

## **INNOVATORY MASTER OF ENGINEERING DEGREE IN METROLOGY**

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### **ABSTRACT**

*This paper describes the development of a new master degree program in metrology. The curriculum is multidisciplinary; it was organized on behalf of support of EU TEMPUS SCM project in cooperation between three universities and under patronage of Ministry of education of the canton.*

*The main objective of the program is to educate graduates having solid metrological background, both theoretical and practical skills, flexible enough to cope with rapidly moving technologies. The other aim is to educate graduates which are able to participate in establishing national metrological system in candidate country for EU membership. The program can fulfil effectively an urgent need to develop high level manpower to support national metrological network and industries. The paper presents a concept of course development, coordination of teaching and laboratories, the current stage of project progress and plans for the future.*

**Keywords:** metrology, metrological infrastructure, metrological documents

### **1. INTRODUCTION**

Science and technology are considered essential to the national socioeconomic and industrial development in the years ahead. To enhance the development of these two elements, greater emphasis has to be placed on a more systematic approach to the acquisition and transfers of technology, from both domestic and foreign sources, which will lead to research and development activities (R & D) for the creation of innovations and more commercial value adding. This approach also requires the availability of basic infrastructure such as national information database and network, intellectual property protection, especially national metrology system. The importance of the national metrology system is well recognized which can be seen from the statement emphasized in the recently adopted law and all documents issued by the government.

A national metrology body will have to take responsibility for, and coordinate with other agencies related to, acquiring, maintaining and development standards of scientific measurement. Trends in modern economy show the need to establish a calibration network to facilitate the traceability of measurement of results to the national and international standards.

Parliament accepted the Law about National Metrology Institute (NMI) and established NMI in 2000. The Institute started to work on 1st of January 2007. Aforementioned Law established three national institutes: for metrology, for standardization and protection of intellectual property, and for accreditation.

In order for the field of metrology to advance in line with the growth in a particular branch of industry, it is necessary to provide the appropriate personnel, up-to-date standards and measuring

equipment. It will be necessary to import sophisticated foreign equipment and specialized experts for metrology. Developing countries must also make an effort to penetrate the domain of fundamental scientific research as it relates to metrology. While it is necessary to use expertise acquired from abroad, it is not usually possible to transfer metrology from the developed countries in a successful manner without the intervention of a domestic, scientific and technological base to ensure the adequate application of such knowledge. Metrology is the science of measurement and it is through metrology that accuracy of measurement is achieved. Metrological capabilities have to provide measurement of physical quantities with the required level of accuracy. The degree of development of metrology in a country also reflects the stages of development in its industry.

After the war in Bosnia and Herzegovina, manufacturing and service companies rapidly began to certificate their quality management systems according to ISO 9000, ISO 14000 and QS 9000 series. Establishing these quality certifications increased their presence, status and opportunities within Bosnian and international markets.

Due to rapid industrial expansion in the surrounding over the past ten years, the demand for science and technology workforce has been rising very quickly. The supply could not keep pace with the demand. The situation in the Balkan area is not the same as in the other countries but the increasing demands for the development ask for specialists especially in the areas not educated previously. As a consequence, Bosnia will face with a serious problem from the shortage of high-level personnel in metrology in the near future, important for high-technology industrial development and fundamental scientific research to ensure the successful transfer of technologies relating to B&H.

There is an urgent need to develop high-level manpower to support the development of the metrological system and industrial development as shown in Figure 1.

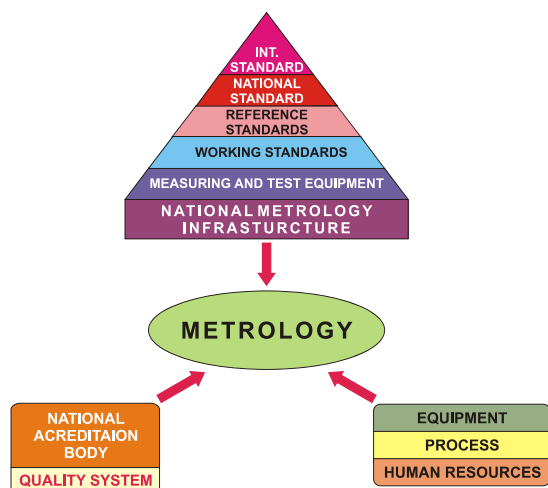


Figure 1. Requirement for course development.

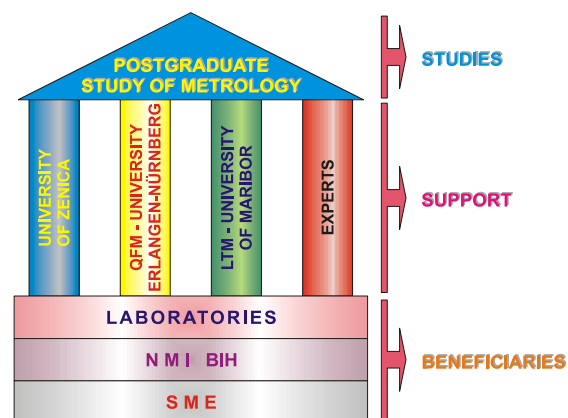


Figure 2. Consortium of interested and involved in metrology

## 2. REQUIREMENT FOR COURSE DEVELOPMENT

At present, Bosnia and Herzegovina can produce only a small number of graduates suitable for metrological development. Courses in measurement sciences and technology have never been offered at both undergraduate and postgraduate levels in Bosnia and Herzegovina. An advanced program at the postgraduate level should be initiated to produce the urgently needed manpower. As education institutions in Bosnia and Herzegovina are generally weak in the area of metrology, a consortium of institutions should be formed for such a purpose.

