

# North Macedonia Milestone Experience

**Goce L. Arsov LSM, North Macedonia LMAG CHAIR**

**This year we are celebrating the 25<sup>th</sup> Section Anniversary  
and 75<sup>th</sup> Anniversary of the Transistor**

## Section Location



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**Population about 2.2 millions**

**Area 25,713 sq. km**

**Capital - Skopje (600,000 inhab.)**

**North Macedonia Milestone Proposal 2018**

**First control of a robot using brain signals.**

**To the proposer's knowledge, is this achievement subject to litigation? No**

**Is the achievement you are proposing more than 25 years old? Yes**

**Is the achievement you are proposing within IEEE's designated fields as defined by IEEE Bylaw I-104.11, namely: Engineering, Computer Sciences and Information Technology, Physical Sciences, Biological and Medical Sciences, Mathematics, Technical Communications, Education, Management, and Law and Policy. Yes**

**Did the achievement provide a meaningful benefit for humanity? Yes**

**Was it of at least regional importance? Yes**

**Milestone proposer(s):**

**Proposer name:** Stevo Bozinovski

**Proposer email:** sbozinovski@scsu.edu

**Please note:** your email address and contact information will be masked on the website for privacy reasons. Only IEEE History Center Staff will be able to view the email address.

**Street address(es) and GPS coordinates of the intended milestone plaque site(s):**

18 Rudjer Boskovic street, Skopje, Macedonia,  
Faculty of Electrotechnical and Information Technologies,  
GPS Coordinates,

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**What is the historical significance of the work (its technological, scientific, or social importance)?**

**Before 1988** controlling a physical object using signals emanating from a human brain was named psychokinesis and was in the realm of the science fiction.

In **1988** in this building, **for the first time in the world**, it was shown how a physical object (a robot) can be controlled using signals emanating from a human brain. **It was 11 years before** such result was achieved for the second time, in 1999, in USA. Contemporary research and applications of controlling physical objects such as home appliances, drones, wheelchairs, and prostheses is spread worldwide, for benefit of society ranging from educational to rehabilitation level.

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**What obstacles (technical, political, geographic) needed to be overcome?**

The most important was the challenge of solving the problem of psychokinesis. **The idea come of using EEG and a robot.** Once the idea come, 11 years before second person in the world getting the same idea, the technical difficulties were to build a experimental setup where the idea will be tested and demonstrated. It included building a special robot polygon for moving mobile robots while connected to a power and signal cables. It was a unique setup, first in the world. Also technical obstacle was building a special software as well as biopotential amplifier interface and robot interface.

## **What features set this work apart from similar achievements?**

It is its pioneering nature. It made a leap from science fiction to engineering. Many people thought of possibility of moving physical object with energy emanating from a human brain, but until 1988 nobody got an idea to record EEG signals and build interface needed to control movement of a physical object (a robot). The achievement was reported at a IEEE Conference in USA.

In 1988 there was no world wide web, so it took 11 years till the next similar achievement, in 1999.(Chapin J., Moxon K., Markowitz R., Nicolelis M. , Real-time control of a robot arm using simultaneously recorded neurons in the motor cortex. Nature Neuroscience 2, pp. 664–670, 1999). It was control of a physical object (a robotic arm) using signals generated inside the brain of an animal, a rat.

## **What features set this work apart from similar achievements?**

The difference between the first and the second achievement is not in the type of robot (mobile rover robot vs robotic arm), it is in a way EEG signals were recorded. The first achievement in 1988 recorded EEG non-invasively, from a human scalp, while the second achievement in 1999, recorded invasively, inside the brain with implanted electrodes.



## **What features set this work apart from similar achievements?**

Other efforts in the world were to control objects on a computer screen but not physical objects to solve the long lasting psychokinesis problem. The challenge was setup by Vidal (1973) and is now known as brain-computer interface challenge. In 1977 Vidal controlled a cursor- like object on a computer screen. In 1988 Farwell and Donchin controlled writing text on a computer screen, at the same year the psychoikinesis challenge was overcome.

**So the control of a physical object using EEG was an unique effort of solving the psychokinesis problem.**

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The five references which establish dates, locations, and importance of achievement are:

**Bozinovski**, S., Sestakov, M., Bozinovska, L.(1988) Using EEG alpha rhythm to control a mobile robot. In: G. Harris, C. Walker (eds.) Proceedings of 10th Annual Conference of the IEEE Engineering in Medicine and Biology Society, , track 17, Biorobotics, New Orleans, LA, vol. 10, pp. 1515–1516 (first short report of the achievement)

**Bozinovski** S. (1990) Mobile robot trajectory control: From fixed rails to direct bioelectric control. In O. Kaynak (Ed.) Proc IEEE International Workshop on Intelligent Motion Control, Istanbul, vol 2: 463-467 (describing the algorithm)

S. **Bozinovski**, “Controlling robots using EEG signals, since 1988,” In S. Markovski, M. Gusev (eds.) ICT Innovations 2012, Springer Verlag, p. 1-11, 2013 (detailed description)

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**Bozinovski S.**, Bozinovski A..(2015) Mental States, EEG Manifestations, and Mentally Emulated Digital Circuits for Brain-Robot Interaction, IEEE Transactions on Autonomous Mental Development 7(1): 39-51 (publication in a IEEE Transactions)

**Lebedev M., Nicolelis M.** (2017) Brain-machine interfaces: from basic science to neuroprostheses and neurorehabilitation, Physiological Review 97:737-867 (a review from the person achieving second control of a robot using EEG signals in 1999, on page 779 pointing out explicitly that "It is worth noting that the first publication on a human controlling a robot with EEG activity dates back to 1988 (85)" where reference (85) is the reference 1 above.) .

***Thank you for your attention***