# Knowledge Management and Professional Profiles in Electronic Systems Engineering.

## The Function of University-Industry Collaboration

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*Abstract*— **This paper presents a work in progress related to the knowledge and competence management techniques applicable in an electronic systems engineering company. It also discusses the role of the university-industry collaboration in the knowledge management process.**

***Keywords: knowledge management; engineering education; professional profiling, electronic systems engineering.***

## I. Introduction

In this paper we describe a work in progress related to the systematization and organization of competence and knowledge management processes in a small electronics engineering company. This work is promoted by an electronics engineering and consultancy company and conducted in collaboration with the Electronics and Telecommunication Department of the University of the Basque Country. The basic objective of the work is the development of a preliminary analysis that could serve as the basis of a collaborative proposal for a project to be presented in the framework of the regional R&D and innovation initiatives.

## II. Electronics Systems Engineering

### *A. Ubiquity of Electronics*

Electronics systems are penetrating all possible aspects of human life, and are being used to improve them. Companies seeking to add value to their products are often driven towards the integration of embedded electronics, transforming traditional devices into more adaptive and useful ones.

In the medical field, electronics systems are not restricted to hospitals; they can also help patients, disabled, elderly and dependent people outside medical facilities.

Modern forms of mass transport system, such as trains, airplanes and cars, use embedded electronics technology to increase safety and performance. In the automotive sector, for example, the share of electronic components in the total value of a passenger vehicle is currently estimated at about 25%, with an expected increase to 33-40% in 2010 and up to 50% thereafter [1].

Electronics is an enabling technology for many sectors and fields of application. The existence of a local electronics industry is widely considered to be an essential contributor to prosperity and growth. This is not only due to the scale of market for electronics products, but also to the radical effect that the application of electronics has on the competitiveness of other sectors of the economy. In the Basque Country (Spain), the Association of Industries for Electronic and Information Technologies (GAIA), comprising more than 190 companies, has structured its 2009-2012 strategic plan with horizontal branches (Electronics and communication technologies) crossing three main vertical sectors of application: energy, transport and health [2].

In addition, we cannot overlook the impact of globalization. Offshoring and outsourcing are spreading globally in all economic sectors, but are especially prevalent in electronics, where even R&D activities are being outsourced. Electronic systems must often be assembled from COTS (Commercial off the Shelf) electronic subsystems and components, which may be manufactured half way around the world. But, at the same time, system integration is becoming more complex and involved. One of the big challenges in electronics systems engineering is to manage the complexity and reliability of the development, operation, and maintenance of embedded electronics systems [3].

### *B. The role of an electronic systems engineering and consultancy company*

While companies operating in various sectors consider electronics as an essential technology, in most cases they view it as a means, not an end, in their business strategy. The rapid evolution of technology and the variety of skills and techniques required for a successful application of electronics in their products is driving them to consider outsourcing of engineering as an optimal solution. Even electronics-related companies follow this trend. One can find a UPS manufacturer that sees its real product not as equipment but as the "power availability at the point of service", and therefore, focuses its strategy in setting the specifications and analysis of the application, outsourcing its development and manufacturing.

Other companies have undergone a rapid shift towards electronics technology. Consider, for example, a wheelchair manufacturer, moving from pure mechanical products towards electric wheelchairs that include power electronics, motor control and battery chargers, and, in addition, intelligent navigation and communication aids.

Distributors of electronics components and subsystems are trying to add value to the supply chain. They can offer the range of components needed for a complete solution, from board level components to enclosures, modules and powerful COTS subsystems. They can provide their customers with sporadic technical support through field application engineers. University departments and technological centres should concentrate their resources in research and basic development. None of these actors is orientated towards engineering or consultancy in complex and high workload projects involving demanding quality and deadline objectives.

An electronics engineering consulting company is the link which fills the gap between the end user needs and the available technological solutions (Fig. 1). It uses knowledge as its raw-material (research results and education from universities, internal R&D and collaborative projects with universities and technological centres) or as a semi-finished product (components, subsystems, tools and technologies produced by specialized companies all over the world, or even free software and hardware projects and communities) and generates applied knowledge as its output. Its role is to process and internally manage this knowledge and apply it properly in its clients' projects. To meet its clients' requirements it is essential to use the right type of knowledge, at the right moment in time, and with the right intensity, in every task and during every stage of the project.

The electronics system engineering process follows an iterative loop from the requirements definition, to functional and structural design. The same process is applied in a top-down approach to every subsystem, module or component.

