Evaluation of Istituto Nazionale di Ricerca Metrologica 2007

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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 I detail 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.

Content

1 Introduction, Method of work

2007 was the first year of operation, where INRIM was operating according to its regulations and new structure after the merging in 2006 of the former IEN and IMGC. This means that the reporting on activities is more complete than the year before, and also some data for 2006 have been revisited. With respect to the previous evaluation report for 2006, this year's report therefore assumes a more normal form of assessment. This also implies that the previously reported Challenges for the establishment of INRIM are changed into literal assessment of progress during 2007 and supplemented with recommendations when found appropriate.

Apart from this, the report has the same general format as last year, where INRIM was considered as a consisting of four divisions (Electromagnetism, Mechanics, Optics, and Thermodynamics) and accreditation; but this year only the Department (*i.e. the four divisions)* was considered; but Laboratory Accreditation, Administration, and Quality management system were not addressed specifically.

The 2007 INRIM evaluation follows the lines of the previous year final document, however it takes into account a larger number of data and digs into them to produce the evaluation. Therefore the work carried out is wider, deeper and more demanding to be understood. It should be added that in some cases, since the analyses were performed using data, which were not prepared for such analyses; and therefore minor inconsistencies in the data set may occur. this is particular true for general data, which were deduced differently in the different sections.

Like for 2006, the criteria for evaluation are divided into three categories, namely scientific work, work as a National Metrology institute, and dissemination work; and a separate chapter is devoted to analysis of INRIM's economy; but specific evaluation points have been modified according the new reporting and feed back from the senior staff of INRIM. Further, the report is influenced by oral presentations from the five units of INRIM and from an extended visit to the laboratories of the Optics Division.

The report assesses INRIM according to its three different missions: Scientific research, National metrology, and Dissemination of knowledge. Further, the organization and economy is analysed.

2 Organizational and operating principles

During 2007, the organisation of INRIM was completed and operating principles were implemented. However, since the managing of an institute t´like INRIM is a dynamic process, the Evaluation Committee find it relevant to continue the assessment of operating priciples, which are stated in the Organizational and operating regulations, Art. 3:

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

The overall assessment of the first year of “normal” operation is that the merger is that INRIM emerges from the joining or IEN and IMGC with no negative effects on the performance of the new institute with respect to the added performance its two constituents, despite the invariable disturbances of such a merger and its associated reorganisation. The potential for improving INRIM’s position as the Italian NMI are clear; although still to be exploited. The Committee considers this as a major achievement with contributions from all levels of staff.

1. In order to exploit fully the potential of INRIM it is recommended that the new institute is promoted and take over the combined reputation of IEN and IMGC.

Further, last years report mentioned some major challenges related to the fulfilment of specific point in the Article 3. This year, the Committee suggests addressing these challenges according to the following recommendations:

2. In order to implement the declared effectiveness and flexibility under the constraints that are imposed by external regulation, the Board of Directors should state explicit policies for how to achieve effectiveness and flexibility under the above mentioned constraints

3. In order to acquire capacities in “new” fields of management such as Human Resource management and commercial dissemination of knowledge, the Board of Directors should initiate actions to insure the accessibility of such competencies to INRIM.

4. In order to motivate staff to take up work in a way that reflects the balanced mission of INRIM, a weighted system of personal appraisals could be established.

3 The scientific performance of INRIM

The scientific performance of INRIM in 2007 shows, from a general and qualitative point of view, similar aspects to that of 2006. The following table, based essentially on data contained in 2007 INRIM activity report, summarizes the key numbers of the four Divisions and of the Department as a whole in terms of scientific research products, human resources.

Table 1 Breakdown of scientific production in 2007

Description	E	M	O	T	TOT
Products:					
Papers in international journals with IF	68	15	26	24	**133**
Other papers in journals + books	9	6	4	4	**23**
Communications in conference proceedings	36	34	31	44	**145**
Technical reports (including reports for contracts)	12	15	20	5	**52**
Comm. at international conferences, seminars and meetings	65	19	47	33	**164**
Comm. at national conferences, seminars and meetings	8	17	7	13	**45**
Total	**198**	**106**	**135**	**123**	**562**
Human resources:					
Researchers and technologists (R&T)	32	22	15	12	**81**
Other scientific personnel (O)	17	10.5	6	15	**48.5**
PhD students & similar grants (P)	13	/	8	6	**27**
Technicians	20	21	8	15	**64**
Total (R&T + O + P)	**62**	**32.5**	**29**	**33**	**156.5**

Due to the spectrum of different activity of the INRIM divisions, the number of equivalent TPE (or FTE) dedicated to R&S INRIM activities is given. From tables "Personale impegnato" of the single programme, we get at Department level:

Table 2 Equivalent Human Resources

Department	E	M	O	T	Total
TPE R&S INRIM	**47,0**	**15,8**	**9,0**	**24,8**	**96,6**
TPE R&S Contract	**10,5**	**7,9**	**10,8**	**5,2**	**34,4**
Total	**57,5**	**23,7**	**19,8**	**30,0**	**131,0**

On the basis on these key numbers, as already done in the 2006 evaluation report we evaluated 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 TPE;

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 TPE;

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 TPE;

Indicator c "Presence at international level" defined as the number of communication at international conferences, seminars and meetings per TPE.

Table 3 Indicators of the activity referred to TPE R&S INRIM

Department	E	M	O	T	Mean value
a_1: "Numerousness of the global production"	**4,2**	**6,7**	**15,0**	**5,0**	**7,7**
a_2: "Numerousness of the scientific production"	**2,4**	**3,5**	**6,8**	**2,9**	**3,9**
b_1: "Mean quality of the scientific production"	**1,4**	**1,3**	**1,8**	**1,5**	**1,5**
b_2: "Numerousness of the scientific production at International level"	**1,5**	**1,0**	**2,9**	**1,0**	**1,6**
c: "Presence at international level"	**1,4**	**1,2**	**5,2**	**1,3**	**2,3**

We note that the considerably higher values of the indicators regarding the numerousness of the production for the Optical division is due to the rather high number of TPE R&S Contract adepts; this demonstrate how the (scientific) production is an outcome not only of the R&S INRIM activity but also of the contract activity. For this reason we recalculate table III assuming as adept contributing to the scientific activity both the TPE R&S INRIM and the R&S Contract ones.

Table 4 Indicators of the activity referred to TPE R&S INRIM + Contract

Department	E	M	O	T	Mean Value
a_1: "Numerousness of the global production"	**3,5**	**4,5**	**6,9**	**4,1**	**4,7**
a_2: "Numerousness of the scientific production"	**2,0**	**2,3**	**3,1**	**2,4**	**2,4**
b_1: "Mean quality of the scientific production"	**1,4**	**1,3**	**1,8**	**1,5**	**1,5**
b_2: "Numerousness of the scientific production at International level"	**1,2**	**0,6**	**1,3**	**0,8**	**1,0**
c: "Presence at international level"	**1,1**	**0,8**	**2,4**	**1,1**	**1,3**

On the basis of this table, we underline some aspects that we consider particularly relevant for the INRIM evaluation.

Numerousness of the scientific production: the average score of 4.7 products/year/adept and 2.4 publications/year/adept for indicators a_1 and a_2 shows the Department is rather active, with a good level of global and scientific production; this figure is similar for all divisions, with an higher productivity level for the optical division.

Quality of the scientific production Because many metrology journals of good quality have IF around or slightly larger than 1.5, a good average scientific production should have such IF: this is indeed the average value of the Depart-

ment, similar in all the Divisions (indicator b_1). This indicator must however be seen in association with indicator b_2, (number of publications in international journals with IF per adept): though being quite satisfactory at the Department level, this indicator underlines a weakness of the Mechanics Division, already signalled in the 2006 evaluation report, which should deserve a closer analysis by the Division and by the Department..

Presence at international level We used the number of Communications to International Conferences per adept (indicator c) to monitor this presence, which is extremely important for an Institute that must take part in significant international activities. This figure is adequate at the Department level, with some weakness of the Mechanics division; the presence of the Optic division at International level is considerably higher than that of the other divisions.

Highlights In the 2006 evaluation report as indicator of "highlights" the number of INRIM publications in journals with IF larger than 2.5 were considered; the percentage of such publications was about 11%, a quite large number. For 2007 this figure is slightly larger (about 13% of the total, with a very large fraction with IF higher than 4). As already commented in 2006, this performance shows the existence in the Institute of high quality scientists, of good laboratories and instrumentation and of a good level of resources.

For the 2007 scientific evaluation, a single number based on the IF factor of publications is not considered enough to evaluate the real scientific research "highlights" of a complex Institute as INRIM; moreover the IF reflects the average quality level of publications of a given journal with no link to the relevance of the publication for INRIM mission. Therefore Divisions were asked to indicate a limited number of their research "products" significant indicators of their top-level research. These products are summarized in the table, following the order given by each division.

