH	Farad from ohm derivation for the connection with physical constants	Primary cell for low electrolitical conductance measurements		3
E3	AC-V&C, RF, AC-P&E		Phase comparison device for high current derivators		1 (1t)
E4	FIELD		Algorithm for the determination of the e.m. radiation absorption rate		1,75 (1t)
E5	AC-P&E, FIELD		Resistance-capacitance partition device for high voltage measurements		2,25
E6	SET, BIOAN	Graphene single layer device for QHE measurements	NANOFAB lab implementation	2	3
E7	MAG.M		Antidot nanostructures	2	2 (2t)
E8	MAG.M		Magnetic tunnel transistor prototype		
M1	MASS, AVOG, DENS	Avogadro and molar Planck ($N_A h$) constant (lattice parameters of WASO04 crystals)			1
M2	FORCE, GRAV, HARD, VIBR		Software to reconstruct a mass distribution generated gravity field		
M3	DENS, VISC, FLOW, PRESS	Low pressure meas. Standard	Nanobalance project and realization for Thales-Alenia Space	1	1 (1t)
M4	LENG	Long range interferometer	Near IR thermal imaging spectrometer		1
M5	DIM.MET		Nano-angles generator for autocollimators calibration		
O1	FR.ST	Cryogenic primary frequency standard ITCsF2		1	2
O2	TIME	UTC – UTC(k) uncertainties	Evaluation of all *timing* aspects of the Galileo system	7	2

Second part

Pro-gram	Metrol. su-bfields	Highlights of research on meas-urement standards and fundamental constants	Other research highlights	students	
O3	PHOT	qu-Candela	Superconducting devices (TES) with <0,2 eV energy resolution	2	2
4	QO	qu-Candela	Sub-shot noise in quantum imaging with twin beams		5 (3t)
O5	TIME PHOT		Network Time Services syn-chronization system		
T1	CT, NCT, HUM	Kelvin definition, Boltzmann constant; Co-C eutectic for HT standard			3,3 (1t)
T2	CT, NCT, HUM	KC EURAMET T.K6 results of the dew/frost temperature scale from -50°C to +20°C			0,7
T3	ACOU.PH	Boltzmann constant	Liquid phase sound velocity device for thermodynamic properties determination		1
T4	ACOU.ENG		Power measurement of High Intensity Therapeutic Ultra-sound up to 500 W		3 (2t)
T5	GAS, INORG, ORG, BIOAN		Volatile Organica Compounds (VOC) reference generator	1	1

As explained above, the research activity is usually separated in "institutional" projects and "other" projects or contracts, although this separation is rather artificial, because also most of the "other" projects are closely related to the metrological fields and thus to the institutional INRIM research, in particular the participation to the joint research programs (JRP) in the IMERA-Plus plan, to the European Metrology Research Programme (EMRP), to the Italian PRIN, to the European Sixth FRP, etc. A view of the two types of research activity of each program is given in the following table, in which we use as indicators of the research vitality the "highlights" indicated at the department level in the final 2009 activity report, eventually integrated with the information given at the division level, and the numbers of 2nd level university degree students and of Ph.D. students (in parenthesis the number of theses discussed in 2009).

Although the separation between "institutional" and "other" projects is only indicative, the data indicate an average high level of research, with a rather uniform distribution among the programs. Some program appear to be involved only in activities non immediately related to the "institutional" mission of INRIM, as already noted in the 2008 evaluation report: this can be expected in a rather large metrological institute because of temporal fluctuations related to the national or international panorama or to the need to develop or maintain useful competences in such fields, but must be monitored in its time evolution.

3.2.2 "Other" projects and contracts

There is a large number and variety of research projects and contracts –more than 200!– ranging from national to international projects, involving small or large amounts of funding and personnel, based on fundamental or applicative subjects, etc. Some of them are clearly of interest for the metrological sectors of INRIM others are only loosely related. To obtain an overall view of the pro-

jects 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 approved projects
- other international projects;
- PRIN 2007 and 2008;
- national and regional projects, contracts or contributions
- "New ideas" and "Relevant investment" internal selection

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

These projects 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 is still continuing.

Table 15: iMERA plus projects

			Description	*E*	*M*	*O*	*T*	Funding (k€)
SI & Fundamental	T1.J1.1	e-MASS	The watt balance route towards a new definition of the kilogram		M2			54,0
	T1.J1.2	**NAH**	**Avogadro & molar Planck constants for the redefinition of the kg**		**M1**			192,6
	T1.J1.4	Boltzmann constant	Determination of the Boltzmann constant for the redefinition of the Kelvin				T3	181,1
	T1.J2.1	OCS	Optical clocks for a new definition of the second			O1		70,9
	T1.J2.3	**Qu-Candela**	**Candela: Towards quantum-based photon standards**			**O3**		105,3
Health	T2.J04	Regenmed	Metrology on a cellular scale for regenerative medicine				T5 T6	106,9
	T2.J07	EBCT	External Beam Cancer Therapy				T4	38,0
	T2.J10	TRACEBIOACTIVITY	Traceable measurements for biospecies and ion activity in clinical chemistry	E2 E4	M3		T5	95,9
Length	T3.J1.1	Nanoparticles	Traceable characterization of nanoparticles		M5			16,7
	T3.J1.4	**NANOTRACE**	**New Traceability Routes for Nanometrology**		**M5**			107,2
	T3.J2.2	NIM Tech	Metrology for New Industrial Measurement Technologies		M5			71,4
	T3.J3.1	Long distance	Absolute long distance measurements in air		M4			67,9
Electricity & Magnetism	T4.J01	Power&Energy	Next generation of power and energy measuring techniques	E3 E5				126,0
	T4.J02	**NanoSpin**	**Nanomagnetism and Spintronics**	**E8**				122,5
	T4.J03	JOSY	Next generation of quantum voltage systems for wide range applications	E1				54,5
	T4.J04	ULQHE	Enabling ultimate metrological QHE devices	E2 E6				58,5
	T4.J07	EMF and SAR	Traceable measurement of field strength and SAR for the Physical Agents Directive	E4 E5				63,9

EMRP - JRP approved Nov. 2009, with INRIM participation

These projects represent the second tranche of EMRP. INRIM participated to the preparation phase with the proposal of 5 Potential Research Topics, which were all included in the 16 Selected Research Topics, and to the call for proposals in the Joint Research Projects (JRP). In the following table are listed the JRP's approved in November 2009, with INRIM participation, with the expected funds which are given according to the "rank" assigned to the proposal.

Table 16 EMRP approved JRP's

Rank	JRP	*Description*	*E*	*M*	*O*	*T*	Expected funding (k€)
1	JRP07	Characterisation of energy gases				T2, T3	54,7
2	JRP03	Metrology for energy harvesting	E4, E2, E7				132,8
2	JRP10	Metrology for Liquefied Natural Gas (LNG)		M3		T3	73,3
2	JRP14	Metrology for smart electrical grids	E3, E5				118,0
5	JRP09	Metrology for solid-state lighting			O2	T2	139,8
7	JRP15	Metrology for high-voltage direct current (HVDC)	E3, E5				47,1
9	JRP01	Metrology for biofuels	E2	M3		T3	140,9
11	JRP04	Metrology for energy saving in electronic devices and electrical machines	E4, E2, E5, E7				
12	JRP06	Metrology for fuel cells				T2, T3	

Other international projects

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.

Table 17: Other international projects

Funding agency		*Description*	*E*	*M*	*O*	*T*	Expected funding (k€)
EC FP7	SSEEC	Solid State Energy Efficient Cooling	E8				233
Bilateral IT-JP		Wideband microwave absorption with magnetic nanopowder and nanostructured materials	E8				Missions
ESA		Next generation compact atomic clock			O1		188
ESA Thales Alenia Space		Giove Mission 2008 extension			O2		90
ESA Thales Alenia Space		Giove Mission			O2		555
ESA GMV (Madrid)	ADVENT	Advance integrity algorithms			O2		69
E.U. Helio UK		Galileo time service provider prototype			O2		154
ESA	ESNIS	Galileo System Test Bed V2			O2		395
ESA	CTT	Galileo Precise Timing Facility (PTF)			O2		255
ASP It-Russia		PDC sources from APP crystals			O4		15
NATO	QKD	Quantum Key Distribution			O4		20
Thales To		Spin rate sensor acquisition system and test		M4			20
EC FP7 - Alesamonti	SOMMACT	Self Optimising Measuring Machine Tools		M5			*537*

PRIN 2007 and 2008

Although not particularly important from the financial point of view, these projects are important because they show the presence of a good connection with the university fundamental research. Only the "2007 PRIN" projects are reported in the table, which were approved only at the end of 2008 and were fully activated in 2009. INRIM participates also in 4 approved projects of the PRIN 2008 selection, which were approved only at the end of 2009 and will thus start in 2010

Table 18: PRIN 2007 projects

coordination	*Description*	*E*	*M*	*O*	*T*	Funding (k€)
Polit.To	Time of flight telemetry		M4			22
Polit.To	Electromagnetic fields mitigation	E4-E5				62
Polit.To	Feasibility study of a Earth-Space quantum communication channel (CCQOTS)			O4		≈ 10
Polit.To & Perugia Univ.	Atomic clocks anomalies			O2		16

National and regional projects, contracts or contributions

These projects 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.

Many projects are a continuation of projects started in previous years; among those started in 2009, of particular interest, not only for the entity of financial support, are

- the NANOFAB facility, that was approved in 2008 but became operative only in 2009, which has significantly improved the potentialities of preparing nano and micro structures, not only for metrological applications, but in general for all the nano-researches in the region,
- the METREGEN and the other bio-metrology projects which underline the growing interest and needs of metrology applications in bioscience.

