CESEC Chair – Training Embedded System Architects for the Critical Systems Domain *

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ABSTRACT

Increasing complexity and interactions across scientific and technological domains in the engineering of critical systems calls for new pedagogical approach. In this paper, we introduce the CESEC teaching chair. This chair aims at supporting new integrative approach for the initial training of engineer and master curriculum to three engineering school in Toulouse: ISAE, INSA Toulouse and INP ENSEEIHT. It is supported by the EADS Corporate Foundation.

In this paper, we highlight the rationale for this chair: need for system architect with strong foundations on technical domains applicable to the aerospace industry. We then introduce the ideal profile for this architect and the various pedagogical approaches implemented to reach this objective.

1. INTRODUCTION

Defining and updating curriculum is a complex task, as instructors have to balance fundamental and applied teachings. This is particularly true in the Toulouse place where our students find position mainly in the aeronautics and space domains. Toulouse has a rich ecosystem of system integrators like Airbus, Astrium and tier-2 and tier-3 companies like Thales, Rockwell Collins, automative companies like Continental, but also service companies like Atos or Cap Gemini to name a few.

This ecosystem is organized around the Aerospace Valley cluster [2] that federates all these companies, encompassing a workforce of 75'000 people, of which 12'500 work in R&D positions. All these companies work in close relationship with teaching institutions, including undergraduates, graduates and PhD programs at various levels: internship periods, seminars and classes.

Toulouse teaching institutions (engineering schools, universities and private institutions) developed several programs to meet needs in highly trained engineers. Aerospace Valley conducted a survey of existing teaching programs for the embedded systems domain. The Toulouse place proposes 3 engineers degree, 4 master programs taught in French, 2 taught in English and 3 advanced master programs, 2 undergraduate programs and 1 apprentice programs. These cover the wide spectrum of embedded system, ranging from electronics, computer science or system engineering. Each of which relies on similar core classes in applied mathematics, physics or electrical engineering ; and also control command, network or energy to various levels.

The link between industry and these institutions is strong. Yet, these interactions are inherently limited by structural constraints that are peculiar to the way curriculum are built: 1) it is driven by individual relationships between professors and direct contact in companies, 2) it is usually a mid-term relationship, limited by companies reassigning people outside of teaching activities, 3) it remains at a limited scale, usually a few hours of presence per industry tutor scattered in various institutions. Still, companies have a key role to complement professors in teaching "real world" constraints (e.g. certification or safety) and challenges (all-electric car, eco-design of aircrafts, etc).

In addition, each curriculum is at a limited scale – to international standard. They range from 15 students (advanced master) to 15 to 120 students for engineering programs depending on elective choices. Furthermore, they remain isolated, with limited interaction across students from different programs. Yet, right after graduation, they will be colleagues.

To solve these apparent contradictions between high needs in embedded system experts and limitation in training, Aerospace Valley called for specific actions to answer heterogeneous requirements:

1. Attract more students in the embedded systems area, where 40% of the workforce is allocated;
2. Lift barriers between curriculum so as to develop a true project-driven view of student projects,
3. Drive a reflexion on the notion of "embedded system architect" as a proxy person between system engineers (in the INCOSE wording) and embedded system experts.

Points 1 and 2 can be seen as basic reorganization of existing curriculum, whereas point 3 calls for a bigger rethinking of our classes. Actually, the increasing complexity and interactions across scientific and technological domains in the engineering of critical systems calls for new, updated, pedagogical approaches.

*This work received the support of the safety-Critical Embedded SystEms Chair – CESEC created by the EADS Corporate Foundation. See http://websites.isae.fr/cesecchair/.

To drive this effort, the EADS Corporate Foundation proposed the creation of a teaching chair called CESEC: safety-Critical Embedded SystEms Chair. This chair, awarded to the three engineering schools ISAE, INSA Toulouse and INP ENSEIIHT, is tasked to meet these three requirements.