Table 5 Ranking of research products as stated by the divisions

E	M	O	T
Paper, IF 2.4, progr E4, "A multiscale approach to the analysis of magnetic grid shields and its validation" *Realization, program E2,* "RC digitally assisted quadrature bridge for farad to ohm traceability" *Paper, IF 4, program E1,* "Overdamped Nb/Al-AlOx/Nb Josephson junctions above 4.2K for voltage metrology" *Paper, IF 4, program E7,* "Field driven structural phase transition and sign-switching magnetocaloric effect in Ni–Mn–Sn"	*Paper, IF 2.4, progr M4,* "Frequency uncertainty for optically Femtosecond Laser Frequency Combs" *Realization, program M4/M5(?),* "Hyperspectral imager" *Realization, program M3,* "Development of micro-thrusters for scientific satellites"	*Paper, IF 6.9, progr O1,* "Precision atomic spectroscopy for improved limits on variation of the fine structure constant and local position invariance" *Paper, IF 3.7, program O4,* "Two photon entanglement generation: different Bell states within the linewidth of phase-matching"	*Paper, IF 3.1, progr T5,* "Comparison between the accumulation capacity of four lichen species transplanted to a urban site" *Paper, IF 6.9, progr T3,* "Polarizability of helium and gas metrology"

The table shows some interesting features; first, all the indicated highlights are significant at international level and they are strongly linked to the INRIM mis-

sion both for the today and for the future metrology. In particular the Committee appreciated some extremely important result/realization/paper as the “RC digitally assisted quadrature bridge for farad to ohm traceability”, “Precision atomic spectroscopy for improved limits on variation of the fine structure constant and local position invariance”, “Development of micro-thrusters for scientific satellites”, “Polarizability of helium and gas metrology”. This findings confirm that a large IF is not the only indicator of the importance of a research product: indeed, besides papers published in journals with very large IF, also papers with medium IF and “realizations” of apparatus/instruments are of top interest. Finally, the Committee underline how excellent highlights are present in all divisions among different research programs.

Relevance with regards to main INRIM mission. INRIM has a dual mission, since it is both a research institute in its own right as well as a national metrology institute. Therefore, in evaluating INRIM’s scientific performance, one cannot respect all “products” as motivated entirely from purely science reasons, and *visa versa.* The committee acknowledges that there must be a blance between the two motivations for research; but no attempt ha been made to assess whether INRIM has made an optimal balance.

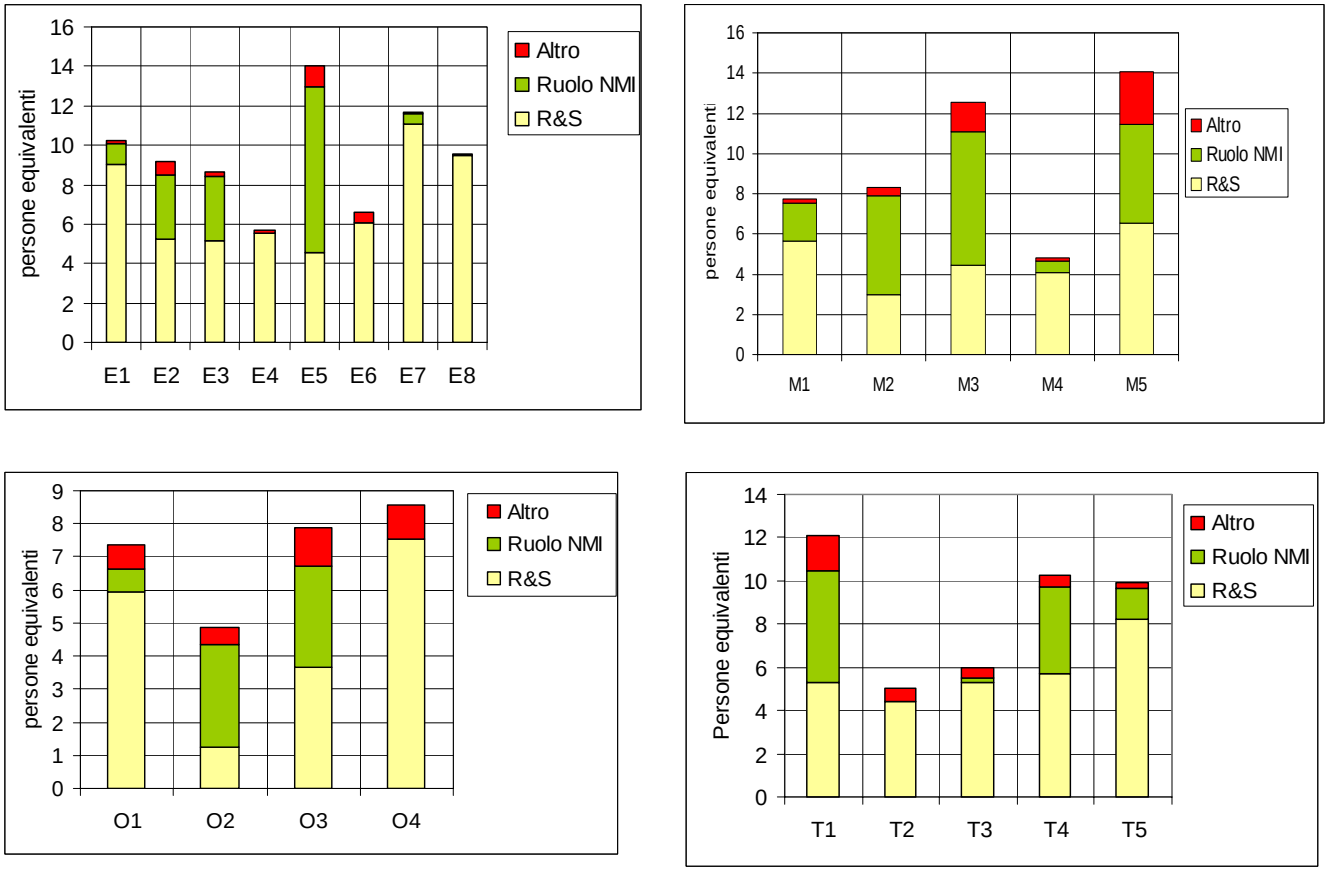

Figure 1 Attribution of persons (full time equivalent) to the programmes of the four divisions of IMRIM

iMERA plus projects The number of approved iMERA plus JRP’s is also considered a complementary indicator of the level of metrological research carried out by the Divisions; however, since these projects are strictly related to the performance of INRIM as a metrological institute, their analysis is reported in the next section.

Concluding remarks and indication of specific actions on scientific performance

Compared to 2006, the Committee appreciated the following positive aspects:

the average quite good level of the scientific production, with points of very high performance, as shown by the above analysis based on significant indicators; the few weakness found has to be addressed by the future actions of the Institute;

the more uniform and well organized presentation of the elements which are important for the scientific performance of the Divisions; without any doubt a relevant advance in the merging of the two original institutes, IEN and IMGC into INRIM was achieved both at Department level and at Division level.

the presence of some transverse activity and of exchange of knowledge and experience among research programs and Divisions, showing a progressive sensibility to the scientific activity of the Institute as a whole;

an open and constructive interaction between the Evaluation Committee and the Department representatives, aimed to a better understanding of the relevant features.

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

1. *a close analysis of the research programs of each division*, with particular reference to the mission of the Institute, taking into account not only the past and present performance, but also the possible evolution in the medium and long term. A particular emphasis to links, synergies with similar programs of other metrological institutes (or, for general research programs, of the other research institutes at the international level) should be given.

2. *a close analysis of the economical and human resources* assigned to each research program should be performed and presented. The description of a large fraction of the results obtained in 2007 ends with a complaint about the insufficient resources. Although this is a natural reaction of the single researchers towards their frustrated expectations, it deserves a critical analysis at the Division and at the Department level, in order to define medium and long term strategies, compatible both with the human resources and with the INRIM role as metrological Institute. This seems very important principally because in the future constant or declining resources will be available.

3. *a clear separation, at the level of Division and of single research program, between the aims, the contents, the results and the perspectives of the activities,* with an order in the presentation which reflects the real priority. The Committee underlines that such a separation is not a pure formatting aspect regarding the preparation of the report, but must be embedded in the future general strategy of the research.

4. INRIM should consider establishing a personal appraisal system that reflects the importance of its work in scientific research.

4 INRIM as National Metrology Institute (NMI)

Italy has two NMIs namely:

National Institute of Metrological Research (INRIM), Turin. INRIM acting as a general purpose NMI with activities in all metrology fields, except ionising radiation

and

Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti (ENEA-INMRI), Rome. ENEA-INMRI is a specialised NMI with activities in only ionising radioation.

Below is described INRIMs role as an NMI, in its role to maintain national measurement standards and disseminate traceable measurements, as well as taking part in international organisations that maintain and develop the SI as a global harmonised measurement system.

