The Department of Electronic Technology and Reliability from the University Politehnica of Bucharest - 50 Years. *Five Decades in the Service of Education and Scientific Research in the Field of Quality and Dependability*

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Introduction

On October 1st, 1971, the ***Chair / Department of Electronic Technology and Reliability (ETR)***[1] was established within the *Faculty of Electronics and Telecommunications (FET)*[2] from the *Polytechnic Institute of Bucharest (PIB)*[3].

In the vision of the founder and first head of the ETR department, Professor ***Vasile M. Cătuneanu***, it aimed to fill a gap in the training of future electronic engineers, by including in the curriculum courses that address the technology of electronic components and systems, as well as related of their quality and reliability.

At the beginning, the Department had three didactic and scientific research directions, namely: electronic technology, quality and reliability and materials for electronics. In this paper, given the specifics of the **IJISC** journal, only the field of quality and reliability will be considered, the educational programs developed in the department during these five decades being viewed in a national and international context.

This study also aims to highlight the changes in the topics considered in the ETR department in the five decades that have passed since its establishment: research and courses that initially focused primarily on quality, reliability and maintainability have also addressed security over the past 15 years, from risk analysis to the study of information security.

[1] Since 2012, the Chair ("*Catedra*", in Romanian) has become the Department of Electronic Technology and Reliability.
[2] The Faculty of Electronics and Telecommunications (FET) from PIB / UPB has become the Faculty of Electronics, Telecommunications and Information Technology (ETTI) since 2005.
[3] Starting with 1992, the Polytechnic Institute of Bucharest (PIB) became the University Politehnica of Bucharest (UPB).

The first heads of the Department were professors ***Vasile Cătuneanu*** (during the period 1971-1986) and ***Mihai Drăgănescu***, corresponding member of the Romanian Academy[4] (1986-1989). After the political changes from 1989, returned to the original name - *Electronic Technology and Reliability*, the Department was successively managed by professors ***Ovidiu Iancu*** (during the period 1990-2008), ***Paul Șchiopu*** (2008-2016) and ***Marian Vlădescu*** (after 2016).

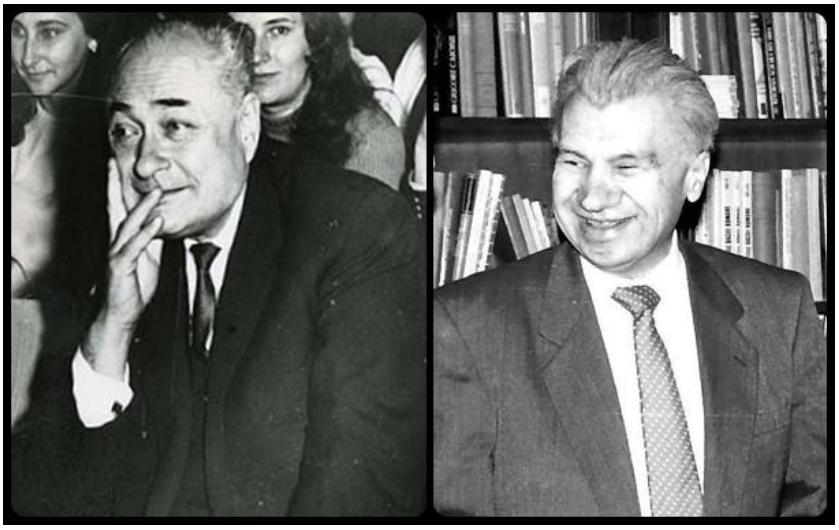

Fig. 1. Professors *Vasile Cătuneanu* and *Mihai Drăgănescu*, first heads of the Department ETR

Preliminary remarks

Dependability, viewed in the interaction of its components - *reliability*, *maintainability*, *availability*, *survivability*, and ***security*** - is a relatively new field compared to traditional technical fields: the first studies in the field of reliability date back to the 50s of last century, when were developed the first American military regulations, due to the specialists from the famous regulatory group in the field of reliability AGREE[5].

Systematic concerns in the field of systems *security* appear at the end of the sixth decade of the last century, and those in the field of *information security* - starting with the eighth decade of the same century.

Globally, the first educational programs in the field of reliability appeared only in the early '60s of the last century. The master's program in *reliability engineering*, started in 1962 at the US Air Force Institute of Technology in Dayton, Ohio, U.S.A. - intended for military personnel and the US administration - is considered the world's first educational program in the field.