In the following, we detail the motivations for rethinking Embedded Systems curriculum, and associated requirements to preserve its quality; we then present the mission and objectives of the CESEC in section 3, we then illustrate its various missions in promoting critical embedded systems domain and actual motivations and reflexions in updating our curriculums by creating projects portfolio in section 4, and define the notion of system architects in section 5.

2. RETHINKING CURRICULUM

In this section, we first review our direct environment, that is a driver for our teaching activities, we then introduce a motivational example and discuss its limits and potential solutions.

2.1 Local environment

Toulouse has a rich teaching environment, with three engineering schools covering various aspects of embedded systems, and the University proposing undergraduate and graduate, or apprentice programs. The total number of students in these programs is 500, and encompass all aspects of embedded systems: computer science, electronics, energy as well as related domains like control/command and applied physics.

Yet, per construction each of these programs is limited to a subset of these concerns: students majoring in computer science will have solid foundations on model-based design, implementation concerns in various languages using several operating systems. Yet, they will have limited knowledge in energy management. Besides, they will know how to specify, design, implement and test atomic functions. But they will lack the "big picture" of system-level integration.

Hence, we received increasing report from our industrial partners that "something" was missing so that our students can be more amenable to understand what system-level issues are. These forces us to adapt the way we train our students to become engineers.

Actually, such motivations is not new, and similar work has already been done, for instance in the Artist Education Group [1], or locally in several universities [12, 11]. Diversity in experience, local factors like contact with industry, number of students, concurrent curriculum call for adaptation.

This is particularly true for Toulouse, where students can be lured by other domains like aerodynamics or advanced propulsion. We must then not only adapt the way we train our students to become engineers, but also balance thematics so that engineers are polyvalent: strong focus in several domains, while being knowledgeable of others.

2.2 A motivational example

Actually, this point is not specific to our direct environment, and stems from the complexity of today critical embedded systems as engineered for the aerospace domain.

As an illustration, let us consider the technical report from Feiler et al. [4]. Although this report is closer to our research activities than our teaching work, it illustrated many of the challenges our students will face when in position.

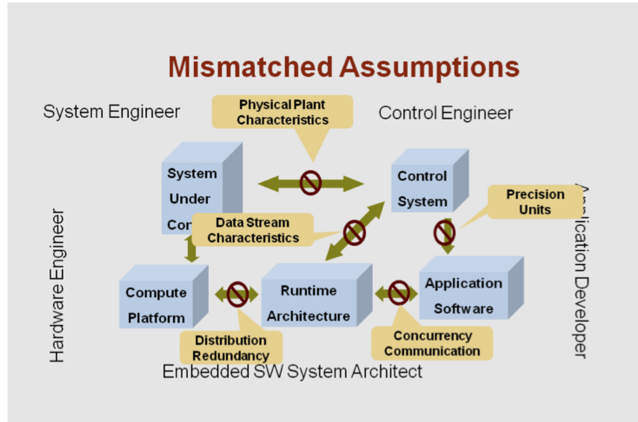

Figure 1: Mismatched assumptions, from. [4]

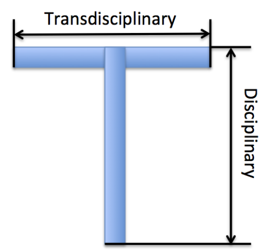

Figure 2: Breadth and width of engineer expertise

In this report, the authors report on existing projects and metrics. They underline the necessity to confront various domain expertise through shared vocabulary, processes and tools. Existing evidence demonstrate that lack of this shared foundation actually delays or jeopardizes complex aerospace projects as demonstrated in various projects such as Arian V maiden flight, Lockheed Martin UAV sensors or Airbus A380 program (see figure 1).

Findings from this report are closed to the feedback from our industrial partners: something is missing in the training of engineers so that mismatched assumptions are caught early enough in the engineering cycle to reduce risks at project-level.

We note that the risk does not come from a domain alone, but from lack of understanding of cross-domain interactions. As spotted by the authors, this is the consequence of separation of concerns and activities that limit interaction and prevent early integration.

