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CER Computers as Weapons of Mass Disruption: The Yugoslav Computer Industry in the 1960s*

Abstract: *The article investigates the history of the CER-10, the first Yugoslav electronic computer, and the subsequent failed attempt for the establishment of the computer industry during the 1960s. While the CER-10 was an important milestone on the Yugoslav road to technological modernization, the aftermath of this project revealed myriads of problems of the entire Yugoslav state system, which included simultaneous implementation of conflicting economic policies, the heavy hand of Aleksandar Ranković and the Yugoslav secret police in the country's economy, as well as the channeling of federal funds into Serbian companies without much economic rationale, all of which eventually ground the establishment of this high-tech industrial sector to a halt.*

Key words: Yugoslavia, computers, CER-10, nuclear program, UDB, Aleksandar Ranković

"It is strange to notice […] that after successful application of CER series computers [domestic companies] were given import licenses for foreign computer equipment without any consultations with domestic designer teams. Computers CER […] in that period were, by any criteria, comparable with IBM, DIGITAL, ICL, UNIVAC and similar foreign computer equipment."[1]

Official history records with much praise and pride the CER-10 [*Cifarski Elektronski Računar* – Digital Electronic Computer] as the first Yugoslav electronic computer. Designed and constructed in the period between 1956 and 1960 at the Institute for Nuclear Sciences "Boris Kidrič" [*Institut za nuklearne nauke "Boris Kidrič"* – IBK; Vinča, near Belgrade, Serbia], the successful CER-10 project added

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[1] Paunović, Vladislav and Hristović, Dušan, "Prikaz i analiza računara CER", *XLIV Konferencija ETRAN*, Sokobanja, June 26–29, 2000, p. 82. (hereinafter: Paunović, V., Hristović, D., "Prikaz i analiza računara CER...") Translation by the author.

the country's name on the short list of only five European nations capable to independently produce electronic computers (Great Britain, France, Germany, Poland and the Soviet Union). Soon after the successful testing of the prototype in 1960, blueprints and the designer team of the CER-10 were transferred to the Institute for Electronics and Telecommunications "Mihajlo Pupin" (IMP, Belgrade) where the machine capabilities were further improved and by 1962 installed in the building of the Yugoslav Federal Nuclear Energy Commission [*Savezna komisija za nuklearnu energiju* – FNEC].[2]

During the 1960s and 1970s, the IMP designed and produced the entire family of CER computers (CER-22, CER-200/202/203, CER-12), including several functional prototypes (CER-20 and CER-30) that were used as bookkeeping machines at the IMP and Ei Niš [*Elektronska industrija Niš*]. CER computers were also used for data processing in a number of state companies, banks and federal agencies, including the Yugoslav People's Army (YPA) which utilized mobile versions in the period between 1965 and 1989 (CER-11, CER-101-Kosmos, CER-111).[3] These Army models were the most complex machines designed and built by the IMP, coupled with three models of HRS-100 computers [*Hibridni računarski sistem* – Hybrid Computer System], which were produced in cooperation with the Soviet Academy of Sciences and delivered to the institutes in Moscow and Novosibirsk.[4]

This is an appealing story, but a very problematic history. Following the aforementionednarrative behind the CER project, Protić and Ristanović eventually admit, with some bitterness attached, that the entire project, "however fascinating it was, could not retain the momentum necessary to keep up with the developments of the global computer industry."[5] Even the superficial glance on the actual production statistics of CER computers paints an even less impressive image. The very first CER-10 was a unique machine, and this scenario was repeated with every successive CER model. More precisely, in the period of 15 years (1960-1975) the IMP produced in

[2] Protić, Jelica and Ristanović, Dejan, "Building Computers in Serbia: The First Half of the Digital Century", *ComSIS* 8, no. 3, June 2011, p. 551. (hereinafter: Protić, J., Ristanović, D., "Building Computers in Serbia…") Other important works on the topic include: Bečejski-Vujaklija, Dragana and Marković, Nikola (eds.), *50 godina računarstva u Srbiji: hronika digitalnih decenija*, Društvo za informatiku Srbije, Institut „Mihajlo Pupin", PC Press, Beograd 2011 (hereinafter: Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*…); Христовић, Душан, "Развој рачунарства у Србији", *Phlogiston: Journal of the History of Science* 18/19 2010/2011, pp. 89–105. (hereinafter: Христовић, Д., "Развој рачунарства…"); Paunović, V., Hristović, D., "Prikaz i analiza računara CER…", pp. 79–82.

[3] Protić, J., Ristanović, D., "Building Computers in Serbia…", pp. 551–552; 556–557; Paunović, V., Hristović, D., "Prikaz i analiza računara CER…", p. 78–80.

[4] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*…, p. 38.

[5] Protić, J., Ristanović, D., "Building Computers in Serbia…", p. 558.

total only 25 or 26 computers of different models and two prototypes (*Table 1*).[6] On the other hand, many of the experts in the field claim that, at the time of their design and production, CER computers could easily compete with contemporary models of leading computer manufacturers, such as IBM, DIGITAL, etc., which were more readily available and purchased in much higher numbers by Yugoslav state companies and government institutions.[7]

The purpose of this paper isto scrutinize these contradictions that stretch between the huge success and almost complete failure of the CER project, and find the missing, or indeed, hidden part of the story. My analysis is based on so far unexplored archival documents about the CER-10 project, complemented with the existing scholarship about the history of computers in Yugoslavia and former Yugoslav republics, as well as general history of computers. The main conclusion is that, although the CER-10 was in fact a modern and functional machine, due to the poor management, legal and other administrative limitations, as well as lack of stable and coherent state policies related to the use and manufacturing of computers in Yugoslavia, the establishment of the computer industry in the country that had a reasonable potential of becoming competitive on the global market was, in reality, yet another case of a missed opportunity. This is particularly important to stress since throughout its history, socialist Yugoslavia was striving for a technological proficiency as a part of the general policy of the country's rapid modernization.

Table 1. CER Family Computers in Production and Operation, 1960-1997[8]

Model	Year of design – end of operation	Users	Production runs
CER-10	1956/60-1966	FNEC, SSUP[9], TANJUG[10]	1
CER-11	1965/66-1988	Yugoslav People's Army	1
CER-20, CER-30	1963, 1965	IMP, Ei Niš, RIZ, TRS[11]	1+1

[6] Protić, J., Ristanović, D., "Building Computers in Serbia…", p. 557. CER-200 series, built between 1966 and 1971, was the only one with the production run in double digits – 15 were built in total, although even in this case, models were fine-tuned towards the needs of particular customers. All of the rest models were built either as unique machines or in very small numbers (one to three, yet different sources provide different numbers).

[7] Paunović, V., Hristović, D., "Prikaz i analiza računara CER...", p. 82.

[8] Protić, J., Ristanović, D., "Building Computers in Serbia…", p. 557; Paunović, V., Hristović, D., "Prikaz i analiza računara CER...", p. 79.