[4] In 1986, the *Department of Electronic Technology and Reliability* and the *Department of Electronic Devices and Circuits* of the Faculty of Electronics and Telecommunications were merged under the name of the *Department of Electronic and Microelectronics Technology*; the leadership of this new Department was assured by Professor *Mihai Drăgănescu.*

[5] AGREE - Advisory Group on Reliability of Electronic Equipment

After 1965, several reliability education programs were developed at various American universities, including the Air Force Institute of Technology Dayton, Ohio, U.S. Naval Post-Graduate School Monterey, California, University of Phoenix, Arizona, Princetown University, New Jersey and Columbus University, New York. "*At least one course in statistics and probabilities and one in the field of reliability must be included in the curriculum of all technical universities*," said Professor *D. Kececioglu* in an article published in the prestigious journal *IEEE Transactions on Reliability* in 1984 [1].

In this context, it is noted that in Romania, especially within the Polytechnic Institute (since 1992, University Politehnica) of Bucharest (PIB / UPB) - the largest technical university in Romania - there have been valuable educational initiatives in the field quality and dependability, which places it at the forefront at European and even global level.

In this paper will be highlighted the main research and educational programs in the field of dependability, developed under the auspices of the Department of Electronic Technology and Reliability of the UPB.

Higher Technical Education in the Field of Quality and Dependability in Electronics and Telecommunications in Romania - Some Historical Milestones

In line with the global trend, research in the field of quality and reliability in the electrical field (and especially in the field of electronics) has generally been 10…15 years ahead of those in other fields.

In Romania, the pioneers of the field of *reliability* are professors **Vasile M. Cătuneanu** (for the electronic and telecommunications field) and **Vasile Nitu** (for the energy field). In the late 1970s, courses in quality and reliability began to be introduced at other faculties in the PIB (especially in the electrical ones), and after the '90s - also in other universities in Romania, especially under the aegis of some European educational projects[6].

Next, in this analysis we will refer only to the field of electronics and telecommunications. Professor Cătuneanu published - in the mid-1960s - the first articles in the field of operational reliability [2], based mainly on Russian technical literature; he also introduced at the end of the '60s the first reliability chapters in the "*Materials*" course taught to the students of the profile faculty of the Polytechnic Institute of Bucharest.

In 1971, Professor ***V.M. Cătuneanu*** - as of Dean of the Faculty of Electronics and Telecommunications (FET) from PIB - has the excellent idea, and at the same time the necessary levers for the establishment of the Department of ***Electronic Technology and Reliability (ETR)***, starting with October 1st, 1971. For this purpose, he selected the best graduates of the 1971 promotion of the Faculty of Electronics - young men and women dedicated to study and research, speakers of several languages of international circulation, as mentioned by *D. Stoichițoiu* and *V. Vodă* in their excellent "*History of quality*" [3].

[6] These courses and educational projects are not analyzed in this paper.

Among those who were called in 1971 to "break up" education and research in the field of quality and reliability in the new department we mention ***Ioan C. Bacivarov*** (Valedictorian of the "*Telecommunications*" section of the faculty), as well as ***Angelica Dogaru*** (married ***Bacivarov***) and ***Adrian Mihalache***, two of the best graduates of the "*Applied Electronics*" section.

Fig. 2. *Professor V.M. Cătuneanu, together with some of his collaborators from the new Department of Electronic Technology and Reliability (1972)*

They began a pioneering work, based primarily on the study of fundamental works in the Anglo-Saxon technical literature, which existed at that time in the "richest" technical libraries in the country: *INID* and *IFA*. In addition to those mentioned above, ***Marieta Georgescu*** (married Dragomirescu) - a graduate of the FET Faculty since 1966 - and, in the late 1970s, ***Florin Popenţiu*** were also included in the *Quality & Reliability Team* of the Department.

Professor ***Cătuneanu*** and his collaborators have the merit of understanding that the training of future electronic engineers can be complete only if the analytical program of the faculty takes into account the entire life cycle of systems and basic concepts of quality and dependability (reliability, maintainability, security) engineering, as well as the notions regarding design for quality, reliability, security, testability, etc., and technological design, must be learned from the faculty benches. They militated for this idea their entire activity, despite many constraints and contrary opinions, coming even from some colleagues or even decision-makers from the faculty.

Fig. 3. *Professor V.M. Cătuneanu, together with members of the Department of Electronic Technology and Reliability - including V. Corlățeanu, Rodica Strungaru, Angelica and I. Bacivarov, Marieta and O. Dragomirescu, I. Rusu, A. Mihalache, M. Brânzan, Monica Mihuț, Dana Gavrilescu, A. Fleșchiu and other collaborators* (*late 70's*)

The first chapters in the field of quality and reliability had already been introduced in the analytical curriculum of the Faculty of Electronics and Telecommunications in the early 1970s (as part of the *Materials* course). The young teachers of the ETR Department prepare new courses, corresponding to each specialization: *Reliability of telecommunications systems, Reliability of electronic equipment, Reliability of electronic components*, etc.), which are successively introduced in the specialized sections, starting with 1973. At the same time, the first technological courses are

introduced in the faculty, because in the vision of the new ETR Department, the design for reliability and maintainability had to be correlated with the technological one to develop high-performance systems.