Table 19: National and regional projects (two parts)

		Table 19 Part I					
Funding agency		Description	Started in	E	M	O	T	Funding (k€)
R. Piemonte - PoliTo	NAMATECH	Nanomaterials and technologies for intelligent monitoring of safety, quality and traceability in confectionery products	2009	E7 E8				86
R. Piemonte - Fidia	MAGDAMP	Magnetostrictively actuated platform for milling induced vibration damping	2009	E4				223
R. Piemonte - Olivetti I-Jet	print TAG	InkJet printing technology for advanced electronics applications	2009	E8				82
Regione Lombardia	OMAL	Coaxial valve with pneumatic action and magnetic driving	2009	E4				91
NKT cables GmbH		Electroducts magnetic screening	2009	E4				14
Teseo spa		Reference for electric instruments calibration	2009	E2				14
EMIT		Energy absorption test of Pt thermoresistances	2009	E2				10
PoliTo		Benchmarking and technological scouting on magnetic materials for applications on the more electric engine	2009	E7				5
Regione Piemonte	STEPS	Systems and technologies for spatial exploration	2009		M5			80
SNAM rete gas		Performance improvement of the natural gas treatment system for the SIT lab	2009		M1			37
Thales Fi		Development of a propulsion system for SmallGeo satellites	2009		M3			30
RAI		Time signal diffusion	2009			O2		65
Autostrade per l'Italia		Lightning performance of LED based light systems	2009			O3		47
Thales To		Spin rate sensor acquisition system and test	2009			O2		20
Regione Piemonte	METREGEN CIPE 2004	Metrology at molecular and cellular level for regenerative medicine	2009				T5	1574
R. Piemonte - Sorin Cardio	ACTIVE	Staminal cells for heart regenerative therapy and medicine	2009				T5	178
Magneti Marelli		Acustic comfort of sport cars	2009				T4	25
Ansaldo Energia		Thermoconvector tube with pressure control	2009				T2	38
Centro reg. antidoping		Metrological advice for chemical and chemical-clinical tests	2009				T5	7

		Table 19 **Part II**						
Funding agency		Description	Started in	E	M	O	T	Funding (k€)
Compagnia S Paolo	NANOFAB	Laboratory for nano preparations	2008	E6 E8				1200
Regione Piemonte	TIPE	Transmission Infrastructure for Power Exch	2007	E4 E5				300
Regione Piemonte		Transistor based on magnetic tunnel effect	2007	E7				97
Ribes ricerche srl		Multiparameter agro-alimentary quality checking and measuring device	2008	E6				190
Abbot SpA Latina		Electrolitical conductance reference	2008	E2				10
CCT Italia srl, GE		Increasing the practice in magnetic shielding	2008	E4				10
Compagnia S Paolo		Atomic standard for mass unit	2008		M1			100
Thales Alenia Space		Satellite propulsion systems	2008		M3			170
Regione Piemonte	D64	Translation device with sub-nanometric resolution	2005		M1			219
Regione Piemonte	E2	Ultrastable optical frequency reference devices for spatial applications	2005		M4			137
ENEA		Transparent materials photometry	2008			O3		70
Compagnia S Paolo	*Hyper	Hyper-entangled states applications	2008			O4		100
Compagnia S Paolo	LINK	1 ps comparisons in optical fibers	2008			O1		400
Regione Piemonte	YTRO	Ytterbium Trap Reference Oscillator	2007			O1		840
Regione Piemonte	Superc…	Superc. device for single photon counting	2006			O3		130
Regione Piemonte	Quantum	Quantum communication	2005			O4		232
GE Sensing		Aluminum oxide capacitive sensors	2008				T2	18
Regione Piemonte	WISE-CELL CIPE 2006	Wide range sensors & instruments for fuel cells	2007				T3	100
Regione Piemonte	CIPE 2004	Quantum dots for optical imaging in biological systems	2006				T5	57

3.2.3 "New ideas" and "Relevant Investment" internal selections

In 2008 INRIM promoted two internal selections, namely "New Ideas" to foster the presentation of new research ideas, which cannot be easily included in the main lines of the institutional research, and "Relevant Investment" to develop or upgrade relevant instrumentation facilities. 70 different projects were presented, 46 for "New Idea" and 24 for "Relevant Investment"; all the projects were judged by external referees and the following projects were funded, for a total of about 1 M€

Table 20: "New Ideas" selection

funding agency	*Description*	*E*	*M*	*O*	*T*
INRIM	4-wave mixing in Cs vapour for non linear spectroscopy			O1 O4	
INRIM	Calibration of photon number resolving detectors through entanglement assisted tomography			O4	
INRIM	Thermo-acoustic methods for energy certifications				T1 T3
INRIM	Quantum flux Josephson junctions	E1			
INRIM	Development of phase slip devices as current quantum standards	E1			
INRIM	Absolute distance measurement with sub-wavelength resolution		M4		
INRIM	Metrology at cellular and macromolecular scale for regenerative medicine				T5

Table 21: "Relevant Investment" selection

funding agency	*Description*	*E*	*M*	*O*	*T*
INRIM	Apparatus for cryogenic measurements	E2			
INRIM	Cryogenic Cs apparatus for time standard			O1	
INRIM	Stroboscopic measurement system	E7			
INRIM	Laboratory for biological metrology	E6			
INRIM	Metrology for ultrasound applications in medicine				T4

The projects became operative only in 2009; the main results reached in 2009 are:

- the two E1 projects succeeded in testing the construction procedure and preparing the first devices, now being characterized, of type π Josephson junctions needed to obtain quantum bits and quantum-phase-slip nanostrips to be used as current quantum standards;
- the new He3 cryogenic insert for QHE measurements is now fully tested (E2);

- the biometrology lab (E6) is now working, with its fluorescence microscopy facility that will allow Raman spectroscopy and Fourier transform IR spectroscopy;
- with the stroboscopic measurement system (E7), the first observations of magnetic domains and of their dynamics were performed;
- in the first part of the project for the absolute distance measurement with sub-wavelength resolution, a 60 GHz synthetic wave was successfully generated (M4);
- in the experiment for the production of correlated LASER sources through the four-wave mixing in Cs vapour (O1-O4) for sub-shot noise measurements in primary frequency metrology and quantum optics, the optical bench at room temperature has been set up and the laser coupling is now being tested;
- the activities of T1, T3 and T4 contributed significantly to the development of the reference Centre for ultrasounds in medicine (CRUM lab) which is one of the important projects in preparation in the biomedical field.

The fraction of project that for some reason are in delay is very huge: it is 31% at Department level, but is higher than 40% for Mechanics and Thermodynamics, only acceptable for Electromagnetism and physiological for Optic.

3.3 Concluding remarks

The Committee underlines the following aspects:

- the quality and quantity of the scientific production is on average good for all divisions;

- the presence at International Conferences, meetings and Organisms, is good and should be maintained also for future years at these levels, even if the foreseen financial difficulties are confirmed;

- the monitoring of the highlights during the last three years is satisfactory at Department level, but shows some weakness at division level;

- the number of PhD students is quite high: the Committee appreciates this aspect and strongly suggests to the management to continue to support PhD students

- the relevant presence and involvement of INRIM in the European Metrology Research Programs is very significant, both in the iMERA plus projects started in 2008 and in the JRP ones approved in November 2009; this demonstrates the quite good expertise of the INRIM scientists in key metrological aspects at European level;

- the start of the NANOFAB and METREGEN projects will strongly improve the research and metrological infrastructure of the Institute;

- the participation in the national PRIN projects of the Education and Research Ministry is appreciable but their number is rather low;

- the approved projects of the 2008 internal calls, "New Ideas" and "Relevant Investment", are producing good results; this demonstrates that the calls are really an efficient way to promote the metrological research.

As already underlined in the previous evaluation reports, most of the scientific production is linked to the INRIM mission and its quantity and quality demonstrate that the Institute is present in metrology at a top international level. The most significant part of the scientific production concerns the development of instrumentation and/or methods, which are important to metrology or may result important for future metrology. A non negligible fraction of products and activity appears to have a less clear link to the mission of the Institute: the presence of such a fraction of "free" research is vital for a research Institute, for many reasons, such as to maintain an open channel to new ideas and to curiosity driven enquiries, to keep alive historical research fields which have been successful to attract funds through contracts on themes indirectly related to metrological research. The point is that the indicators provided in the annual report are not sufficient in order to evaluate their compatibility with the Institute's main activity and the management should accurately monitor this aspect.

Also for 2009 activity, no clear common selection criteria were used to choose the highlights. The Committee suggests for the future to use one of the following criteria: present a number of highlights equal to a fixed fraction (10% for instance) of the number of adepts of the Division; consider as highlights the publications that have an Impact Factor higher than the mean value of the Division plus 2σ; define for each Division a threshold for the Impact Factor above which publications are considered as highlights.

As already underlined in previous reports, some programmes are not involved in activity strictly related to the institutional mission of the INRIM; this is not judged negatively on a yearly basis, but will be monitored in the next years, because all activities on a long term should be linked to the INRIM role. In this respect the Committee noted that, apart three programmes (E8, O4, O5), all the others are involved in the approved metrological European projects of the European Metrology Research Programme.

The overall quantity of projects, particularly the national and regional ones, continues to be excessive with respect to the resources available in the Institute: priorities or selection criteria should be formulated to avoid interference with the INRIM main activities. The Committee appreciated that for each active project the causes of delay were indicated; very often the main claimed cause is the lack of personnel and/or time to dedicate to the project and this again shows the need to define priority criteria.

3.3.1 Specific actions on scientific performance

The following specific actions are suggested by the evaluation Committee to improve the scientific performance and its documentation:

1. define criteria based on clearly agreed indicators to choose highlights of the scientific production;

2. increase the interaction with universities at the National level, with a larger participation to PRIN/FIRB projects and collaboration also with universities different from Politecnico of Torino;

3. define the strategy with respect to the external contracts, as already requested in the previous report;

4. provide the publication list of the last three years, reporting together with the Impact Factor also the number of citations obtained.

5. consider establishing, at the INRIM level, a personal appraisal system that reflects the importance of the work in scientific research. To the degree that such a system exists, it would be useful to present it to the Committee for evaluation.

4 Performance as National Metrology Institute

The three 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.

The NMI-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 NMI-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 NMI-tasks are discussed below, followed by a analysis of its allocation of resources. Finally, some conclusions are given

4.1 Maintenance and upgrading of national standards

Appendix C of the KCDB gives the number of entries for INRIM in Table 22. 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. The area "Radioactivity and Ionising Radiation" is included for 2009 and is handled by the designated institute INMRI-ENEA.

Measurement Area	Division	2006	2007	2008	2009
Acoustics, Ultrasound and Vibration	T	38	42	42	42
Amount of substance	T	7	10	10	10
Electricity and Magnetism	E	201	201	206	206
Length	M	34	39	39	39
Mass and Related Quantities	M	105	105	108	108
Photometry and Radiometry	O	23	23	23	23
Thermometry	T	29	29	29	47
Time and Frequency	O	16	16	16	16
Total for INRIM		**453**	**465**	**473**	491
Ionising Radiation	INEA				98
Total for Italy					**589**

Table 22. INRIM's calibration measurement capabilities (CMC) for the period 2006-2009.. In 2009, the figures for INEA-INMRI are also given. In 2009, the global number of entries were approaching 23 000

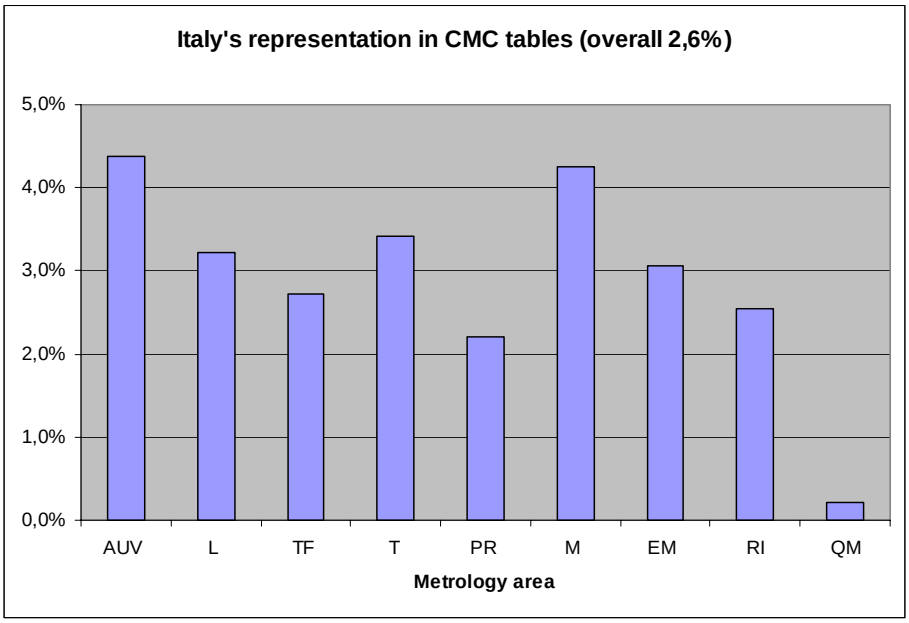

Figure 1. Italy's representation in the CMC tables of the KCDB for the 9 metrology areas and relative to all participants. Note that in the KCDB flow is part of mass. The overall Italian participation is 2,6 %

In Figure 1 is shown the distribution of Italian CMCs between the nine metrology areas[1]. It indicates that Italy has a very broad coverage (or little specialisa-

[1] Note that EURAMET distinguishes between 10 "subject fields" and keeps Mass and Flow separated.

tion) with the strongest areas being acoustics and mass. The exception is Chemistry, where the Italian participation is weak

From this it appears that INRIM is in a steady state with respect to the number of calibration services that it provides to customers. The only exception is the significant increase in CMCs in Thermometry; however, this is not a result of en increased effort at INRIM, since it comes from CMCs that were submitted in previous years and only appear now because of delays in the acceptance of data in the KCDB appendix C.