[9] *Savezni sekretarijat za unutrašnje poslove* (State Secretariat for Internal Affairs)

[10] *TANJUG – Telegrafska agencija nove Jugoslavije* (Telegraph Agency of New Yugoslavia)

[11] *RIZ – Radio industrija Zagreb; TRS – Tvornica računskih strojeva Zagreb* (Computing Machines Factory, Zagreb)

CER-22	1966/68-1975	Beobanka, Jugopetrol, Beogradski vodovod i kanalizacija	2 (3)
CER-200/202/203	1966/71-1985	Planika-Kranj, PIK-Tamiš, GIK-Banat, Kanal DTD, Mehanografija, Jugopetrol, VMA, Ei Niš, Poljobanka, IMP	15
CER-12	1969/71-1997	*Kreditna banka Zrenjanin,* ERC IMP	2
CER-101-Kosmos	1972/73-1988	Military Technical Institute	1
CER-111	1974/75-1988	Yugoslav People's Army	1

Solving Mathematical and National Security Problems

It has to be emphasized that the design and construction of the first electronic computer in Yugoslavia was indeed a heroic achievement and a quantum leap in technological modernization of a country that was highly underdeveloped before 1945 and without any experience in this innovativetechnology.[12] According to the official data, right before the start of the Second World War Yugoslavia was an agricultural country, with a roughly 75-78% peasant population, the illiteracy rate as high as 44.6%, only 1.3% of population with secondary education, and a miniscule 0.15% holding a university degree.[13] Yugoslav authorities obviously had to invest lots of time, money and energy into making such a giant scientific and technological breakthrough. While it is not the purpose of this paper to explain the entire process of the rapid modernization and development of Yugoslavia after 1945, it would be, nevertheless, important to understand first why the Yugoslav authorities developed computer technology.

Often considered as "the first computer", the ENIAC (Electronic Numerical Integrator and Computer) was designed as a general-purpose machine that would speed upcalculations for the US Ballistic Research Laboratory, as well as to decipher codes. However, the first problem programmed on the ENIAC was a series of calculations for thermonuclear reactions for a project of the Los Alamos Research Lab

[12] The ENIAC (Electronic Numerical Integrator and Computer) was designed and built between 1944 and 1946, and is often considered as the first computer in the world. More in, Williams, Michael R., "A Preview of Things to Come: Some Remarks on the First Generation of Computers", in *The First Computers – History and Architectures*, Rojas, Raúl and Hashagen, Ulf (eds.), The MIT Press, London and Cambridge 2000, pp. 1–3. (hereinafter: Williams, M. R., "A Preview of Things to Come…")

[13] Petranović, Branko, *Istorija Jugoslavije 1918-1978*, Nolit, Beograd 1981, p. 150. (hereinafter: Petranović, B., *Istorija Jugoslavije*…); Pleština, Dijana, *Regional Development in Communist Yugoslavia*, Westview Press, Boulder, San Francisco, Oxford 1992, pp. 12–13. (hereinafter: Pleština, D., *Regional Development*…)

in 1945; the ENIAC finalized calculations in two hours (two weeks with the setup) that would otherwise require some 100 man-years.[14] Using this logic in the opposite direction, Nofre argues that the primary reason for the ill-fated establishment of the UNESCO International Computation Centre in the late 1940s was the reluctance of the US administration to share the high-speed electronic computer technology with their West European partners. The main argument was that for the needs of mathematical calculations in all branches of science, small digital calculators and differential analyzers would be more than sufficient.[15] Therefore, a statement may be hazarded at this point, that at least in the beginning of the digital age, in the late 1940s and early 1950s, only developed nuclear programs actually needed electronic computers. It would seem highly unlikely that the Yugoslav need for computers was comparable to the American.

Surprising as it may be, the development of computer technology in Yugoslavia was in fact a spin-off project of the country's nuclear program. Yugoslav authorities started to pursue their nuclear ambitions almost immediately after the war, with the establishment of the IBK, already in 1947/1948.[16] The IBK was initially designed as the leading institute in the network of a number of different institutions dedicated to the development of nuclear science and technology in Yugoslavia.[17] Already from the beginning, the Yugoslav nuclear program was an important component of the much bigger and long-term strategy of assuring the country's self-sufficiency in the field of national defense. The importance of this strategy may be found in the fact that in this period almost two thirds of the annual federal budget was channeled to national defense projects.[18] Stevan Dedijer, the director of the IBK between 1952 and 1954,

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[14] Rojas, Raúl and Hashagen, Ulf (eds.), *The First Computers – History and Architectures*…, pp. 122–125, 175–176; Protić, J., Ristanović, D., "Building Computers in Serbia…", p. 549.

[15] Nofre, David, "Managing the Technological Edge: The UNESCO International Computation Centre and the Limits to the Transfer of Computer Technology, 1946–61,"*Annals of Science* 71, no. 3, 2014, pp. 421–422. (hereinafter: Nofre, D., "Managing the Technological Edge…")

[16] Bondžić, Dragomir, *Između ambicija i iluzija. Nuklearna politika Jugoslavije 1945–1990*, Institut za savremenu istoriju, Društvo istoričara Srbije „Stojan Novaković", Beograd 2016, pp. 58–60. (hereinafter: Bondžić, D., *Između ambicija i iluzija*...); Петровић-Нешковић, Бранислава (ed.), *Пола века Института „Винча" (1948–1998)*, Институт за нуклеарне науке „Винча", Завод за уџбенике и наставна средства, Београд 2000, pp. 20–22. (hereinafter: Петровић-Нешковић, Б. (ed.), *Пола века Института „Винча"*...).

[17] Петровић-Нешковић, Б. (ed.), *Пола века Института „Винча"*..., p. 66. Institute for Geological and Mining Exploration and Research of Nuclear and other Raw Materials (Belgrade, 1947/8), Physics Institute "Jožef Stefan" (Ljubljana, Slovenia, 1949) and the Institute for Atomic Physics "Ruđer Bošković" (Zagreb, Croatia, 1950). Bondžić, D., *Između ambicija i iluzija*..., pp. 58–71); Institut za tehnologiju nuklearnih i drugih mineralnih sirovina, "Istorijat ITNMS-a", http://www.itnms.ac.rs/page.asp?id=istorijat, accessed on January 12, 2018.

[18] Alberts, Gerald and Oldenziel, Ruth (eds.), *Hacking Europe: from Computer Cultures to Demoscenes*, Springier, London, Heilderberg, New York, Dordrecht 2014, pp. 109–110 (hereinafter: Alberts, G., Oldenziel, R. (eds.), *Hacking Europe*…).

reveals details from one secret meeting held in 1950 during which Edvard Kardelj, one of the leading Yugoslav politicians and ideologists, declared that Yugoslavia must have its own atomic bomb "even if it costs us [the Yugoslavs] half of our entire income for years to come."[19]

However, the importance of the Yugoslav nuclear program was not directed exclusively to the country's defense strategy. The IBK was also expected to perform the role of a leading institution in scientific and industrial development of Yugoslavia. Already in 1946, Pavle Savić, the leading Yugoslav nuclear scientist and the intellectual force behind the establishment of the IBK, wrote a letter to the Yugoslav President Josip Broz Tito in which he stressed that the future "Physical Institute" should be "the most advanced institution of the kind", a central institute around which the entire "Academic city" and the "state Academy of Sciences" would be established "that would coordinate preparation of cadres and raise our [Yugoslav] science and industry."[20] In the project proposal it was also mentioned:

> "The Institute will have additional laboratories – cores of future independent institutes. The Physical Institute itself would become the center of a network of corresponding institutions that will have to be established to meet our [Yugoslav] strengths and capabilities and further developed for efficient support of our science and technology."[21]

Kanazir confirms that the IBK was the country's "strongest interdisciplinary scientific institute" that developed scientific disciplines previously unknown in Yugoslavia, and "a center for dissemination of new cadres and new knowledge."[22] Other authors equally insist that the IBK "spread and supported scientific research in companies, institutes and universities" throughout Yugoslavia.[23] This concept was actually developed into a statutory obligation of the FNEC immediately after its establishment in 1955. The FNEC's Sector for Scientific Research was supposed to, among other things, "design programs of scientific research" in industrial and

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[19] Dedijer, Stevan, *Špijun kojeg smo voljeli: Autobiografija*, V.B.Z., Zagreb 2011, p. 177. (hereinafter: Dedijer, S., *Špijun kojeg smo voljeli*…).

