Abstract

This paper presents the single national entry-point put in place by the CNFM (National Coordination for Learning in Microelectronics) mainly to answer to electronics industry engineer's lifelong learning needs. It addresses the technical, organizational, financial and legislative aspects relative to lifelong learning and shows the figures of trained people in the fields of micro and Nano-electronics.

Keywords: Lifelong learning; microelectronics; Nano-electronics, national network; semiconductors industry engineers; employability; company.

1 INTRODUCTION

Since the 60s-70s, the evolution of microelectronics technology has contributed changing the socio-economic landscape of France in the fields of computing, communication, transport, environment, energy and medicine. It has enabled both the increase of productivity in all sectors of activity and the transition from a decreasing heavy industry to innovative activities with high added value. This evolution has led to the need for dedicated technology platforms and associated technical support to promote the teaching of knowledge and know-how in microelectronics and nanotechnologies fields. But the investments to be made to provide resources and equipment to meet these training course needs were so enormous that the solution was to create 40 years ago a network of 12 inter-university clusters or joint microelectronics centres. This organization brought together and shared operational resource, and defined a geographical distribution adapted to the presence of industries, research laboratories and training institutions. This network was named CNFM: National Coordination for Education in Microelectronics and nanotechnologies [1].

In 2011, as part of the "Investment Plan for the Future" promoted by the French government, the CNFM network applied and was selected for an 8-year project entitled "IDEFI-FINMINA" [2]. One of the eight work packages consisted in creating a single national entry point for lifelong learning, first for engineers in the electronics industry to maintain their employability and second for university faculties to maintain their expertise at the state of the art of the technology.

After presenting the national network and its main activities, the paper deals with the organization of the lifelong learning in connection with universities and companies in order to meet the future needs of digital society. On the basis of several effective realizations, the challenges to be taken up are highlighted and the different approaches are detailed.

2 PRESENTATION OF THE CNFM

The French national network for education in microelectronics and nanotechnologies is organized through an official structure, a Public Interest Group (GIP), recognized by the Ministry of Higher Education and composed of fourteen partners. Twelve are academic institutions in charge of the twelve joint microelectronics centers with other local institutions, and two are industrial organizations (or unions), representing the French electronics industry. These two industrial structures represent the majority of companies, more than 150, which are working in France in the field of electronics, microelectronics, and electrical engineering. Their participation in the network is important and yearly orientation council are organized in order to discuss technology trends and allows the CNFM to adopt the best strategy in order to meet industrial needs.

The twelve academic institutions and the two industrial unions are the official partners of the GIP structure. The twelve microelectronics centers were strategically spread throughout the territory and
mainly located in areas where activities carried out by electronics or semi-conductors industries and academic institutions were already developed, as displayed on figure 1.

Since its creation in the 80s, the CNFM focuses on making heavy educational resources such as professional CAD tools, cleanroom technological manufacturing, physical, electronic and electrical characterizations, analog and digital architectures, or industrial test equipment available for common use, by eighty-nine academic institutions (universities and engineering schools) for initial and continuing education, sixty public research laboratories and industrial partners. With the aim of minimizing duplicating (equipment) platforms, the CNFM financially supports (at least partially) the twelve clusters that manage more than eighty platforms, including seven cleanrooms. Every year, more than 16,000 students are trained on the operational resources.

The GIP-CNFM also contributes to the dissemination of knowledge through the organization of biannual education days to foster exchanges between teachers in micro and nanoelectronics [6], the publication of a newsletters relative to the life and activities of the network [7], its participating to international conferences (such as MSE, ITHET, EDUCON or EURODOTS program) [3,4,5], the organization of the European congress on training in microelectronics (EWME). At the national level, the network organizes each year the National Doctoral Days (JNRDM) of the field and the realization of the PhD national days in the domain.

In 1986, the CNFM National Services [78] structure was created and hosted by Montpellier CNFM microelectronics centre to allow the shared purchased and the distribution of CAD (Computer Aided Design) licenses for the design of microelectronic components and systems. CAD software licenses include Cadence® [9], Synopsys [10], Silvaco® [11], Mentor Graphics® [12] and Coventor® [13] suites. In 1996, a similar initiative was launched for the acquisition and pooling of national technological equipment for the industrial test of integrated circuits [14]. The equipment was renewed in 2006 and is still used every year for initial and continuing education in Montpellier and from remote sites. A third platform was launched later for the purchase and distribution of circuits and programmable cards from Altera® (now Intel®) [15], Xilinx® [16] and Digilent® [17]. It was joined by two new platforms, dedicated to Lifelong Learning [18] and digital security [19], both set up in the framework of the Excellence Initiative for Innovative Training project (IDEFI-FINMINA) [4].