2.3 From I-shaped to multidiscplinary

From the previous points, we reviewed our own curriculum in the Toulouse area. A working group inside the Aerospace Valley cluster made a critical review of existing embedded systems curriculum. From these analysis, we draw the following conclusions:

- We noted that the actual definition of each of the 12 proposed programs were built on core knowledge in mathematics, physics. On top of which specialized classes were taught in computer science, control, network, electronics or energy. From these, a few transverse classes focusing on applications

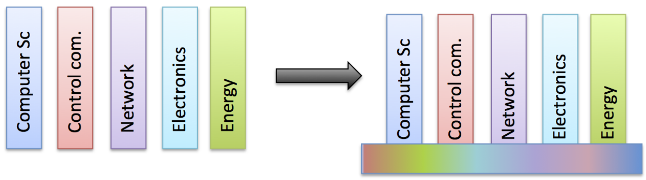

Figure 3: From I-shaped to multidisciplinary engineers

are set to move from theory to application. Yet, they represent a limited part of the classes and are implemented as team projects at the end of the program.

- The part dedicated to projects is limited to the students part of the curriculum, without interaction with other classes.
- Furthermore, students are mostly specialized in one domain out of five.

Actually, following the word of Tim Brown from IDEO, our engineers are mostly "I-shaped", that is with a deep understanding of one technical domain (see figure 2). This is done at the cost of narrowing the transdisciplinary vision that helps engineers understand interactions across domains like impact of energy on performances and thus on algorithmic to be deployed.

Widening the scope of discipline so as to gain a "T-shape" has been widely recognized as a way to increase engineers efficiency [8, 10]. Yet, it is also recognized that there are some pitfalls in the integration of more disciplines in curriculum as reported by [5]. The most significant one being that widening the scope of knowledge reduces the foundation of the "T".

As we noted before, not only need to widen the scope of our engineers to move closer to a "T-shape", we also need to increase multidiscplinary awareness. This is what we call the system-level vision. This vision has two complementary facets:

1. mastering one area of expertise while having enough competences to interact with engineers from other fields;
2. having enough transverse expertise to take system-level decisions (architecture, interfaces, trade-off) that will impact domain experts.

These two facets are mandatory to conduct projects in the aerospace domain where a large team of engineers work on complex systems across multiple companies and eventually countries. Therefore, "I-shaped" engineers must actually be "ш-shaped"[1]: that is several "I"'s with at its bottom a solid multidisciplinary foundation, capable of understanding system-level issues (see figure 3). Such ш-shaped engineer would act as a "system architect", making the junction between system and domain experts. We will reflect more on this notion of "system architect" in the next sections.

2.4 Elements of solution

To instruct multidisciplinary engineers, with a strong system-wide expertise, we need to rethink not the complete curriculum we have in place. Experience demonstrates that it is mature and addresses actual industry requirements. What is needed is to rethink the interrelation between our classes to highlight those cross-domain boundaries, and how to solve them.

We note such multidisciplinary point of view can make sense only for engineering or master of science curriculums. These already have a wide spectrum of concepts and notions. Undergraduate programs do not cover domains deep enough while graduate programs from the university are too narrow and specialize students to a high level. Hence, the Foundation EADS and CESEC partners decided to focus first on engineering degrees (the French "Grandes Ecoles") to conduct a pilot experiment.

Furthermore, there cannot be a one size fits all curriculum. Each of our existing programs has its role in the Toulouse ecosystem: computer or hardware experts, complex modeling and applied mathematics, system engineers, etc. Instead, we need to create or facilitate relations across programs.

To motivate these modifications in our teaching programs, a teaching chair as been setup thanks to support from the EADS corporate foundation. We present this setting in the next section, and further discuss how it helps promoting a multidisciplinary approach for the engineering of critical embedded systems for our students.

3. CESEC CHAIR

In this section, we list the motivation for the CESEC teaching chair, and introduces its implementation.

3.1 Motivation

The safety-Critical Embedded SystEms Chair (CESEC) is a teaching chair created by the EADS Foundation in January 2013, for a three year period. It has been awarded to three engineering schools in Toulouse: ISAE, INSA Toulouse and INP-ENSEEIHT[2].