[20] Arhiv Jugoslavije, Kabinet Maršala Jugoslavije, 836, II-6-a/2 (hereinafter: AJ, KMJ 836, II-6-a/2). Pavle Savić's letter to Tito, March 17, 1946.

[21] AJ, KMJ 836, II-6-a/2. "Project for the construction of the Physical Institute in Belgrade", March 17, 1946.

[22] Јевтић, Милош, *Разговори са Винчанцима*, Институт за нуклеарне науке „Винча", Београд 1998, pp. 47–48. (hereinafter: Јевтић, М., *Разговори са Винчанцима*...).

[23] *Четрдсет година Института за нуклеарне науке „Борис Кидрич"*, Институт за нуклеарне науке „Борис Кидрич", Београд, 1988, p. 1 (hereinafter: *Четрдесет година Института*…)

university institutes, as well as to provide documentation for prototypes developed at the IBK to companies capable for their serial production.[24]

As strategies go, this one was impressive, and its implementation seems to be an equally heroic achievement. The first Yugoslav nuclear reactor, independently designed and constructed at the IBK, became fully operational in March 1958. This small reactor was supposed to be used as a training machine for the scientists and technicians that would operate the much larger 6.5/10 MW Soviet nuclear reactor that became operational at the IBK in December 1959. These two powerful research instruments were actually main goals of the so-called "Vinča Project" that was in full motion in the period 1956-1959.[25] In the following years, the Yugoslav nuclear program and development of related technologies evolved rapidly. This was recognized by the U.S. Gilpatric Committee already in 1964 which placed Yugoslavia in the group of eleven countries that "have or will soon have the capability of making nuclear weapons, given the requisite national decision."[26]

The IBK scientist obviously needed high-speed calculations. This can be observed in the fact that the first two IBK scientists who received their PhD titles were Rajko Tomović and Dušan Mitrović, pioneers in the field of computer science in Yugoslavia, and leading designers of the CER-10.[27] Tomović and Mitrović started tinkering with this technology already in 1947, working for the Ministry of Electricity on the development of the "network analyzer", analogue calculating machine finished in 1949 as the first of its kind in Yugoslavia and tenth operational in the world.[28] Already in 1951, Tomović and Mitrović established the Mathematical Laboratoryat the IBK with the task to "participate in solving mathematical problems […] and to focus on development and construction of electronic calculating machines."[29] The results soon followed: based on the Mitrović's doctoral dissertation, the machine for solving systems of 30 linear equations with equal number of variables was designed

[24] AJ, Savezna komisija za nuklearnu energiju 177, f. 22. a.j. 89 (hereinafter: AJ, SKNE 177, f. 22, a.j. 89). Organi i tela SKNE. Predsedništvo SKNE, 1955–1956. Poslovnik II sektora Savezne komisije za nuklearnu energiju, 1956.

[25] Bondžić, D., *Između ambicija i iluzija*..., pp. 141–146; Петровић-Нешковић, Б., *Пола века Института „Винча"*..., pp. 26–29.

[26] Gavin, Francis J., *Nuclear Statecraft: History and Strategy in America's Atomic Age*, Cornell University Press, Ithaca and London 2012, pp. 78–79 (hereinafter: Gavin, Francis J., *Nuclear Statecraft*…).

[27] Христовић, Д., „Развој рачунарства…", pp. 90–94.

[28] Bečejski–Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., p. 46; Tomović, Rajko and Mitrović, Dušan, *Elektronika u službi čoveka*, BIGZ, Tehnička knjiga, Beograd 1956, pp. 82–85 (hereinafter: Tomović, R., Mitrović, D., *Elektronika*...)

[29] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., pp. 45–46; Петровић-Нешковић, Б., *Пола века Института „Винча"*..., p. 226.

in 1952, followed by the electronic differential analyzer (1952), this time based on the Tomović's dissertation.[30]

Combining Yugoslav strategies for scientific development, importance of the nuclear program, national defense strategies, the money invested in these projects and the IBK's role in all of them, it would seem logical that computer technology and the CER-10 was supposed to play the role of a dual-purpose machine; designed both for the civilian and military application and equally capable of solving complex mathematical problems, analyses of different electro-mechanical systems, as well as the design and management of complex scientific or industrial machines and weapons systems.Not surprisingly, this conceptwas indeed put into practice.

One of the earliest evidence about the cooperation between the FNEC and the YPA comes from 1956, when a detailed concept was designed by the State Secretariat for National Defense. The idea was that "existing military institutes and other military institutions" that were working on scientific research or application of modern technologies, "will use the results of nuclear science institutes for the needs of their own research."[31] Following this strategy to the letter, in the late 1950s the YPA representatives were considerate enough to stress in their shopping list of technologies and devices that were supposed to be developed at the IBK, those that were also "applicable for civilian protection" and were not necessary to be developed independently.[32]

Focusing exclusively on the development of the electronic computer technology, it is worthy to stress that the Military Technical Institute (MTI) also "developed" an analogue calculator in 1952, as well as several electronic systems for control of artillery fire (after 1961), which included electric computers as integral sub-systems, thus pointing to a conclusion that as computer technology was mastered by the IBK, it was immediately transferred to military institutes.[33] While it is impossible to draw strong conclusions without additional evidence, it is nevertheless interesting that the development of computertechnology in the MTI and the IBK was so well coordinated. At the very least, this suspicion is indirectly confirmed by the fact that even analogue calculating machines created by Tomović and Mitrović in the early 1950s were used for a variety of calculations in the Federal Statistical Office [*Savezni zavod za sta-*

[30] Tomović, R., Mitrović, D., *Elektronika*..., pp. 85–88; Петровић-Нешковић, Б., *Пола века Института „Винча"*..., pp. 226–227.

[31] AJ, 177 SKNE, f. 22, a.j. 89. Organi i tela SKNE. Predsedništvo SKNE, 1955–1956. Zapisnici sa sednice Pretsedništva održane 26. maja 1956. godine u Beogradu, May 26, 1956.

[32] AJ, 177 SKNE, f. 1. Plan naučno-istraživačkih radova za potrebe narodne odbrane u 1958. godini.

