3. Institutional development plan for the next 4 years (2012-2015)

The 2012-2015 timeframe covered by this development plan corresponds to the second half of the *medium term strategy of IMT (2009-2015), as revised in October 2009*[1]. There are no essential changes to this officially submitted strategy (to ANCS), although the present SWOT analysis shows that some weaknesses are less stringent, whereas the threats (arising from the economical and financial situation in Romania and Europe) are raising more uncertainties. Whereas the direction of evolution will remain the same, a better management of resources is needed. It is our belief that the flexibility and adaptability of the institute will continue secure a healthy pathway, while the opinion of experts conducting this evaluation will be essential. Certainly, the plan put forward here will be revised after the evaluation.

The plan reflects the ambition of IMT to play a distinct role at the national and regional scale. Once its performance in research is clearly recognized by the presence in numerous European projects, IMT is moving to a more aggressive strategy related to the so-called "knowledge triangle": not only research, but also education and innovation

The sketch of the plan (as indicated in the model) is essentially related to the development of the *tangible and intangible assets* of the institute. It will be worthwhile, however, to underline the mutual interaction between the development of these assets (e.g. between human resources and infrastructure; between human and financial resources, respectively; between financial resources and infrastructure).

3.1 Scientific SWOT analysis

Basically, the SWOT analysis from the medium-term strategy (quoted above) is still valid. Some of the weak points identified there have been *counteracted* in the meantime (e.g. through the success of the CENASIC structural-funds project proposal), whereas the threats have been *amplified* by the economic and financial crisis. The output of the SWOT analysis should guide the development plan.

Strengths

- Domain and topics of advanced research strongly connected with Key Enabling Technologies (KET) - see details in the next section.
- Participation to a large number of European projects[2] (11 projects in FP7, 4 in ENIAC/PPP in nanoelectronics, 5 in the ERA-NET scheme etc.), augmenting the experience and credibility of the organization.
- A European Centre of Excellence (financed by the EC, 2008-2011), devoted to RF MEMS and MOEMS. This IMT centre is also involved in an Associate European Laboratory (LEA), called Smart MEMS, with CNRS-France.
- A unique European centre for carbon-based nanomaterials, which is under development (CENASIC project, financed from structural funding)[3].
- A number of experienced researchers with high international visibility, part of them with substantial expertise and achievements in foreign academia.
- A large number of scientific cooperation links with dozens of external partners co-participating in consortia of various European projects.
- Partnerships with multinational companies and academic entities from Romania.
- An advanced facility with a broad range of state-of-the-art equipment, constituting *a technological platform* (for micro- and nanotechnologies).

[1] Please see: http://www.imt.ro/evaluation2011/IMT-Medium-term-strategy-2009-2015-English-translation-A1.pdf
[2] For details, please see: http://www.imt.ro/evaluation2011/IMT-and-European-cooperation-A3.pdf
[3] An article related to CENASIC from the latest Science & Tech. magazine can be seen here: http://www.imt.ro/evaluation2011/IMT-SciTech-referring-article-Dec-2011-A12.pdf

- A specialized infrastructure for providing scientific and technological *services*: *IMT centre for MIcro- and NANOFABrication* (IMT-MINAFAB[4]), unique in the new Member States (EU). This centre is ISO 9001:2008 certified.
- Infrastructures for technological transfer and innovation (MINATECH-RO: Scientific and technological park for micro-and nanotechnologies[5], http://www.minatech.ro; CTT-Baneasa: Technology transfer centre in micro-engineering[6], http://www.imt.ro/ctt).
- A performing ITC system, with an experienced team.
- Experience and continuous activities in multidisciplinary education (undergraduate and postgraduate – in cooperation with universities) and training[7] (including Eurotraining) and IMT's own programme for postdoctoral studies (training by research).
- Stability of human resources and steady increase in the number of experienced research personnel, with specific competences related to certain key topics in EU Programmes.
- Relatively high cohesion and integration of scientific targets among laboratories (research teams).

Weaknesses

- Human resources are still insufficient, especially on the lower-end and higher-end of scientific specialization.
- The quality of scientific results varies greatly from one research team to another.
- A relatively low number of national patents and no international patents (especially due to large costs not covered by projects).
- Low level of technological transfer and just one spin-off company.
- Low level of interaction with the local industry, with the exception of a couple of multinationals.

Opportunities

- Redefining the research and innovation in Europe (i.e. by underlining the key emerging technologies and their interaction) may create a favorable context for R&D institutes with high-tech capabilities.
- International companies active in Romania have a potential interest in developing R&D activities in cooperation with local research and education organizations. Particular emphasis on the recently initiated cluster related to the automotive industry.
- The results of the recently concluded prospective study related to nanotechnologies in Romania (NANOPROSPECT)[8], once taken into account, have the potential to facilitate the development of R&D organizations active in this field through more focused interactions and joint projects with the local industry.
- Exploiting the potential interest of emerging countries, with rapid development in industry and science, for cooperation in (providing access to) micro-nanotechnologies.

Threats

- The long time of penetration of new technologies in industry (including the low level of proactive efforts of innovative SMEs).
- Lower level of private funding for research, and possible aggravation of this situation due to global crisis.
- Stronger competition anticipated in the accessing of EU funds, due to lower level of funding at the national level (direct effect of the financial crisis in the EU).