4.1 Maintenance and upgrading of national standards

INRIM maintains standards in 9 (out of 10) Subject fields defined by EURAMET:

- Mass and related quantities
- Electricity and magnetism
- Length
- Time and frequency
- Thermometry
- Ionising radiation and radioactivity (This contains the work of ENEA)
- Photometry and Radiometry
- Flow
- Acoustics, ultrasound and vibration
- Amount of substance (also named Metrology in Chemistry)

In order to have an impression of the size of INRIM, one may take the number of declared CMCs in the KCDB appendix C. Here one finds that INRIM is the fourths biggest NMI in Europe, and it is also the fourths most active.

In the following, a quantitative comparison between INRIM and the National Institute of Germany and that of Denmark is given. Before doing so, it is necessary to summarise the metrology organisation in the three countries.

	Germany	Italy	Denmark
Signatory NMI:	Physikalisch-Technische Bundesanstalt (PTB), Braunschweig	National Institute of Metrological Research (INRIM), Turin	Danish Fundamental Metrology Ltd (DFM), Lyngby
Other NMIs and DIs:	Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL), Braunschweig Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin Umweltbundesamt (UBA), Langen	Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti (ENEA-INMRI), Rome	AREPA Test & Calibration (AREPA) Danish Electronics, Light & Acoustics (DELTA) Danish Primary Laboratory of Acoustics (DPLA), Naerum Danish Technological Institute (DTI) (Teknologisk Institut) FORCE Institute (FORCE Technology), Brøndby National Laboratory for Geometrical Metrology (NGM) Research Centre Risoe (DANIAmet-Risoe)

Table 6 institutional organisations of Germany, Italia, and Denmark

	Metrology Area	PTB	INRIM	DFM
AUV	Acoustics, Ultrasound and Vibration	X	X	X
AoS	Amount of Substance	(X)	X	X
EM	Electricity and Magnetism	X	X	(X)
L	Length	X	X	(X)
M	Mass and Related Quantities	X	X	(X)
F	Flow (included in M)	X	X	
PR	Photometry and Radiometry	X	X	X
RI	Ionising Radiation	X		
T	Thermometry	X	X	
TF	Time and Frequency	X	X	

Table 7 Areas of work at PTB, INRIM, and DFM, following the classification of EURAMET. X indicate exclusive activity within an area, whereas (X) indicates that an activity in the country is share between several institutes in the country.

The institutional organisations of metrology in the three countries is summarised in the Appendix A of the Key Comparison Data Base KCDB developed and maintained at the BIPM (www.bipm.org). They are shown in Table 6 and reflect that all countries have a general purpose and coordinating national metrology institute (NMI), which signs the CIPM-MRA on, behalf of the member state. On top of the NMI, countries have designated institutes (DI) that maintain measurement standards and possess metrology capacities in specific fields. In Germany, the designated institutes operate mainly in metrology related to food, chemistry, and environment, whereas in Denmark the seven DIs have a broader but still specific metrology mission. Table 7 indicates the areas of activities of the three NMIs PTB, INRIM, and DFM and it demonstrates that they are not entirely comparable

Appendix B of the comparisons that countries have participated in, classified as “key comparisons” KC that probes the most basic quantities of metrology, and “supplementary comparisons” SC that probes more applied and derived units of quantities. Key Comparisons are arranged globally and have participation from only the best laboratories worldwide, whereas Supplementary Comparisons may be of regional nature to make sure that all NMIs are linked together globally.

Appendix C of the KCDB contains the Calibration Measurement Capabilities CMC that participating NMIs and DIs declare based on their participation in comparisons, as well as their accepted quality system.

Contents of KCDB	PTB	INRIM	DFM
Appendix A	4	2	7
KC & SC Appendix B	430	217	50
CMC Appendix C	1000	465	101

Table 8 Summary of the contents of KCDB for PTB, INRIM and DFM. Numbers for PTB and DFM are somewhat uncertain due to their sharing with DIs.

Table 8 summarises the contributions from the NMIs of Germany, Italy, and Denmark. PTB and INRIM are comprehensive NMIs of big European countries that are supplemented by DIs in one, but different metrology area. On the other hand DFM only represents a fraction of national metrology in a small country and surrounded by substantial efforts from DIs. As opposed to PTB that has the traditional mission of satisfying all metrology needs in Germany, INRIM and DFM cannot, to different degrees, pretend to complete in their coverage of metrology needs in their respective countries.

	KC			**SC**			**CMC**		
	PTB	**INRIM**	**DFM**	**PTB**	**INRIM**	**DFM**	**PTB**	**INRIM**	**DFM**
AUV	20	5	12	1	0	0	76	42	29
AoS	73	8	9	1	1	0	50	10	8
EM	58	36	15	18	10	3	326	201	11
L	21	19	7	29	14	5	94	39	7
M	95	60	4	21	12	1	201	105	7
F									
PR	19	9	0	11	1		66	23	8
RI	98			23			79		
T	12	12		2	2		27	29	
TF	1	1		0	0		25	16	
	397	**150**	**47**	**106**	**40**	**9**	**944**	**465**	**70**

Table 9 The contribution to Appendix B and C of the KCDB from PTB, INRIM and DFM for the 10 metrology areas, defined by EURAMET.

The entries to Appendix B and C of the KCDB for each specific metrology area are shown in Table 9; and from this the following may noticed:

- As one might expect INRIM positions itself in between the biggest NMI of Europe, the PTB, and one of the very small NMIs, DFM. However, in fields such as acoustics and Chemistry, the difference between big and small is rather little. But this is for different reasons.

- In Acoustics, DFM has established a comparatively big effort because of the size of the industry that is related to this subject in Denmark. Whereas INRIMs effort is comparatively small.

- In chemistry, all three NMIs have very limited efforts; but whereas PTB has established a connection with particularly BAM that makes the total German effort very big, Italy and Denmark have no metrology activity outside their NMIs.

4.2 Participation in international organisations

Here, INRIM's participation in the work under the Meter Convention and in EURAMET is described, whereas its participation in other bodies is described in section 5.2.1

CIPM	PTB	INRIM	DFM
CIPM representation	1	1	1
Presidents since 1875	4	1	0
CC participation (current)	10	9	3
CC presidents (current)	0	1	1

Table 10 Participation in CIPM

The Meter Convention is an international treaty organisation, signed in 1875 by 18 states and now encompassing 78 states. It is ruled by the ´18 member Comité International des Poids et Mesures, elected at the quadrennial General conference. CIPM elects its president and operates the BIPM. CIPM currently has 10 Consultative Committees with participation of the leading institutes within the technical fields of the CC. Table 10 summarises the participation in CIPM. PTB and INRIM belong to the group of "big contributors to the Meter Convention that is supposed to be represented at the CIPM, whereas the DFM only occasionally will have this opportunity. The table shows the expected numbers for INRIM and the two other NMIs, given their respective profiles, described above.

EURAMET	PTB	INRIM	DFM
Presidents since 1987	3	0	1
TC participation (current)	12	11	9
TC chairmen (current)	2	1	0
Project participation (current)	126	68	37

Table 11 Participation in EURAMET

EURAMET (founded in 2007) and its predecessor EUROMET (founded in1987) is the European collaboration between NMIs and DIs. It is ruled by a Committee that has representation by all member 33 states and which elects its President. All members have the right of representation in each of the 12 Technical Tommittees TC. Table 11 summarises the participation of INRIM in EURAMET and the two other NMIs. Each TC runs collaboration projects. The table shows the expected behaviour of the three NMIs, perhaps with the exception that Italy has never held the presidency of EURAMET or EUROMET.

4.3 iMERA Plus programme

An interesting development for European NMI's in relation to research took part in the form of the socalled iMERA Plus programme. This is a special ERA Net Plus action within the 7. Framework for research and development. It addresses the need for high level research in metrology as general support to European innovation and competivity.

iMERA is founded on the formulated research programme for metrology, the "EMRP programme", for which FP7 has awarded 21 M€. A call was arragned to address four subject within EMRP, namely:

- Development of the SI
- Metrology for Health
- Electrical Metrology
- Length Metrology (including nanometrology).

Since the selection process followed the standard procedure for FP7, the evaluation of projects was based on only scientific criteria, which makes it an interesting case for assessing the true quality of the research of NMI's.

Altogether, 39 projects were submitted in September 2007, and INRIM was partner in 30 proposals. 21 projects were successful with 17 having INRIM participation, and 4 being lead by INRIM. These numbers demonstrate the high scientific level at INRIM and place it fourth in Europe. Benchmarking with PTB and DFM are given below.

NMI	PTB	INRIM	DFM
Participation in funded 21 iMERA Plus Projects	20	17	4
Coordination of funded 21 iMERA Plus Projects	7	4	0

This demonstrates the very strong position of INRIM, when it is evaluated on scientific terms amongst NMI's

4.4 Overall assessment and recommendations

INRIM fulfils its role as an National Metrology Institute in a way that is fully compatible with is own size and with the size of Italy. It is very well linked into the international network of the Meter Convention and the European regional metrology organisation EURAMET.