[33] *Vojnotehnički institut Vojske Jugoslavije: 50 godina*, Vojnotehnčki institut Vojske Jugoslavije, Beograd 1998, pp. 85–86. (hereinafter: *Vojnotehnički institut Vojske Jugoslavije*...)

tistiku], but also in the Aeronautical Institute [*Vazduhoplovni institut*] and Military Technical Institute [*Vojnotehnički institut*].[34]

The CER-10 project, not unlike its analogue predecessors, was obviously an idea engendered by the IBK scientists out of a shear necessity for high-speed calculations related to the nuclear program. Furthermore, computer technology was continuously being transferred to the national defense sector where similar need for computers existed. Thus, by the early 1960s the Yugoslav decision-makers could be satisfied that their preset strategy for the country's scientific and technological modernization, as well as for autarchy in the military industry was working as a well tuned machine.

Offspring of the Almighty Creator

Being directly related to the Yugoslav national defense strategy and the ambitious plans for overall modernization, industrialization, and indeed, nuclearization of the country, it should not come as a surprise that activities and projectsof the IBK were shrouded in secrecy. Bondžić reveals that right from the start the research program of the IBK and other institutions dedicated to the nuclear programwere under the control of the Yugoslav Directorate for State Security [*Uprava državne bezbednosti* – UDB], headed by Aleksandar Ranković, at the time the Vice-President of the Yugoslav Federal Government and Federal Minister of Interior Affairs. In the initial period (1948-1955), the extended arm of the UDB was the Directorate for Coordination of the Scientific Institutes [*Uprava za koordinaciju rada naučnih instituta*]. Through this institution the Federal Government and the UDB monitored and coordinated all activities of scientific institutes – construction of laboratories, provisioning of equipment and raw materials, technical and scientific staff, transfer of sensitive technologies, etc.This situation was formalized in 1955 with the establishment of the FNEC, again under the watchful eye of almighty Ranković who was the FNEC's director until 1962.[35]

The FNEC was actually the absolute owner of every technology developed in scientific institutes under its control and not a single invention or original design could have been officially patented, although the dissemination of technology to industrial

[34] Петровић-Нешковић, Б., *Пола века Института „Винча"*..., p. 226. The Military Technical Institute became increasingly interested in using computers for high-speed calculations after the establishment of the Rocket Institute [*Raketni institut*] in 1957, which soon led to the development of its own Computer Center [*Računski centar*] as a subsidiary. More in: Dragojević, Milorad, *Razvoj našeg naoružanja. VTI kao sudbina*, Zadužbina Andrejević, Beograd 2003, p. 39. (hereinafter: Dragojević, M., *Razvoj našeg naoružanja*…)

[35] Bondžić, D., *Između ambicija i iluzija*..., pp. 74–76, 117–118. In the moment of the establishment of the FNEC Ranković also held the position of the Vice-President of the Federal Executive Council (*Savezno izvršno veće* – Yugoslav Federal Government) and the State Secretary for Internal Affairs.

facilities in the country was formally supported.[36] The records show that the FNEC did not even have to follow standing regulations for the technical documentation, thus managing to keep high security standards of their projects. For example, the ambitious and very expensive "Vinča Project" was funded by the Federal Executive Council (the Yugoslav Federal Government) only on the basis of the FNEC's approval of their own project. This was, of course, made much easier by the fact that Ranković was the Vice-President of the Federal Executive Council and personally signed the necessary approval, effectively being his own *judge, jury and executioner*.[37] In other words, Ranković and the FNEC were behaving like a state-within-a-state institution, not responsible even to the federal government, at the very least until 1962 when Ranković was removed from the position of the director of the FNEC, or more likely until his political demise in 1966.[38]

The turning point for the CER-10 future was actually the Law on Model of Financing Scientific and Research Institutes that was passed in 1960 and began to be implemented in 1961. The law stipulated limitations in financing of projects in scientific institutes from the federal budget in order to make them more market oriented; the state funding still remained, but only for projects that were approved in advance with detailed specifications, designed for companies that were final users of technology and were supposed to contribute financially in their development.[39] This is again in accordance with the existing strategy for the country's scientific and technological modernization in which the IBK played a central role. However, the results were not necessarily great. The view from the MTI reveals true dimensions of the impact of the law on research institutes. According to Dragojević, by the early 1960s cutting down of the defense budget and investments in the MTI's research projects led to abandonment of many complex weapons systems of that were in the prototype stage. This shockwave spread quickly to companies in the military and civilian industry that cooperated on the MTI projects and produced chaos and financial deficits.[40]

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[36] AJ, 177 SKNE, f. 1. Zaštita patenta i ustupanje pronalaska fabrikama, July 11, 1957. It is almost paradoxical that the complete technical documentation for the CER-10 is still available in the archives of the FNEC.

[37] AJ, 177 SKNE, f. 22. a.j. 89. Organi i tela SKNE. Predsedništvo SKNE, 1955–1956. Pregled investicionog elaborata Projekta Vinča, April 11, 1956; AJ, 177 SKNE, f. 4. Rešenje o nadležnosti za odobravanje investicionog programa za određene objekte Instituta „Boris Kidrič" u Vinči, May 21, 1956.

[38] Pirjevec wrote probably the most complete and balanced biography of Ranković, with a detalied analysis of his fall. See more in, Pirjevec, Jože, *Tito i drugovi*, Mozaik knjiga, Zagreb, 2012, pp. 486–518 (hereinafter: Pirjevec, J., *Tito i drugovi*…). Compare with: Ranković, Aleksandar, *Dnevničke zabeleške*, Jugoslovenska knjiga, Beograd 2001, *passim.* (hereinafter: Ranković, A., *Dnevničke zabeleške*...)

[39] *Institut „Mihajlo Pupin" – riznica znanja – 60 godina uspešnog rada*, Institut „Mihajlo Pupin", Beograd 2006, p. 9 (hereinafter: *Institut „Mihajlo Pupin"*...); Петровић-Нешковић, Б., *Пола века Института „Винча"*..., pp. 32, 69.

[40] Dragojević, M., *Razvoj našeg naoružanja*…, pp. 39–40.

The FNEC had to adapt to the given circumstances and by 1960 it was frantically distributing the entire production of the "nuclear instrumentation" to companies capable to start their serial production, expecting that "in 1961 domestic companies will become completely independent and capable to supply domestic needs in the entire specter of standard needs."[41] The documents about the CER-10 reveal the true impact of the Law on Model of Financing Scientific and Research Institutes on this project and the entire Yugoslav computer industry at the time of its conception. The FNEC started officially to channel the funds to the CER-10 project only in 1958. At the time, the CER-10 was being developed at the IBK as an experiment for the construction of "a single digital electronic calculating machine" for general use.[42] Tomović, one of the leading designers of the CER-10, confirms that the IBK team initially wanted to design "a cheaper machine that would have universal applicability in solving mathematical problems […] and numerical data processing."[43]

However, in an obvious attempt to provide first for the national defense and security sector, the FNEC quickly took control of this project and expanded it to a production of another version of the CER-10, capable to "perform some special programs in statistical data processing."[44] This additional, top secret project of the FNEC was initiated in 1959 under the code name "Statistical Arithmetic Machine S-2", and it was ordered specifically for the State Secretariat for Internal Affairs. In reality, this was the same machine as the CER-10, only with added Statistical Unit [*Statistički organ*] – the S-2 machine.[45] However, by 1960 the FNEC was obviously well aware of the new legislation about the financing of scientific projects and the technical documentation for the CER-10, coupled with the entire IBK Mathematical Laboratory were transferred to the IMP, established only a year earlier as a "scientific institution and a high-tech company." In the following year, and following the same logic, even the IBK's Laboratory for Automatics and Laboratory for Digital Technology were also transferred to the IMP.[46]

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[41] AJ, 177 SKNE, f. 25, a.j. 95. Organi i tela SKNE. Stručni Savet SKNE, 1960–1967. Izveštaj o radu u 1960. godini na polju nuklearne instrumentacije, April 26, 1961.