The permanent evolution of software and hardware tools offered by the 5 platforms requires academic users (teachers-researchers, researchers, doctoral students, research engineers) to regularly attend training courses to master these technologies for education, innovation and research purposes.
3 LIFELONG LEARNING ACTIVITY

The lifelong learning activity has two components:

- Continuing education activities dedicated to academics (teacher-researchers, PhD students, researchers, research engineers) on the four platforms hosted by the National Services. CAD and prototyping training courses are provided by the trainers of our industrial partners: Cadence®, Silvaco®, Mentor Graphics®, Coventor®, Synopsys® for the trainings relative to the integrated circuit design technology platforms and Xilinx®, Intel®, Diligent® for the ones relative to prototyping. Academic teachers attached to Montpellier CNFM cluster provide lifelong learning trainings on digital security and industrial test platforms.

- Lifelong training courses for academic and industrial people are given by academic trainers on all the operational resources of the CNFM network, including the National Services testing and digital security technology platforms. This organization is summarized in Figure 2.

<table>
<thead>
<tr>
<th>Platforms</th>
<th>Offer</th>
<th>Audience</th>
<th>Trainers</th>
<th>Nb</th>
<th>Training courses</th>
<th>On-line</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Services</td>
<td>✔</td>
<td>Aca.</td>
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<td>&gt;4</td>
<td>✔</td>
<td>Annual</td>
</tr>
<tr>
<td>CNFM Network</td>
<td>✔</td>
<td>Ind.</td>
<td></td>
<td>64</td>
<td></td>
<td>✔</td>
<td>Annual</td>
</tr>
</tbody>
</table>

Figure 2. The CNFM network national continuing education offer. The platforms can be the GIP-CNFM National Services ones, or those of the twelve clusters distributed on the territory.

3.1 National Services lifelong learning offer

Each year, the National Services establish a planning of training modules in collaboration with the managers of the training departments of the companies providing the software and hardware suites of the Design and Prototyping platforms. This calendar also includes the courses delivered on Digital Security and Industrial Test platforms elaborated by academic teachers. This plan is then distributed to all users of higher education institutions in France (Universities, public engineering schools and research laboratories). The offer concerns:

- Instructor based training courses on CAD tools: Cadence® [9], Mentor Graphics® [12], and Coventor® [13],
- Instructor based training courses on prototyping tools: Intel® [15], Xilinx® [16] and Diligent® [17],
- Instructor based training courses on hardware security [19] and industrial test [14],
- E-learning courses offered by Cadence for the design of integrated circuits [9],

In fact, from the five industrial partners, Cadence®, Synopsys®, Coventor®, Silvaco® and Mentor Graphics®, that supply CAD software suites to National Services, only Cadence® has developed a policy of continuing education for the academic people. Mentor Graphics® started following Cadence’s strategy in 2018.

The courses are organized either at the University of Montpellier where National Services offices and classrooms are hosted, or in one of the CNFM centres, or in an engineering school associated to CNFM network, like Telecom ParisTech [20]. Since 2018, Montpellier CNFM cluster is a technological platform of University of Montpellier [21].
3.2 CNFM network lifelong learning offer

3.2.1 Strategy

The strategy was to collect ideas for lifelong learning from teachers attached to the twelve CNFM centers located in French cities close to electronics activity (Paris, Orsay, Lille, Strasbourg, Grenoble, Lyon, Nice-Marseille, Montpellier, Toulouse, Bordeaux, Limoges and Rennes) and to develop a uniform online lifelong short and long training courses catalogue.

Trainees would benefit from the expertise of CNFM teachers and the shared operational resources of the CNFM network. It includes software suites for the design and prototyping of integrated circuits, technology plants for component manufacturing and characterization, and an industrial tester for circuit verification as well as the classrooms of all educational institutions of the network. The aim is to meet the needs of the industry in collaboration with the continuing education services of educational institutions (Universities and engineering schools) in order to improve the competitiveness of companies in this economic sector, helping them to bring technological innovations, to update the skills of employees or to develop new ones to improve their employability and enable the implementation of career development projects. Companies and engineers are also encouraged to request new lifelong learning adapted to their needs. Continuing education offer targets academic people as well allowing them updating their expertise on technologies for education and research aspects.

For academic institutions and people, companies’ human resources director, continuing education service manager and employees, the CNFM online catalogue is a single national entry-point to a large network of lifelong learning courses in microelectronics and nanotechnologies taught by academic experts of their field on high-tech equipment.