In a typical electronics systems project, a broad range of competences and skills may be required. Managing competencies of the people who need to perform specific tasks or jobs in a project can crucial to the success or failure of the project.

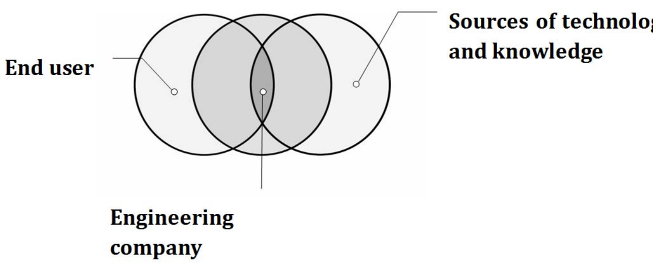


Figure 1. The role of an electronic systems engineering company

## III. Professional Profiling based on Competency and Competence management.

In this section we differentiate between competence (the specific level of knowledge, skills, experience, etc. necessary to carry out a defined function) and competency (the description of the knowledge, skills, experience, etc. necessary to carry out a defined function).

Competency and competence management is the process of identifying, classifying and analyzing competencies, and managing competences of the people working in a project. This process must be the basics of professional profiling, selection, hiring, career development, training and evaluation. Core competencies are those key competencies that all members of the organization must master, along with the vision and mission of the company. There is also a distinction between soft and hard competencies (the latter being equivalent to knowledge, skills, and abilities or KSA). In current management and education literature, the structure and management of core and soft competencies has received considerable attention. But, for a small engineering company, the more specific and hard competencies are as much as important as the soft or core ones. This perception is in line with studies that confirm that specific technical competence is the most valued characteristic of an engineer [5]. Our attention will be focused on the structure and management of those hard competencies in the electronics systems engineering.

This work in progress is fundamentally devoted to classification and parameterization. From a static point of view it is a try to establish taxonomy, covering the spectra of skills and knowledge of interest, with fine grain definition, analyzing detailed and very specific skills.

As an example of static classification requirements, it can be mentioned the case of single board computers (SBC) related skills. The static competencies classification must include from the fundamentals of computer architecture to the most specialized and detailed skills, such as the ones related to very specific form factor standards.

From the dynamic point of view, the skills and competences should evolve to adapt to market and client needs. The classification should include parameters to allow analysis of the dynamics, predicting the need for taking actions in order to control the evolution.

Some other examples can be considered to see the importance of this dynamic consideration. In fewer than ten years, a specialist in power supply and power converter design, has had to evolve from a profile involving important design related skills towards a new profile involving specification, selection and verification of converter modules, designed and manufactured by OEM suppliers. Now the engineer has to focus on the study and analysis of standards applicable to the sector. The new profile would be more systems engineering oriented. The impact of offshoring with its cost reductions and standardization of power converter modules has greatly reduced the need or advantage of home-made designs.

As a second example, the case of a microcontroller specialist can be considered. From development with small 8- o 16-bit microcontrollers, programming in assembler or C language, the engineer has had to move towards development with SBCs based on powerful ARM or x86 embedded processors, running RTOS (real time operating systems) or embedded Linux. The new professional needs now to be knowledgeable about driver development and the integration of applications combining compiled and scripted languages, network services, etc

Being able to predict those changes and quickly conforming to them is critical for a small engineering company, which must adapt with agility to new market circumstances and customers, sometimes in very demanding sectors, such as transport or energy.

Our work is currently focused on the development of a software platform for skills and competencies classification. The classification follows a tree structure, with fundamental branches (analogue and power electronics, digital, computer science, communications and networks etc.) split into more specific and specialized branches so that the classification of competencies related to projects and sectors of current interest is prioritized (Fig. 2).

There is also a need to decide the parameterization of every skill related field. Regarding the competence level, classic classifications based on Bloom's taxonomy or the Anderson variant, competence levels of Dreyfus professors [6], and previous experiences [4][9], like the ones applied in clinical practice[7][8] are being considered.

The static tree classification with competence levels has to be graphically analyzable, yielding at a glance the specialization profile for a professional, a team or project requirements. The dynamic parameterization must be also easily analyzable, both for forecasting and for assessment of professional recycling programs. A spectral representation similar to the that used in engineering and physics, indicating the difference between "low frequency" skills (those fundamental skills that are very permanent and are only slowly renewed) and "high frequency" skills (those achieving obsolescence quickly or that have to be acquired and renewed frequently) is proposed.