Over the period of 2006-2009, there have been some new activities in chemistry (Amount of Substance). This limited effort covers (very limited) measurement capabilities in four diverse fields: Gases, electrolytic conductivity, metals and alloys, and bio analysis; and it is difficult to see from Table 22 if the effort in chemistry is satisfactory. Alternatively, it could grow faster at the expense of one of the traditional fields or by partnering with other competent bodies in the form of designated institutes.

Finally, Table 22 demonstrate the Ionising Radiation is a significant metrology field in Italy that could deserve more national attention for its contribution to Italy's metrology organisation.

Measurement Area	**Div**	**2006**	**2007**	**2008**	**2009**
Acoustics, Ultrasound and Vibration	T	5	5	5	5
Amount of substance	T	8	9	13	13
Electricity and Magnetism	E	46	46	46	49
Length	M	33	33	37	38
Mass and Related Quantities	M	72	72	76	79
Photometry and Radiometry	O	10	10	8	8
Thermometry	T	14	14	15	15
Time and Frequency	O	1	1	1	1
Total for INRIM		**189**	**190**	**201**	**208**
Ionising Radiation	INEA				26
Total for Italy					**234**

Table 23. Time development of comparisons that support INRIM's CMCs in Table 22. For 2009, the figures for INEA-INMRI are also given. In 2009, the global number of entries was approaching 900.

Appendix B of the KCDB gives the number of comparisons that support INRIM's CMCs. Table 23 gives the numbers for INRIM and for 2009 for the whole Italian metrology organisation. The KCDB distinguish between key comparisons that concern basis quantities and supplementary comparisons that deal with "non-basic" quantities; and comparisons are split into CIPM-comparisons, covering selected NMI's world wide, and regional comparisons, which are normally linked to a CIPM-comparison to document global equivalence for a measurement quantity.

It should be noted that the comparisons mentioned in Table 23 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.

Non-compliances that affect the validity of CMCs have resulted in the removal of CMC's from appendix C for 8 countries. This has not involved Italy.

Table 23 shows that the participation in Comparisons is well developed in Italy and demonstrates a slow but steady increase

Last year's benchmarking with two foreign NMI's have not been repeated, since no significant changes have been noticed. Instead, benchmarking with 8 foreign countries is discussed in the thematic report 7.1.

4.2 Participation in international organisations

4.2.1 Metrology organisations

INRIM's participation in the work under the Meter Convention and in EURAMET is described,

The Meter Convention is an international treaty organisation, signed in 1875 by 18 states and now encompassing 82 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 78 institutes – from 47 Member States, 27 Associates of the CGPM, and 3 international organizations – and covers a further 134 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 2009 INRIM maintained its traditional high activity in the CIPM and its consultative committees. There are only few changes with respect to 2007. One significant change was that INRIM, via its permanent seat in CIPM, took over the presidency of the Consultative Committee for Length, CCL.

Also in EURAMET, INRIM has maintained the activity of 2008. The European Metrology Research Programme and the funding of an article-169 institution, operated by EURAMET came into operation with its first call on energy. The seven year EMRP-programme has a budget of a total of 400 million €, equally shared between the participating states and the EU. The EMRP and its precursor, the iMERA Plus programme now continue to give scientific results that are treated in section 3. INRIM played a significant role in establishing and operating the EMRP programme.

4.2.2 Standardization, Scientific and Technical Committees

The standardization activity is particularly pursued at the INRIM Institute by participating to national (UNI, CEI, CIG, CTI, AICQ, etc.) and International

(ISO, IEC, IUPAC, CISPR/A, CIE, CEN, IAU, ITU-R, etc.) standardization committee and also by coordinating some of these committees. The participation to metrological and accreditations organisms, beyond other 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 NMI work

The NMI work takes up a significantly different proportion of the staff's time in INRIM's four divisions, as shown in Figure 2 and table 25 of section 8.6. According to these data, in 2009 INRIM allocated 59,5 FTE to NMI work, or 29% of staff working time, compared to 61 FTE and 30% respectively in 2008 of staff working time. This is a significant amount that deserves attention from management as well as incorporation in the appraisal schemes of personnel. Unfortunately, there is no tradition for analysing in detail the NMI work at metrology institutes, but a preliminary analysis for Danish Fundamental Metrology indicates that at DFM, 23% of the working time is dedicated to NMI work, with 15% going to maintenance of standards and 8% to international organisations.

As to the allocation of time to NMI work in the four divisions, it ranges from 14% in OPTICS to 49% in MECHANICS. Provided that the estimates have been carried out in a uniform way, these differences reflect the different technical content in the divisions, and there seems to be no magic target number for the NMI work.

From the analysis in section 8.6 there are only insignificant changes in the allocation of resources to NMI work from year to year and from division to division.

4.4 Overall assessment and recommendations

The NMI work at INRIM appears very stable but not stagnant. There is a satisfactory dynamics within the constant overall budget.

In 2009, INRIM continued to fulfil its role as a National Metrology Institute in a way that is fully compatible with its size and the size of Italy. It is very well linked into the international network of the Meter Convention and the European regional metrology organisation EURAMET.

Work has been going on to work along the recommendation stated in the 2008 report, namely to ensure that the four divisions estimate their allocations of resources in a uniform way.

Hence the NMI work of INRIM is on a very solid ground.

However, thematic report 7.1 benchmarks INRIM with 8 foreign national metrology institutes. From this it appears that INRIM is non-typical in some aspects; and this is of course an opportunity to take new directions for NMI work at INRIM.

5 Dissemination of results.

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; 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 2008. 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 24.

Table 24 Dissemination policy and strategies

	Knowledge Improvement	Competence improvement	Efficiency in resources use improvement	INRIM brand improvement	Competitiveness Improvement
internal (INRIM-Division)	Continuous updating (ICT, quality, safety and security, ..) and seminar	Internal training	Cooperation between division and program	n.a.	Standard and CMC Improvement
other NMI	Bilateral and multilateral Agreement	Foreign researchers and researchers abroad	International cooperation with other NMI	n.a.	Support of new NMI
companies	Research contract	Personal detachment	Metrological services (accreditation of laboratory, calibration and test)	n.a. (Prize, ..)	Patents and licenses; Spin-off
scientific community	International Conference, Standardization Committee	Theses (doctorate, I and II level)	Cooperation with University and Research Institute	Congress Organization and Sponsorship	Common Researche Plataform
society	Information and Education (environment, safety, security, legal metrology)	External Training	Cooperation with regional institution and association	n.a. (Publicity, ...)	Common Laboratories

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 25

Table 25– Knowledge transfer – other product applications

Description	2006	2007	2008[1]	2009
Research programmes and contracts: contracts active in the year	40	65	77 (82)*	70
Research programmes and contracts: contracts signed in the year	15	26	21 (39)*	21
Research programmes and contracts: total income (k€)	2384	1425	(4148)*	2847,2
Regione Piemonte		567,4	538,9	1327,3
European Community		187,0	688,9	319,0
Industrial Companies		449,3	463,6	973,1
Other public		199,1	647,9	227,8
Patents filed in Italy and requests for European patents	1	4	4	1
Extension of patents abroad	2	1	4	3
Calibration procedures in force	228	242	238	229
Testing procedures in force	30	30	9	18
No. of calibration certificates, test reports and other documents issued	1675	1916	1857	1641
Income from calibration and testing activities (k€)	1681	1853	1868	1690
Laboratory accreditation activities: no. of active accredited laboratories	170	177	177	175
Laboratory accreditation activities: income from accredit. activities (k€)	903	800	1175	745
Designed instruments and devices:				
Electromagnetism Division		-	3	2
Mechanics Division		1	-	5
Optics Division	n.a.	8	2	1
Thermodynamics Division		3	-	4
Total		12	5	12
Outstanding realized instruments, devices and software:				
Electromagnetism Division	1	9	11	15
Mechanics Division	5	10	13	8
Optics Division		6	6	4
Thermodynamics Division	5	10	24	13
Total	11	35	54	40

[1] Some of the 2008 data have been modified with respect to the 2008 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 details only generic actions in sustaining technology transfer and innovation support to industries. Furthermore the mechanisms to promote and to 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 a high direction careful planning.

5.1.1 Calibration and test reports

Also in the 2009 INRIM is not been very active in the patents and licenses field. Only 1 new patent has been granted in 2009 and 3 other existing patents have been extended as European or USA patents. In particular, the patents granted in 2009 are reported in the following Table 26.

None patent has been mentioned in the INRIM Highlights 2009, 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 26– INRIM Patents

Div.	Typology	Title	Patentees	Notes
E	Extension of European Patent to USA	Contact-less device for temperature measurements in turbo-molecular pumps	Inventors: O. Bottauscio, G. Crotti, M. Chiampi, F. Fiorillo	Patent No. 08425236.0-1236. Patent owner: VARIAN S.p.A.
E	Slovak National Patent	Magnetostrictive strain sensor	Inventors: P. Balaz, J. Bydzovsky, P. Svec (Bratislava, SK); Kraus Ludek (Praha, CZ); M. Pasquale	Brevetto n. 286132 GOIL 1/12 Cooperation: P. Svec
T	Extension of National Patent to European Patent	A new industrial polluting treatment method by means of cavitation hydrodynamics	Inventors: R. Spagnolo, D. Madonna Ripa, A Troìa	
O	Extension of European Patent to USA	Atomic Beam Tube with Counter Optical or Atomic Beams	Inventors: F. Levi, A. Stern	No. US 2009/0302957A1 (December 2009) Cooperation: AccuBeat (Israel), Sepa spa (Italy)

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 institutes Italian (e.g. INO-CNR, ENEA) and European (e.g. PTB), it is possible to notice that:

- INRIM patent number for year and person (approximately 1 for every 50 unit of staff) is comparable with ones of other Italian institutes (about 1 for every 30 unit of staff for INO-CNR and 1 for every 400 units of staff for the PTB);
- unlike other institutes, INRIM patents information is not easily available in the INRIM website (e.g. http://www.ptb.de/s/p/ internet/PatentDB/index_en for PTB, http://www.ino.it/?p2=prodotti-della-ricerca&p=brevetti-e-progetti for INO-CNR, http://brevetti. casaccia.enea.it/ for ENEA).