It should be noted that, unlike the "traditional" technical fields (such as mathematics, physics, electrical engineering, etc.), for which there was already a serious background and many fundamental works published, the field of *quality and reliability* was new, and it was effectively "developed" by the members of the profile team from the ETR Department: from the elaboration of the didactic programs to the writing of some specialized books and textbooks, as well as by arranging and equipping specialized laboratories.

During the difficult period of 1975 - 1990, the sprouts of a *Romanian school of reliability* are already emerging, in which the members of the reliability team of the ETR Department had an important role: fundamental works in the field are published [4]…[9] and scientific research contracts are concluded to solve real industry reliability and profile research issues, such as increasing the reliability of electronic TVs and computers, analyzing and increasing the reliability and security of electronic equipment in shipping and the chemical industry, making equipment for testing electronic components and computer systems, etc.[7]

Fig. 4. *Professors Adrian Mihalache, Angelica Bacivarov, and Ioan Bacivarov at the Pan-European Conference "e-learning Society" (2002)*

Among ***the new didactic*** and ***scientific research fields*** developed and imposed in Romania by these professors, we mention: *the reliability of telecommunication systems, the analysis of the reliability and security of highly functional importance systems, the*

[7]A selective list of the main scientific - national and international - research contracts in the field of quality and reliability within the ETR Department, as well as the works elaborated by them is given on the EUROQUALROM Laboratory website, www.euroqual.pub.ro.

*dependability management, human reliability (**Ioan Bacivarov**), reliability and security of computer systems* - both *hardware and software, fault-tolerant systems / computers, automatic testing and technical diagnosis (**Angelica Bacivarov**), uncertainty theory (**Adrian Mihalache**), reliability optimizations (**Florin Popențiu**).*

The new **ETR** Department consolidates its presence and the leading role of the field in the Romanian scientific landscape of that period also by organizing several scientific events, the most important of which is, of course, the *National Symposium "Electronic Technology and Reliability"*. The first edition of the symposium was organized at P.I. Bucharest in November 1977 (president: *V.M. Cătuneanu*, scientific coordination: *Ioan C. Bacivarov*), and several scientific and administrative personalities of the moment spoke in the opening. A wide selection of the over 120 papers presented at the symposium was included in a large volume published by the Didactic and Pedagogical Publishing House [10]. The symposium "*Electronic Technology and Reliability*" had 10 more editions, in different university centers, until 1990, when it ceased to exist and was replaced by other conferences in the field, among which of course the most important will be the *International Conference on Quality and Dependability, CCF*[8], now at the 16th edition.

Fig. 5. Participants at the first edition of the *National Symposium "Electronic Technology and Reliability"* (November 1977), including Professors V. Cătuneanu, G. Cartianu, N. Necula, E. Diatcu, U. Wiener, R. Tomescu, A. Bacivarov a.o.

During the '80s, Professor Cătuneanu and other members of the specialized team from the ETR Department are involved in organizing and coordinating quality-reliability sections of various national conferences and symposia (Romanian Academy sessions, national conferences on electronics and telecommunications, SACEP symposia, etc.).

Despite the restrictions of that period, members of the reliability team in the ETR Department are becoming increasingly visible internationally, by publishing articles in prestigious international scientific journals such as *IEEE Transactions on Reliability*,

[8] The *International Conference on Quality and Dependability,* ***CCF***, is organized by SRAC (beginning with 1986), under the aegis of several international organizations, including IEEE. The scientific chair of **CCF** is Prof. Ioan Bacivarov.

Reliability Engineering & System Safety, *Microelectronics and Reliability*, etc., or by submitting papers to well-known international reliability conferences held in England, France, or Hungary.

Fig. 6. *Romanian and foreign participants in the International Conference on Quality and Dependability - CCF 2014*

As editors of the few Romanian scientific journals that appeared until 1989, Prof. ***V. Cătuneanu*** *(Automatică și Electronică / Automation and Electronics, Telecomunicații / Telecommunications)* and Dr. ***Ioan Bacivarov*** *(Calitate, Fiabilitate, Metrologie / Quality, Reliability, Metrology)* contributed to the highlighting of the most important results of local scientific research in the field.