[42] AJ, 177 SKNE, f. 148, a. j. 1010. Ispitivanje i puštanje u pogon cifarskog elektronskog računara (CER). Dokumentacija Instituta „Mihajlo Pupin", 1961.

[43] Tomović, Rajko, *et al*., „Cifarski elektronski računar-CER Instituta „Boris Kidrič", *V Konferencija ETAN*, Beograd, 1960, AU, 1, pp. 305–306. (hereinafter: Tomović, R., *et al*., „Cifarski elektronski računar-CER...")

[44] AJ, 177 SKNE, f. 148, a. j. 1010. Ispitivanje i puštanje u pogon cifarskog elektronskog računara (CER). Dokumentacija Instituta „Mihajlo Pupin", 1961.

[45] AJ, 177 SKNE, f. 1. Ugovor između Savezne komisije za nuklearnu energiju i Instituta za nuklearne nauke „Boris Kidrič" o izradi statističke aritmetičke mašine S-2, February 27, 1959; AJ, 177 SKNE, f. 1. Strogo poverljivi dopis Instituta „Mihajlo Pupin", Saveznoj komisiji za nuklearnu energiju, October 2, 1961; Tomović, R., *et al*., „Cifarski elektronski računar-CER...", pp. 305–314.

[46] The IMP was officially established in 1959, although its history dates back to 1946 when the Serbian Academy of Sciences (SAS) established the Institute for Telecommunications and Institute

Dušan Hristović, one of the scientists involved in the CER-10 project, reveals that the IBK was actually supposed to construct two computers, one for the Federal Government and one for the State Secretariat for Internal Affairs, but also that the IBK team had spent all the money on a single machine and abandoned work on the second.[47] The contract for the development of the S-2 machine (the CER-10 with the Statistical Unit) was signed between the FNEC and IBK in 1959, and by 1961 when three laboratories were transferred to the IMP, much of the work was already finished in the IBK, but could not be continued without the team of scientists who developed the project, nor it could be easily started in the new *home*. This seems to be the prime reason why the construction of a second CER-10 never started, even if the funding was abundantly available.[48] Furthermore, it seems that transfer of the entire CER-10 project necessarily produced additional costs, at the very least for salaries of people involved in it. With a combined impact of new legislation, already by the end of 1961, the director of the IMP was complaining to the FNEC that if additional funds are not provided, the IMP would be forced to stop further work on finalization of the computer, thus confirming that even the production of a single computer was endangered.[49]

The Law on Model of Financing Scientific and Research Institutes of 1961 clearly limited the absolute freedom with which the FNEC distributed the federal funds. It seems that frantic transfer of technologies and already finished projects that had a potential to thrive on the market to civilian industry was an attempt to avoid future budget restrictions for the most important projects, all in accordance with the new law. Consequently, the FNEC would also retain enough leverage in decisions about the financing of the nuclear program that, at least in this phase, had absolutely no chanceto be marketed.The FNEC was also very reluctant to relinquish the control over the CER-10 project to the potentially volatile market conditions, or indeed the ownership of sensitive technology to the civilian institute. The fact that the first director of the IMP was Đorđe Kovačević, previously the director of the Security Institute [*Institut bezbednosti*], speaks volumes about high security standards of the work conducted at the IMP, its role in the wider network under the control of the

for Electronics. After several years of creation of "spin-off" institutes, in 1950 SAS merged them all into the Institute for Research of Electric Phenomena "Nikola Tesla" [*Institut za ispitivanje električnih pojava*]. In 1959, several laboratories of this institute became the core of the IMP. *Institut „Mihajlo Pupin" – riznica znanja*..., p. 5.

[47] Vuković, Boris, „Tito obezbedio novac za pravljenje prvog jugoslovenskog računara", *Blic*, June 11, 2011, https://www.blic.rs/it/tito-obezbedio-novac-za-pravljenje-prvog-jugoslovenskog-racunara/8ecxdgw, accessed on January 12, 2018.

[48] AJ, 177 SKNE, f. 1. Izrada aritmetičke mašine (S-2). Dopis Instituta za nuklearne nauke „Boris Kidrič" Saveznoj komisiji za nuklearnu energiju, September 8, 1961.

[49] AJ, 177 SKNE, f. 1. Strogo poverljivi dopis Instituta „Mihajlo Pupin" Saveznoj komisiji za nuklearnu energiju, October 2, 1961.

FNEC, as well as Ranković's strategy of positioning his close collaborators in the most important government and industrial institutions and enterprises.[50] The funds for finalization of the CER-10 seem to be also provided by Ranković since the final order for the computer came from the State Secretariat for Internal Affairs, thus again confirming the existence of Ranković's invisible, yet heavy hand and informal channels.[51]

This combined effort seemed enough to secure the CER-10 future, only not necessarily as the designers initially planned. Theimprovedversion of the CER-10, with addition of a Statistical Unit, eventually became a complex (de)ciphering machine that was fine tuned specifically for the use by the Yugoslav secret police (UDB) and the State Secretariat for Internal Affairs.[52] Many years later, several engineers that worked on the development of the CER-10 confirmed that the machine was primarily designed for "statistical crypto data processing."[53] Hristović also reveals, with some pride, that the CER-10 was indeed used to decipher secret coded messages, and at least in one occasion, Yugoslav President Tito used information decipheredby the CER-10 as a specific *ace in the sleeve* during his diplomatic missions in the Middle East, to the distress of the superpowers.[54]

This almost anecdotic episode about the successes of the Yugoslav diplomacy did not necessarily speed up solving of mathematical or financial problems ofthe country's scientific institutes. Combined with the fact that the distance between the FNEC's headquarters, where the CER-10 was eventually installed, and the IBK was some 25 kilometers, it is very difficult to imagine that the first Yugoslav computer performed too much of calculations in scientific projects, including the nuclear program. This is indirectly confirmed by the fact that the management of the IBK wasforced already in 1962 not only to buy the West German ZUSE Z23 computer, but to share it in following years with other scientific institutes and companies under

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[50] *Institut „Mihajlo Pupin" – riznica znanja*..., p. 9. Kovačević even worked since 1948 as an electrical engineer at the State Secretariat for Internal Affairs and obviously presented a tried and tested cadre.

[51] AJ, 177 SKNE, f. 1. Strogo poverljivi dopis Instituta „Mihajlo Pupin" Saveznoj komisiji za nuklearnu energiju, October 2, 1961.