However, as an intermediate size INRIM is in the danger of placing itself "between two chairs" and trying to cover two many metrology disciplines without having the necessary resources, instead of focusing on fewer disciplines and exploiting systematically potential appointing Designated Institutes and of in-

ternational coordination that EURAMET provides. It is therefore recommended that:

1. INRIM should consider the situation in Metrology in Chemistry, where Italy appears week and possibly designate one or several DIs.

2. INRIM should systematically review its own portfolio of metrology competences, in order to concentrate more on its strong points and defer to EURAMET partners the disciplines where INRIM competences are sub-critical.

3. INRIM should consider establishing a personal appraisal system that reflects the importance of its work as a national metrology institute.

5 INRIM's 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).

5.1 Dissemination of competence to the companies

Knowledge dissemination to companies was carried out by INRIM Institute with different activities as reported in Table 12.

Table 12– Knowledge transfer – other product applications

Description	2005	2006	2007
Research contract activities	60	40	65
of which new ones	30	15	26
Patents filed in Italy and requests for European patents	2	0	4
Extension of patents abroad	0	2	1
Calibration certificates issued	1651*	1431	1587
Test reports issued	234	188	197
Other certificates and reports issued	16	56	132
CMCs published	409	453	465
Calibration laboratories accredited	170	170	177
Calibration procedures in force	235	228	242
Testing procedures in force	24	30	30

5.1.1 Patents and licenses.

INRIM is not very active in the Patents and licenses field. In the last three years only 6 patents have been granted (among these, three have been extended as European patent) and none of these has been mentioned in the INRIM Highlights 2007, submitted to Evaluation Committee. In particular, the patents granted in 2007 are reported in the following table.

Table 13 Patents granted in 2007 to INRIM divisions

Div.	Typology	Title	Patentees	Notes
E	European Patent	*Method and apparatus for measuring electric currents in conductors*	G. Cavagnolo, O. Bottauscio, G. Crotti, M. Zucca, M. Chiampi Cooperation with Herholdt Controls S.r.l.	Classific. Internaz.: G01R15/18
E	European Expension of National Patent	*Apparatus for the determination of ethanol content in liquid or aeriform substances and corresponding processes*	M. Rocchia, A.M. Rossi, G. Zeppa, L. De Stefano	Dic. 2006
M	National Patent	*method for the determination of the geometric errors in a machine tool or measuring machine*	A. Balsamo e M. Verdi. Cooperation with Hexagon Metrology (Grugliasco, Torino)	Mag.2007
M	European Patent	*Measuring the distance between two satellites with nanometer accuracy,by an interferometer technique.*	S. Cesare, M. Pisani Cooperation with Alenia Spa	Apr. 2007
M	European Patent	*5 degrees of freedom sensor for the control of satellite attitude in formation flying missions based on optical sensors*	S. Cesare, M. Pisani Cooperation with Alenia Spa	Apr. 2007

Also, it is not clear the patents/licenses spin-off for industrial, economic and technologic 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 reports

The reliability of measurement instrument represents a fundamental prerequisite for all quality systems. In particular, all measurements results should be traceable to the SI. The calibration activity in 2007 issued about 1.500 calibration certificates and other metrological services, as reported chart 7. As a consequence, about 60.000 calibration SIT and 120.000 simply traceable certificates were issued.

5.1.3 Accreditation services.

Since the mid-1970'es, 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 about 170 accreditations according to the standard ISO/CEN 17025.

Through accreditation of laboratories, INRIM potentially can disseminate its high technical knowledge to the industrial practitioners of metrology. Although this happens, it appears to happen on a case-by-case and personal basis, and not determined by Institute efforts.

5.1.4 Scientific metrological services

Less than 2% of INRIM total budget (k€ 26.253,4) comes from research activities involving private companies. In particular k€ 567,4 comes from projects and contracts financed by Piedmont Regional Authority for research projects funding, k€ 187,0 for research contracts with EC, k€ 199,1 for research activities submitted to other Public Bodies, k€ 499,3 for research activities involving private companies, k€ 1853,2 for consulting, calibrations, equipment tests and other activities.

Nevertless it is important to underline that in 2007 public and private contract number increased significantly. In 2007 the INRIM drew up 26 new research contracts (in the same year more than 65 research contracts were already activated). Among these, particularly interesting are:

- the numerous IMERA contracts testifying the excellent scientific value of the research units at INRIM;

- the research contracts drawn up with aerospace industry;

- the several contracts drawn up with metrological partners.

5.1.5 Spin-off and technical personnel detachment

No spin-off activities have been carried out in 2005-2007 and no procedures at moment are available at INRIM to promote spin-off activities.

An interesting knowledge transfer procedure is that provided in Italy for the Law n. 196, 24-06-1997, (named “Pacchetto TREU”), considering the public research detachment as a way to re-launch the research activity in PMI. In 2007 the INRIM obtained 2 research units with TREU Law, working in measurement instrumentation construction and calibration companies, but often these do not involve high skill personal.

Generally, the knowledge transfer activity to the companies does not appear to represent a prior activity at INRIM. As a consequence, such activity still depends on the researchers sensitivity instead of being the consequence of the Institute strategy. As a consequence, there is a gap between capabilities and results, in terms of patents and spin-off. In order to reduce this gap it is necessary to set up a policy and take measures able to boost patent activity and application of research activity.

In the evaluators opinion, it should be verified the interconnection between scientific and industrial metrology. In particular:

- all research results could be evaluated in terms of patentability or know-how for innovation;

- a systematic plan for dissemination and marketing should be carried out to improve the number and quality of innovation transfer activities;

- a post–monitoring activity on INRIM knowledge transfers (paying particular attention to the patents) should be carried out in order to evaluate the industrial knowledge transfers effectiveness.

5.2 Dissemination of 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. Details related to the first three activities are given in Table 14.

Table 14 Knowledge transfer – education and training

Description	2005	2006	2007
Graduate courses with INRIM participation	7	9	10
Theses completed during the year (doctorate, level III)	9	8	6
Theses completed during the year (level II)	12	11	11
Theses completed during the year (level I)	17	35	20
Foreign researchers at INRIM (man-months)	27	15	10
INRIM researchers abroad (man-months)	33	50	35
INRIM seminars with internal experts	27	28	15
INRIM seminars with external experts	25	23	29

In particular, the INRIM Institute knowledge transfer methods are:

5.2.1 Participation in the 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 ((see Section 15.3). The participation to metrological and accreditations organisms, beyond other scientific and technical organisms, also represents a particularly qualified and significant activity (see Section 2.5/ 2.6 of INRIM 2007 internal report). In 2007 there were 165 scientific collaborations activated with research bodies and Universities. 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.

5.2.2 Education and Training.

Training constitutes an integral part of the activities of INRIM, as it appears from INRIM Annual Report “chart 8”. It is also noteworthy that “education and training” is one of key elements of INRIM’s vision (see Section 9). The very fruitful relations with different University such as the Polytechnic and University of Turin, Polytechnic of Milan, University Federico II and University of Cassino together with dedication grants for thesis work at INRIM ensures a high concen-

tration of graduate work at INRIM, compared to most national metrology institutes.

In 2007, 20 first level degree thesis, 11 master degree thesis and 6 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 2007 a large number of lessons have been held by lecturers in Universities (32 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, EMITLAS, 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.

All this activities reflects the interesting attitude at INRIM that science is part of our cultural heritage not only a modern non-cultural exercise. This attitude has vanished from most national metrology institutes of today's technocratic world.

5.2.3 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:

i) Guided tours (science day) and multimedial aids for the high school students

ii) 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_07.shtml);

iii) Scientific seminars held at INRIM by both internal scholars and external institutions;

The organization and the participation in scientific congresses and workshops are also notable: 41st IUPAC World Chemistry Congress, 5-11 agosto 2007; V National Congress "Metrologia & Qualità", 14-16 march 2007; XXIV National Congress GMEE, 5-8 September 2007; III National conference of the Gruppo del Colore, 24-26 october 2007; Workshop NanoMetrology 2007 (collaborating with AIRI), INRIM, 14-15 june 2007; Workshop on "Acoustic Determination of the Boltzmann Constant … ", 20-21 sept 2007; Single-Photon Workshop, 25-28 settembre 2007; Laser physics 2007, Leon (MX), workshop 7; 6th Workshop "Proficiency Testing in Analytical Chemistry, …", Roma, 6-7 ottobre 2007; Meeting EUROMET Executive Committee, Torino 21-23 marzo 2007; InTeRSeC 14-15-16 (collaborating with Associazione CMM Club Italia), INRIM, 2007. Another exam-

ple of local initiative linked to European programmes is represented by the INRIM participation to the Torino Time Consortium within Galileo Programme activities.

5.2.4 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, such as the participation to the Legal Governative Committee of MiSE (Comitato Centrale Metrico). INRIM drew up a formal agreement with National Research bodies for health ISS ((National Health Institute) and for environment APAT (Agency for Protection of the Environment). 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. Finally in most of these areas the INRIM is the authority named to measurement traceability.