Finally the impact of patents on the INRIM is not systematically estimated and only few Patents seem actually to be used by companies. Also, it is not clear the role of patents/licenses, spin-off in the improvement of product processes.

Modern product development relies on a closer collaboration between knowledge centers 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 2009 issued about 1.463 calibration certificates and other metrological services. In particular, details of such activities are reported in the following Table 27.

Table 27– INRIM Calibrations and tests in 2006-2009

Division	*Report Number*			
	Calibration Certificates	*Test Reports*	*Other Reports*	*Total Reports*
E	587	74	25	686
M	420	0	14	434
O	189	39	13	241
T	235	75	4	314
Tot. 2006	**1431**	**188**	**56**	**1675**
E	640	38	85	763
M	462	3	9	474
O	251	37	22	310
T	234	119	16	369
Tot. 2007	**1587**	**197**	**132**	**1916**
E	614	22	62	698
M	414	2	23	439
O	222	30	10	262
T	337	106	15	458
Tot. 2008	**1587**	**160**	**110**	**1857**
E	701	16	45	762
M	373	1	14	388
O	207	18	1	226
T	182	79	4	265
Tot. 2009	**1463**	**114**	**64**	**1641**

In the last three years the number of calibrations and tests is continuously decreased (e.g. tests number is even halved). This phenomenon can be attributed to the economic crisis, but it should be carefully monitored.

In the 2009 the human resources dedicated to the calibration and test activity are about 24 units (corresponding to 12% of whole personal). So the pro-capita

report number is about 68 reports a year for a person; this index seems to be quite 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. Indeed, this is still the case in Italy, where a special section of INRIM accredits 175 laboratories according to the standard ISO/CEN 17025. Details of this activities are reported in Table 28. 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 28– INRIM Accreditation Activities

Description	***Number***
New accredited Laboratories	7
Extensions	23
Renewals	55
Surveillances	57
Inter-comparisons	123
Updated Quality Documents	15
Technical guides	1

Also, during 2009 INRIM is continued the reorganization process of the Italian Laboratory Accreditation Service with the constitution of an independent consortium (COPA) in order to acquire the autonomy required by the European co-operation for Accreditation (EA) for accreditation services. This procedure was completed in the 2010 with the convergence of COPA in ACCREDIA (the Italian National Accreditation Body appointed by the State to perform whole accreditation activity) whose promoting partners are private and public Institutions (including INRIM).

5.1.4 Scientific metrological services

Only the 4% of INRIM total budget comes from technical and research activities involving private companies, but this quantities is doubled in the last year. Furthermore about 1/4 comes from self-funding: in particular k€ 1327 comes from projects and contracts financed by Piedmont Regional Authority for research projects funding, k€ 319 for research contracts with EC, k€ 228 for research activities submitted to other Public Bodies, k€ 973 for research

activities involving private companies, k€ 1690 for consulting, calibrations, equipment tests and other activities, k€ 745 for laboratory accreditation. It is important to underline that in the last years public and private contract number is increased significantly and doubled with respect to 2006.

As shown in the following Table 29, in the 2009 all divisions have been active in research contract concluded. In particular the INRIM drew up 21 new research contracts (and in the same year more than 70 research contracts were already activated).

Table 29– *New (N) and Active (A) Contracts in the 2009*

Div	*European*		*National*		*Regional*		*Industrial*		*Total*	
	A	N	A	N	A	N	A	N	A	N
E	9	0	2	1	6	4	6	3	23	8
M	8	2	1	0	5	1	2	2	16	5
O	11	1	4	2	5	0	0	0	20	3
T	3	0	0	0	5	3	3	2	11	5
Tot	**31**	**3**	**7**	**3**	**21**	**8**	**11**	**7**	**70**	**21**

Among these, particularly interesting are:

- the numerous iMera-Plus contracts testifying the excellent scientific value of all INRIM Division (with particular reference to Optic and Mechanic divisions);

- the cooperation of all INRIM Division with the Piemonte Regional Authority for the realization of some research poles (innovation Mechatronics and Advanced production systems poles) and with the bank Foundation (Compagnia di San Paolo) for the realization of a NanoFab Laboratory (with particular reference to Thermodynamic and Optic divisions);

- the industrial research contracts drawn up with agricultural food (for Electro-magnetic Division), aerospace, environmental and other fields.

5.1.5 Spin-off and technical personnel detachment

No spin-off activities have been carried out in 2007-2009 and no procedures at moment are available at INRIM to promote spin-off activities.

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 of knowledge and competence in the society and scientific community

As regards the scientific knowledge dissemination, the INRIM Institute pursues such aim with several activities: i) participation in 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.

5.2.1 Education and Training.

Training constitutes an integral part of the activities of INRIM, as it appears from INRIM Annual Report. It is also noteworthy that "education and training" is one of key elements of INRIM's vision. The very fruitful relations with different Polytechnic and University (e.g. the Polytechnic of Turin and Milan, University of Turin University of Roma "La Sapienza", Naples "Federico II", Pisa, Cassino, etc.) together with dedication grants for thesis work at INRIM ensures a high concentration of graduate work at INRIM, compared to most national metrology institutes.

In 2009, 19 first level degree thesis, 14 master degree thesis and 11 PhD thesis have been discussed.

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 intro training. In 2009 a large number of lessons have been held by lecturers in Universities (about 700 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, ANGQ, CMM Club Italia, EMIT-LAS, Istituto Tagliacarne, ecc.)

It is also interesting to notice that cultural events assimilated by INRIM Institute to technical training activities. To such purpose have been held several seminars within internal and external professional courses. A further activity is represented by the international mobility, even thought a slight decrease in such activity has been observed for both internal and external personnel.

5.2.2 Dissemination of competence to the scientific community and civil society

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

- 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);

- 11 divulgative conferences in the 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_09.shtml);
- 32 scientific conferences and seminars held at INRIM by both internal scholars and external institutions;
- a preliminary study on the realization of museum INRIM;
- a surveying on the main library indices.

The organization and the participation in scientific congresses and workshops are also notable:

- VI Congresso Nazionale "Metrologia & Qualità" (Torino, 7-9 aprile 2009)
- Assemblea annuale dei Soci del CMM Club Italia (Bologna, 20 aprile 2009)
- EFTF 2009 (Besançon, 20-24 April 2009)
- 2nd periodic meeting iMERA Plus JRP "qu-candela" (Sofia, 22 April 2009)
- International Magnetics Conference - INTERMAG 2009 (Convention Center, Sacramento, Ca USA, 4-8 May 2009)
- Nanoforum 2009 (Torino Incontra, 9-11 giugno 2009)
- In collab. con: ITER, PoliTo, UniTo, CamCom
- 36° Convegno Naz. Assoc. Italiana di Acustica (Torino, 10-12 giugno 2009)
- 18th International Laser Physics Workshop (Barcelona, 13–17 July 2009)
- 19th International Soft Magnetic Materials Conference (Torino, 6-9 Sept. 2009)
- Mid-term meeting iMERA Plus JRP "qu-candela" (INRIM, 9-11 Sept. 2009)
- 2009 Meeting of the Universal Network for Magnetic Non-destructive Evaluation (Torino, 10-11 sett. 09). In collab. con: Iwate Univ. Morioka (Japan)
- CCPR-WG-SP-TG4 meeting (BIPM, 14 September 2009)
- IV Workshop on Progress in Determining the Boltzmann Constant (INRIM, 22-24 settembre 2009)
- Meeting annuale del CCT-WG4 e del gruppo tecnico TG-SI sulla ridefinizione del kelvin (23 settembre 2009)
- "Mid term meeting" per il progetto iMERA T1.J1.4 (INRiM, 24 settembre 2009)
- Second periodic meeting iMERA Plus JRP "EMF and SAR" (INRIM, 11-12 ottobre 2009)
- Brainstorming meeting in preparation of 2010 EMRP Call "Industry" (INRIM, 12-13 ottobre 2009). In collab. con dr. T. Schrader del PTB
- Single Photon Workshop 2009 (Boulder, 3–6 November 2009)
- 41st Annual PTTI Meeting (Sant Ana Pueblo, New Mexico, 16-19 Nov. 2009

Between the dissemination activities the NTP (a free downloading software to sincronize and calibrate the PC clock) is a very interesting and appreciable time

tool; in the evaluators 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) ex APAT. 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.

In 2009 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 ISS and ISPRA): in such field the INRIM Institute has carried out research activities aimed to the improvement of the measurement equipments and techniques, test campaigns for environmental measurements and realization of standards for traceability (traceability of ozone measurements).

5.3 Conclusive considerations about dissemination of knowledge and improvement proposals

The activities of knowledge diffusion to 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 and with the community and the scientific academy. Nevertheless, despite the last years notable efforts, still a sensible gap exists between the legal, health and environment metrology and the scientific metrology. As a consequence it should be desirable a detailed program, approved by concerned authorities, aimed to the individuation of the chemical and physical quantities for which a national metrological traceability is needed (as already suggested in previous Evaluation Report 2006, 2007 and 2008). The INRIM Institute should then organize 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 2009. So we can affirm that the industrial knowledge transfer activity does not appear to represent a prior activity at INRIM. Such activity depends on the researchers sensi-

tivity 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.

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 the new media communication; vi) to diffuse the INRIM image with specific publicity action to better diffuse the "INRIM" brand in the industry and not only in the scientific community; vii) to evaluate all research results could 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.

As concluding remarks, the challenges with respect to INRIM's manifold dissemination activities still appears 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 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 equipments; the use of a specific network;

3. to establish a systematic overview of its dissemination of knowledge an results and to bring them in line with the mission of the institute. This could be formulated in a policy document, traduced in a strategic actions with appropriate human and economic resources and, finally, periodically verified;

4. to implement a specific staff for a coordination of the industrial knowledge dissemination; this activity could be also carried out in cooperation directly with industrial stakeholder or with a transfer technology specialist.

6 Economic analysis

Institute-wide economic figures are reported from the 'Annual report 2009' [1, 2], and compared as usual with similar figures of two European Metrology Institutes, the Danish Fundamental Metrology (DFM),[3] much smaller than INRIM (DFM staff is about 10% of INRIM), and, the German PTB,[4] larger than INRIM (INRIM staff is less than 15% of PTB). Having the Institute reached the third life year, a triennial trend is reported and analysed, showing in the a significant improvement both in self-funding and investments, as they were some of the guidelines to INRIM management traced out in the past evaluations. An economic index as the income-per-staff is estimated and compared. Income per staff should indicate the Institute capability of transferring knowledge and technology, that were developed as pure institutional and basic research, into applied research and commercial activities. As such, INRIM looks more aggressive than PTB and less than DFM, but the gap toward DFM has entered the uncertainty threshold typical of such benchmarks. INRIM positive trend in self-funding may be better appreciated by comparing 2007, 2008 and 2009, which is done below.

6.1 Overall assessment and benchmark

6.1.1 Key economic figures

Table 30 compares 2009 INRIM income and expenses to DFM and PTB figures. Operating result, if positive (surplus), is treated as expenditure in the order of the next financial year. If negative (deficit), as in 2009, is treated as an item of the current year income. As such, total income and expenditures come to balance. PTB income has been forcedly estimated as it is missing in the 2009 report, as it is available from the Internet.