3.2.2 Single national entry-point

The online consolidated catalogue proposes continuous training courses ranging from awareness to specialization, combining the excellence of theoretical teaching and practice on the latest generation equipment for the acquisition of knowledge and know-how, either proposing to upgrade fundamentals or to learn advanced skills. This dematerialized offer comes in the form of harmonized training fact sheets uploaded on web pages. Each fact sheet of this online catalogue provides information on the topic of the training course specifying the objectives and learning outcomes, prerequisites, daily program, duration and schedules, location, contact for registration and educational information, conditions validation of achievements, the cost per participant and their minimum number for the organization of the training. This latest information makes possible to guarantee profitability because they include the full costs, i.e. the internal costs (training room, course materials, use of the operational resources of CNFM network for labs, payment of the trainer,) and external ones (management of the training by the continuing education service).

The catalogue centralized all training data sheets elaborated by teachers from the network of 12 inter-university clusters. Only academic people can offer continuing education training course and thus enrich the current database, named GECO [2]. This database supports in total three platforms hosted by National Services: CAD, FPGA and LIFELONG LEARNING platforms as displayed on figure 3.

![Figure 3. Home page of the National Services database accessing to CAD, FPGA (Field Programmable Gate Array) and LifeLong Learning platforms.](image-url)
From LIFELONG LEARNING platform, first, trainers must query the administrator to have an account to propose new training course. Then they have to fill a formatted training sheet with the following information:

- Training course title,
- Objectives and skills,
- Duration, date and venue,
- Targeted audience and min/max participants,
- Pre-requisites, program and teaching method,
- Trainer contact for educational and technical request: name and email,
- Continuing Education Services contact for registration: name, email, phone and fax numbers,
- Cost,
- Assessment method.

Any new continuing education sheet is submitted to the lifelong learning platform manager’s validation before being added to the database. Training courses are gathered with CNFM centre. Seven out of twelve CNFM centres are involved in this activity:

- MIGREST, CNFM centre of Strasbourg, Nancy and Metz: 11 training courses,
- PACA, CNFM centres of Marseille and Nice: 25 training courses [23],
- PCM, Montpellier CNFM centre: 8 short training courses [7],
- PFLM, Lille CNFM centre: 7 training courses [24],
- CIMIRLY, CNFM Lyon centre: 4 training courses,
- PMIPS, CNFM Paris South centre: 8 training courses,
- AIME, Toulouse CNFM centre: 1 training course.

Most of the on-going training courses in microelectronics and nanotechnology are three up to five days long in order to match teachers’ and the trainees’ availability (engineers in the industry). However, training courses were developed in a way they could be combined with others to form modules of 100 hours in order to be eligible to CPF (Personal Training Account), a request expressed by Continuing Education Services Departments of universities.

3.2.3 Continuing Education Services

CNFM relies on the Continuing Education Services (CES) of universities and engineering schools hosting each CNFM center of the network to manage training registrations and catering, and to deal with request of financial support from employees.

In France, every year, companies have to contribute to their employees’ lifelong learning abounding their CPF (Personal Training Account) of a credit in euros equivalent to twenty hours of training course. Joint bodies collect companies’ funds and interface with CES every time an employee requests the usage of her/his CPF to attend lifelong training course.

Collaborations have been established between seven CNFM centers and Continuing Education Services of the universities of Montpellier [25], Strasbourg [26], Marseille [27], Nice [28], Lille [29], Paris South [30], Lyon [31], Toulouse [32] and Grenoble [33]. Continuing Education Services (CES) also promote CNFM training courses to local economic activities.

Agreements have been signed with the CES of the universities of Strasbourg, Aix-Marseille, Lille and Montpellier for the dissemination of the CNFM offer on their websites and the organization of training. These agreements thus place collaborations with CES within the legislative framework of continuing training, guaranteeing the application of the latest laws (Personal Training Account) and issuing certificates of participation.

3.2.4 Communication

The online catalogue can be accessed from the CNFM website (http://www.cnfm.fr//formation-continue) or the National Services website (http://web-pcm.cnfm.fr/formation/). Both links provide the list of sixty-four lifelong learning trainings. When someone consults a specific course and displays the
details of the training fact sheet, he/she navigates seamlessly between the website [18] and the
database GECO [22].

The promotion of lifelong learning opportunities is achieved through presentations at national trade
fairs like “ENOV’A”; regional electronic events like JRE (Regional Electronic Day) organized by
ACSIÉL Alliance Electronique, the CNFM main industrial partner [34], and regular meetings with
corporate human resources departments.