In 2007 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 APAT and ISS): 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. Furthermore a very interesting in progress activity is represented by the project iMERA about “Metrology at molecular and cellular level in regenerative medicine”, with the aim of increasing INRIM possibilities of involvement in the Regenerative Medicine European Centre of Excellence (a centre that will be set up as part of one of the iMERA Plus projects).

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 Evaluation Report 2006). The INRIM Institute should then organize the knowledge dissemination activities about International System of Units also for such quantities.

The challenges with respect to INRIM's manifold dissemination activities still appears to be:

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

2. INRIM should consider establishing a personal appraisal system that reflects the importance of dissemination.

6 Economic analysis

6.1 Applicable documents

1) INRIM, Relazione consuntiva 2007 (in Italian), approvato dal Consiglio di Amministrazione, 22 Aprile 2008

2)INRIM,' Risultati e dati 2007' (in Italian)

3)INRIM, 'Annual report 2007' (in English), approved by Board of Directors, 22 April 2008.

4) INRIM, 'Electromagnetics Division Report 2007', 'Mechanics Division Results 2007', Hand-outs at Meeting of INRIM Evaluation Committee, 1-3 July 2008.

5) K. Carneiro, E. Canuto, G. Rinaudo, S. Mobilio, M. Dell'Isola "Evaluation of Istituto Nazionale di Ricerca metrologica 2006, Report No. DFM-2008-R08, DFM, 19 June 2008.

6) INRIM 'Spesa totale', E-mail message from E. Procopi, 4 November 2008.

7) INRIM 'Situazione entrate', E-mail message from E. Cortese through Presidenza INRIM, 5 November 2008.

6.2 Content

Economic analysis is twofold.
First Institute-wide economic figures are reported from the 'Annual report 2007' (doc. 3), and compared with similar figures of two European Metrology Institutes, the Danish Fundamental Metrology (DFM) Institute, much smaller than INRIM (DFM staff is less than 10% of INRIM), and, the German PTB, larger than INRIM (INRIM staff is less than 15% of PTB). An economic index as the income-per-staff is derived and compared, which shows INRIM to stay in the middle of the DFM and PTB. 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.
Second, a detailed economic analysis of the Institute Divisions is tried; the aim is to give insight into Division productivity through definition and estimation of an equivalent product as in Table 9. The resulting productivity index in Table 11 must not be kept as absolute but suitable to Division comparison. Income from research projects, contracts and external service activities is then balanced against different cost items showing propensity/restraint in the way of economic production. In this fist trial, general expenses have been excluded from cost items, as well as internal service activities have not been assessed. As a result, restraint to economic production and to procedure therein seems to emerge, which does not contradict the intermediate position of INRIM between DFM and PTB, as suggested from the income-per-staff index.

6.3 Overall assessment and benchmark

6.3.1 Key economic figures

The following Table compares 2007 INRIM income and expenses to DFM and PTB figures. Comparison with INRIM figures in previous years was already reported in the 2006 evaluation document (doc.5) and is not repeated here.

Table 15 Key economic figures for INRI; DFM and PTB for the year 2007

(+) It consists of Ministry (MIUR) funding, referring to permanent and temporaty staff, as well as grants and scholarships.

(++) It includes Regional funding.

(+++) It includes other receipts.

(°) It includes both permanent and temporary staff.

No.	Item	INRIM		DFM		PTB	
		Value [ME]	%	Value [ME]	%	Value [ME]	%
0	**Income**						
0.1	Institutional funding (+)	19,95	80	1,39	62	114,97	86,5
0.2	Research contracts/projects (++)	1,40	6	0,34	15	7,4	5,5
0.3	Income from commercial activities (+++)	3,40	14	0,52	23	10,53	8
0.4	**Total**	**24,76**	**100**	**2,25**	**100**	**132,9**	**100**
1	**Expenses**						
1.1	Personnel costs (°)	15,29	64	1,44	65	74,4	56
1.2	Other operating costs	6,05	27	0,6	27	29,5	22
1.3	Investments/depreciation	2,24	9	0,17	8	29	22
1.4	**Total**	**23,58**	**100**	**2,22**	**100**	**132,9**	**100**
2	Operating result	1,18	5	0,02	1	-	0
3	Accumulated surplus						
3.1	Carried over from previous year	1,50		1,67		NA	
3.2	Surplus of the year	1,18		0,02		NA	
3.3	Carried over to the next year	2,68		1,69		NA	

Remarks

1) For what concerns income, DFM has a higher rate of non-institutional income (close to 40%) compared to a 20% of INRIM and a 15% of PTB.

2) For what concerns expenses, INRIM and DFM percentages look very similar. What emerges is the rather low fraction of INRIM investments (< 10%) com-

pared to PTB (> 20%), which is compensated by a higher labour cost of INRIM. This fact should be deemed as critical to INRIM development both in pure and applied research.

6.3.2 About surplus

At the beginning of 2007 there was an INRIM surplus ('avanzo di amministrazione') of 1,5 MEuros produced by many sources:

1) decrease of estimated expenditures,

2)revenues from research contracts and co-financed projects bounded for some amount to the contracts themselves but not yet specifically bounded to some expenditure order,

3) other resources, for instance services, not yet bounded to some project,

4) differences between income and expenses in the administration and accreditation bodies,

5) personnel variations due to retirement, resignation or recruitment,

6) others.

Among the above mentioned items the most important contribution was due to the remnants after one year of activity of the Regional research projects in 2006. This amount may be estimated roughly as 2/3 of the total budget (see doc. 5), and correspond to 1,1 MEuros which is supposed to have produced, at the end of the second year (2007), a surplus of 0,55 MEuros to be transferred as 'avanzo di amministrazione' to 2008 INRIM budget. The reason of the rough estimates is that expenses of this specific project ensemble occur at a lower rate than expected because of the Region rules to get reimbursements (for the investments only the depreciation is considered and INRIM has to add its own money).

At the end of 2007 the surplus was about 2,68 MEuros mainly due to late time of arrival of the definite Ministry contribution, when it was no longer allowed to fulfill budget variations. The increase of the Ministry contribution was about 1,65 MEuros with respect to the amount temporarily estimated from the previous one. If we ignore this last-time variation the 'net' 2007 surplus reduces to about 1 MEuros, lower than 2006 surplus, and due to Regional projects for the great part. As a matter of fact, in 2007 new short-period Regional projects produced competence receipts for about 0,55 MEuros, to be added to 0,55 MEuros residuals from 2006 triennial projects, thus roughly explaining the net 2007 surplus of 1 MEuros.

All these operations, due to public administration requirements, makes it heavy to separate expenditures of Regional contracts from all the other economic movements. To partly overcome such difficulties, the detailed economic analysis per Division was based on the 2007 invoices and the actual Regional funding in 2007. Of course, neither invoices nor actual funding exactly synchronize with the costs (labour and equipments) of the 2007 activities, though may be kept as a reasonable approximation.

6.3.3 Income-per-staff index

The following Table reports the income-per-staff indices derived from the Table 1 and the permanent staff amount.

Table 16 Key economic indices for INRIM, DFM and PTB

(+) Permanent and temporary staff

No.	Item	INRIM	DFM	PTB
0	Total personnel (+)	224	18	1616
1	Key indices [ME/staff unit]			
1.1	Total income per staff	0.111	0.124	0.082
1.2	Project income per staff	0.006	0.019	0.005
1.3	Commercial income per staff	0.015	0.029	0.007

Remark. As anticipated above, INRIM stays in the middle between DFM and PTB. Note however the commercial index, which doubles PTB, is mainly due to Institutional-like activities, as calibration and laboratory accreditation, which though not diminishing INRIM economic asset yet narrows market propensity. A similar remark was already raised in the past evaluation (doc. 5), and will be restated in the per-Division analysis.

6.4 Assessment per division

The detailed report offered by the 'Relazione consuntiva 2007' (doc 1) allows performing economic assessment of the Institute activities and subdividing them by Division. The assessment, though affected by some uncertainty and arbitrariness as explained below, is believed to be significant as it provides

1) compact productivity figures of the key Institute activities, namely R&D and Calibration and Test (C&T), as they allow comparing the different Divisions, and, correlated with the employed resources, may aid in investigating origin of criticalities and weakness, as well as suggesting improvement in resource acquisition and distribution;

2) balance of income and expenses of the commercial activities and funded projects (collectively named 'granted research' throughout), so as to asses efficiency in the use of resources; unfortunately, missing information prevents their accurate partition among the different kinds of activities, as they are performed with different source and mix of resources;

3) last but not least, the method adopted and deployed hereafter, less uncertainty and arbitrariness, may provide Institute and Divisions a common pathway to improve data collection and exploitation in view of a continuous and uniform monitoring.

Main uncertainty and arbitrariness come from two sources.