The last rows of Table 30 give details of the origin of the operating result as a difference between surpluses; surplus practice has been explained in 2007 evaluation document and will not be repeated here.

Remarks to Table 30 are the following:

1) Differently than 2007 and 2008, DFM and INRIM rates of non-institutional income are rather close (26% versus 22 %) compared to 14% of PTB. It should be remarked that the DFM quota was severely reduced from 40% in 2008 to 26% in 2009. The positive, undeniable fact, is the capability of INRIM to keep its quota around 20%. Notice that the 26% value in 2008 must be kept as biased because of a special funding of 1,87 MEuro, not repeated in 2009. In the absence of a specific study/plan/rule indicating which should be the expected

[1] INRIM, 'Relazione consuntiva 2009 (in Italian).

[2] INRIM, Results and resources in the years 2006 to 2009, Draft 02/07/2009. See also Revised tables, hands-out.

[3] DFM, Annual report 2009 (in Danish), and personal communication by K. Carneiro.

[4] PTB, Zahlen und Fakten (Figures and facts), 2009

self-funding quota for Metrology Institutes like INRIM, values greater than 20% might be retained adequate.

Table 30 Key economic figures for INRIM; DFM and PTB 2009

No.	Item	INRIM		DFM (note 3)		PTB (note 4)	
		Value [ME]	%	Value [ME]	%	Value [ME]	%
0	**Income**						
0.1	Institutional funding (+)	21,10	74	1,78	72	140,3 (*)	86
0.2	Research contracts/projects	2,85	10	0,30	12	10,40	6
0.3	Income from commercial activities (++)	3,05	11	0,34	13	12,30	8
	Interests			0,03	1		
0.4	Deficit	1,40	5	0,05	2	0,00	0
0.4	**Total**	**28,40**	**100**	**2,50**	**100**	**163,00**	**100**
1	**Expenses**						
1.1	Personnel costs (°)	15,75	55	1,64	66	85,80	52
1.2	Operating costs	7,30	26	0,51	20	39,90	25
1.3	Investments/depreciation	5,35	19	0,17	7	37,00	23
1.4	Direct costs	NA		0,18	7	0,60	0
1.5	Operating result (surplus)	NA	NA	0,00	0	NA	
1.4	**Total**	**28,40**	**100**	**2,50**	**100**	**163,00**	**100**
3	Accumulated surplus						
3.1	Carried over from previous year	4,60		1,77		NA	
3.2	Surplus (deficit) of the year	-1,40		-0,05		NA	
3.3	Carried over to the next year	3,20		1,72		NA	

(+) 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 2009 PTB report.

(°) They include both permanent and temporary staff.

2) For what concerns expenditures, INRIM and PTB percentages look very similar. The same holds for investments that were a key issue raised in the past evaluations. It should be remarked that INRIM management has withstood the income shortage in 2009, which is of the same order of the 2008 special funding, at the price of reducing the accumulated surplus: the negative operating result corresponds to such a manoeuvre. As a result, investments have been kept at the same level as in 2008, in agreement with specific suggestions of the Evaluating Committee.

6.1.2 Economic trend

Having the Institute reached the third life year in 2009, a triennial trend can be tried as reported in Table 31 and Figure 2. They employ the same items and data of Table 30.

Table 31 INRIM, PTB and DFM economic trend from 2007 to 2009

No.	Item	2007 values	2008 values	2009 values
		Value [ME]	Value [ME]	Value [ME]
0	**Income**			
0.1	Institutional funding	19,95	20,5	21,1
0.2	Research contracts/projects	1,4	4,25 (2,38+)	2,85
0.3	Income from commercial activities (calibration, test, accreditation, others)	3,4	3,65	3,05
0.4	**Total INRIM**	**24,76**	**28,4 (26,5+)**	**27**
1	**Expenses (balanced)**			
1.1	Personnel costs	15,29	14,9	15,75
1.2	Other operating costs	6,05	6,9	7,3
1.3	Investments/depreciation	2,24	5,6	5,35
1.5	Operating result	1,18	1	-1,4
1.4	**Total INRIM (balanced)**	**24,76**	**28,4**	**27**
1.5	**Total INRIM (actual expenses)**	**23,58**	**27,4**	**28,4**
1.6	**Total DFM**	**2,22**	**2,30**	**2,51**
1.7	**Total PTB**	**132,9**	**141,2**	**163**

(+) without the special funding of 1.87 MEuros

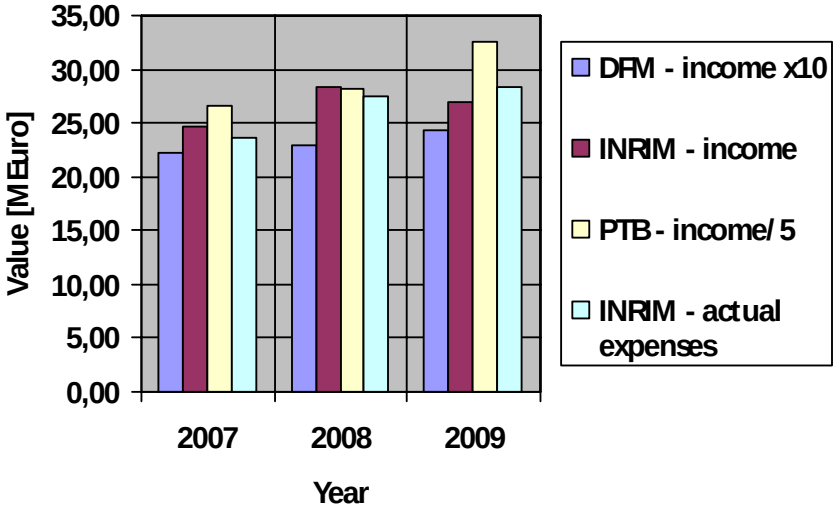

Figure 2– Triennial trend of INRIM, DFM and PTB income versus INRIM actual expenses

Remarks to Table 29are the following:

1) Whereas DFM and PTB income and expenses steadily increased along the triennial 2007 to 2009, the same did not occur to INRIM. Year 2009 witnesses income decrease from 28.4 to 27,0 MEuros (-5%): the special funding of 1,87 MEuros obtained in 2008 did not repeat in 2009.

2) Analysis of the different items shows institutional funding and research income (the latter free of special funding) have increased with respect to 2008. What sharply decreased is the commercial income (calibration and test). Though likely due to economic contingency, the shortage should be a concern to INRIM management as it was considered a solid Institute asset On the expense side, INRIM management has withstood the income shortage at the price of reducing the the surplus by 1.4 Meuros. As a result, the expense trend (especially investments) has been kept.

3) One might compare INRIM shortage to the significant PTB budget increase from 2008 to 2009: from 141 to 163 MEuros (+15%). No justification can be evinced from PTB reports, except that is not due to self-funding, which has remained unchanging. It might be due to a special funding, since the PTB income has remained rather constant from 2000 to 2007. Note the percentage increase is the same as for INRIM from 2007 to 2008.

Better insight may be obtained splitting self-funding (in Table 31 and Figure 3) into different items. To better assess the triennial trend, the special funding of 1,87 Meuro awarded to INRIM in 2008, has been taken as a separate item. Notice, however, the latter should be included in the self-funding total, in the case the INRIM economic trend would be projected over longer terms.

Table 32 INRIM self-funding, personnel costs and investments (details)

No.	Item	2007	2008	2009
		Value [kE]	Value [kE]	Value [kE]
0	**Self-funding source (research)**			
0.1	Regione Piemonte	567	539	1327
0.2	European Community	187	689	319
0.3	Other public bodies	199	648	228
0.4	Research contracts	449	464	973
1	**Total - research**	**1402**	**2340**	**2847**
2	**Calibration, test and accreditation**	**2653**	**3043**	**2436**
3	**Others**	**746**	**542**	**611**
4	**Total self funding-commercial**	**3399**	**3585**	**3047**
5	**Total self funding**	**4801**	**5925**	**5894**
6	**Self /institutional funding [%]**	**24**	**29**	**28**
7	**2008 special funding**	**NA**	**1870**	**NA**
8	**Personnel costs**			
8.1	Permanent/temporary personnel + travel	14203	13204	14143
8.2	Research grants, scholarships	1083	1673	1601
9	**Total**	**15286**	**14877**	**15744**
10	Investments (without the 2008 special funding)	1588	2833	4672

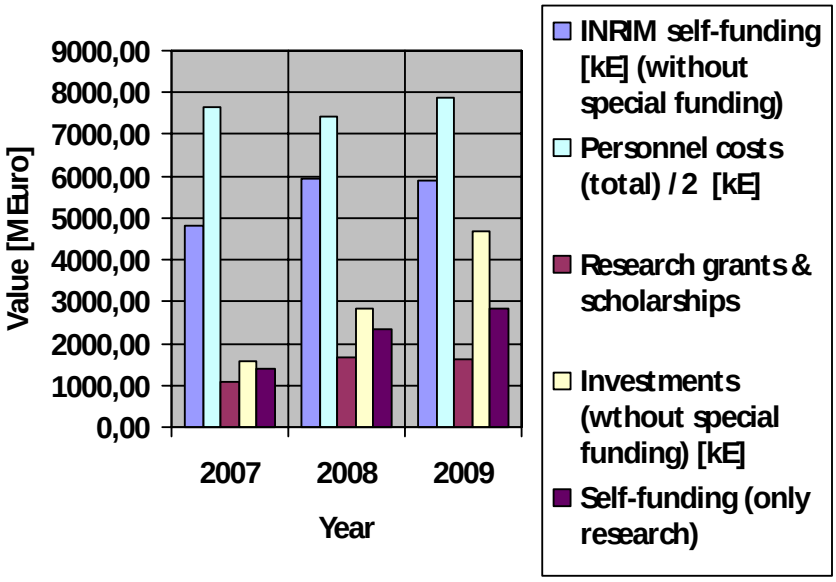

Figure 3– Trend of INRIM self-funding, investment and personnel costs.

Remarks to Table 32 are the following:

1) Investment and self-funding show a triennial positive trend, to be compared with constant personnel costs. Self-funding trend is better appreciated by separating research (research contracts/projects) from commercial self-funding (calibration,…) as the latter has diminished in 2009. Remarkably, the latter reduction has been completely balanced by the increase of the research income. One may deduce INRIM potentialities are still not fully deployed: keeping investments at the same level of 2008 (the year including a special funding) might be a leverage in this respect, in agreement with past suggestions of the Evaluation Committee, and INRIM 2009 policy.

2) A second leverage that looks blocked in 2009 concerns research grants and scholarships. The 2007 to 2008 remarkable increase (+50%) did not repeat in 2009, as the latter shows a slight decline. Actually, it should be taken as flexible degree-of-freedom in the hands of INRIM management for modulating INRIM staff, in the face of a sluggish regulations constraining permanent and temporary staff. This point was already issued in past evaluations. Incidentally, no official account/plan of this labour is available in the documents (for instance they are not included as a staff, differently than PTB and DFM reports).