After 1990, Professor ***Ioan Bacivarov*** became involved in the establishment and editorial coordination of specialized international journals (including *Asigurarea Calității - Quality Assurance*, since 1995, *Calitatea - Acces la succes / Quality - Access to Success*, since 2000, and the *International Journal of Information Security and Cybercrime - IJISC*, since 2012). As Editor / member of the Editorial Board of some prestigious international journals in the field, including *Quality Engineering* (USA) and *Reliability Engineering & System Safety* (Elsevier, UK), he has contributed to the better international visibility of Romanian research in the field of quality and dependability.

The Postgraduate Academic Program "Quality, Reliability, and Maintainability of Complex Systems"

An important moment for the development of profile education was the launch in 1972, under the coordination of Professor ***Cătuneanu***, and with the substantial contribution of his young collaborators, of *the postgraduate program* in the field, the first promotion obtaining graduation diplomas in 1973.

This postgraduate program ran uninterruptedly for 36 years, from 1972 to 2008, with about 1600 students graduated, specialists with higher education, mainly in the technical field (over 95% of graduates), but also in the economic field. It is, without a doubt, one of the most successful postgraduate technical education programs with the longest existence in Romania. Between 1976 and 1980, the course coordinator was Prof. ***Vasile Corlățeanu**, PhD* and since 1981 the courses have been coordinated by ***Ioan C. Bacivarov**, PhD.*

Initially, this postgraduate program focused mainly on the field of *reliability* (being, in fact, originally referred to as *"Postgraduate courses in reliability"*) and, partially, on *maintainability*, but after 1982 the courses' scope was extended, successively, to all aspects of *dependability* (reliability, maintainability, security). After 1990 it began to address the *entire issue of quality*, seen in the synergy of its sides. The issue of security was addressed in the course *"Reliability and security of highly functional importance systems"*, held by Prof. ***Ioan Bacivarov*** between 1985 and 2008.

Many of the prestigious Romanian specialists in the field of quality and dependability in Romania have contributed, over the years, as professors in the postgraduate academic program "*Quality, reliability, and maintainability of complex systems"*. We are very pleased to mention, working in the early stages of the courses, the names of the university professors ***Vasile Cătuneanu, Vasile Corlățeanu, Vasile Nitu***, ***Cezar Ionescu***, ***Tudor Baron***, as well as those of the associate professors ***Dan Stoichițoiu***, ***Eugeniu Diatcu***, ***Ulrich Wiener***, ***Dumitru Niculescu*** and others.

We can mention among the specialists who, for a longer or shorter period, taught courses in the postgraduate program in the field of quality and dependability, organized under the auspices of the Department of Electronic Technology and Reliability: Prof. ***Angelica Bacivarov***, PhD (testing and technical diagnosis, fault tolerance), ***Marius Bâzu***, PhD (reliability of components), Prof. ***Marieta Dragomirescu***, PhD (reliability of electronic equipment), Prof. ***Adrian Mihalache***, PhD (theory of renewal, mathematical foundations of quality and reliability), Prof. ***Gheorghe Oprișan***, PhD, Assoc. Prof. ***Rodica Tomescu***, PhD (mathematical foundations of quality and reliability), ***Dan Stoichițoiu***, PhD (assurance and certification of quality), Prof. ***Sorin Ionescu***, PhD, ***Traian Teodoru***, PhD (quality management), Prof. ***Ioan Bacivarov***, PhD (fundamentals of dependability, modern approaches in reliability and maintainability, reliability and security of highly functional importance systems, assurance and certification of quality and dependability).

From the above name list, it is noted that some of the most important Romanian specialists in the field in the last 5 decades have contributed to the training of students, from industry and research (before 1990), as well as from companies and ministries (after 1990), and, what it is perhaps more important, to make them aware of the importance and theoretical and practical aspects of implementing quality and dependability.

The European educational project TEMPUS S_JEP-11300 "EUROQUALROM" and later the European educational program ERASMUS / SOCRATES exerted a particularly positive influence on this postgraduate academic program, as well as on the master's programs that followed it. Thus, the curricula / syllabuses have been reconfigured to be in line with those of prestigious universities in the European Union (and especially with those of the *European Program in Quality of Complex Integrated Systems - EPIQCS*).

In fact, considering the level of these postgraduate courses and - later - of the master's program in the field, the University Politehnica of Bucharest was accepted as an associate member of the *European EPIQCS Program*, completed with the *European Masters for the Quality of Complex Integrated Systems* [11].

TEMPUS Project - EUROQUALROM - Anchoring Specialized Postgraduate Education at European Coordinates

The largest and most important project developed within the Department of Electronic Technology and Reliability in the '90s was, of course, the European project ***TEMPUS S_JEP-11300 "EUROQUALROM"*** (international coordinator: Prof. ***Ioan Bacivarov***, PhD, contractor: Prof. ***Marin Drăgulinescu***, PhD), a program whose results were also appreciated by the European Commission's education bodies, which considered it a "model project in the field".