[52] AJ, 177 SKNE, f. 148, a. j. 1010. Ispitivanje i puštanje u pogon cifarskog elektronskog računara (CER). Dokumentacija Instituta „Mihajlo Pupin", 1961; Tomović, R., *et al*., „Cifarski elektronski računar-CER...", pp. 305–314. Comparing these descriptions of the CER-10, it is evident that the Statistical Unit has only been added to the original project. Furthermore, the description of the Statistical Unit in the original documentation clearly reveals that its purpose was purely for deciphering codes, or finding "coincidences" in two different groups of words and numbers.

[53] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., pp. 37–38.

[54] Vuković, Boris, „Tito obezbedio novac za pravljenje prvog jugoslovenskog računara", *Blic*, June 11, 2011, https://www.blic.rs/it/tito-obezbedio-novac-za-pravljenje-prvog-jugoslovenskog-racunara/8ecxdgw, accessed on January 12, 2018.

the control of the FNEC.[55] Adding insult to injury, the ZUSE Z23 was not completely adequate for calculations related to the Yugoslav nuclear program since it was "slow", although scientists who used it found some comfort in the fact that it was "reliable."[56] In fact, even though the scientists and engineers of the IBK independently managed to develop and construct the CER-10 as a modern electronic computer and primarily for problems they needed to solve working on the country's nuclear program, it is absolutely paradoxical that the IBK never actually utilized any model of the CER family of computers.[57]

The additional piece of this confusing puzzle comes from the fact that the CER-10 probably was not the first Yugoslav computer. The confusion comes from the problem in defining what "the first computer" actually means on a global level or in a given society.Williams effectively argues that it is difficult to speak about "the first computer" or even "the first generation" of computers since, depending on the accepted definition, many machines would fall in or out of the list. Therefore, it would be more appropriate to speak about "first computers", a number of machines that were developed in the second half of the 1940s.[58]

In Yugoslavia, Branko Souček and his team from the Institute for Atomic Physics "Ruđer Bošković" (IRB) in Zagreb (Croatia) developed between 1955 and 1959 the project for the "256-channel, amplitudinal analyzer, memory, logics and programs", which was somewhat similar in design to the CER-10, only much faster.[59] However, this story is, as with the CER-10, a bit romanticized. In Souček's own words, his "amplitudinal analyzer" was used "for measurements of the energy

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[55] AJ, 177 SKNE, f. 11. Nabavka digitalne računske mašine „ZUSE-23" za Nuklearni institut u Vinči, September 26, 1962; AJ, 177 SKNE, f. 136. Korišćenje digitalne mašine ZUSE Z-23, December 1964. In 1964, external users of the ZUSE-23 computer were: *Energoprojekt, Institut za automatiku i telekomunikacije „Mihajlo Pupin", (IMP) Matematički institut SRS, Energoinvest-Sarajevo, Elektrotehnički fakultet – Beograd, Institut „Ruđer Bošković" – Zagreb, Građevinski institut JNA*.

[56] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., p. 46; Петровић-Нешковић, Б., *Пола века Института „Винча"*..., p. 229. For certain calculations related to the experiments in the nuclear reactor this computer was so slow that the data processing would sometimes last for several days.

[57] Петровић-Нешковић, Б., *Пола века Института „Винча"*..., pp. 226–230; Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., pp. 45–53.

[58] Williams, M. R., "A Preview of Things to Come…", pp. 1–3.

[59] AJ, 177 SKNE, f. 148, a. j. 1010. Ispitivanje i puštanje u pogon cifarskog elektronskog računara (CER). Dokumentacija Instituta „Mihajlo Pupin", 1961. Compare with Frković, Marijan, *et al.*, "A contribution to the history of computing and informatics in West Balkan countries", *Uporabna Informatika*, Vol. XXIV, no. 4, 2016, pp. 192–193 (hereinafter: Frković, M., *et al.*, "A contribution to the history…"). The author of this article is hardly an expert in computer science, yet the existing information provides some clues about the speed of each machine: for the CER-10 it was 100 kc/s (or 100,000 cycles per second), while for the Souček's computer it was "the unbelievable speed of a million cycles per second." Both machines used similar type of ferrite memory and other components purchased abroad.

specter of radiation", and not as a general purpose calculating machine.[60] Nevertheless, Souček's machine was digital, used similar components as the CER-10, and necessarily performed certain calculations, even if designed for a specific purpose.[61] In that respect, it absolutely deserves to be included in the group of "first computers" in Yugoslavia, neck to neck with the CER-10. In fact, Souček's computer was advanced enough to raise the interest of Willy Higinbotham, at the time the director of the U.S. Brookhaven National Laboratory (BNL), who visited Souček at the IRB in 1963 to inquire about his machine. Soon enough, Souček became a researcher in the BNL (1964-1966) where he further developed his computer and in following years became a renowned scientist in fields of computer science and cybernetics.[62] Although Souček's intellectual strengths and scientific prowess were proven, he obviously lacked the patronage and protection of almighty Ranković and the FNEC to contribute to the development of computer technology in Yugoslavia. This should not come as a great surprise as it seems that Ranković was predominantly focusing on providing lucrative business deals and technical blueprints almost exclusively to the companies and institutes in Serbia, although the funding for these project came from the federal budget. This was definitively the case with the CER-10.[63]

Who Needs the CER-10 When We Can Have IBM Computers?

Previous analysis seems to suggest that beside the state security sector and scientific institutes there was not much interest for computers in Yugoslavia. The reality, however, could not be more different. According to the UN methodology, in 1965 Yugoslavia was on the twentieth place in the world in a number of installed computers.[64] In 1971 the *New Scientist and Science Journal* announced that Yugoslavia was growing "ripe for computer boom."[65] The need and desire for computers in the country's civil sector were obviously strong, only not for CER machines.

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[60] Souček, Branko, „256 kanalni amplitudni analizator, memorija, logika, programi," *Elektrotehnika u industriji i pogonu*, Časopis Elektrotehničkog društva Hrvatske, Vol. 2, No. 4, 1959, p. 132 (hereinafter: Souček, B., „256 kanalni amplitudni analizator…")

[61] Souček, B., „256 kanalni amplitudni analizator…", pp. 132–139.

[62] Institut "Ruđer Bošković", "Professor Branko Souček: Pioneer of computer science and cybernetics in Croatia," http://www.irb.hr/eng/Research/Joint-Scientific-Support-Units/Centre-for-Informatics-and-Computing/A-memorial-service-for-professor-Branko-Soucek/Repository/Newspaper-clippings/Professor-Branko-Soucek-Herak-edition, accessed on January 8, 2018; "Welcome to BNL", *BNL Personnel Office Bulletin Board*, Vol. 17, No. 52, October 6, 1964, p. 2.

[63] During my own research in the FNEC's archives I did not find a single document about Souček's computer, even though the IRB was under the direct control of the FNEC at the time.

[64] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., p. 110.

[65] "Yugoslavia grows ripe for computer boom", *New Scientist and Science Journal*, September 9, 1971, p. 576.