3) The significant increase of industrial contracts (+100%) in 2009, seems demonstrating INRIM potentialities in the knowledge transfer, a concern that was repeatedly raised by the Evaluation Committee. Although it would deserve a deeper analysis, for the present one might wish INRIM will be capable of keeping the same level in the future.

4) Last but not least, the sharp increase (>100%) of the regional research projects further corroborate the assessment of INRIM potentialities. Leaving aside the accounting debate whether regional funds should be referred to 2009 or spread over the whole project duration, the committee would like to point out that regional funds may share advantages and drawbacks. On one side they

allow investments, on the opposite side they could restrict the milieu where research cooperation/competition should develop. From such a standpoint, one may wonder whether a correlation exists with the sharp decrease of the European Community funding.

6.1.3 . Income-per-staff index

Table 33 reports the income-per-staff index as derived from Table 30 and the permanent/temporary staff amount.

Table 33 Key economic indices for INRIM, DFM and PTB

No.	Item	INRIM 2007	INRIM 2008	INRIM 2009	DFM 2009	PTB 2009
0	Total personnel (+)	224	222	228	20	1704
1	Key indices [kE/staff unit]					
1.1	Total income per staff	111	128	119	125	86
1.2	Project income per staff (without the 2008 special funding)	6	11	12	15	6
1.3	Commercial income per staff	15	16	13	17	7

(+) Permanent and temporary staff

Remarks to Table 33 are the following:

1) During three years from 2007 to 2009, the project income per staff has reached the commercial income per staff. This should be kept as a remarkable 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. Though the above balance is partly due to a contingent reduction of calibration and test income in 2009 (but it would deserve an adequate analysis), 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) At the same time INRIM has come very close to the performance of a small and aggressive institute as DFM. Besides the wish this path will be continued, the Committee suggests 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.

6.2 Conclusions and recommendations

The same conclusions as in 2008 report can be iterated: overall economic analysis and benchmark 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. Management should make any effort to keep the present rank, and that has been done in 2009, as for keeping investments at the same level of 2008: one must recall 2008 income was biased by special funding.

Also the suspended issue in 2008 evaluation, about the role of the research contracts (and of calibration and test activities), and more generally of the know-how dissemination to the Italian industries, has shown a positive and significant answer in 2009. INRIM should take advantage for becoming a proposer to national industry.

Shadows still remain, though deserving deeper and wider analysis (not only from an economic standpoint). 1) expenditures for grants and scholarships did not increase in 2009, 2) European funding sharply decreased. Both items should deserve special attention by INRIM management.

7 Thematic report

7.1 Benchmarking

In order to put the performance of INRIM into perspective, the committee has shown its development with time in Table 23, Table 27, and Table 31 well as well as in Figure 3. Further, INRIM's performance is benchmarked against selected institutes in Table 33.

In Chapters 3 to 6, benchmarking has been performed, when possible and in a somewhat ad hoc way. Most systematically, the economical analysis in Chapter 6 has used the data from PTB in Germany and DFM in Denmark to benchmark key economic figure. However, in general, the Evaluation Committee has found it difficult to make accurate conclusions from comparisons between institutes; This is due to the fact that there is no uniform or standardised way to report performance parameters at INRIM and at the institutes that it would be interesting to compare with INRIM.

The present thematic report takes its starting point in two databases, where the registration is indeed standardised or at least highly harmonised, namely the *Science Citation Index*, and the database of the CIPM- MRA, *KCDB.* Since it would be attractive to benchmark INRIM against the same institutes for both Science and NMI behaviour, and since the KCDB only contains data from NMIs, a number of NMIs have bee chosen for the comparison. Hence, Table 34 lists seven NMIs with both similarities and differences compared to INRIM. These institutes have then been analysed in the *STN* as well as in the KCDB.

Acronym	Institution	Country	Why Benchmark?
CEM	Centro Español de Metrologia	Spain	Similar in size to INRIM, government institution
DFM	Danish Fundamental Metrology	Denmark	Small NMI, with a scientific profile
INRIM	National Institute of Metrological Research	Italy	-
KRISS	Korean Institute of Standards and Science	Korea	Similar in size to INRIM and part of a big scientific institution
LNE	Laboratoire National de Métrologie et d'Essais	France	Bigger than INRIM, part of a national test institute
METAS	The Federal Office of Metrology	Switzerland	Smaller than INRIM, government institution
NRC	National Research Council	Canada	Similar in size to INRIM; part of Canadian Research Council
VSL	Dutch Metrology Institute	Holland	Smaller than INRIM, with a high profile

Table 34 Seven national metrology institutes with different organisational characteristics, sizes, and profiles, which makes benchmarking interesting.

7.1.1 Benchmarking Citation impact

Institution	Publications 2005-2009	Citations 2005-2009	Citation impact CI
NRC	221	739	3,3
DFM	29	91	3,1
KRISS	123	312	2,5
VSL	40	81	2,0
METAS	50	97	1,9
INRIM	275	479	1,7
LNE	38	59	1,6
CEM	10	6	0,6

Table 35 Publications and Citations for the five-year period 2005-2009 for the seven NMIs that have been chosen to be benchmarked against INRIM. Source: *Science Citation Index, STN*

Table 35 shows the result of an STN-search for the five-year period 2005-2009, meaning that the citation index chosen for this study is the ratio between the number of citations in the given period and the publications in the same period. The five-year length is chosen to reflect timeliness in the search and not "eternal truth" (cf. discussion in section 3).

When the eight institutes are ordered according to CI; and the IF for the journal *Metrologia* of 1.78 is introduced in Figure 4, the scientific quality at INRIM (as measured by CI) is in the lower end. Although INRIM's CI matches the IF (and CI, since IF and CI are identical for a journal) of *Metrologia*, it is only higher than the two NMIs that have no tradition for scientific work.

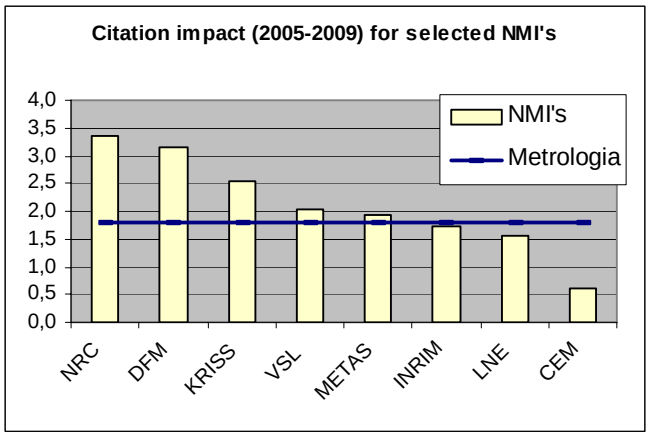

Figure 4. Benchmarking Citation index for INRIM and the seven selected national metrology institutes. The number for Metrologia is also shown.

7.1.2 Benchmarking, using data of KCDB

In 1999 the Mutual Recognition Arrangement under the CIPM was signed, and currently, metrology organisations from 75 states participate. The CIPM-MRA set procedures for mutual acceptance of measurement results under the Metre Convention. The acceptance is based on successful participation in comparisons, which are registered in the Appendix B of KCDB database and on a satisfactory operation in accordance with the quality standard 17025, which is registered at the BIPM. The accepted calibration measurement capabilities CMC are registered in Appendix C of the KCDB.

After 10 years of operation, the KCDB content is based on a harmonised approach, so that the statistics that can be drawn from the database is relevant for benchmarking.

Below, we give three examples of benchmarking using the KCDB:

CMC entries for appendix C. This indicates how many "metrology services" is provided by a national metrology organisation

Participation in comparisons from Appendix B. This indicates how much effort is dedicated to document the CMCs that are declared.

Ratio between CMCs and comparisons. This indicates how "far the light shines" from each comparison on the calibration portfolio, or how "efficient" a national metrology organisation is in making calibration offers for each comparisons. After all comparisons are a cost, and calibrations give income.

CMC tables (KCDB appendix C)

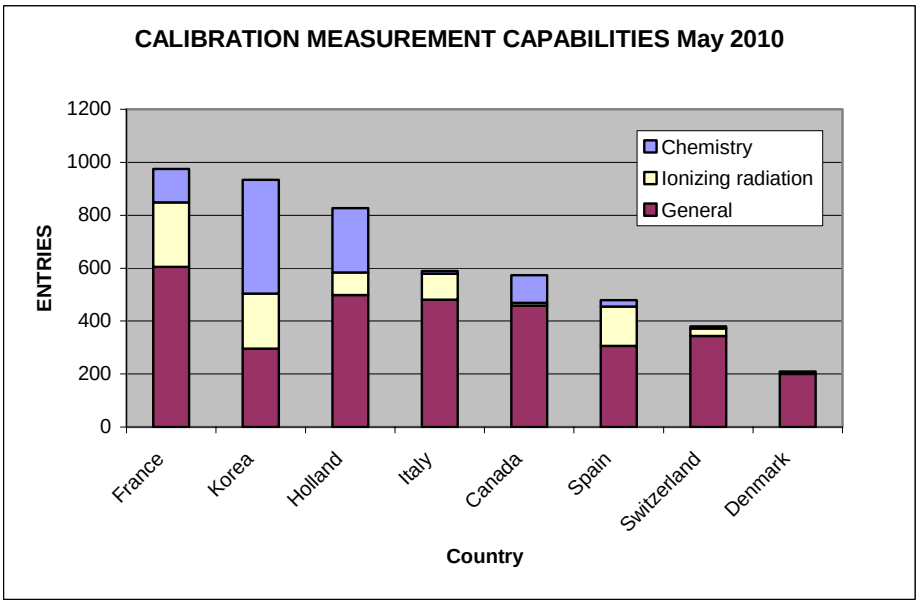

Figure 5 Calibration measurement capabilities CMC for Italian metrology organisation taken from the KCDB, and the seven foreign organisations.

Figure 5 shows extracts from the CMC tables for the eight countries chosen for benchmarking. The CMC-areas (cf. Figure 1) are grouped in three groups: General metrology (consisting of the seven traditional "areas" of mass, length etc.) Ionising Radiation (consisting of 3 sections), and Chemistry (consisting of 15 sub fields).

Excluding Chemistry, the figure shows that Italy has the second greatest numbers of CMCs of the chosen countries, demonstrating the high amount of dedication of INRIM and INEA to make their knowledge available to calibrations for laboratories. However, when it comes to Chemistry, Italy, Switzerland, and Denmark have done very little to follow the developments in Chemical Metrology, a fact that also is evident from Figure 1. Notably, Korea and Holland have had major investments in this field, specifically in gas metrology.

Key and supplementary Comparisons (KCDB Appendix B)

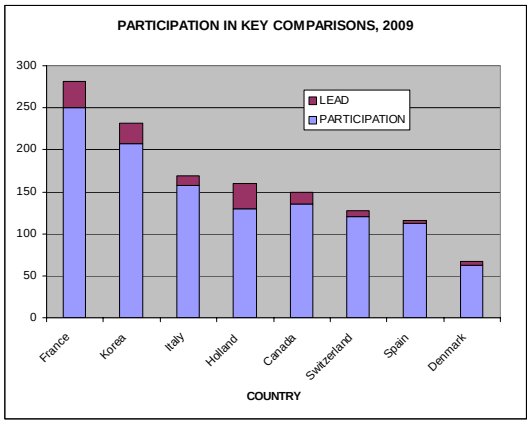

Figure 6 Italy's representation in the key comparisons of the KCDB compared with the seven selected countries.