It aims at strengthening the "system" dimension into their existing training in the field of critical embedded systems and attract more students in this field.

This Chair is tasked to develop a new engineering education pedagogy of critical embedded systems, through three axes:

1. scholarships to attract the best french and foreign students in the field of safety-critical embedded systems.
2. a portfolio of projects developed in collaboration with the aerospace and automotive industry,
3. a summer school open to international , is aimed at both professionals and young engineers and industry students. Its objective is to provides a broad view on a particular topic. For 2013, the topic was on UAV. See CESEC website for more details.
4. teaching programs will be enriched to define and strengthen the "system" dimension.

We review these elements in the subsequent parts.

[1] from the Russian letter "sh"

[2] See `http://websites.isae.fr/cesecchair/` for more details

3.2 CESEC implementation

As we mentioned in the previous section, the CESEC focuses first on engineer degrees so as to bring future engineers to multidisciplinary "ɪɪɪ-shaped" engineers. The chair supports three engineers curriculum in Toulouse:

- ISAE – Institute for Space and Aeronautics Engineering. ISAE is a reference in all aerospace domains. It provides a large multidisciplinary view of aerospace domains (physics, mechanics, applied mathematics, control, etc), combined with elective classes in embedded system, telecommunication, computer science.
- INSA Toulouse – National Institute for Applied Science. Focuses on broad scientific knowledge: embedded systems, system engineering and majors in electronics, critical software-intensive systems and minors in security, sensors, etc.
- INP ENSEEIHT
  Proposes three majors in its last year of training: electronics, telecommunications and software for critical systems.

Let us recall that in France, engineering curriculum lasts five years. The first two years are training classes for competitive exams. After selection, students receive three years of training. Usually, only the last semesters are elective. An six month internship period concludes the curriculum, usually in the industry.

In addition, CESEC also support advanced masters and masters of science taught in English, and open to foreign students:

- ISAE : MSc Aeronautical and Space Systems (AESS),
- INSA & ENSEEIHT : MSc Electronic Systems for Embedded and Communicating Applications
- ISAE & ENSEEIHT: Advanced Master in Embedded Systems. This master is open to foreign students with a master degree. It aims at completing knowledge in Embedded systems, see section 5 for more details.

For these three programs, scholarships are available to cover part of the tuition fees and part of the living expenses during the master. These incentives are covered thanks to the support provided by the EADS foundation.

All these curriculums will benefit from CESEC: first through the project portfolio, a coordinated set of projects that will irrigate the teaching content that we present in the next section; then through a careful review of the content of the classes.

4. PROJECT PORTFOLIO

In the previous section, we presented the numerous programs impacted by the CESEC. We also highlighted the necessity to widen the scope of our teaching to incorporate multidisciplinary aspects. Yet, this cannot be done all of a sudden, and must be balanced with the long history of each curriculum and associated school. Furthermore, each teaching program is scrutinized regularly by higher institution regulatory bodies ("Commission des Titres d'ingénieurs") in charge of assessing its content (level, duration, adequacy to industry requirements, etc).

Hence, we have limited room for maneuver: any modification should be within the scope of existing activities, or limited in scope. We decided to use existing time allocated to projects to instigate the multidisciplinary approach we need. To do so, we decided to use CESEC to motivate cross-curriculum and cross-institution collaboration through a portfolio of project.

4.1 Defining a projects portfolio

All our curriculums rely on several projects executed by our students to turn theory into practice. Usually, these projects are defined on opportunistic basis: need for research development or direct application of knowledge. Yet, there is no strong connections between projects, so that each team of students is working in isolation from other projects, without interfaces to a wider project.

We defined the concept of a *"projects portfolio"*. Such projects portfolio will aggregate projects across several domains and specialities intra or inter-schools, by leaning on industrial concrete cases. Let us note this is one of the few occurrences where students from different curriculum will work together.

This platform operates an innovative educational initiative to allow the students combined within the CESEC to have at the same time a global vision (associating project management and system approach) and a vision more focused in their domain of training (computer science, electronic, automatic). The acquired experience in the management, the coordination and the multidisciplinarity of this platform is key to the learning experience.