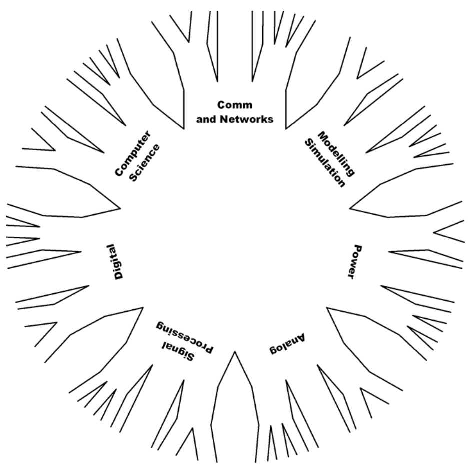


Figure 2. The competency tree

## IV. KNOWLEDGE MANAGEMENT

The approach to knowledge management (KM) is from the eclectic point of view of engineers approaching any management fad [10][11]. KM has raised strong interest in the business community, but perhaps some managers are thinking about KM as the magic solution that will allow a company to keep engineer's brains after they leave. For us, an important aspect of KM is that the effectiveness of an engineer performance, key of any success, depends on the proper delegation of intellectual tasks and authority to knowledgeable and empowered professionals [15].

Nevertheless, for a company dealing with complex and multidisciplinary projects, the handling of data, information, and their processed forms cannot be disregarded. From that point of view the definition of KM as the systematic and explicit management of knowledge-related activities [12][13][14] can be easily shared. It can also be agreed that a KM strategy must pursue a direct connection between an organization's intellectual assets, both explicit and tacit, and positive company results.

The analysis is based on some well-accepted definitions such, as the Ackoff pyramid [17] and the associated transformation process [16] that can be schematized as:

- The raw material is data
- Understanding of relationships in data gives information.
- Understanding of patterns in information gives knowledge.
- Understanding principles in knowledge gives wisdom

It is also relevant to pay attention to the identification of the opposite terms: absence or false data, misinformation and non-knowledge [18]. Most failures in critical systems, even causing loss of human life, can be attributed to misinformation or non-knowledge. Fail tolerant system design must take into account the flow of data, information and knowledge and establish procedures to avoid failures.

The new information is transformed into knowledge by means of internal processes of association. As in a complex state machine, new knowledge depends on input (information) as much as on the previous knowledge. This transformation is executed by human minds, individually, or by means of some collaborative interchange of ideas and thinking [12]. The transformation of knowledge in wisdom is the realm of pure human intelligence. At the present time we have a started the systematization of the basic actions [12]:

- Collection of data, maintaining daily record of data related to task and jobs.
- Processing of data in order to obtain information, and make the information available.
- Individual and collective processing of information to generate tacit knowledge.
- Try to make tacit knowledge explicit by socialization

The process should be effective and simple. Internally, as a tool, we are using a collaborative intranet that includes task management software, document repository, version control, wikis and forums.

For company-university collaboration we are analyzing a process based on the systematic accumulation of data, information and pre-processed knowledge that can be conveyed from company to university. Professors at the university can complete the process to synthesize new knowledge by using generalization and conceptualization. The new knowledge is conveyed back to the company and, in some cases, others possible recipients, such as students, by means of courses, papers or reports.

An example can illustrate this process. In recent years there has been a rapid transition in standards related to communication between CPU and peripherals in SBCs. A migration from parallel buses such as ISA or IDE towards high speed serial buses such as PCI-Express, SATA, or USB has taken place. A company can obtain initial knowledge of these new technologies by processing information from manufacturers and standardization bodies, and can also gain some experience in specific applications, involving both hardware and software design. Involvement of academia would undoubtedly be beneficial in this process. A university department can approach the study of high-speed serial buses from a broader perspective, and can even assign the subject in end-of-term projects or thesis. The work in progress is oriented towards the systematization of this kind of process, establishing systematic means of collaboration. More theoretical subjects such as application of formal methods in specification and validation of systems, model based engineering, reliability and fault tolerance, etc. can benefit of this industry-university interchange of ideas.

## V. Conclusions and Future Work

The viability of an electronics system engineering company depends directly on the competitive quality and application of its knowledge assets. Realistic and effective management of those assets is an unavoidable strategic activity. University-industry collaboration is a mutually beneficial way of closing the knowledge of loop, conveying structured knowledge from academia to industry and experience in the opposite way, from the professional field to academia.

As a future work we are proposing a research project, devoted to analysis of techniques and processes applicable in competence and knowledge management. Other interested partners can join in the effort. The involvement of the Spanish University for Distance Education (UNED), with its ability to provide education and training to active professionals, would be very valuable.

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