## 3. THE CONSORTIUM

On the occasion of EU SCM TEMPUS project, the Master of Engineering degree program in metrology has been established. This unique and first of its kind program has been offered, both in theoretical groundwork and laboratory skills, by the consortium of 3 universities, namely: Chair for Automation and Metrology at the University of Zenica, Chair for Metrology and Quality Management at the University of Erlangen, Department for Production Technologies (Laboratory for Technological

Measures) at the University of Maribor, and a number of experts from other institutions. The six objectives in organizing the consortium are as follows:

- to produce graduates at the master degree level in industry, and fundamental measurements.
- to promote research and development activities in metrology.
- to strengthen selected University in Zenica in the area of metrology through staff development and R&D funding supports.
- to promote the offer of courses in metrology as electives at the bachelor degree level and master in science and engineering.
- to deliver advanced courses on metrology to practice engineers and scientists.
- to put the groundwork for future Ph.D. program in metrology in Bosnia and Herzegovina.

The budget for the master program is partially supported by EU funds with a participation of students.

#### 4. PROFILE OF THE COURSE

The Master of Engineering degree program in Metrology is a two semester master course. It comprises of strongly selected appropriate areas in science, engineering and technology. The objectives of the course are:

- to educate graduates having adequate theoretical groundwork and practical skills in metrology to work in a related field.
- to have master degree graduates for various areas in mechanical metrology, to cover all fields like dimensional metrology, computational metrology, vibrations, noise, measurement uncertainty, and calibrations, etc.

Table 1. Metrology program structure.

1. Compulsory courses	2. General courses	3. Elective courses	4. Definition of Master thesis
Metrology for research and development	Measurement uncertainty	GPS, Geometrical product specifications	
Standardization	Calibration documentation and laboratory management	Testing product characteristics	
Measurement planning and processing of results	Instrumentation	Measurement of process properties	
Metrology infrastructure			

#### 5. RESULTS AT THE MIDDLE OF STUDY

Results of the study are quite good comparing to the previously organized postgraduate courses. We tried to experiment and to evaluate knowledge of the students. Every student works on his own topic in a written form, and makes a public presentation. Results of the study are presented for the first semester of the study and presented in diagrams, figures 3 and 4. It is evident that very intensive and compressed study gave satisfactory results. A majority of students passed their exams, in spite of employed status all of the students.

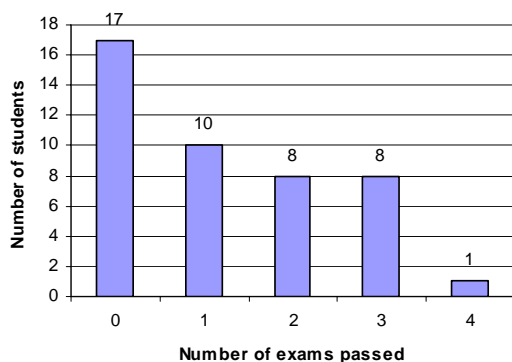


Figure 3. Number of exams students passed after the first semester.

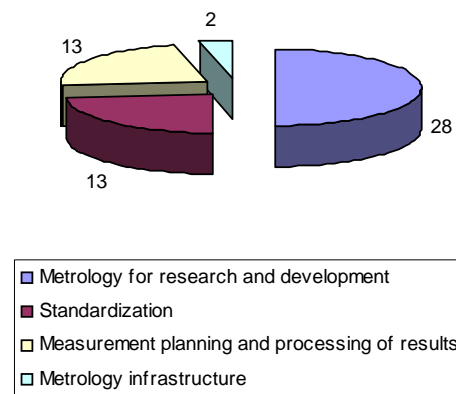


Figure 4. Number of students who passed exams immediately after the first semester.

**PoMaCoM**  
Postgraduate Master Course "Metrology"

organized by: University of Zenica, University Erlangen-Nürnberg and University of Maribor  
supported by European Union Tempus programme

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### POSTGRADUATE STUDY CURRICULUM

**A. COMPULSORY COURSES**

Course Name (click on the course name to see the details)	Semester		ECTS
	I	II	
<b>Metrology for research and development</b>	30	7	
<b>Metrological infrastructure</b>	15	3	
<b>Standardization</b>	20	5	
<b>Measurements planning and processing of results</b>	15	3	
<b>Measurement uncertainty analysis</b>		15	3
<b>Calibration, documentation and laboratory management</b>		20	5
<b>Instrumentation</b>		30	7

**B. ELECTIVE COURSES (Students choose one of the offered elective courses)**

Course Name (click on the course name to see the details)	Semester		ECTS
	I	II	
<b>Testing product characteristics</b>		30	7
<b>Measurement of process properties</b>		30	7
<b>Geometrical product specifications</b>		30	7

**C. MASTER THESIS**

Course Name	Semester		ECTS
	I	II	
Writing master thesis - consultations		30	20

**COURSE CONTENT**

**1. METROLOGY FOR RESEARCH AND DEVELOPMENT**

Semester: I  
Compulsory course  
Hours: 30

Course content:

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Figure 5. Course web page.

## 6. CONCLUSIONS

Students adopted the study excellent. All students have some working experience and they decided to continue the study. Unusual way of evaluation and contacts every week, all kinds of support including written and electronic materials, everyday consultations, prepared them to pass their exams successfully. About one third of students, a month after finishing first semester passed all exams. Comparing to the previous organized postgraduate studies this one is more successful. Except mentioned reasons, a great motivation for study a new area and first attractive study contribute to the motivation of the attendees.

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