The educational project ***"EUROQUALROM"*** was developed within the European program ***TEMPUS - PHARE*** between 1996 and 1999 and it involved partners with brand achievements in the field of quality and dependability, mainly from the university environment. The interface with the sphere of industry and services was ensured through two of the main Romanian non-governmental organizations in the field of quality assurance and management at that time, namely the *Romanian Society for Quality Assurance (SRAC)* and the *Romanian Foundation for Quality Promotion (FRPC)*.

If we refer to local universities, we must mention the participation of the main Romanian universities in the **technical** field (*University Politehnica of Bucharest - Faculty of Electronics and Telecommunications* and *Faculty of Power Engineering* - both faculties with notable achievements in engineering, quality assurance and reliability) and the **economic** one (*Bucharest Academy of Economic Studies*, also with important contributions in the field of quality control and management), as well as two other technical universities active in this field, respectively the universities of *Oradea* and *Pitești.*

Among the prestigious universities in the European Union participating in the **TEMPUS S_JEP-11300 project "EUROQUALROM"** is worth mentioning the *National Polytechnic Institute of Grenoble* (France), coordinator of the European Educational Program on the quality of complex integrated systems - EPIQCS, *University of Piraeus* (Greece), coordinator of the Program European Educational Center for Total Quality Management - EMPTQM, the *Institute for Strategic Quality Management* at the *Erasmus University in Rotterdam* (Netherlands), the *Polytechnic Institute of Turin* (Italy), and the universities of *Angers* and *Paris - ENSAM* (France), *Barcelona* (Spain), *Lisbon* (Portugal), *Paisley* (United Kingdom).

The main objective of the **TEMPUS** project **"EUROQUALROM"** was the *reconfiguring of curricula* in technical (especially electrical - electronic and energy) and economic faculties, to include in educational programs the *issue of quality* (seen in the interaction of its components, static and dynamic) and in particular *quality assurance, control, certification*, and *management*, following the requirements of economic organizations and Romania's desire to participate in Euro-Atlantic structures, which also involved an alignment with European standards in this vital area [12].

Fig. 7. *EU TEMPUS S-JEP 11300 "EUROQUALROM" - A successful European educational project. An image from the meeting of the Steering committee (Oradea, 1999) with the participation of Professors Cristina Mendonca and Amilcar Goncalves (University of Lisbon), Ton van der Wiele (University Erasmus, Rotterdam), Daniela Popescu (University of Oradea), Tudor Baron (Bucharest University of Economic Studies) and Ioan Bacivarov (University Politehnica of Bucharest)*

The aim was also to *reorganize courses* in the field of quality and dependability, in line with those taught in elite universities in European Union (EU) countries, as well as to *modernize the teaching methods* used in this field (mainly through the intensive use of *computer-assisted training* and *multimedia systems*). The issue of *ensuring and managing the educational process in higher education* was also considered, including the development of appropriate models and metrics for its *monitoring* and *evaluation*. This project was one of those that laid the foundations of the local system of ensuring and certifying the quality of technical and economic higher education.

The first stage of the project aimed at the elaboration of a ***strategy*** *to approach quality* in higher education - technical and economic - in Romania, in cooperation with the EU partners, following the system used by the profile universities in the European Union.

To achieve the objectives of the TEMPUS project "EUROQUALROM", several *working groups* were formed with goals related to the development of optimal strategies for the introduction of quality issues in higher education. Among the most active working groups, we mention those having as object of study the implementation of quality in technical and economic higher education, respectively the quality assurance, the quality engineering, the quality management, the industry-education interface, the specific problems of small and medium universities, specific problems of quality assurance in higher education, etc. The conclusions of the work meetings were presented in several debates / round tables and meetings organized under the auspices of the TEMPUS project S_JEP-11300-96 "EUROQUALROM", including the workshops

"Strategy for Addressing Quality in Technical and Economic Higher Education in Romania" (Bucharest, November 30, 1997), *"Strategies for Romanian and European Union Universities on Higher Education in the Field of Quality"* (ENSAM Paris, April 3 - 4, 1998) and *"Romanian and European University and Postgraduate Programs in Quality and Reliability"* (Oradea, May 17 - 18, 1999).

Fig. 8. *The coordinator of the European educational project TEMPUS, Professor Ioan Bacivarov, opening one of the workshops TEMPUS - EUROQUALROM dedicated to higher education in the field of quality and reliability with professors Ioan Constantin, Marin Drăgulinescu, Vasile Cătuneanu, Bernard Dumon, and Tudor Baron (1998)*

It should be noted that the attention of the Steering Committee of the TEMPUS Project "EUROQUALROM" has always been on t*he best possible dissemination of the results obtained*, both nationally and internationally, a fact achieved through the 6 books and over 60 articles and scientific communications published as a result of this project.