The Internet (http://web-pcm.cnfm.fr/formation) and social media (LinkedIn, Facebook, Twitter,
YouTube) are today number one channels for disseminating information:

- Any new training course is published in the “News” section and its schedule can be found in the
  “Calendar” section of the National Services Internet website: http://web-pcm.cnfm.fr

- Any announcement made on the website is automatically relayed on the various social networks
  of the Montpellier CNFM centre: Facebook [35], LinkedIn [36] and Twitter [37]. Specific articles
  are also posted on these communication media.

- A video clip in design motion was elaborated with Artcam Production Company [38] to promote
  the online lifelong learning courses catalogue. Posted on “CNFM COMMUNICATION” channel
  on YouTube [39], it fostered the acknowledgement of the CNFM lifelong learning activity.

4 CONTINUING EDUCATION OUTCOME

After seven years, the online catalogue proposes sixty-four short-duration continuing education fact
sheets in the field of microelectronics and nanotechnologies mainly for industrial people. These
proposed trainings are covering computer-aided design, fabrication processes, characterizations and
tests, and are focused on the practice training that gives the know-how, a mandatory skill in this field.
Its elaboration took several years to lead to a consolidated single national entry-point, so that many
actions have only been recorded since 2014.

The network has organized several training courses chosen from the catalogue but also at the request
of companies. The objective was to significantly increase the proportion of lifelong learning in all
activities of the CNFM network. However, the initial objectives have not been as easy to achieve,
especially since French legislation has been amended twice in the last five years, which has increased
the constraints on access to lifelong learning. Fortunately, the emergence of e-learning set-up by the
teachers has significantly allowed increasing the number of actions carried out by the network during
the last academic year.

In the same period (2014-2018), academic learners have shown a major change of posture and
interest of topics. Due to cost constraints, they have been led to develop e-learning more than face-to-
face learning with an instructor [40] and have therefore focused on FPGA (Field Programmable Gate
Array) cards and system cybersecurity to match education and research to the Internet of Things (IoT)
boom. Thus, CAD continuing education trainings have decreased in favor of prototyping and hardware
security ones, all courses proposed by the National Services. Today, numbers are balanced but it is
pertinent to think that both prototyping and digital security trainings growth will follow the increase of
smart objects usage.

Table 1 presents lifelong learning activity from 2014 to 2019 versus reference indicators. 2019
Recorded parameters are the number of training days and the hours of course per participant
(academic or industrial) for all types of continuing education courses (face-to-face learning and e-
learning).

<table>
<thead>
<tr>
<th>Year</th>
<th>Day/reference</th>
<th>Hrs*part/reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>30 / 36</td>
<td>2366 / 2500</td>
</tr>
<tr>
<td>2015</td>
<td>37 / 40</td>
<td>2089 / 2750</td>
</tr>
<tr>
<td>2016</td>
<td>15 / 45</td>
<td>994 / 3000</td>
</tr>
<tr>
<td>2017</td>
<td>110 / 50</td>
<td>2801 / 3400</td>
</tr>
<tr>
<td>2018</td>
<td>652,5 / 55</td>
<td>7223,5 / 3600</td>
</tr>
<tr>
<td>2019</td>
<td>- / 60</td>
<td>- / 4000</td>
</tr>
</tbody>
</table>
5 REALIZATIONS

5.1 Catalogue based lifelong training from MONTPELLIER CNFM centre

The Internet of Things (IoT) sees the appearance of ever more connected objects. In such a context, the security aspect of these objects is more relevant than ever. To overcome these vulnerabilities, two complementary methods must be implemented in parallel. It is necessary to educate users to avoid risky behavior but also to create more secure objects by training engineers to these issues. This is the reason why twice a year since 2017, 2-days training courses relative to hardware security of integrated circuits and systems are organized in Montpellier CNFM center. Most of industrial participants come from local electronics companies. Their learning objectives are either to get a first experience in the domain or to reinforce existing theoretical knowledge with practice on the hardware security platform. At the end of each session, trainees are welcomed to fill a training survey form. Outcome is unanimous: the expertise of the teacher and the high-technology platform provided by the Montpellier CNFM center result in high efficiency training course.