Already in the 1950s a number of state companies, federal institutions and banks started to digitalize their administration and production processes. According to Hristović, one of the first big computer systems in the country was purchased by the Federal Statistical Office [*Savezni zavod za statistiku*] in 1957, followed in a quick succession by the Yugoslav Federal Assembly, National Bank of Yugoslavia, State Bookkeeping Office [*Služba državnog knjigovodstva*], etc.[66] The Mining and Smelting Complex Bor [*Rudarsko-topioničarski basen Bor*–RTB], at the time one of the largest copper mines in Europe, was one of the first Yugoslav industrial enterprises to digitalize its data processing already in 1959 with the installation of the Univac 60 computer system. This trend was visible across the country. Focusing only on the Univac 60 model, soon after the RTB Bor, the same system was installed by the agriculture machine factory IMT Belgrade [*Industrija motora i traktora*] and the PIK Sljeme [*Poljoprivredno-industrijski kombinat Sljeme*], food production and processing company from Zagreb.[67] Official documents reveal that by 1962 there were already 380 computer systems of various types and manufacturers installed in Yugoslav companies and government institutions.[68] In the light of this information, the decision to secure the future of the CER project by offering it to the growing Yugoslav computer market seems like a credible strategy. However, the fact remains that very few of these machines were CER family computers. The real question is, why?

As mentioned earlier, a total of 25-26 units of CER computers were produced until the mid-1970, and not all of them were in simultaneous operation, thus capturing only a small fraction of the Yugoslav market. At the time when the CER-10 was finalized in 1962, the IMP already produced and installed one even bigger and more complex computer for the YPA, their experts were in the process of developing a prototype of the bookkeeping computer (CER-20 and CER-30) and were offering to develop another advanced computer system for the use in scientific institutes, thus covering the requirements of the market, at least in variety of different types of machines.[69] While the IMP's ability to continuously develop modern computers was impressive, this is in contradiction with their production records.

Part of the problem was, yet again, another set of legislation, or indeed, continuously changing economic policies in the country. Since the introduction of the Regulation for the Acquisition of Industrial Property Rights Abroad in 1954, ex-

[66] Христовић, Д., „Развој рачунарства…", p. 102.

[67] Milivojević, Dragan R. and Pavlov, Marijana, "Half a Century of Computing in the Serbian Copper Mining and Metallurgy Industry", *IEEE Annals of the History of Computing*, Vol. 34, No. 3, July-September 2012, pp. 34–36. (hereinafter: Milivojević, D. R., Pavlov, M., "Half a Century of Computing…")

[68] AJ, 177 SKNE, f. 11. Nabavka digitalne računske mašine „ZUSE-23" za Nuklearni institut u Vinči, September 26, 1962.

[69] AJ, 177 SKNE, f. 11. Nabavka digitalne računske mašine „ZUSE-23" za Nuklearni institut u Vinči, September 26, 1962.

tended in 1956 also to the import of necessary equipment, decisions for purchasing of foreign technology and equipment were firmly in the hands of industrial facilities. In effect, this meant that it was the Yugoslav industry that was deciding which part of the national income would be used for purchases of equipment, know-how or even which new technologies should be researched and developed, not the central government.[70] Followed by continued efforts in decentralization and market-oriented R&D and production (as with the 1961 Law on Model of Financing Scientific and Research Institutes), industrial enterprises reached even greater autonomy over their earnings, up to a level of 70 percent by 1965, which simultaneously drained republic and federal revenues, and equally, their capability to finance further research or even to maintain the existing level of funding.[71] At the same time, the IMP eventually managed to orient to the market and secure up to 90-95 percent of its income through a variety of contracts with industry, but this happened only in the mid-1970s. It seems more likely that most of the 1960s was spent in a slow and even desperate attempt to adapt to continuously changing circumstances.[72] Focusing only on the process of installation and utilization of computers in Yugoslav companies, it is worthy to notice that in 1962 the FNEC's experts were stunned to report that it was "chaotic, almost anarchic", and that actual utilization of capacities of existing machines was in a range of only 5-25 percent. It was also remarked that it was "not possible to speak about some national benefit with such chaotic purchases of machines [computers]."[73]

While the Yugoslav decision-makers were stretched between two irreconcilable desires, to support the budding indigenous computer industryand market-oriented

[70] AJ, Savezni sekretarijat za industriju 589, f. 296 (hereinafter: AJ, 589 SSI, 296). Analiza registrovanih ugovora o pribavljanju prava industrijske svojine u inostranstvu, Beograd 1962; Kutlača, Đuro and Semenčenko, Dušica, *Nacionalni inovacioni sistem u Srbiji: prošlost, sadašnjost, budućnost*, Institut „Mihajlo Pupin", Akademska misao, Beograd 2015, p. 85 (hereinafter: Kutlača, Đ., Semenčenko, D., *Nacionalni inovacioni sistem u Srbiji*…). The problem is obviously more complex than suggested here. At least for the acquisition of foreign licenses, companies had to receive approval from the Federal Secretariat for the Industry. Although, this was often just a formality, since the directors of big industrial facilities were in most of the cases members of the League of Communists of Yugoslavia, and could easily push their decisions through the system, even if through their unofficial channels. The outcome was, nevertheless, the same.

[71] Woodward, Susan, "Review: Reforming a Socialist State: Ideology and Public Finance in Yugoslavia", *World Politics* 41, No. 2, January 1989, pp. 296–297. (hereinafter: Woodward, S., "Review: Reforming a Socialist State…")

[72] *Institut „Mihajlo Pupin" – riznica znanja*..., p. 5; Bondžić, D., *Između ambicija i iluzija*..., p. 223; Петровић-Нешковић, Б., *Пола века Института „Винча"*..., p. 32. In 1965 nuclear institutes managed to secure only 6 percent of their income from contracts with industry, and in the 1970 they still received up to 75 percent of their budget from the FNEC. While it is expected that nuclear technology was more difficult to market, the gradual switch towards the market must have been unavoidable for all other research institutes, with a variable success.

[73] AJ, 177 SKNE, f. 11. Nabavka digitalne računske mašine „ZUSE-23" za Nuklearni institut u Vinči, September 26, 1962.

behavior of research institutes and industrial enterprises, the IBM was the quickest and most efficient company in filling this gap. Already in the early 1960s, the IBM was holding 55 percent of the Yugoslav computer market and 85 percent of the total value of installed computers, followed by other companies such as ICL, Univac, Bull-General Electric or NCR.[74] Furthermore, one of the reasons for purchasing the ZUSE Z23 computer for the IBK in 1962 was in fact the desire to establish licensed production of these computers in the Slovenian Iskra company; another ZUSE Z23 was installed in the same year at the Institute of Mathematics, Physics and Mechanics in Ljubljana. Soon enough, the Iskra started the assembly of ZUSE Z23 computers.[75] This expanded into a production of the Iskra ZUSE Z23 V model, yet by 1967 the ZUSE KG went bankrupted and was bought by Siemens AG and very few of Iskra-ZUSE computers reached customers, while the company did not produce other computers until the late 1970s.[76] Following the country's decentralization policies, it should not be surprising that the entire project for the establishment of the production of computers in Slovenia was based on the cooperation between the University of Ljubljana, Nuclear Institute "Jožef Stefan", Iskra, Executive Council of Slovenia and several other institutions of Slovenian government that provided most of the necessary funding where the FNEC already had limited influence.[77]

The first Yugoslav company that intended to start the serial production of electronic computers based on the CER technology was the Ei Niš [*Elektronska industrija Niš*], and it seems that this was a case of a continued effort to maintain the original strategy for the country's technological modernization. The only difference from the Iskra scenario was that it was happening in Serbia. The Ei Niš was one of many companies in the network of FNEC's partnersinvolved in the country's nuclear program, "oriented to the production of complex devices for the ionizing radiation protection as well as calculating machines", but also "the equipment for the hot-lab"

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[74] "Yugoslavia grows ripe for computer boom", *New Scientist and Science Journal*, September 9, 1971, p. 576.