[4] For details, please see: http://www.imt.ro/evaluation2011/IMT-MINAFAB-General-description-A2.pdf
[5] For details, please see: http://www.imt.ro/evaluation2011/IMT-MINATECH-RO-A8.pdf
[6] For details, please see: http://www.imt.ro/evaluation2011/IMT-CTT-Baneasa-A8.pdf
[7] For details, please see: http://www.imt.ro/evaluation2011/IMT-Education-activities-A4.pdf
[8] An article that refers also the NANOPROSPECT project from the latest Science & Tech. magazine can be seen here: http://www.imt.ro/evaluation2011/IMT-SciTech-referring-article-Dec-2011-A11.pdf

- Lack of restructuring of national funding in research, lack of thematic focus in general priorities, uncertainty related to public spending.

3.2 Strategic scientific objectives and directions

Strategic objectives of the institute for the period 2009-2015 as stated in the "medium-term strategy" of the institute from October 2009[9] are reiterated here. In fact, the achievements in the last two years, including the financing from structural funding of a new centre of research, confirmed the fact that *the institute is well on track following the above strategy*. On the other hand, the launch of European "*Horizon 2020*" is *confirming the interest for the key concepts of the IMT's strategy*, such as convergent technologies, open innovation or knowledge triangle. Some details from the recently launched documents are provided below.

On 30th of November 2011, the main documents of the new programme "*Horizon 2020*" (2014-2020) have been luanched by the European Commission. This is not just a new Framework Programme for Research and development, but *a joint programme for Research and Innovation*. Horizon 2020 brings together all existing EU research and innovation funding schemes, including the Framework Programme for Research, the innovation-related activities of the Competitiveness and Innovation Framework Programme and the European Institute of Innovation and Technology (EIT). The total budget will be 80 billion euro. The basic challenge is the integration of research and innovation "by providing seamless and coherent funding from idea to market". Behind this there is the idea that *Europe must regain its potential for production*, based on the existing market and IP.

As far as *technological focus* is concerned, the programme intends to "build *leadership in enabling and industrial technologies*, with dedicated support for ICT, nanotechnologies, advanced materials, biotechnology, advanced manufacturing and processing, and space, while also providing support for […] combining several Key Enabling Technologies". The targets are related to *societal challenges*, which are: Health, demographic change and well-being; Food security, sustainable agriculture, marine and maritime research and the bio-economy; Secure, clean and efficient energy; Smart, green and integrated transport; Climate action, resource efficiency and raw materials; Inclusive, innovative and secure societies. The overall goal is sustainable development, whereas the role of science and technology will increase in this time of economical and financial crisis, providing a better chance for sustainable recovery.

The IMT strategy should be also related to the National Reform Programme of Romania (2011-2013), as well as to the findings of the "Prospective study for nanotechnologies in Romania" (NANOPROSPECT, 2010-2011), as shown below.

Confirming IMT mission. On medium and long term, the institute intends to consolidate its role of **technological pole in the domain of micro-nanotechnologies and convergent technologies**. During the last years, its interaction with foreign companies, as well as with SME's and multi-nationals acting in Romania has increased. The educational activities are much better developed. IMT is visible at the national level, but it also intends to play a role *at regional scale* and become a partner in the recently initiated system of European technological centres. A hidden aspect is, for example, the undeclared competition between Romania and Poland, with both countries exploiting the valuable human resources and making substantial investments in equipments. Our country may gain, however, an advantage from initiatives such as a national strategy or more efficient infrastructures, whereas Poland has been more active with spin-off and start-up companies.

The strategic objectives of the institute on medium term (representing the implementation of the IMT "mission") are unchanged (since October 2009): The institute will extend its visibility and international cooperation as a **centre of excellence** in research and development related to the **integration/convergence of technologies** (micro-nano-

[9] Please see: http://www.imt.ro/evaluation2011/IMT-Medium-term-strategy-2009-2015-English-translation-A1.pdf

biotechnologies) and their applications in various domains. Emphasis will be put on the study and implementation of technologies for modeling, obtaining, processing and integrating in advanced systems of nanomaterials and nanostructures with special properties (with a particular emphasis on carbon-based nanomaterials).

a. The institute will consolidate the technical offer based on its clean room facilities, equipments and computational techniques, by providing a **platform for interaction of the Romanian research in micro-nanotechnologies with the industry and the academic environment**. Through the activities carried out so far, IMT has a unique position at national level; these activities will be developed and strengthened. ***The main instrument is the Centre for Micro- and Nanofabrication IMT-MINAFAB***, which offers a wide range of scientific, technological, computing and testing facilities.

b. In order to increase the degree of application of research results, **the institute will form a "cluster" of organisations oriented towards technological development and commercialization of activities**. The main instrument will be the existing infrastructure for technology transfer and innovation. Pragmatic but well organized procedures will be used in order to identify the technological needs of internal and external beneficiaries, while also allocating internal resources to attract the beneficiaries into collaboration and delivery of technological services. An extremely important direction of IMT activity should be patenting (especially abroad) and exploitation of patents in cooperation with industry.

The current and future research directions of the institute are listed below:

A. Development of nanoelectronics, photonic and microwave components

- Developing new techniques for micro/nanofabrication of components and microsystems using silicon technology and wide band gap semiconductors (GaN, AlN), as well as dielectric materials, polymers, carbon-based materials, ceramics and piezoelectric materials.
- Development of new techniques for design/simulation and characterization of materials, micro/nano-structures and systems.
- New concepts and structures of devices (nano-electronics, photonics, microwave) and Microsystems (Optical MEMS, RF-MEMS)

B. Advanced materials

- New *nanostructured materials* (semiconductors, organic, hybrid - organic / inorganic) *with controllable properties, new functionalities* and improved performance, without a negative impact on health and environment.
- Synthesis and processing of materials with special electronic, mechanical and thermal properties, used as substrates for advanced micro-nanosystems. Focus on graphene, silicon carbide, nanocrystalline diamond.
- Advanced materials and biomaterials for the improvement of the quality of life: nanomaterials, biomaterials and hybrid materials.
- Micro and nanocomposites for constructions, industrial applications, transport.
- Development of *advanced techniques for nanomaterials and nanostructures characterization.*

C. Development of new technologies

- Development of new conventional and unconventional technologies for fabrication (including "soft lithography", replication technologies) to obtain cheap products in large quantities.
- Technologies for structuring and integration of carbon-based materials.
- Micro-and nanomechanics, unconventional technologies in high precision mechanics.