From the educational point of view, the restructuring of undergraduate and postgraduate courses at partner universities has been carried out following current European requirements. As a result of this project in particular in the Faculty of Electronics and Telecommunications of the UPB, the postgraduate academic program in the field was modernized, and starting with 1996 the first post-academic program (master's degree) *"Quality and reliability engineering"* began to operate.

The curricula of the postgraduate and master's educational programs coordinated by the ETR Department have been continuously improved, to be following the existing norms and regulations at the national and international level in the fields of quality and dependability. Particular emphasis was put on the issue of quality assurance, certification and management, reliability and security, several courses with this topic being introduced. The norms from the ISO 9000, ISO 14000, ISO 27000, CEI 300 series, the integrated quality, environment and safety management systems, the modern tools of total quality management, the Six Sigma method, etc. have started to be studied in this context.

It should be noted that since the late 1990s - including through European TEMPUS programs of this type - quality and reliability courses (university and

postgraduate) were introduced at most faculties in the UPB and most important technical universities in Romania; this has of course helped to complete the training of students with the requirements of real technical systems, as well as those of manufacturing companies.

Master's Programs in the Field of Quality and Dependability

Starting with 1996, based on the experience gained through the postgraduate academic program *"Quality, reliability, and maintainability of complex systems"*, the individual TEMPUS programs, as well as the TEMPUS program - EUROQUALROM, in the ETTI Faculty, UPB was implemented the master's program ***"Quality and Reliability Engineering" - ICF***, the first master's degree in the field in Romania (lasting 1 year). This master's program, which has been operating successfully for a decade, was coordinated by Prof. ***Angelica Bacivarov.***

Starting with 2006, taking into account the new requirements of higher education related to the implementation of the "Bologna cycle", the master's program ***"Quality and Dependability in Electronics and Telecommunications" - ICSFET***, started to operate in the Faculty of ETTI - UPB, coordinated successively by professors ***Angelica Bacivarov*** and ***Ioan Bacivarov***; it was based on the experience and improvements made - for a decade - to the ICF master's degree. Given the high competition since admission, as well as the favorable evaluations on the satisfaction of master's students and employers, the ICSFET program can be considered as one of the successful master's programs developed within the ETTI Faculty of UPB.

The master's students appreciated the fact that this program provided them with the specialized knowledge in fields little or not at all approached in the undergraduate studies, but necessary for the exhaustive training of the future engineers. It is important to mention that most graduates of this master's program were employed - mostly in the *Quality - Reliability - Safety and/or Testing - Diagnosis* - departments of Romanian or multinational enterprises and companies, their training being favorably appreciated by employers.

Among the teachers from the Department of Electronic Technology and Reliability within ETTI - UPB who contributed to the success of these master's programs we mention professors ***Ioan C. Bacivarov, Angelica Bacivarov, Adrian Mihalache, Norocel Codreanu, Alexandru Vasile, Orest Oltu, Iulian Năstac, Lucian Milea*** and others.

It should be mentioned that some of the specialized courses on quality assurance and certification and reliability, quality management, the security of information systems, standardization and legislation in the field, quality control of technological processes, etc. were taught by well-known specialists in the field from the *Romanian Society for Quality Assurance - SRAC (**Dan Stoichițoiu**, PhD, **Cristinel Roncea**, PhD and others), the Institute for Microtechnologies - IMT (**Marius Bâzu**, PhD), Police Academy „Al. I. Cuza" Bucharest (Assoc. Prof. **Ioan-Cosmin Mihai**, PhD), the Romanian Association for Information Security Assurance - RAISA (**Gabriel Petrică**, PhD, **Sabina Axinte**, PhD) or other institutions (**Luminița Copaci**, PhD, **Costel Ciuchi**, PhD)*. This allowed the linking of the courses taught with the real problems of the European economy and society, in general, and of the Romanian ones, in particular, and contributed to the rapid integration of the graduates in the profile companies.

Fig. 9. *Class of 2017 of the ICSFET master's program, ETTI - UPB*

Another major postgraduate program - for the implementation of which the ETR professors contributed - was the master's in "***Quality, Reliability, Maintenance, Risk and Safety in Electrical Engineering***", a project funded by the World Bank. This master's degree was organized through the cooperation of the Faculties of *Electronics and Telecommunications* (responsibles Prof. ***Ioan Bacivarov*** and Prof. ***Angelica Bacivarov***), *Power engineering* (responsible Prof. ***Cezar Ionescu***), *Electrical Engineering* (responsible Prof. ***Octavian Popescu***) and *Automation and Computers* (responsible Prof. ***Valentin Sgârciu***) from UPB and was a real success of the university's postgraduate education from 2000-2010.