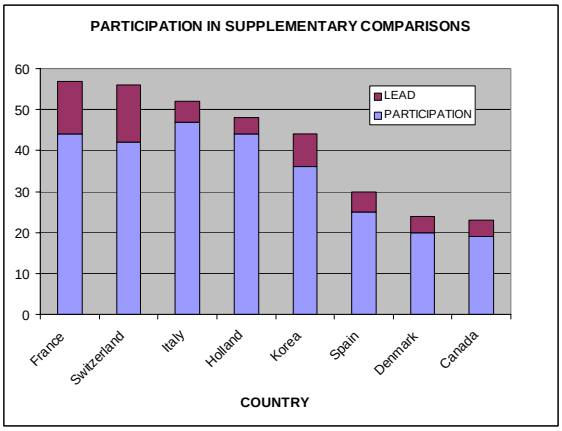

Figure 7 Italy's representation in the supplementary comparisons of the KCDB compared with the seven selected countries.

Figure 6 and Figure 7 show the participation in Key and Supplementary Comparisons by the eight countries. Key comparisons were originally meant to deal with "key quantities" such as base units, whereas supplementary comparisons were dealing with "more applied" quantities such as derived units; but the distinction between KC and SC have developed somewhat differently within the nine metrology areas, and is not entirely stringent.

Italy's participation is third in both KCs and SCs, demonstrating that INRIM and INEA put emphasis on both base and derived units. Counter examples are Korea and Canada that put relatively more emphasis on base units.

Relation between Comparisons and CMCs

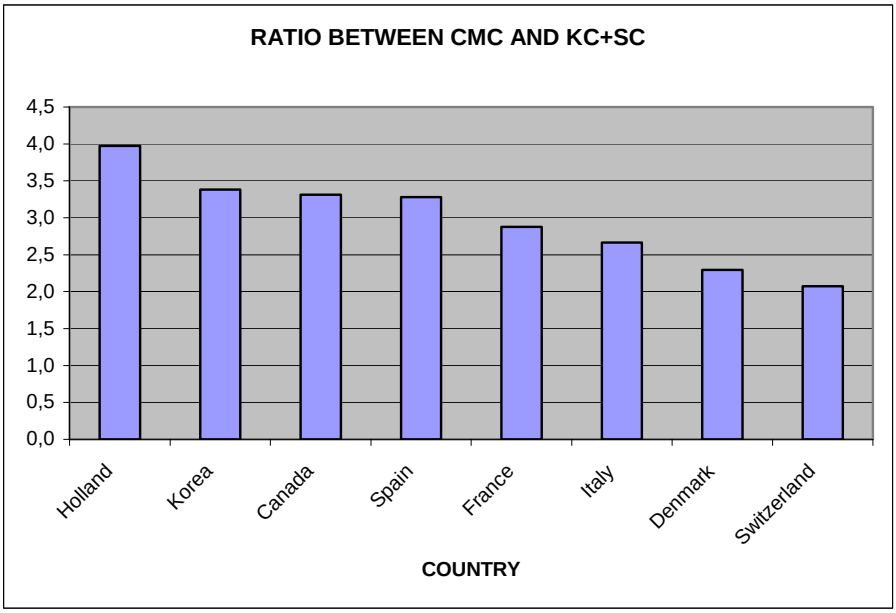

Figure 8. This figure shows the average number of CMCs that is supported by one comparison.

As mentioned above, CMCs represent products of NMIs and comparisons represent cost connected with delivering the products. Therefore, the ratio between the numbers of CMCs and the number of comparisons indicate some kind of efficiency of the product portfolio.

Smaller countries would be expected to be "less efficient" in this respect, because of the few quantities in each metrology area that they can offer. Bigger countries are on the other hand expected to be more efficient. If a country is highly specialised in its metrology services, it will appear more efficient.

Figure 8. This figure shows the average number of CMCs that is supported by one comparison. The two top countries are Holland and Korea, and they have both been specialising in gas metrology within the area of chemistry. At the bottom, one finds the smaller countries Denmark and Switzerland. France and Italy, traditionally the two biggest countries in a metrology sense of the eight countries in Table 34, are both in the lower half of the table.

Regarding INRIM, this result seem to emphasize the difficult it has to cover "everything" and take up new fields such as nano- and chemical metrology under a constant budget. Again the solution is to associate with one or several Designated institutes with specific and relevant competences, whom new tasks can be delegated to.

8 Annexes

8.1 List of acronyms

Acronym	Explanation
BIPM	Bureau International des Poids et Mesures (Sèvres, France)
CC	Consultative Committee of the CIPM
CEM	Centro Español de Metrologia
CEN	Centre Européenne de Normalisation
CI	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.
CIPM	International Committee for Weights and Measures (Metre Convention)
CIPM-MRA	Mutual Recognition Arrangement of the CIPM from 1999
CIVR	Committee for the Evaluation of Research (Italy)
CMC	Calibration measurement capabilities (Entry in KCDB appendix C)
DFM	Danish Fundamental Metrology Ltd (Danish metrology institute)
E	Electromagnetism division of INRIM
EMRP	European Metrology Research Programme
ENEA-INMRI	Italian Designated Institute for Ionising Radiation
EURAMET	European Association of Metrology Institutes
FTE	Full Time Equivalent (corresponding to the workload of one full-time employed person)
IEC	International Electrotechnical Committee
IF	Impact Factor of a scientific journal (average number of citations from an article in the journal)
iMERA	Implementing the Metrology European Research Area
INRIM	Istituto Nazionale di Ricerca Metrologica
ISO	International Standardization Organization
IUPAC	International Union of Pure and Applied Chemistry
JRP	Joint Research Project of the EMRP

KC	Key Comparison (Entry in KCDB Appendix B)
KCDB	Key Comparison Database of the CIPM-MRA
KRISS	Korean Institute of Standards and Science
LNE	Laboratoire National de Métrologie et d'Essais
M	Mechanics division of INRIM
METAS	The Federal Office of Metrology
MIUR	Ministero dell'Istruzione, dell'Università e della Ricerca (Italian Ministry of Education, University and Research)
NMI	National Metrology Institute
NRC	National Research Council
O	Optics division of INRIM
PTB	Physikalisch Technische Bundesanstalt (German metrology institute)
SC	Supplementary Comparison (Entry in KCDB Appendix B)
T	Thermodynamics division of INRIM
VSL	Dutch Metrology Institute

8.2 Organizational and operating principles

The article 3 of the Organizational and operating regulations set the principles for the organisation and operation of INRIM. They are given below, and they are referred to in the main text of this report:

a) Flexibility and rapid decision-taking, achieved by delegating functions and roles

b) Periodical verification of its organisational structures, in order to guarantee a rational use of resources and to ensure consistency with the goals defined in planning documents

c) Effectiveness and efficiency in the use of its human and technical resources

d) Assessment of resources and constant monitoring of their effective use

e) Support and development of technical and scientific training, with particular attention to top level training

f) Attention to continuous professional updating of its personnel

g) Exploitation of its historical and museum heritage

h) Circulation, communication and transfer of the results of the research activities

8.3 Executive Summary of 2006 report

The Evaluation Committee (Comitato di Valutazione, "Committee"), established according to art. 11 of the operative rules (Organisational and operating regulations) has performed the evaluation of the Istituto Nazionale di Ricerca Metrologica, INRiM, for the year 2006, based on the Activity Report 2006 and talks with institute responsibles (President, Director general, Department Director, Division Heads, Head of the Laboratory accreditation service).

Based on the annual report of 2006, the Committee has formulated a number of "challenges" that it suggests to be addressed by the Board of Directors.

For INRIM in implementing its operating principles:

To implement the declared effectiveness and flexibility under the regulatory constraints, which government imposes.

To acquire capacities in "new" fields of management, such as Human resource management and commercial dissemination of knowledge.

For INRIM in pursuing its successful scientific record are:

- To be able to allocate appropriate resources to new fields within a constant (or declining budget). This involves critical reviews of current activities and reallocate of human resources.
- To review its very wide portfolio of research topics in view of the establishment of a new institute with a new mission.

As a National Metrology Institute:

- It is major challenge to develop its new divisions so that they ensure a positive development of INRIM as a major NMI in the world.

With respect to INRIM's manifold dissemination activities:

- To establish a systematic overview of its dissemination of knowledge and of results and to bring them in line with the mission of the new institute. This could be formulated in a policy document.

In relation to the attraction of funding:

- To establish a clear overview of INRIM's financing and its correlation to the use of resources (both human and economic), and to set targets for INRIM's performance that are realistic. It may be of help to establish a focussed economic reporting system that facilitates the managerial decision-making.

8.4 Executive Summary of 2007 report

Executive Summary

The Evaluation Committee (Comitato di Valutazione, "Committee"), established according to art. 11 of the operative rules (Organisational and operating regulations) has performed the evaluation of the Istituto Nazionale di Ricerca Metrologica, INRIM, for the year 2007, based on the Activity Report 2007, supplemented with the annex Risultati e Dati 2007. Further, an on-site visit was made during 1-3 July 2008 where the Evaluation report for 2006 and the progress during 2007 were discussed in detail during talks with senior officials of the institute (President, Director general, Department Director, Division Heads, Head of the Laboratory accreditation service).

The findings of the Committee for 2007 may be summarised as follows:

- INRIM has successfully established itself in its first year of operation after the merger between the former institutes IMGC and IEN; but it would benefit from further organisational development to optimise the management to the details of iNRIM's mission, including personal development of the staff. The Committee makes four recommendations for improvement.
- The overall scientific research is satisfactory, but it would benefit from more transparency in how resources are allocated and how specific projects and program are prioritised.
- INRIM fulfils it role as a National Metrology Institute in a satisfactory way. However, in order to meet the needs of the future with new demands but constant and decreasing funding, new ways of prioritising resources should be established. The Committee makes three recommendations for improvement.
- The dissemination of knowledge is a multifaceted problem, where INRIM has many, but rather uncorrelated, activities. The Committee recommends that INRIM develop a common strategy for its dissemination.
- The Committee has made a detailed economic analysis of INRIM. The Committee makes eight recommendations for improvement.

8.5 Executive summary of the 2008 report

The findings of the Committee for 2008 may be summarised as follows:

Overall, INRIM has developed satisfactorily during 2008, both with rexpect to previous years as well as with respect to comparisons with other National Metrology Institute (benchmarking), where this is possible. Reports from 2006 and 2007 have been approved by INRIM; but equally important it has given rise to constructive discussions within the department in its continuous search for improving its performance. One result is that both the external and internal planning and reporting are now more transparent and consistent, making the necessary analyses of the Evaluation Committee more coherent. At the same time the reports have also become progressively more detailed, and it is therefore relevant to discuss the optimum level of detail of the next reports.

The Scientific Performance shows similar aspects as previous years. This year the Committee has evaluated not only the "research products" (536 in 2008), which are documented essentially by the publications, but also the overall research activity, in terms of projects and realizations of scientific relevance. The analysis has been done for each division separately, and compared with the allocation to resources for each division respectively. Average citations give an impact factor of 3,5 and a citation index of 2,17, which demonstrates as previous years the competent and diverse research activities of INRIM, a fact which is amplified, when a selection of 14 highlights are analysed. The Committee also appreciated the focus on quality that the concept of New Ideas has borne out.