- Development of technologies for the heterogeneous integration of microstructures and systems and assembly/micro-assembly techniques, quick assembly.

D. Integration and convergence of technologies

- Integration of micro-and nanotechnologies and development of a set of mixed technologies (example: microfluidics/ICT/micro-nano, bio/ICT/micro-nano, chemo-bio/ICT/micro-nano, RF MEMS/NEMS).
- Nano-bio-technologies: computer-based analysis and experimental studies of nano-bio interaction; combining nano-chemistry with nano-biology, microfluidics, with the aim to obtain biosensors and biochips.

With the completion (in 2013) of the *Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials (CENASIC)* the research directions for IMT will be consolidated with the following stated priorities: (1) Processes for *silicon carbide* based micro- and nanostructures; (2) Technologies for *graphene* and hybrid micro- and nano-electromechanical systems; (3) Technologies for *nanocrystalline diamond* and applications in MEMS/NEMS and precision mechanics.

The above variety of topics (reproduced from the existing strategy) is related to the following two major directions:

A first major direction corresponds to the "Information and Communication Technology" (or Information Society Technologies) priority 1 of PN II, research area 1.7 (nanoelectronics, photonics, micro-and nanosystems). The "micro-nano" theme in PNCDI II (PN II) is closely correlated with corresponding theme/priority 3 (ICT) in FP7. In this direction, IMT has reached a certain level of maturity and performance, confirmed recently by winning the MIMOMES project, which finances an European centre of excellence in "*RF and opto MEMS*", as well as to many other FP7 and PPP projects.

A second major direction, which will correspond to *an important extension of IMT activity* corresponds to the priority "Materials, processes and innovative products" in PN II, in the broader context created by the theme/priority 4 (NMP) in FP7. In the frame of "materials, processes and innovative products" priority, the products and technologies are addressed mainly to industries, but also to the areas (priorities): health, environment, agriculture, food safety and security (as in FP7).

We will briefly mention below **how attractive these orientations are in view of "Horizon 2020"**. We are quoting here a fragment showing relevant matching with our stated strategies : "*A major component of 'Leadership in Enabling and Industrial Technologies' are Key Enabling Technologies (KETs), defined as micro- and nanoelectronics, photonics, nanotechnology, biotechnology, advanced materials and advanced manufacturing systems. Many innovative products incorporate several of these technologies simultaneously, as single or integrated parts. While each technology offers technological innovation, the accumulated benefit from combining a number of enabling technologies can also lead to technological leaps*".

Going to details of "Horizon 2020", we are stressing that **Information and Communication Technologies (ICT)** priority includes *direction 1.1.1. A new generation of components and systems: engineering of advanced and smart embedded components and systems, with* micro-nano-bio systems and smart integrated systems, and direction *1.1.6. Micro- and nanoelectronics and photonics*. We are also mentioning "*ICT-specific research infrastructures* such as living labs *for large-scale experimentation* and *infrastructures for underlying key enabling technologies* and their integration in advanced products and innovative smart systems, including equipment, tools, support services, clean rooms and access to foundries for prototyping". This perspective is of upmost interest for IMT, which aims at integrating its infrastructure in an European system.

As far as **Nanotechnologies** are concerned, IMT is interested in the following directions of "Horizon 2020": *1.2.1. Developing next generation nanomaterials, nanodevices and nanosystems***;** *1.2.2. Ensuring the safe development and application of nanotechnologies* **(**providing validated

scientific tools and platforms for hazard, exposure and risk assessment and management) and *1.2.4. Efficient synthesis and manufacturing of nanomaterials, components and systems.*

Development of applications (for components, micro/nanosystems, materials and technologies) will be crucial for the institute. The strategy selects the following:

- Application of nanostructured materials and nanotechnologies **in traditional industries** and constructions in order to improve product quality and functionality;
- **Energy harvesting and conversion** systems at the nanoscale;
- Transducers, sensors, microgrippers based on new materials and technologies;
- Integration of smart micro/nano systems (sensors, actuators, control systems, mechanical structures) and development of **industrial applications, as well as applications in transport;**
- Micro/nanostructures and systems for **communications;**
- Micro-nanosystems for **biomedical applications** (prevention, diagnostic and treatment);
- Sensors and micro/nanosystems for environmental and **food quality** monitoring.

The involvement of industry is essential for successful developments in applied research. IMT is close to industry (Infineon Technologies, Thales etc.) in European projects, especially in ENIAC–JU (Public Private Partnership), devoted to nanoelectronics. The cooperation with local industry is less substantial. While waiting for a new national orientation in research and innovation (following the EU concepts), for the moment we can only mention the National Reform Programme (2011-2013), because ICT, energy, automotive industry are considered of strategic importance. At this date, the results of "*Nanotechnologies in Romania: a prospective study* (NANOPROSPECT)" are still to be taken into account by authorities; this study is evaluating the potential in the field and is recommending priorities such as nanoelectronics, energy and health.