1) Though the full time equivalent (FTE) measure is rather detailed in doc. 1, no way is provided for translating FTE into labour cost; to this end, personnel and FTE have been partitioned into three categories, and the average gross labour cost of each category was provided by INRIM administration (doc. 6).

2) Definition of product units is rather direct for Calibration and Test (C&T) activities, but rather arbitrary for internal R&D. As a matter of fact, several product items are listed and quantified in doc. 1, but no way is suggested how to aggregate them into an equivalent R&D product unit. Here a path is suggested and managed in a simple, uniform, though partly arbitrary way. Reduction of arbitrariness can only stem from INRIM strategy.

6.5 Deriving economic elements

The procedure which has been followed, is reported in some detail below.

1) Definition and aggregation of the main activities to be assessed.

2) Aggregation of labour effort per Division and activity.

3) Labour cost estimation.

4) Partition of the overall labour (FTE units) into staff categories.

5) Partition of the activity FTE into labour categories according to some rules.

6) Derivation of costs per activity.

7) Estimation of income and products.

6.5.1 Aggregated activities

As a first step, activities are partitioned into

1) Internal research and development (shortly R&D, R&S INRIM in doc1)

2) Granted research (shortly GR, R&S Contratti in doc. 1)

3) Calibration and test (shortly C&T, Taratura e prove in doc. 1).

The above activities may be defined as ‘production activities’ of the Institute, as they yield outside visible and distributed products.

Minor activities listed in doc. 1 have been merged into the above ones according to the following Table

Table 17 INRIM activity list and merging

No.	To be assessed	From doc. 1 (Italian)	From doc. 3 (English)
1	R&D = Internal R&D	R&S INRIM	INRIM R&D
		Mantenimento	Maintenance
		Gestione e altro	Management
2	GR=Granted R&D	R&S contratti	
3	C&T = Test and calibration	Taratura e prove	Calibration and test
		Supporto al SIT	Accreditation support

Remark: As a first remark, dissemination activities, though detailed in 'Risultati e dati 2007' (doc. 2), are not treated as separate in doc. 1. Separating dissemination and training from R&D may be a suggestion for the future, as they deliver a different product with respect to R&D. As a further remark, minor and service activities, like maintenance, management, … should be referred to as sub-activities of the main activities.

6.5.2 Aggregated labour effort in FTE units

The second step aggregates the labour effort per Division and activity. In doc 1 each activity has been referred to different programmes per Division and, within each programme, to each staff category involved in the programme. Activities have been measured through 'full time equivalent' (FTE) units. In Table 4 the FTE figures of each programme and each staff category have been summed up and referred to the three 'production' activities listed above.

The resulting aggregated FTE per division and activity is reported below; figures are usually rounded off to the third significant figure.

Table 18 Aggregated FTE per activity and per Division. R&D includes related maintenance and management. Comm. includes calibrations, test, and accreditation.

Division	Dedicated FTE per activity in 2007			
	R&D	Granted R&D	Comm.	Department
Electromagnetics (ELM)	57,7	10,2	10,1	**78,0**
Mechanics (MEC)	31,7	8,6	10,0	**50,3**
Optics (OPT)	19,6	11,4	3,3	**34,3**
Thermodynamics (THD)	32,7	5,2	7,7	**45,6**
Department manegement				**5,2**
Department Total	**141,7**	**35,4**	**31,1**	**208,2**
INRIM management				71,4
INRIM Total				279,6

6.5.3 Labour cost estimation

The third step aims to estimate the labour cost, which is subject to some uncertainty. Though more accurate estimates may be derived from other INRIM data, the computational exercise should be kept as significant, being uniform for all divisions and therefore such as not distorting their relative assessment.

First, three different staff categories are separated, namely 1) permanent staff (shortly PS, including fixed–term staff, TD in doc.1), 2) appointed staff (shortly AS, cococo/pro in chart 18 of doc.3) and 3) granted staff (shortly GS) paid through research grants and scholarships. Though total labour expenses and amount for each staff, available in doc. 1 and in the 'Annual report 2007' (doc. 3, from chart 14), might allow some rough estimation (see Table 5), we preferred to retrieve the average gross labour cost per each category from INRIM administration (doc. 6). As a result, costs of the technical operators and of the administrative clerks matched our estimation; the same could not be said of the researchers/technologists cost as they were largely overestimated, because of retirement and delayed fees paid in 2007, not be included in labour and not detailed in the available documents.

The FTE cost of the permanent staff is then computed assuming each staff providing 1 FTE unit. The same applies to the appointed staff. The residual FTE is referred to the granted staff, which is reasonable as they include Ph.D. students which are part-time involved. Table 5 shows the results of the the procedure. The mean permanent staff is computed adding the weighted staff of the three categories. Note such categories correspond to the permanent staff partition which is provided for each Division.

6.5.4 Partition of the overall labour into staff categories

The fourth step is to partition the total FTE of each Division into the above categories. FTE, from doc 2, is accompanied by the employed staff (in brackets) when different.

Table 19 FTE cost computation

(°) Assuming each staff provides 1 FTE to overall Institute activities

(*) Gross labour cost only refers to 2007 activities, having excluded, following doc. 6, retirement ('indennità di anzianità') and delayed fees paid in 2007; as result, 2007 labour amounts to 11893,3 kE less than 13915,3 kE, the figure reported in documents 1 and 3. This leaves some arbitrariness to the calculations; however it is uniform over Divisions.

(++) =Total labour/mean staff=11893.3/181,5

(+) Obtained by splitting the labour costs of 13915,3 kE reported in documents 1 and 3.

	Permanent staff (PS) categories			
	Researchers & technologists	Technical operators	Administrative clerks	Total
Staff amount (°)	97	98	29	224
Gross labour cost [kE] (*)	6353,6	4299,0	1240,7	11893,3
Salary per staff, relative to R&T	1	0.67	0.65	
Weighted mean staff +)				181,5
Per capita labour cost = 1 FTE cost [kE] (our estimates +)	65,50 (80,34)	43,87 (48,21)	42,78 (48,21)	65,50 (++)
Other staff	Appointed staff (AS)	Labour cost [kE]	Grants, scholarships (GS)	Labour cost [kE]
Staff amount	19	478,2	45	605,2
Division FTE	16		36	
1 FTE cost [kE]	25,17		16,8	

Table 20 FTE partition into categories

(+) Research fellows & scholarships figures are rather uncertain and incoherent among the different tables of the applicable documents

(°) See the remark below

	Researchers - FTE (staff)	Technicians - FTE (staff)	Administrative clerks - FTE (staff)	Appointed staff - FTE (staff)	Grants & scholarships (+) –FTE (staff)	Total
ELM	34 (36)	20 (21)	1,5	4	16 (20)	75,5
MEC	23 (24)	21 (22)	0,5	1 (4)	2 (2)	47,5 (°)
OPT	16	8	0,5	1 (2)	6 (11)	31,5
THD	15,5 (16)	15	0,5	4 (6)	8,5 (12)	43,5
Total FTE (staff)	88,5 (92)	64 (66)	3	16	32,5 (45)	198
General services – staff	4+1	32	26			
INRIM staff	97	98	29			

Remark: the rule of computing the granted staff FTE as a remainder does not fit the data of the Mechanics Division, as it would lead to zero FTE. On the other hand, it is clear from doc 1 that 2 (two) research fellows (RF) are full time employed. The balance is obtained by decreasing both research and technical staff by one unit as reported in Table 18. Correction is in view of not increasing labour costs.

Remark: Table 18 shows a 72%=32,5/45% of the granted staff (grants, scholarships, Ph.D. students) activity is dedicated to R&D; one may suppose the remaining 28% is devoted to study and training, which is deemed at the edge of sufficiency. Note however the latter percentage would increase by assuming the granted staff (21 people) were fully dedicated to R&D, leading to about 50% of Ph.D. student activity dedicated to study and training, the value being adequate. But in this case, the granted staff would be deprived of study and training time! The remark must not be taken as conclusive, but management should be concerned with the subject!

6.5.5 Partition of the activity FTE into labour categories

The fifth step is to assign staff categories to activities. Also here there is some arbitrariness due to lack of information. Rules are the following.

1) Calibration and test is assumed to be performed by technicians and administrative clerks, the latter within a limit of 1 FTE; note the same rule was employed in the past INRIM assessment to compare C&T revenues per staff.

2) Granted research (GR) is assumed to be performed as a rule by technicians, the appointed staff and researchers in the same percentage (1/3), but with the prevalence of researchers and possibly by administrative clerks if any.

3) Internal R&D is assumed to be performed by the remainder of all categories except the administrative one.