There are eight recommendations regarding *Scientific Performance*. A common theme is to ensure a positive development based on explicit strategies and transparent decision process in order to ensure an evolution coherent with INRIM's mission and strategies.

In 2008, INRIM continued to fulfil its role as a *National Metrology Institute* in a way that is fully compatible with its size and the size of Italy. It is very well linked into the international network of the Meter Convention and the European regional metrology organisation EURAMET. Since 2006 there has been a steady increase in the number of measurement capabilities, as registered in the KCDB database appendix C (473 in 2008) as well as in the number of registered comparisons in appendix B (201 in 2008). INRIM's contributions to both the Meter Convention and to EURAMET are also very significant, and the same holds the numerous "stakeholder organisations" that embrace modern metrology. The allocation of human resources to the work ranges from 16% to 52% within the divisions.

The recommendations are that the work continues to put the NMI work of INRIM on even more solid ground than is the case at present and ensures that new areas such as chemistry can be given adequate resources. Also it should be ensured that the divisions estimate the allocations of resources in a uniform way.

The evaluation of *dissemination of knowledge* is based on the legislative decree n. 38/2004, which explicitly describe the following activities: i) knowledge and

technology transfer to science, industry and society; ii) development of the calibration laboratories network; iii) high level scientific and technical services; iv) technical standardization; v) education and training; vi) technical support to legal, health and environmental metrology. The most prominent activity is related to calibration, where the number of accredited laboratories reached 177, and the number of issued calibration certificates was 1857. Also, INRIM has introduced the Training and Diffusion of Scientific Culture Commission and this is a visible way of demonstrating the strategic importance of the activity. On the other hand number of patents remains low; and knowledge transfer to companies does not represent a prior activity at INRIM. Such activity still depends on the researchers' sensitivity instead of being the consequence of the Institute strategy.

The recommendations related to INRIM's Dissemination of Knowledge focus on setting transparent strategies, or one comprehensive strategy for all activities mentioned in the decree.

Economic analysis is performed for INRIM as a whole for 2008 and compared with similar figures of Danish Fundamental Metrology (DFM, significantly smaller than INRIM) and Physikalisch-Technische Bundesanstalt (PTB, which is significant larger than INRIM)). Regrettably, economic figures are scarcely reported, and only the two mentioned NMI's give figures of sufficient detail. The income per staff is 0.127 M€ for 2008 and puts INRIM in between DFM and PTB. The income per staff should indicate the Institute capability of mixing pure institutional and basic research activities with applied research and commercial activities. As such, INRIM looks more "aggressive" than PTB and less than DFM, but the gap toward DFM looks diminishing. From 2007 to 2008, INRIM had a positive trend in self-funding going from 1402 M€ to 2340 M€ respectively. The substantial support from the Region of Piemonte plays here a significant role.

The Committee would appreciate if the reporting in the future would allow an Economic analysis per division and per financing source. However, as mentioned above the details of reporting will have to be discussed in view of the benefits.

A common wish from the Committee is to discuss a review system and possibly a personal appraisal scheme that balances the many facets of INRIM's activities.

8.6 Allocation of resources

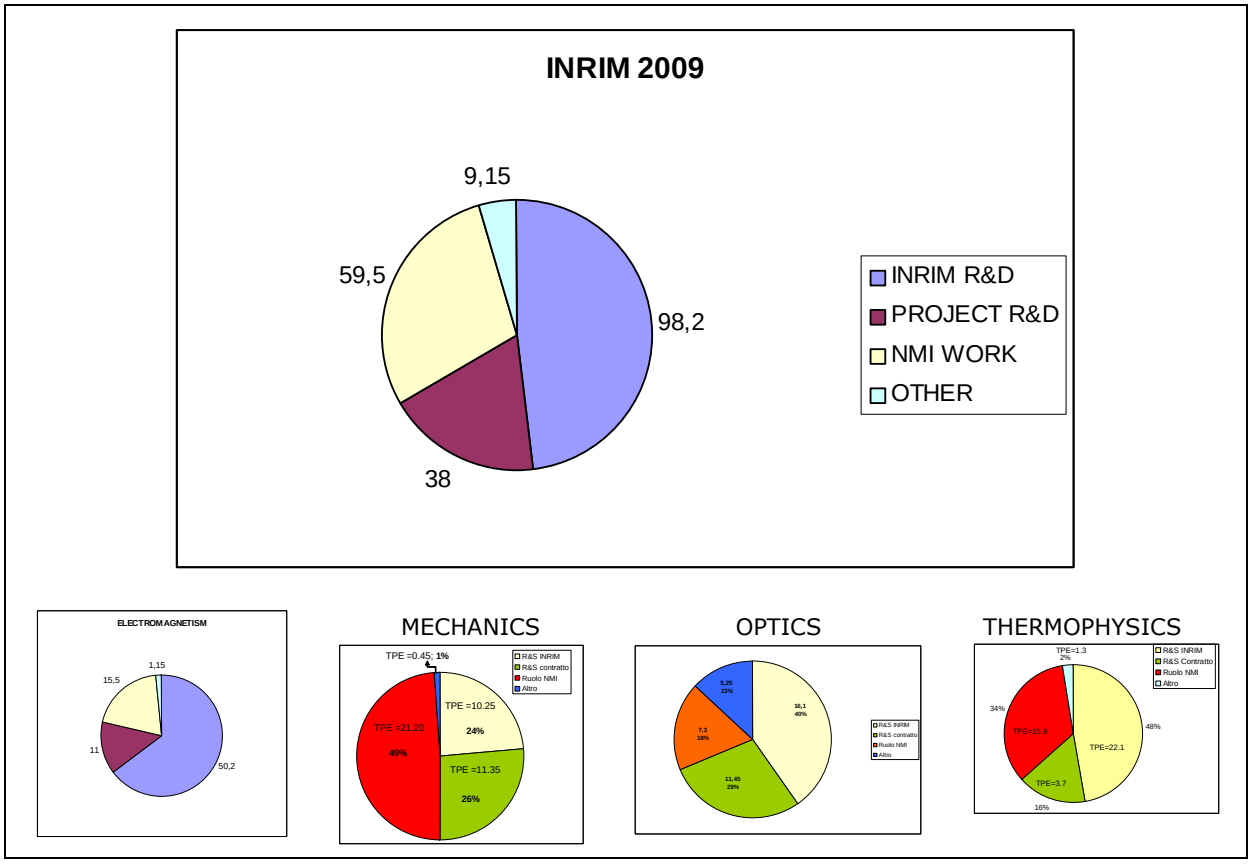

Figure 9 INRIM's allocation of human resources in terms of full time equivalent (FTE) in 2009.

Like in 2008, INRIM reported in 2009 how many resources that have been given to each type of work: Research, NMI work, and other. The latter contains dissemination of work, but may be other activities as well. The result is shown in Figure 9, both for the whole INRIM as well as for the four divisions.

	INRIM	E	M	O	T
INRIM R&D	48%	64%	23%	40%	50%
PROJECT R&D	19%	14%	26%	30%	9%
NMI WORK	29%	20%	49%	18%	36%
OTHER	4%	1%	2%	13%	5%

Table 36: Fractions of FTE resources dedicated to different activities for divisions in 2009

	2008	2009
INRIM R&D	48%	48%
PROJECT R&D	17%	19%
NMI WORK	30%	29%
OTHER	4%	4%

Table 37 Fractions of FTE resources dedicated to different activities for INRIM in 2008 and 2009

8.7 Using IF and CI to measure publication quality

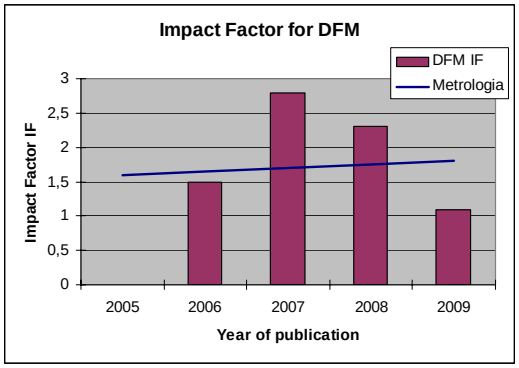

Figure 10. Impact Factor IF for the publications from DFM in the period 2006-2009. Source: Science Citation Index, STN

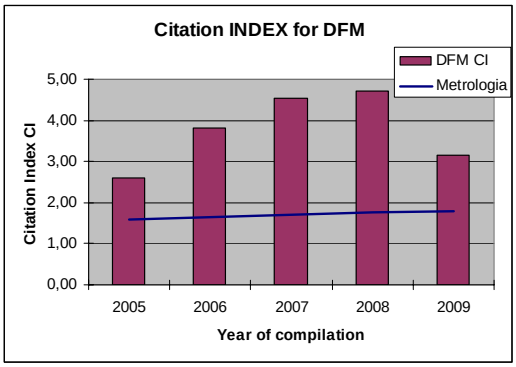

Figure 11. Citation Index CI for publications from DFM in the period 2005-2009. Source: Science Citation Index, STN

In section 3 the quality of INRIM's publications is assessed in terms of *Impact factor, (IF)* and *Citations Index (CI).* Some trends and comparisons with comparable institutes are given. But no systematic analysis could be made.

The purpose of this section is to give some systematic background for the two figures, based on data from DFM.

The IF stems from the characteristics of journals that are included in the *Science Citation Index*. For instance, a paper published in *Metrologia* in 2009, is given the IF 1,780, which was the IF for this journal in that year. The IF for a persons, groups of persons or institutions, is the average of their publications' IF that year.

IF is convenient because it is available immediately, when the journal of publication is know. However, the IF tells little about how much a given article is cited.

Figure 10 shows the historic data for Danish Fundamental Metrology, DFM. It appears clear that for the very small number of publications (typically six per year) it is not possible to get a very accurate picture of the quality of publications.

In order to get a more specific picture of the number of citations that an article gives rise to, one may resort to the CI. This figure for a given article states the number of references that were given to that article in a given period prior to the year of compilation. A person's or an institution's citation index is the average number of references that were made in a year from articles that were published in the chosen previous years.

Figure 11 gives the parameters CI for DFM. The period of tracing back was chosen to be five years, so that the compilation for 2009 covers the publications, which were published *and* cited in the period 2005-2009. Five years cover the

typical "lifetime" of metrology publications.[1] Of course self-citations were not included.

Comparison between IF and CI shows that DFM's publications are cited significantly more frequent that the average for the journals, where the articles are published, a quality that does not emerge from analysis of only IF. And whereas the IF of DFM is similar to that of Metrologia, the CI is significantly higher.

It would be interesting to see, if similar observations could be made for INRIM.

Other factors may be applied in further bibliometric analysis of publications; but all of them have deficiencies and should not be used as the only measure of publication quality. In particular, evaluations of individuals appear delicate.

In conclusion, both IF and CI are parameters that tells something about the scientific quality of a person or an institution; but should not be used on too small ensembles. If benchmarking is performed, extreme care must be taken that the data are compiled in identical ways.

[1] The Technical University of Denmark DTU, uses four years.