Note. While following closely the developments at the European level, IMT is also participating (through its representatives) at the foresight processes organized by the Commission in paving the way for new fields of R&D such as graphene flagship, regulatory testing for nanomaterials, computer-aided modelling at the atomic and molecular scale.

Organizational aspects

The strategy that IMT put forward in 2008 and consolidated in 2009 was suggesting a number of concepts in order to make research more efficient. These will be reviewed below, in order to size their importance for the development plan.

- First, there was the idea of creating the so-called **open experimental laboratories**. This concept describes one important equipment or group of equipments with certain functionality, providing a number of scientific and/or technological services. This is not an entity within the organizational diagram, but a functional resource. The equipments in an experimental laboratory are usually operated by one or several researchers or development engineers and the facility is *open* to all users, either from IMT or from other organizations. This was a solution to the fact that the experimental infrastructure of IMT was developed rapidly (2006-2009) - as a result of a high number of projects proposed by individual researchers - whereas it should be managed at the level of the institute (see also below the section dedicated to "human resources"). The concept was really successful, and a large number of experimental laboratories become visible within the centre of services IMT-MINAFAB. For the following period of four years this concept will be reinforced with the consolidation of existing laboratories (increasing the responsibilities of people in charge) and the creation of new ones. The IMT-MINAFAB will incorporate all these laboratories, including them in the ISO quality system.

At this moment we will stress again the importance of IMT-MINAFAB, as an equivalent to the experimental facilities for micro- and nanotechnologies existing in prestigious universities and R&D institutes abroad. There are *two key features*: from the technical point of view, it provides a *clean-room type environment* for costly and demanding equipments. Secondly, the facility is an *"open centre"* providing interaction between various groups of researchers, as well as support for innovation and for educational activities.

- Secondly, it was the idea of creating **clusters** of various projects related to a certain field, facilitating interaction between research teams in IMT, with the purpose of focusing and better exploiting existing resources. The implementation of this idea was in a certain sense jeopardized by the dramatic cut in financing of the national programmes (since 2009), with no new calls for projects and financial shrinking of the existing projects. Despite these difficulties, the concept was implemented to some degree by creating new laboratories or rethinking the orientation of others. Moreover, at the end of 2010, a new structure of the R&D department allowed regrouping of laboratories in a number of so-called "centres of research". The next four years (2012-2015) must show the potential of all these centres, which exhibit today various degrees of maturity and efficiency.
- The 2008 strategy was also suggesting creation of "**technological platforms**" (in a restricted sense; not to be related to European Technological Platforms), i.e. creating or regrouping resources dedicated to certain means of micro-nanofabrication (expertise, equipments, processes, technologies). The interest was present within certain laboratories, but not at the scale of the whole institute, because there was no motivation related to a specific industrial demand. Following this concept, however, *a new laboratory* ("L10", focusing on micro- and nanofluidics) was created with the support of structural funding for competitivity (POS-CCE). The idea of creating dedicated platforms will continue to be pursued. Anticipating or responding to industrial needs and benefitting from the organizational resources of the MINAFAB facility, the aggregation of resources under the "flagship" of technological platforms will deserve a special attention.

3.3 The human resource strategy

The strategy related to human resources will continue to be the cornerstone of the overall strategy of the institute. IMT still needs a continuous increase in the number and quality of researchers, while other categories of personnel are also necessary.

The essential means for attracting and maintaining competent research personnel (including Romanian researchers with foreign experience) are:

a) the dynamics and the informed flexibility of strategic research directions;
b) quality, diversity and operational state of the experimental infrastructure;
c) attractive working conditions, including attractive salaries;
d) opportunities for professional growth and development such as usage of advanced experimental instruments, collaboration with international consortia in high-level projects, Ph.D. and postdoctoral activities, participation in conferences, external educational activities etc.
e) promotion to higher levels of professional status.

Note. With respect to the last point we would like to stress the full success (December 2011) of the promotion of IMT researchers to the highest levels of professional status (CS I, CS II), according to the most demanding standards set up recently by the Ministry of Education, Research, Sports and Youth.

The above opportunities have been previously recognized and should be preserved. Annual evaluation and specialized training are becoming common practice.

A new approach is the planned action for the habilitation of a number of outstanding researchers as supervisors of Ph.D. studies in cooperation with the University “Politehnica” of Bucharest and even a doctoral school within IMT.

Special attention will be given to attracting *graduates* with high enthusiasm for scientific research. In this strategy there is also an intention to promote the "short/mid-term internship" offers, relying on the special opportunity provided by the advanced experimental infrastructure and its specialized personnel. The institute will also be open to an exchange of personnel with the industry, depending on the interest shown (such as by Infineon Technologies Romania).

Regarding the *technical support personnel*, the next four years will bring the need for a partial turnover and corresponding specialized training of newly arrived replacement technicians and engineers by the existing staff. Most of the current personnel are highly specialized (former members of the Bucharest electronics industrial platform), but some are approaching retirement. Especially for the equipments in the newly -or near-future- commissioned clean room spaces that have critical requirements (such as storage, manipulation and transport of special process gases), the quality and stability of the support personnel will be the essential priority in the turnover process.

Interaction between the policies related to human resources and the financial policy. The autonomy and responsibility of the individual researchers are part of the organizational culture (see also section 3.4 hereafter), and represent the connection point of these policies. The researchers are free to have the initiative in elaborating proposals for any kind of project calls, to set up a group (an *ad-hoc* research team) by attracting any specialist within the institute. Once a proposal is successful, the researcher in charge remains in control of funding. Overall, the researchers are stimulated to acquire new sources of funding and this results in contributions to the budget of the institute.