The result of the rules is shown in the Table below, which is nothing else than an expansion of Table 18

Table 21 Assignment of the FTE per activity to the staff

Division	Staff category	Dedicated FTE per activity in 2007			
		Internal R&D	Granted R&D	Test & calibration + accreditation	Total
ELM	Total	55,0	10,5	10,0	75,5
	Researchers	28,0	4,0	0,0	32,0
	Technicians	8,0	3,0	9,0	20,0
	Administrative	0,0	0,5	1,0	1,5
	Appointed	1,0	3,0	0,0	4,0
	Grant & scholarship	18,0		0,0	18,0
MEC	Total	29,3	8,0	10,2	47,5
	Researchers	18,0	3,0	0,0	21,0
	Technicians	7,8	2,5	9,7	20,0
	Administrative	0,0	0,0	0,5	0,5
	Appointed	1,5	2,5	0,0	4,0
	Grant & scholarship	2,0	0,0	0,0	0,0
OPT	Total	17,5	10,8	3,2	31,5
	Researchers	10,5	4,5	0,0	15,0
	Technicians	1,0	4,3	2,7	8,0
	Administrative	0,0	0,0	0,5	0,5
	Appointed	0,0	2,0	0,0	2,0
	Grant & scholarship	6,0	0,0	0,0	6,0
THD	Total	30,7	5,1	7,7	43,5
	Researchers	10,0	2,0		12,0
	Technicians	6,2	1,6	7,2	15,0
	Administrative			0,5	0,5
	Appointed	4,5	1,5		6,0
	Grant & scholarship	10,0			10,0
Department	Total	132,5	34,4	31,1	198,0
	Researchers	66,5	13,5	0,0	80,0
	Technicians	23,0	11,4	28,6	63,0
	Administrative	0,0	0,5	2,5	3,0
	Appointed	7,0	9,0	0,0	16,0
	Grant & scholarship	36,0	0,0	0,0	34,0

6.5.6 Costs per activity

The sixth step is to compute costs of the different activities, according to the following rules. The cost items are the following:

6.5.7 1) Labour is computed from Table 18 and Partition of the overall labour into staff categories

The fourth step is to partition the total FTE of each Division into the above categories. FTE, from doc 2, is accompanied by the employed staff (in brackets) when different.

Table 19.

2) Travel costs only refer to internal R&D.

3) Equipment costs ('investment'), in absence of other information, are proportionally partitioned to internal and granted R&D according to labour.

4) Consumable costs ('Funzionamento') are proportionally partitioned to all activities according to labour.

5) Equipment mortgage is missing, but is partly included in the equipment cost, since the latter should be spread over future years.

The resulting costs are shown in Table 22.

Table 22 Estimated costs of the different activities

Division	Cost category	Cost per activity in the year 2007 [kE]			
		Internal R&D	Granted R&D	Test & calibration	Total
ELM	Researchers	1834	262	0	2096
	Technicians	351	132	395	878
	Administrative		21	43	64
	Appointed	25	76		101
	Grant & scholarship	302			302
	Total labour	2513	491	438	3441
	Travel	89			89
	Investments	428	82		510
	Consumables	194	37	35	266
	Total	3224	609	473	4306
MEC	Researchers	1179	197		1376
	Technicians	342	110	426	877
	Administrative			21	21
	Appointed	38	63		101
	Grant & scholarship	34			34
	Total labour	1593	369	447	2409
	Travel	56			56
	Investments	290	79		369
	Consumables	152	41	53	246
	Total	2090	490	500	3080
OPT	Researchers	688	295		983
	Technicians	44	189	118	351
	Administrative			21	21
	Appointed		50		50
	Grant & scholarship	101			101
	Total labour	832	534	140	1506
	Travel	61			61
	Investments	251	155		406
	Consumables	62	38	11	112
	Total	1207	727	151	2085
THD	Researchers	655	131		786
	Technicians	272	70	316	658
	Administrative			21	21
	Appointed	113	38		151
	Grant & scholarship	168			168
	Total labour	1208	239	337	1784
	Travel	79			79
	Investments	269	45		314
	Consumables	239	40	60	338
	Total	1716	323	397	2515

6.5.8 Income and products

The last step is to estimate income and product of each activity

1) R&D products: the objective is to cumulate different product as papers, patents, metrology comparisons, prototypes, which are listed and plotted in doc.1. A simple way is suggested, which may seem at first sight arbitrary but hides and suggests a strategy in planning and pursuing an adequate portfolio of product items. Each product item, except prototypes, is assigned a weight, giving advantage to papers published in IF journals. Actually, paper impact factor (IF) is not employed, because, to author's knowledge, no clear metrology is available to convert between IF of different journals and fields. Of course, the same argument may dispute weights, but, as a suggestion, they should be selected in advance as a R&D management objective either by the Department or more accurately by each Division. The following Table lists the R&D products and their 'provisional' weight. The reader should be aware that the Table below is the heart of the present assessment, and though being arbitrary is uniformly applied to all Divisions.

Table 23 R&D product items and weights

No.	Product item	Weight	Comments and suggestions
1	IF journal paper	1	To explore a way for assessing paper quality through IF, authors' total, page size, reviewers' total, foreign researchers
2	Edited Proceedings	2	They should not be kept as books, which might deserve a higher weight, but as a recognition of the editing capability
3	Book chapters and other journals	0,5	To separate book chapters, subject to peer review, from journals, especially from Supplement to Metrologia, the latter being without review
4	Int. Proc. papers	0,3	To assess them through number of revisions, authors' total, page size
5	Int. Communications	0,1	As their total and the relevant labour effort look rather significant (see Table 10), their weight should be carefully defined
6	National Comm.	0	idem as above
7	Technical reports	0	They should be shifted to be contractual products
8	Patents	2	A first distinction should be made between patents stemming from pure and granted R&D, the latter to be shifted to contractual products. A second distinction should refer to registered patents (0,5 weight) and successful patents (2). A finer assessment should pass through patent cost and revenues.
9	Metrology comparisons	1	The weight, provisionally uniform, should separate 'tout-court' comparisons from improvements and from published comparisons (Supplement to Metrologia).
10	Prototypes	NA	Not applicable (NA). To explore a measurement yardstick so as to make applicable: costs, revenues, innovation, …

The resulting weighted sum of the different products as in Table 20, may be kept as an equivalent amount of IF papers. Productivity will be estimated from this amount.

2) Granted R&D: only financial income is considered. Operating results are estimated under two different conditions: a) income only covers equipments, consumables and non permanent staff as in the Regione Piemonte projects (project balance), b) income covers all costs as in industrial contracts (contractual balance). Project balance is applied to Regional and EU projects. Contractual balance is applied to contracts with industry and public bodies. Also in this case, additional data were provided by INRIM administration (doc.7) helping to separate Division income into different categories as reported below.

3) Calibration and test (C&T) is assessed through balance and productivity. C&T product is obtained as the plain sum of calibration certificates and test reports. Also in this case weight might apply.

6.6 Economic analysis

6.6.1 R&D productivity

We start from the product items of each Division as shown in Table 24

Table 24 R&D product items per division

No.	Product item	Weight	ELM	MEC	OPT	THD	INRIM
1	IF journal paper	1	68	15	26	24	133
2	Edited Proceedings	2	0	0	1	0	1
3	Book chapters and other journals	0,5	9	6	3	4	22
4	Int. Proc. papers	0,3	36	34	31	44	145
5	Int. Communications	0,1	65	19	47	33	164
6	National Comm.	0	8	17	7	13	45
7	Technical reports	0	12	15	20	5	52
8	Patents	2	2	3	0	0	5
9	Metrology comparisons	1	4	11	7	19	41
10	Prototypes	NA	NA	NA	NA	NA	NA
11	Weighted total		98	47	50,5	61,5	257

Productivity is computed as the inverse of the unitary cost of the weighted total and indicates the mean total of equivalent products per 1 kEuro. The computation elements and results are in Table 25.

Table 25 R&D productivity

No.	Type	Item	ELM	MEC	OPT	THD	INRIM
1	Elements	R&D cost [kE] =C	3224	2090	1207	1716	8237
2		Weighted product =P	98	47	50,5	61,5	257
3	Results	Unitary cost [kE] =C/P	32,9	44,5	23,9	27,9	32,0
4		Productivity [1/KE] =P/C	0,030	0,022	0,042	0,036	0,031

Assessment:

1) Two Divisions (OPT and THD) show much higher productivity than the Institute average. A third Division (ELM) is close to Institute average. A fourth Division (MEC) looks rather below the average. Which is the reason? The difference appears undisputable, and such to contrast any argument supported by uncertainty and arbitrariness in the weight selection and the adopted rules. The concern should deserve meditation by INRIM management. Incidentally lower productivity applies to larger Divisions.

2) Restricting to MEC Division one reason may be traced back to a lower amount of IF journal papers (15 versus a Division average of 133/4=33). One may also note the very low amount of non permanent staff (12% versus INRIM 28%, see Table 12), and especially of research fellows and Ph.D. students. This subject should be further concern to management, i.e. keeping Ph. D. students and research fellows at a reasonable percentage of the permanent staff (> 20%?). Note however such a reasoning does not fit ELM Division where the percentage of non permanent staff is only slightly lower than OPT and THD. Finding the reason would request an intriguing investigation, likely passing through accurate analysis of the eight ELM programmes. May a further factor be the average age of the researchers? Unfortunately, only Institute-wide data are reported in the applicable documents. As a conclusion, note the Institute-wide percentage of non permanent staff and Ph.D. students is rather significant, through concerns may be issued about their turn-over. Table 12 shows non permanent versus permanent staff (the latter including fixed-term staff) and Ph. D students.