Fig. 10. Graduates of the master's program *"Quality, reliability, maintenance, risk and safety in electrical engineering*", together with professors Angelica Bacivarov, Ioan Bacivarov, Octavian Popescu and Valentin Sgârciu (2007)

Following the example of the European universities that the *EUROQUALROM Laboratory (ETR - ETTI)* has been collaborating with for over three decades, we can say that successful master's programs can only be achieved through close cooperation with renowned organizations and companies with activities related to the field (in some universities in the EU, over 50% of the courses are taught by associate professors) and that is why we want to develop this cooperation in the future.

Fig. 11. *Members of the commission for the dissertation exam at the ICSFET master's program within ETTI - UPB (June 2016): Prof. I. Năstac, Prof. Angelica Bacivarov, Prof. I.C. Bacivarov (chairman of the commission), Prof. A. Manea, Prof. A. Mihalache*

Thanks to the European educational mobility programs *ERASMUS / SOCRATES*, about 50 ICSFET master's students were able to carry out educational internships of 3 months each at universities in the European Union (especially at *ISTIA - the University of Angers* and *TIMA - INP Grenoble*, France, with which the Laboratory *EUROQUALROM - ETTI - UPB* has excellent relations of educational and scientific collaboration), where they elaborated, in co-tutelage, the dissertation works. At the same time, 18 French students from the University of Angers completed their ERASMUS internships at the EUROQUALROM Laboratory in the last decade.

Over the last decade, the focus of security concerns has shifted to security, and in particular to cybersecurity, which has been reflected in the restructuring of the ICSFET program. At the same time, especially at the Faculties of Electronics and Automatic Control of UPB, other master's programs have been developed that include, to a greater or lesser extent, this issue: a particularly positive fact, given that the demand for cybersecurity specialists is constantly growing.

PhD in Reliability

The first professors who, after 1971, received the right to conduct doctorates in reliability in I.P.B., in the field of electronics and respectively, automation, were ***Vasile M. Cătuneanu*** (*Electronics*) and, later, ***Dumitru F. Lăzăroiu*** (*Automation*). Under their leadership, young professors from the university environment completed their doctorates: *Ioan Bacivarov* (1978), *Adrian Mihalache* (1979), *Angelica Bacivarov* (1980), *Ioan Hohan*, and others, but also young researchers in the field, including *Dan Stoichițoiu*, *Eugenie Stăicuț*, and *Ioan Tutoveanu*.

After the political changes of December 1989, there was a revival in higher education: after a decade of stagnation, advances in higher education were permitted and high-performing teachers received the right to conduct doctorates in reliability since 1991: *Ioan Bacivarov* in telecommunications (under the patronage of ICTc), *Angelica*

Bacivarov and *Adrian Mihalache* in electronics (under the patronage of ICPE, respectively ICE). Under their leadership, important researchers in the field are finalizing their doctoral theses, among which *Marius Bâzu, Traian Teodoru, Marcu Buşe,* and others.

After 2000, in the context of the restructuring of technical higher education following the "Bologna cycle", there is also a restructuring of doctorates and, unfortunately, *reliability* disappears as a doctoral specialty. However, Professor ***Ioan Bacivarov*** has been accredited to conduct doctorates in the field of "*Electronic Engineering and Telecommunications*" since 2000. Under his leadership are completed several valuable doctoral theses in the field of quality, reliability, and security, such as those developed by *Alin Mihalache, Florina Băbuș, Răzvan Lupan* (doctoral theses coordinated in co-tutoring with professors from the Quality - Reliability Department of the University of Angers, France)[9] and more Romanian theses in the field.

Fig. 12. *Professors B. Dumon and A. Kobi (ISTIA - University of Angers, France) and I.C. Bacivarov ("Politehnica" University of Bucharest) with two of the PhD students they coordinated in co-tutoring, R. Lupan and A. Mihalache (Angers, 2004)*

Among the valuable doctoral theses in the field of reliability and security of information systems coordinated by Prof. ***Ioan Bacivarov*** and completed in the last decade are those developed by *Ioan-Cosmin Mihai, Luminița Copaci, Costel Ciuchi, Gabriel Petrică, Sabina Axinte, Ionuț-Daniel Barbu* and others[10]; they then contributed