5.2 On request short lifelong training from Lille CNFM centre

On the request of the French company Saint Gobain [41], the CNFM center of Lille has developed a dedicated 3-day training course for one employee whose need was to reinforce her theoretical knowledge of the operation in near-field microscopes. Her objective was to master the usage of surface characterization tools (AFM and STM) that she daily manipulated as she targeted to lead her team and optimize the usage of their operational means. The continuing education service of the University of Lille took care of the administrative and logistical management of the training. The employee was very satisfied of both the organization and the program of the course, the availability and skills of the teachers and the quality of the lab equipment (AFM and STM type microscopes) provided by Lille CNFM center. At the end of training course, the employee was quickly able to apply her new skills to improve her professional effectiveness (better interpretation of surface characterization results) and her employability. The company is also very satisfied with the fast return on investment.

5.3 On request lifelong training plan from PACA CNFM centre

On the request of the company ST-Microelectronics of Rousset site [42], PACA CNFM center developed a continuing education training plan to offer the opportunity to employees who wish to reorient their career to product engineering job within the company.

The program was defined on the basis of the initial objectives established by the company human resources, the applicants’ managers, the training manager, and the teachers of PACA CNFM (Marseille) center. The educational team elaborated a syllabus of 250 hours that focused on the knowledge of manufacturing process, methodologies for designing, testing and characterizing integrated circuits, and operations on automatic test equipment. During a year, participants studied at PACA CNFM cluster one day per week, with the exception of the industrial test module. As neither test expertise nor test equipment was available at PACA CNFM cluster but Montpellier, the teacher move there to train the participants during a full week and they connected remotely to test equipment located in Montpellier's CNFM centre for the duration of the laboratories.

The first training plan was organized in 2013 with five participants. Few months later, the five applicants were interviewed internally about the benefits of the training. They answered that it allowed them to:

- adapt to their workstation (all),
- develop their skills (all),
- improve their professional efficiency (all),
- be prepared for their new position (75%),
- get familiar with and be more quickly operational on their new workstation (50%),
- maintain their employability (50%).

The company ST-Microelectronics Rousset being satisfied with this first experience of professional reconversion, this same training plan was renewed in 2015 with 7 engineers. In 2017, this training plan
was modified at the company’s request to offer a dual course to product engineer and to quality engineer jobs with a common core syllabus.

6 CONCLUSION AND PERSPECTIVES

This paper presents an innovative project called IDEFI-FINMINA, sponsored by French Government, whom one purpose is to offer to industrial and academic people having lifelong learning needs, specialized training courses where they will receive the state-of-the-art concepts from experts and will benefit from the CNFM operational resources to get highly skilled.

Thanks to its pedagogical and operational assets as well as to very important efforts in terms of communication, the CNFM network is now identified as a central player in continuing education in the field of microelectronics. Nevertheless, the number of days of training or face-to-face trainees is lower than we expected. This is due to profound changes in learners’ position from public and private sectors in front of the need of regular training. Online learning has often supplanted face-to-face training for economic reasons and availability. However, this evolution seems contradictory with the real needs of the industry which requires the learning of know-how, a mandatory complement of theoretical knowledge [43-44]. This later can only be acquired on technological platforms such as those accessible within the national network. In addition, economic and legal contexts have drastically evolved since the beginning of IDEFI-FINMINA project, including stricter regulation of access to professional continuing training, which has resulted in a reduction in applications. Finally, the online catalogue is a good tool to show the diversity of skills that industrial people looking for technical training courses can acquire as part of the CNFM lifelong learning activity. However, most of the trainings that have been carried out were on company request, for a small number of trainees and a specific agenda which has not allowed capitalizing the continuing education development efforts for reuse. Nevertheless, it is clear from the evaluation of the trainings survey forms that learners are greatly satisfied of the trainers’ pedagogy and the operational means put at their disposal.

This situation should evolve with the launch of the Official branch of the Electronics Industry in March 2019. CNFM members, involved in working groups within the framework of the Industry Monitoring Committee (CSF), should work on identifying more precisely the companies’ lifelong training needs in terms of: nature and level of training, training course organization (sessions or cycles, disciplinary or multidisciplinary groups, location, duration, fragmentation), validation and qualification.

The CNFM focus on three areas to improve lifelong learning single national entry-point:

- Recognition and visibility: improve the referencing of the website in liaison with our partners, conduct seminars and short courses in synergy with other lifelong learning actors, improve communication on social media,
- Spectrum broadening of the online catalogue to smart objects, embedded systems and electronics in general in order to meet the needs of companies beyond the field of microelectronics alone,
- Diversification of the offer of continuing education in order to cover all levels and more particularly the technician one.

The end of IDEFI-FINMINA project on December 31th, 2019, will be an opportunity for the CNFM to assess its actions in the field of continuing training, to evaluate the actions implemented and to draw up a plan for the years to come.

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ACSIEL Alliance Electronique: http://www.acsiel.fr/

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