The portfolio of projects is organized as a regular call for projects, with a financial counterpart to support educational activities brought thanks to the funding CESEC receives. Participants have to propose a set of coordinated students projects in the field of critical embedded systems. This set of projects must involve at least two institutions (schools and/or companies) and covers a wide spectrum of knowledge and competencies.

Proposals are evaluated on several criteria, such as:

- Impact on the initial training: number of students, change in disciplines touched, etc.
- Collaboration with industry, other curriculums;
- Importance for the critical embedded system domain

An important aspect is the collaboration with other curriculums. One of our objective is to enforce a better understanding of typical project management issues, but also difficulty to interact with teams from other domains. We decided to favor projects with a clear roadmap for their execution, and interaction between students from different curriculums.

A first call has been issued in Spring 2013. We received four proposals, originating from the combination of seven pedagogical teams. Topics covered all range of critical embedded systems: drones, electrical vehicle, satellite platforms and avionics platform. Each proposal had a different focus: control command and advanced navigation for the drones project; power management and safety for the electrical vehicle; model-based and system engineering for the satellite platforms project and multi-core and advanced programming paradigms for the avionics platform. Around 60%

of students enrolled in embedded system classes will participate in these projects. Other students will rely on existing projects, or will be directly part of research projects.

Thanks to CESEC, we can propose new projects that receive fundings to build associated platforms; we also received commitments from our industry partners that they will allocate engineer and experts to help in the definition and mentoring of these projects. Let us note this is a significant evolution: usually management is reluctant to distract experts from business-related projects.

The projects have been selected in June 2013, and will be executed during the university year 2013-2014. A seminar and a report on the execution of these projects will be made available on the CESEC website.

4.2 Project portfolio: drone collaboration

In this section, we present briefly one accepted projects, based on collaborative drone missions.

The general objective of the project is to define the architecture and prototype a "system of systems" made of a swarm of UAVs: quad-rotors and RC helicopters. Nodes will participate in an observation mission. We aim at building such swarm, hence many topics are covered: on-board image processing, navigation and guidance, hardware and software co-design, software architectures. Astrium and Eurocopter will mentor these projects, and provide guidance in the technological choice.

The portfolio will provide projects to 60 students, scattered in the following curriculums:

- Master of Science AESS (ISAE): 250h for first year students, 150h for second year students;
- Advanced master in Embedded Systems (ISAE and ENSEEIHT): team project of 150h;
- Engineering classes at ISAE: 150 hours in second year, 30 hours in third year;
- Engineering classes at INSA, CS and Control/Command classes: 30 hours

The objective is to define collaborative missions that would be implemented on a swarm of drones. The following topics will be approached by the students, forming different projects:

- System engineering and model-based engineering: apply a system family approach to model available UAVs, their variability and performance. Devise a methodology to configure a UAV given a set of mission objectives;
- Virtual distributed simulation: define a simulation workbench to run a priori a mission in a 3D virtual environment prior to test it indoor or outdoor;
- Safety analysis: from the description of a mission, UAVs and a theater of operation, evaluate safety measures to ensure the security of the operators;
- Image processing: extend navigation capabilities to use 1) cameras, or 2) hybridized sensors (fusion of information from various sources);

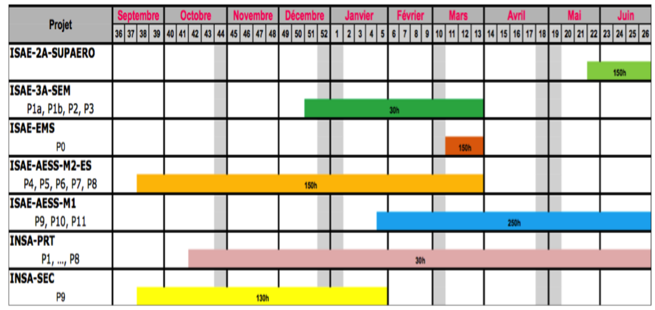

Figure 4: Project "drone collaboration" planning

- Software/Hardware co-design: optimize resource consumption by discharging the main CPU using a FPGA, for instance for image processing or IMU;
- Electro-magnetic compatibility: from the design of a UAV, identify sources of system disruption that emerges from the integration of electronic components;

These projects rely on existing UAV platforms developed at ISAE and INSA. They aim at extending particular subsystems, but also perform system-wide integration to solve particular problems.