Interaction between the policy related to human resources and the strategy related to infrastructure. It is widely recognized that a high-quality infrastructure is essential for attracting and maintaining experienced researchers. However, the investments in infrastructure are useless in the absence of adequate human resources able to operate and exploit the equipments, apparatus and specialized software. The sophisticated and computerized state-of-the-art equipments are requiring motivated and skilled personnel from different domains. There are *several key points in the policy* which will be maintained and developed within the institute: first, these equipments will be - as a rule - operated by *researchers*; secondly, access to equipments will be granted to *any researcher of the institute* (that is, not restricted to one research team). To make this approach realistic, the specialist in charge of an equipment in high demand will receive a special *stimulus*; also, he may be aided by an adequately trained colleague. The operation of almost all equipments is currently included in the *ISO system of quality* existing in IMT-MINAFAB.

Differences between the performances of different research groups. If a research team does not perform in satisfactory parameters for periods longer than 3 years, a restructuring need is raised. Each time a change becomes necessary, the detailed structure of the R&D department can be modified. A new generation of young and rapidly promoted researchers (with the experience of Western academic and private organizations) may become soon a factor for change.

3.4 Mechanisms of stimulating the appearance of new research directions

The general momentum is decided by the strategic orientation of IMT towards the micro-nanotechnologies field, continuously focused by the orientation of European research.

Research teams and individual researchers have been stimulated to open and address new research directions and to exploit their assessed potential through the following management policies:

- constantly facilitating broad interaction with academic partners and companies within various European consortia (FP7, PPP, ERA-NET, Flagships projects such *Graphene* and *Guardian angels* etc.), as well as bilateral international cooperation;
- actively facilitating visits and workshops for exchange of information;
- participation to various brokerage events;
- participation to the activities organized by the European Technologies Platforms in particular (including development of their strategies);
- granting and encouraging free initiative of IMT researchers in approaching national and European calls for research grants, in particular the calls from the "Ideas" programmes;
- promoting access to scientific literature, as well as to internal reports;
- promoting and maintaining, as much as possible, close connections with the industrial environment (multinationals, SMEs);
- fostering priority partnerships with leading academic institutions and research groups in Romania and abroad;
- effecting organizational mechanisms, such as the flexible creation of new research labs and/or departmental centers, according to the evolution of external/internal scientific targets and knowledge.

These mechanisms will be further endorsed and additional activities will consist of:

- promoting best practices in information exchange and dissemination;
- strengthening the internal practice of regular inter-team seminars for information/result exchanges and knowledge/news transfers;
- introducing a new practice of conducting bilateral meetings with multi-national companies and academic partners, devoted to brain-storming for creating a common agenda.

3.5 Financial SWOT analysis

Strengths

- Strong participation in European projects (both FP7, and other financial schemes).
- Substantial financing from structural funding.
- The scientific personnel are stimulated to apply for a variety of R&D funding opportunities.
- An efficient management team, skilled personnel for economic operations, and specialized software packages.

Weaknesses

- Low input attracted from the business sector.
- High costs associated with the operation of the technological infrastructure.
- Cash-flow difficulties, especially at the beginning of the year.

Opportunities

- Possible financing for infrastructures of national interest and/or financing of the services for SMEs (the newly introduced innovation-voucher system).
- Expected increase of correlation in the financing policy for research and innovation at the national level.
- New schemes of financing in the European Union, through the "Horizon 2020" programme.
- Possible advantages from the upcoming institutional funding.

Threats

- Lack of financing stability and predictability within national programmes.
- Unpredictable delays in financing (reimbursements) from structural funding, due to lengthy and unstable bureaucratic procedures and not only.
- World economic and financial crisis and associated budget cuts at the national level.

3.6 Infrastructure: investment plan and strategy

Latest investment achievements. Due to the special demands required by R&D in micro- and nanotechnologies (MNT), constant and coordinated investments in the experimental infrastructure have represented a main priority of IMT's strategy. As a technological institute, IMT has recognized early in its development that in order to become an important international actor it must pay special attention to ensuring *competitive operational facilities* and *associated expertise* for a wide range of experimental platforms. As mentioned in the "Self-assessment report for the previous 4 years", this objective has been achieved through a steep investment program based on revenues from national and international projects: more than 7M euro in the 2006-2009 interval, and another 1M+ euro in 2010-2011, were spent for equipments and support infrastructure[10].

These investments allowed the institute to officially launch in April 2009 a renewed, state-of-the-art and open facility represented by the IMT-centre for MIcro-NANOFABrication[11] (IMT-MINAFAB, www.imt.ro/MINAFAB). IMT-MINAFAB operates several clean-room areas and specialized laboratories - totaling a surface of almost 700 sqm. - and modern equipments worth more than 8M euro; some of them are unique at national and regional level. The centre was certified according to SR EN ISO 9001:2008 in June 2011 by TÜV Thüringen e.V. IMT-MINAFAB accommodates one of the three class 1.000 clean rooms currently running in Romania, and represents the sole concentration of spaces with high purity air at the national level. This aggressive investment program has enabled IMT to radically extend its R&D capabilities, leading to participation in more demanding international projects (FP7, ENIAC) and to new contacts and collaborations with multinational companies operating in Romania (Honeywell, Infineon, Renault) and international partners.