[9] **Alin-Gabriel Mihalache**, *Modélisation et évaluation de la fiabilité des systèmes mécatroniques: application sur système embarqué*, Thèse de Doctorat, Directeurs de thèse: Prof. **Fabrice Guerin** et Prof. **Ioan Bacivarov,** Université d'Angers, 2007.
Florina Băbuș, *Contrôle de processus industriels complexes et instables par le biais des techniques statistiques et automatiques***,** Thèse de Doctorat, Directeurs de thèse: Prof. **A. Kobi** et Prof. **Ioan Bacivarov**, Université d'Angers, 2008.
Răzvan Lupan, *Évaluation de la performance financière et organisationnelle des politiques qualité,* Thèse de Doctorat, Directeurs de thèse: Prof. **Alain Capiez** et Prof. **Ioan Bacivarov**, Université d'Angers, 2009.
[10] **Ioan-Cosmin Mihai**, *Contributions to the study of the survivability of information systems*, Doctoral thesis, UPB, 2011.

to the training in the field of IT security, both in the projects / workshops organized by RAISA and in the ICSFET master's program. Noting the value of doctoral theses, as well as other works in the field of cybersecurity developed by these PhD students (whom he had the opportunity to meet at the *CCF 2016* international conference), Professor ***A. Birolini***, who is considered a "guru" of European reliability, said that, in his opinion, "the future of the field is assured in Romania".

Fig. 13. *PhD students in the field of cybersecurity, coordinated by Prof. I. Bacivarov, who presented papers at the CCF 2016 international conference, together with professors A. Birolini (ETH Zurich) and Angelica Bacivarov (UPB)*

Final Considerations

This paper was intended to be a review of the main didactic and scientific programs in the field of quality and dependability developed under the auspices of the Department of *Electronic Technology and Reliability (ETR)* of the PUB in its five decades of existence. It is also intended to be a modest tribute to the multitude of Romanian specialists in the field who contributed to the implementation of these programs, some of which, including the founder of the ETR Department, Professor ***V.M. Cătuneanu***, have already passed into eternity…

[10] **Luminița Copaci**, *Contributions to ensuring and increasing the quality and safety of information systems*, Doctoral thesis, UPB, 2011.
Virgil-Liviu Ilian, *Reliability and dependability issues for autonomous robots*, Doctoral thesis, UPB, 2012.
Costel Ciuchi, *Contributions to the development of an IT system for decision-making processes. Computer systems security modeling*, Doctoral thesis, UPB, 2012.
Gabriel Petrică, *Contributions to security assurance of information systems in online environment*, Doctoral thesis, UPB, 2019.
Sabina Axinte, *Research on verification and validation techniques for information systems*, Doctoral thesis, UPB, 2020.
Cătălina Gherghina, *Contributions to the improvement of the quality and security of IP based services in intelligent telecommunications networks*, Doctoral thesis, UPB, 2020.
Ionuț-Daniel Barbu, *Cyber security: the vulnerabilities of future information systems*, Doctoral thesis, UPB, 2020.

The ETR Department has been - since the 70's a real "*pole of excellence*" in the field, both through educational programs and through scientific research in the fields of quality and dependability developed. It is important to mention that in their implementation, in addition to the professors from the Department, the best specialists in the field from research institutes and enterprises were attracted.

In addition, after 1990, courses in the field of quality and reliability were introduced - according to the ETR model - at other technical faculties in Romanian universities.

At this milestone, we can say that beyond the technical, economic, or managerial knowledge they transmitted to students, the postgraduate courses and master's programs in quality and dependability organized under the auspices of the specialized team in the ETR Department have the merit *to raise awareness* among a large number of graduate and postgraduate students in the technical, economic or of services fields about the importance of modern tools and approaches, as well as the legislation in this topical interdisciplinary field.

After five decades of higher technical education and scientific research in the field of quality and reliability in electronics and telecommunications, we can speak today of a real "*Romanian school*" in the field, whose achievements are known and appreciated both nationally and internationally. Important international specialists in the field, including professors *A. Birolini, A. Barreau, Ton van der Wiele, E. Zio, Michele Cano, A. Goncalves, A. Kobi, L. Balme and others*[11] confirmed these achievements at important international conferences in the field (including *ESREL, QUALITA, CCF*).

An argument in this direction is represented by the over 60 books and 800 articles and scientific communications published in the country and abroad by the members of the *Quality - Reliability Team* of the ***ETR Department***, as well as more than 60 national and international scientific research grants coordinated by them. Also, the numerous technical journals they have created / coordinated and the specialized national / international conferences they have initiated and coordinated support this statement, too.

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[11] Many of these prestigious European professors, with whom we collaborated in the TEMPUS project "EUROQUALROM", gave guest lectures in the field of quality and dependability in various workshops, symposia, and educational programs (master's and doctorates) organized under the patronage of ETR - ETTI.

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