Students will be deployed on these projects based on their initial background, and formation objectives. The various projects span over the university year with synchronization across teams and projects. Therefore, students will experiment multidisciplinary approach while performing their own project. Actually, the portfolio has been defined so that students will have the opportunity to exchange their view, for instance the impact of some choice when doing co-design on safety analysis or on EMC.

The definition and preparation of those projects require a significant effort from the pedagogical teams, and from support engineers. CESEC will help by allocating extra resources, but also mentoring from experts from the industry.

These projects concur to the first step of CESEC: developing a multidisciplinary approach for our students. The second step, becoming system architect requires a more significant update of our classes. It is discussed in the next section.

5. UPDATING CURRICULUM

We indicated in the motivations for the CESEC chair is the necessity to have system architects that can make the junction between system engineer, working at a high-level of abstractions; and domain experts, that implement specific subsystems.

As such, system architects emerge as an intermediate position in large projects. Let us refine its definition, and then explain how we are adapting the Advanced Master on Embedded Systems to train such system architects.

5.1 System engineers or architects?

As we stated in the introduction, the Toulouse higher education institutions did a review of curriculums in the embedded systems domain. We noted that curriculums domain of expertise range from systems engineering (a-la INCOSE) to various domain specific concerns like electronics, computer science, network, energy, etc.

At first, one may consider that ш-shaped engineer are systems engineer, that is people trained to apply a strong process-driven discipline. NASA [9] defines systems engineering as *Systems engineering is a holistic, integrative discipline, wherein the contributions of structural engineers, electrical engineers, mechanism designers, power engineers, human factors engineers, and many more disciplines are evaluated and balanced, one against another, to produce a coherent whole that is not dominated by the perspective of a single discipline.*

As such, systems engineer works at a high-level of abstraction. Yet, pursuing INCOSE definition from [6] *Systems Engineering [..] is creating and executing an interdisciplinary process to ensure that the customer and stakeholder's needs are satisfied in a high quality.* Therefore, they are more process minded.

We claim such profiles does not complete well with domain experts. The field of expertise of the embedded system domain alone is so wide that understanding its exact scope, and balancing design choice require a large expertise. Similar statements can be done for other domains.

Systems engineers require an intermediate level expert in the discipline of architecting embedded systems. The word "architect" is important, as it conveys *fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution* as defined by ISO [7].

Understanding principles of design and evolution is key to evaluate design modification as submitted at system-level to see whether they compromise the systems. Actually, authors in [3] remind us that much defects in aerospace projects are related to such lack of understanding. Hence, we want embedded systems architect to be ш-shaped: that is, have a strong solid multidisciplinary foundation, capable of understanding system-level issues We review in the next section how we plan to achieve this vision in one curriculum.

5.2 Towards system architect: EMS

The Advanced Master on Embedded Systems, or EMS, is a specialized master. Following the definition from the "Conférences des Grandes Ecoles" that promotes them, these masters are widening the expertise of students with a master of science or equivalent level. Such curriculums last one year, one academic semester and an internship of six months.

Entering students are either graduate students without prior work experience; or have a 3 to 8 years of working experience but with a lesser degree, usually a bachelor. They all have a major in one of the domains of the master.

EMS is jointly operated by ISAE and ENSEEIHT, each institution bringing its expertise in specific fields. EMS follows since its inception a multidisciplinary approach: it is based on a mix of theoretical and practical classes built on computer science, electronics, control/command, network, energy and aerospace applications. The later being a set of seminars by the industry, and applied courses on various fields like optimization, safety.