Investment strategy and term planning. The strategy for investments will continue to set as its highest priority *the development of the experimental infrastructure*. This focus has two motivations. *First*, a continuous enlargement of the experimental capabilities is a must in the highly dynamic field of research addressed by IMT, ensuring the potential to approach increasingly complex topics and to join top-level project consortia and industrial partners. *Secondly* -as it has been confirmed also after the launch of IMT-MINAFAB- developing and maintaining a modern infrastructure brings essential "second-order" benefits (intangible assets) by: attracting experienced researchers, promoting interdisciplinarity and clustering, ensuring extremely efficient "intellectual collisions" of researchers in common experimental spaces, raising the interest of industrial entities for direct (hands-on) and indirect (services) access and collaboration, offering the necessary framework for education and training-by-research of young scientists (thus creating and preserving a quality critical mass for the future of the organization).

[10] For details, please see: http://www.imt.ro/evaluation2011/IMT-Revenues-and-investments-dynamics-A7.pdf
[11] For details, please see: http://www.imt.ro/evaluation2011/IMT-MINAFAB-General-description-A2.pdf

The identified strategic priorities for infrastructure investments for the next 4 years are as follows:

1. Investments for the enhancement of *existing* areas of expertise and achievements

1.1 Selective acquisitions of available functional modules for the existing tools - the aim is to ensure optimal capitalization on the capabilities of the existing equipments. Some of the priorities in this category were already addressed in 2008-2011. Remaining focus is on: the lithography zone, X-ray diffraction, on-wafer characterization, scanning probe microscopy, multiphysics numerical analysis.

1.2 Increase of the capabilities for basic processing - with focus on physical material depositions and precision doping.

1.3 Allocation of larger, dedicated budget for equipment maintenance and revisions - while the current allocation allowed almost undisturbed operational status, there is a need for efficiency upgrades.

2. Major investments for enhancing the capabilities in *selected R&D directions*

2.1 Coordinated equipment acquisitions to enable development and integration of new technologies in three classes of carbon-based nanomaterials - a dedicated structural funds project (CENASIC, 2010-2013) is underway, and this is planned to bring extremely efficient convergence towards approaching new directions and technologies in silicon carbide, graphene and nanocrystalline diamond integrated nanomaterial research. Major research tools in the new clean room that is also planned in the project will cover advanced -multi-process, and high-temperature- thermal processing, ultrahigh-vacuum deposition with complex integrated characterization, and wide frequency-range spectroscopy.

2.2 Significant growth of capabilities in high-performance computing - the need to enhance the current capabilities in power computing is determined by the newly emphasized directions such as: atomic-level simulations, lab-on-chip microfluidics, plasmonic systems, coupled field analysis.

2.3 Significant enlargement of capabilities for nanoscale processing and characterization - focus on ion beam and on high-power electron beam microscopy. These have been identified as the main limiting factors towards addressing the full range of nanotechnology experiments.

3. Investments for the *general infrastructure*: new developments and renovations

3.1 Development of a new center for R&D in carbon-based nanomaterials - besides the clean room-grade major tools, the 6M euro CENASIC project will bring: a new 200sqm, class 1.000 clean-room; a new 4-levels building; 8 new, equipped, laboratories; office spaces for researchers and internship collaborations. The coherent technical and organizational integration of the new center in the general IMT-MINAFAB infrastructure is a process that has already been initiated.

3.2 Renovation/modernization of selected technological areas - new equipment acquisitions will need proper accommodation, while the large (1.800 sqm) available technological building of IMT is only partly upgraded at high standards.

3.3 Modernization/renewal of selected support infrastructure - with focus on: general backup system for diesel-oil based alternative energy supply, clean room air-filtering system, pure water system.

3.4 Renovation/modernization of IMT's office building - the main office building needs essential renovation and strengthening works.

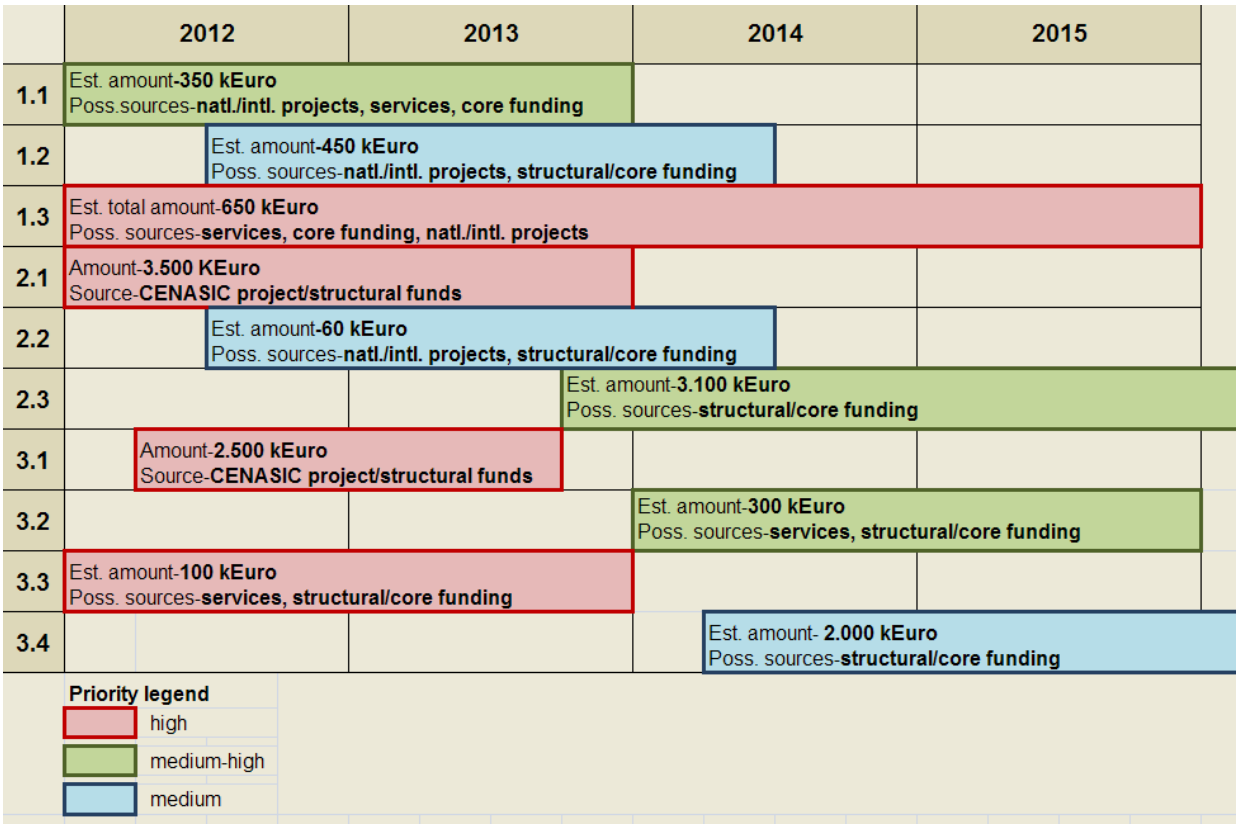
Notes:

a) While IMT-MINAFAB represents a high-level infrastructure, unique at the national level, its operation costs are pressing heavily on the budget of the institute. Minimizing the operation costs or intensifying the services provided to various industrial clients will not be sufficient for covering all the necessary expenses for optimal operation. Therefore, one of the present priorities is to promote the infrastructure towards its recognition as a *facility of national importance* - that would allow partial subvention.

b) As mentioned hereinbefore, *human resources* are essential for proper exploitation of such a facility. Strategically, their *quality* must be maintained -through dedicated reward- and continued- by keeping focus on *preserving* the full coverage for all tool/technological needs.

c) In order to increase the value of this tangible asset of the institute, as well as the efficiency of exploitation, another priority is to progress towards a *coordinated policy of alliances* - both at the national and at the European level. The "Capacities" programme of FP7 was financing such a framework for networks providing experimental services; unfortunately, less successful in engaging countries from Eastern Europe.

The chart below maps the investment priorities against estimated time evolution, estimated costs, secured and possible sources, as well as their comparative prioritization.



3.7 Technology transfer and the attraction of non-public funds

Technology transfer, as well as attraction of non-public funds are among the weak points of IMT (see the SWOT analysis).

IMT conducted various activities related to technology transfer, such as: creation of technology transfer and innovation infrastructures (science and technology park, centre for technology transfer); creation of a centre of scientific and technological services (IMT-MINAFAB) which is providing support for the interaction between researchers and

companies; participation to a number of projects related to innovation and technology transfer; participation to innovation salons and exhibitions etc[12]. However, the results are below expectations. Apart from some errors done by IMT (e.g. the institute does not have specialized personnel with a real experience and motivation for marketing) the situation can be also explained by the following factors:

- There are just a few national companies interested to use the new micro- and nanotechnologies and exploit possible niches of the global market. Therefore, the local demand for real exploitation of these innovative technologies is low.
- Not only in Romania, but also in Europe in general, many SMEs focused on innovation are just exploiting public funding and the interest to compete on the market is practically absent. Even multinational companies acting in Romania are interested to access public funding for their own needs (low interest in cooperation with public R&D organizations).

The above context, superposed with the current economic crisis, contributed to a lack of emphasis on the specific activities requested by efficient transfer of technologies resulted from research. Even the undertaking of collaborating with a foreign consultancy company for increasing the related know-how did not succeed in mobilizing the IMT researchers in being more active in technology transfer efforts.

In what concerns the accessing of non-public funding, the overall economic crisis has impacted the potential of companies to invest in R&D; unfortunately, this occurred just at the time when IMT could have exploited its recently acquired experimental capabilities. Although a limited number of services have been provided to a number of companies, the funds obtained from such activities is still negligible in the overall budget of the institute.

In order to increase the effectiveness of technology transfer attraction of non-public funds, the development plan for the next 4 years consists of:

- Involving the Board of Directors and the Administration Board in the implementation of measures related to technology transfer (TT);
- Hiring personnel specialized in TT and/or training the existing one (2012);
- Encouraging the researchers and the engineers involved in technological development to focus on filing international patents (even though the necessary funding is a limiting factor); encouraging spin-offs (with a continuation of cooperation between the new company and the institute);
- Reevaluating the involvement of companies housed by the science and technology park MINATECH–RO (coordinated by IMT) in technology transfer focused on product development (2012), followed by the selection for the park of the most promising companies in this respect;
- Reinforcing the communication within the network for knowledge transfer and innovation in micro- and nanotechnologies set up by IMT (60 research groups and companies);
- Providing free (or reduced–fee) training for introducing interested companies to the field of micro- and nanotechnologies;
- Enlarging/diversifying the IMT offer for effective cooperation with companies (developing new products and technologies, providing scientific and technological services); one key point is the development of complete technological services for prototyping and (small scale) production with the help of new investments, especially CENASIC (2013);
- Participation to international fairs related to the field; visits and discussions with companies acting in the field or interested in applying the new technologies (starting 2012);

[12] Sample titles of product datasheets are downloadable at: http://www.imt.ro/evaluation2011/IMT-RD-Products-A5.pdf

- Reorientation towards potentially new markets, especially in emergent countries, e.g. in Asia (starting 2012);
- Strategic studies and analysis - in cooperation with consultancy companies - for revising the range of the institute's collaboration offers and their more intensive dissemination (web page, printed materials) (since 2012);
- Stressing on continued membership and active communication with organizations providing networking between research and industrial entities;
- IMT is seeking cooperation with industrial clusters, such as the "automotive industrial cluster".