Table 26 Permanent versus non permanent staff

Table 20
(+) The amount is uncertain, but it should be <=2 in any case

No.	Type Item	ELM	MEC	OPT	THD	INRIM
1	Permanent research/technical staff	57(°)	46 (°)	24 (°)	31(°)	158
2	Non permanent staff including PH. D. students- total	24 (30%)	6 (12%)	13 (35%)	18 (37%)	61 (28%)
3	Ph.D. students	11 (14%)	0 (+)	5 (14%)	6 (12%)	22 (10%)

3) Comparison of the unitary R&D cost with other Institute would be very interesting, but is deemed outside the present assessment due to lack of information.

6.6.2 Granted R&D operating result

Obtaining reliable operating results of the granted R&D turned out to be rather difficult 'rebus sic stantibus'. To offer some preliminary insight and considerations, granted R&D have been merged into 'projects' and 'contracts' (see Table 14), and the following definition of contractual and project balance is repeated here

1) Project balance= income less non permanent staff cost, equipments/consumables, and general expenses (not accounted for).

2) Contractual balance= Project balance less permanent staff cost, and general expenses (not accounted for).

Of course, part of non permanent staff and equipments/consumables may have been employed to fulfill contracts, but no rule/data are available to the purpose.

Department-wide funding and accreditation contracts (see Table 14) were kept outside of this analysis.

Table 27 Granted R&D balance [kE]

No.	Type	Item [kE]	ELM	MEC	OPT	THD	INRIM
1	Cost items	Labour cost	491	369	534	239	1633
1bis	PS	Permanent staff	415	306	484	201	1406
1ter	NP	Non permanent staff	76	63	50	38	227
2	EC	Equipments and consumables	119	121	193	84	517
3	Contracts	Contract income	30	163	139	73	405
3bis		Public body contract income	0	61	89	50	200
3ter	CI	Total income	30	224	228	123	605
4	CB	Contractual balance (CI-PS)	-385	-82	-256	-78	-801
5	Projects	Regional funding	224	0	313	0	537
5bis		EU funding	0	0	46	27	73
5ter	PF	Total funding	224	0	359	27	610
6	PB	Project balance (PF-NP-EC)	29	-184	116	-95	-134
7		Total balance (PB+CB)	-356	-266	-140	-173	-935

Assessment:

1) The first impression is that granted research, either project or industrial contract, is actually managed as pure research, i.e. paying meager attention to labour as a direct cost! The same impression, but expressed in other words was already made in past evaluations. Reviewers cannot refrain from issuing some concern about INRIM attitude and endowment in making profit from commercial research, as profit achievement requires strict/persistent time and material control of each cost item. This does not mean INRIM should forcedly equip/endow

in this sense, but INRIM management should be aware, as it may favour projects instead of contracts, or improve contractual conditions and budget.

2) Comparison between Division looks variegated. On the average, as expressed by the total balance (last row in Table 13), OPT and THD show a less negative balance than ELM and MEC (a similar rank emerged from productivity Table 11). On the opposite, separate ranking of project and contract balances show ELM and OPT (mainly stemming from the former IEN) to behave in a similar manner (positive project balance, highly negative contractual balance), which is the opposite to MEC and THD (mainly stemming from the former IMGC), whose contractual balance, only slightly negative, is paired by none or small-budget projects. Were such a ranking due to systematic matters and not just incidental, it would point out a higher propensity by MEC and THD toward contracts than projects, whereas, as already observed, projects, by their nature, seem more adequate to the Institute, as they allow for instance personnel and equipment investments.

3) Highly negative balances would require a justification, which cannot be pursued here. As a general impression, the reported FTE seems rather far from the result of accurate reckoning.

4) Last but not least, a significant effort, kindly supported by the Institute administration, was necessary to built Table 28and to harmonize Division (from doc 1) with the Institute-wide income, as reported in Table 14. Of course, both conform to some criterion, as the Division income just refers to 2007 invoices, whereas the Institute-wide income accounts also for awarded projects as the Regione Piemonte funds. Besides, they look not tuned to the present account, as they do not care of synchronizing income and costs. Would this procedure be of some interest, more appropriate data should be provided.

Table 28 Granted R&D income, Institute-wide [kE]

No.	Contract/project type	From Division accounting (2007 invoices)	From Institute accounting (+)
1	Research projects (Regione Piemonte)	NA (224 °)	567
2	EU projects	NA	73
2bis	Subject to project balance	73 (297)	610 (54%)
3	Public bodies Contracts	NA	200
4	Industrial contracts	NA	405
4bis	Subject to contractual balance	605	605 (46%)
5	Total of assessed activities	678 (902)	1215
6	Organizational activities (iMERA Plus)- Department-wide	NA	115
7	Region contribution	NA	30
8	Laboratory accreditation	NA	44
9	Total	NA	1496
(+) From the Annual report 2007 , NA = not available, not applicable (°) From hand-outs (doc 4)			

6.6.3 Calibration and Test operating result

We remember the costs reported below are free of general expenses. Only consumables are reported: they were disaggregated from a total amount per Division in way proportional to labour.

Table 29 Calibration balance and unitary cost

No.	Type	Item	ELM	MEC	OPT	THD	INRIM
1	Elements	Labour cost [kE]	438	447	151	337	
2		Consumables [kE]	35	53	12	60	
2bis	TC	Total cost [kE]	473	500	163	397	1533
3	IN	Income [kE]	702	462	318	368	1850
4	CE	Certificates [Number]	763	474	310	369	1916
5	Results	Balance [KE]	229	-38	155	-29	317
6	Certificate cost, price and profit	Unitary cost [kE] =TC/CE	0,62	1,05	0,53	1,08	0,80
7		Unitary price [kE] =IN/CE	0,92	0,97	1,03	1,00	0,97
8		Profit (IN-TC)/IN	33%	-8%	49%	-8%	17%

Assessment

1) The balance is positive only in the average and for a pair of Divisions (ELM and OPT). Of course, the resulting balance must be kept with caution due to estimated costs. The impression is that the balance would decrease instead of increasing by pursuing a more accurate accounting. As a matter of fact no general expenses, and no equipment cost have been included neither maintenance, nor research labour. On the other hand support to accreditation has been included. Note C&T has always been considered as a key and profitable activity. Some issues arise about: are C&T procedures sufficiently automated? How costs are computed? Is non-permanent staff employed?

2) Balance and profit look very different by merging Divisions into two groups: OPT and ELM (mainly from the former IEN) show a profit close to 40%, whereas MEC and THD (mainly from the former IMGC) show no profit at all (slightly negative). Which is the reason? Being C&T a prominent and institutional activity, a deep analysis of the serious divergence should be made, and remedies suggested and tried.

2) Comparison of unitary cost and price with foreign institute would be interesting but is not deemed feasible.

6.7 Conclusions and recommendations

1) Data must be coherent and complete throughout all documentation, which may be achieved by endowing the Institute with a unique data base.

2) Only three activities have been considered, namely internal R&D, granted R&D and Calibration and Test. Dissemination should be considered as a further independent activity, not to be included with R&D.

3) Divisions show levels of R&D productivity, which are significantly different. A very preliminary correlation with the deployed resources seems indicating scarcity of non permanent staff (especially Ph.D. students) among the causes of a lower productivity, especially in the regards of IF papers. As a matter of fact, although not mature, Ph. D. students and research fellows should be the most aggressive in research and publishing. A recommendation to carefully plan their acquisition and involvement is raised. A further recommendation is to carefully design their activity plan so as to allow sufficient study and training time.

4) R&D productivity has been estimated by defining an average product by weighting R&D items of different sort. Weight, here provisional, should reflect management directions and strategy. A recommendation to better understand and investigate the subject is raised.

5) Labour, cost and income data are still incomplete and incoherent to achieve a significant assessment of granted R&D. The first impression, though the overall income seems equally partitioned between contracts and projects, is that both of them are just conducted as pure research or in the limit a research project, i.e. not considering labour as a cost item, since not funded. Recommendation to investigate the subject and provide more significant data is raised.

6) Calibration and test activity shows a positive balance (in absence of general expenses), but a more accurate accounting should be applied to reinforce such result.

7) Last but not least, economic/production analysis, made on a basis of adequate indices - strictly related to management strategy - may dissect virtues and inefficiencies of human activities, and indicate cures and recovery ways. INRIM management is recommended to proceed along the exposed line, possibly refining it.

8) INRIM should consider establishing a personal appraisal system that reflects the importance of all staff to contributing to the fund raising.