Since 2011, and in parallel to the definition of the CESEC, EMS evolved in parallel to our internal thinking on the definition of an embedded systems architect. The initial objective of EMS was to recruit students with a background in one of the domains of the master, and widen its understanding of the embedded domain by completing its vision. Hence, the master was often perceived as difficult, with many complex subjects to master.

CESEC, and prior discussion, led us to isolate the need for system architects. An architect being highly knowledgeable in many fields, the foundation of EMS remained similar: out of the 555 hours of classes, 305h are core classes on subjects like co-design, real-time languages, etc. Those were maintained as such, or updated to follow the state of the art.

The remaining hours are dedicated to the engineering of embedded systems. Initially, they were focused on technological challenges. Since 2011, we are modifying them so that they not only present domain-specific challenges, but also system-wide challenges, e.g. electrical vehicle and safety; safety analysis and system level constraints, etc. The objective is to use the boundaries of domain-specific classes to also demonstrate the boundaries of domain-specific work area and R&D challenges. This helps building the system-level foundation required that defines ш-shaped engineers. Hence, each class is the occasion for a set of case studies to emphasize the system-level vision an architect requires to understand the impact of any design choice.

As we defined it, the academic session of the Master program consists of a large program covering the five disciplinary fields while focusing on the architectural aspect and a set of application-oriented lectures and seminars.

- Computer science (47 h), Real time language, Architecture description language, Real time operating systems
- Control systems (59 h), Design and Validation of DES, Feedback Control, Signal Processing
- Electronics (73 h) Digital representation of analog signal, Microprocessor and DSP architecture, Architecture and Design of FPGA and ASIC integrated, Hardware and software synthesis and co-simulation, RF Front-end architecture
- Energy (63 h) Actuator and converter control, Electromechanical and static energy converters, Autonomous energetic systems, Embedded electrical network
- Networks (63 h) Embedded networks: an introduction, Specific buses and networks, Real time networks, Design and validation of real time protocols, Architecture of fault-tolerant buses, Dimensioning of an avionic network
- Embedded systems engineering – Applications (113 h) Real time control of a space system, Hybrid Systems, System Engineering, Real time control of a mechatronics system, Packaging and wireless applications, Aircraft technics, Space systems, Automobile technics
- Embedded systems engineering – Courses (83 h) System Dependability, Certification, Embedded systems and computer Security, Optimization, Electromagnetic compatibility, Mechatronics integration

A team project completes the master. It is part of the project portfolio presented in the previous section. Its objective is to solve a system-level issue by combining two domains. For instance: safety analysis of a family of drones, modeled using an architectural description language and the AltaRica language for safety analysis.

CESEC also contributes to the teaching program through high-level seminars and case studies that are disseminated in various classes for space or aeronautics systems.

Graduated students would require a strong working experience to become expert. Yet, through this complementary training, they are now sensitive to the many issues that arise when designing or implementing a critical embedded systems.

EMS is training students with either an existing master, or some work experience, to become embedded systems architect. An open question is: could this be extended to initial training, for instance engineering classes? This is currently under discussion as part of CESEC.

6. CONCLUSION

Defining and updating curriculum is a complex task, as instructors have to balance fundamental and applied teachings. This is particularly true in the Toulouse place where most of our students find position in the aeronautics and space domains. In this paper, we presented the safety-Critical Embedded SystEms Chair – CESEC created by the EADS Corporate Foundation in January 2013, for a three year period.

We first introduced the local context in which it has been set up: in Toulouse, targeting three engineering schools. We then introduced requirements for a multidisciplinary, system-wide vision of embedded systems engineering for the aerospace domain. Finally, we introduced the multiple initiatives put in place to achieve this goal: project portfolio, summer school and updated on master programs.

CESEC is a good opportunity for the embedded system curriculum in Toulouse to foster long-term collaboration on various activities. This first report on the chair context and activities will be followed by other interim report focusing on how we built the project portfolio on the long term and how we adjust to ever changing requirements from our industrial partners, but also students' expectations.

CESEC will publish on its website interim reports on the project portfolio, associated summer school and grants offered to students willing to study critical embedded systems.

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