Note. The IMT policy in developing its relations with companies can be greatly facilitated by the financing policy at the national or European scale. For example, IMT may benefit from the already launched national system of inno-*vouchers* financing the access of companies at the experimental facilities of research institutes. Also, the development of a national "research and innovation" plan similar to the Innovation Europe 2020 can be – in principle – very useful for exploiting the capabilities of IMT for industrial cooperation.

3.8 Strategic partnerships and visibility: events, communications, collaborations

The plan for *increasing the number and intensity of strategic partnerships* consists of:

- Strengthening the existing R&D partnerships: with Honeywell Romania - officially signed agreement of cooperation, Infineon Technologies Romania, the Korean Institute for Electronics–KETI - officially signed agreement of cooperation, Universite Catholique de Louvain - officially signed agreement of cooperation, as well as the partnerships in the Associated European Laboratory (LEA) with LAAS, Toulouse (France), and FORTH, Heraklion (Greece);
- Strengthening the partnership in education with the University "Politehnica" of Bucharest (especially by providing M.Sc. courses, laboratory classes, summer internships); possibly extending the partnership in the activity of a doctoral school, joint supervision of M.Sc. and Ph.D. thesis etc.;
- Developing partnerships related to the implementation of the CENASIC project (creation of research centre focused on carbon-based nanomaterials, which seems to be unique in Europe); an important tool can be the proposed participation to the Graphene Flagship project, once accepted for financing;
- Developing national and/or regional (i.e. Eastern or South–Eastern Europe) partnerships in providing services, based on the collaboration with the IMT Centre for Micro- and Nanofabrication (IMT-MINAFAB); it is worthwhile to note here that the proposal of IMT for a "*Romanian-Bulgarian Services Centre for Microsystems and Nanotechnologies*" was approved recently within the *Programme of cross-border cooperation Romania-Bulgaria* (2007-2013);
- Developing partnerships focused on specific research directions with institutes of the Romanian Academy (chemistry, biology) through the Centre for Nanotechnology of IMT (CNT-IMT), itself working *under the aegis* of the Romanian Academy;
- A special short-term target is to reinforce the partnership within the NANOPROSPECT consortium (which was coordinated by IMT), in an attempt to valorize the findings of the prospective study devoted to nanotechnologies in Romania (the so-called NANOPROSPECT, project financed between October 2010 and May 2011). Such an endeavour should lead in principle to *a national strategy in the field*. IMT is also ready to play an active role and use its experience in implementing the following recommendations of the NANOPROSPECT: (a) Set-up of a *National Network for Nanotechnologies*

(research groups, companies, NGOs etc.) for communication and exchange of results promoting closer cooperation; (b) Set-up of a Network of Experimental Facilities to ensure coordinated development and exchange of expertise between its members, as well as provide services to third parties, including companies.

In what concerns the institute's visibility, the plan also includes the *organization of regular or special-purpose events*, as follows:

- IMT will continue to organize annually in Sinaia (Romania), the international conference CAS (Annual Semiconductor Conference), an IEEE event (the 35th edition will be held in 2012); the conference is also hosting joint or satellite events (e.g. meetings of consortia from European projects); the Workshop for automotive electronics (industry and academia), organized in 2010 jointly with Infineon Technologies Romania, will be repeated in 2012 and 2014; starting with 2012 IMT will designate a "guest of honor", i.e. an organization which will benefit from a special position in the conference (invited lectures, exhibits etc.);
- IMT organizes the annual *National Seminar for Nanoscience and Nanotechnology* (the 10th edition took place in 2011), which is promoting the results of Romanian research in this domain; the one-day event is organized by CNT-IMT, under the aegis of the Romanian Academy (the best papers are published in a special volume, in English);
- IMT will continue to organize annually (each December) the "*IMT day"* (day of open gates), each time with a different highlight and with different target groups as visitors;
- IMT will be one of the local organizers of the ESSCIRC/ESSDERC 2013 (European Conferences on Solid State Circuits/Devices), an event with wide international participation, held for the first time in Eastern Europe (Bucharest, September 2013); as Chair member of ESSDERC, the institute will promote a better visibility of Romanian research in the field, as well as the interaction with education and industry;
- IMT intends to repeat in 2012 the very successful NanoElRei Summit (Nanoelectronics in Romania: research, education, innovation) held in 2010 and 2011, which was organized at the initiative of the ENIAC Joint Undertaking (Public-Private Partnership in Nanoelectronics) and with the cooperation of Infineon Technologies Romania;
- Focusing on collaborations with international consortia in high-level projects will continue to be one of the strategic priorities of IMT.

The development plan also considers the role of IMT in some *publications* which are important for the scientific community interested in micro- and nanotechnologies. The related objectives are:

- Continue the coordination (by academician Dan Dascalu) for the series of books in English called "*Micro- and nanoengineering"* edited by the Romanian Academy, with at least two volumes a year, one publishing the best papers presented at the annual national seminar devoted to nanoscience and nanotechnology (see above), the other devoted to the MEMSWAVE annual European workshop, initiated (in 1998) by IMT and devoted to micro-nanosystems for microwave and millimeter waves.
- Continue the support for the *Romanian Journal for Information Science and Technology* (ROMJIST), an ISI-ranked publication of the Romanian Academy (editor-in-chief academician Dan Dascalu) which publishes issues devoted to micro- and nanotechnologies.