[75] AJ, 177 SKNE, f. 11. Nabavka digitalne računske mašine „ZUSE-23" za Nuklearni institut u Vinči, September 26, 1962; Frković, M., *et al.*, "A contribution to the history…", pp. 195–197; Pivec, Franci, "First Real Computers in Slovenia", *IT STAR Newsletter*, Vol. 6, No. 4, 2008, pp. 11–12. (hereinafter: Pivec, Franci, "First Real Computers…"). Frković and others inquire about the reasons for choosing the ZUSE Z23 machine for purchasing the license for the Iskra Kranj, and the archival reveal that the sole reason was that the Z23 remained in the country after the Belgrade Technical Fair in 1962, and it was decided to use the opportunity not to return the machine, but to purchase for a reduced price it for the IBK and Iskra Kranj, eventually hoping for the license agreement with the ZUSE company.

[76] Bejek, Miha, *et al.* (eds.), *FRI 20: 20 let Fakultete za računalništvo in informatioko Univerze v Ljubljani*, Fakulteta za računalništvo in informatiko, Ljubljana 2016, pp. 14–15. (hereinafter: Bejek, M., *et al.* (eds.), *FRI 20*…); Zuse, Konrad, *The Computer-My Life*, Springer-Verlag, Berlin Heidelberg GmbH, 1993, p. 153. (hereinafter: Zuse, K., The Computer…)

[77] Frković, M., *et al.*, "A contribution to the history…", p. 197.

of the IBK.[78] Starting in 1962, the Ei Niš cooperated with the IMP on the development of the electronic bookkeeping computer, and the outcome were prototypes CER-20 and CER-30, used in these two companies. However, the development of indigenous computer industry was slow, most likely due to a variety of aforementioned contradictory policies, and the Ei Factory of Computing Machines was established only in late 1971. In the following years, the company started to produce a number of micro-computers and large computer systems, but this time in cooperation with the Kienzle and the Honeywell (in the 1970s and 1980s).[79]

Rationally analyzing the situation, the Yugoslav authorities wanted to put the situation under control and already in the 1960s introduced strict import and export regulations that restricted foreign companies from establishing their own affiliates in the country. However, this strategy was more oriented to keeping the hard currency in the country than anything else, and it was doomed from the start. Due to the fact that Yugoslav companies had an ever growing freedom in distribution of their income and choosing their production programs, those that were technically and technologically capable (like Iskra or Ei Niš) more readily represented foreign manufactures on the domestic market.[80] This only further undermined the development of the indigenous computer industry. Eventually, thiscreated a situation in which high diversity of computer systems in the country only further limited capacities of data transfer between Yugoslav companies and state institutions or agencies, since many of existing computer systems were not compatible with models of other manufacturers.[81] Therefore, cooperation in the potential technology transfer never appeared „not even in their embryonic form."[82] Paradoxically, this confusion on the Yugoslav computer market seems to reflect the similar confusion in the entire state, where cooperation between Yugoslav republics was in a rapid decline since the early 1960s, even if it existed in the previous period.

The final problem in development of the computer industry in Yugoslavia was a highly limited number of educated engineers and technicians. Even foreign observers easily identified that in the field of information technologies, "an overriding problem for the Yugoslavs is the chronic shortage of adequately trained personnel."[83] One of the reasons for the aforementioned low utilization of existing computers in the country

[78] AJ, 177 SKNE, f. 25, a.j. 95. Organi i tela SKNE. Stručni Savet SKNE, 1960–1967. Izveštaj o radu u 1960. godini na polju nuklearne instrumentacije, April 26, 1961.

[79] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., p. 64; Христовић, Д.,"Развој рачунарства…", p. 97; Protić, J., Ristanović, D., "Building Computers in Serbia…", p. 557. Another users of CER-20 and CER-30 computers were RIZ Zagreb and TRS Zagreb.

[80] Frković, M., *et al.*, "A contribution to the history…", p. 195.

[81] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., pp. 80–81.

[82] Kutlača, Đ., Semenčenko, D., *Nacionalni inovacioni sistem u Srbiji*…, p. 85.

[83] "Yugoslavia grows ripe for computer boom", *New Scientist and Science Journal*, September 9, 1971, p. 576.

was exactly the lack of engineers trained in this field.[84] This situation was evident already in the early 1960s when it was admitted that "we [Yugoslavia] do not have possibility to educate students during their studies, while in other countries machines [computers] already became a handy instrument in every technical school."[85]

The Electro-Technical Faculty in Belgrade introduced the program for Data Processing only in 1967, while the Department for Data Processing was established in 1971. However, initially the program was "far below the coursework on famous universities", which was compounded with the fact that the first computer for training of students was purchased only in 1968 as a joint effort of a number of state institutions that provided the necessary funding – and it was the IBM 1130, not the CER.[86] On the Mathematical Faculty in Belgrade, the first course in this field was introduced in 1961, yet regular lectures started in 1964. Paradoxically, the entire program was based on the Soviet literature and university programs, which probably were not completely compatible with predominantly American computers that were used in Yugoslavia. The situation started to change in 1969, but it was too little too late for the country's emerging computer industry.[87]

The situation was similar in Slovenia and Croatia. Professor Souček set up the first Laboratory for Cybernetics in 1966, and during the 1966/67 he also established the Scientific Electronic Computer Center [*Znanstveni elektronski računski centar* – ZRCE]. At the same time, the course Digital Computers was introduced at the Faculty of Electrical Engineering and Faculty of Science, and in 1970, the Faculty of Electrical Engineering introduced a new undergraduate course named Computer Science for 3rd and 4th year students, alongside the postgraduate course with the same name.[88] The ZUSE Z23 computer purchased in Slovenia in 1962, became the basis for the establishment of the Computer Centre in the following years, in a joint effort by the Institute of Mathematics, Physics and Mechanics and the Nuclear Institute "Jožef Stefan" (NIJS) in Ljubljana, as the first open-access computer center in the country.[89] The first full computer course called Automatics [*Avtomatika*] was introduced in 1968 at the Electro-Technical Faculty.[90]

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[84] AJ, 177 SKNE, f. 11. Nabavka digitalne računske mašine „ZUSE-23" za Nuklearni institut u Vinči, September 26, 1962.

[85] Ibid.

[86] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., p. 27.

[87] Bečejski-Vujaklija, D., Marković, N. (eds.), *50 godina računarstva u Srbiji*..., pp. 56–57.

[88] Frković, M., *et al.*, "A contribution to the history…", p. 194.

[89] Pivec, Franci, "First Real Computers…", pp. 11–12; Gams, Matijaž, "Editorial: 'Michie-Turing' IS2014 Award Recipient: Janez Grad", *Informatica* 38, 2014, pp. 311–313. (hereinafter: Gams, Matijaž, "Editorial…"). Pivec and Gams differ significantly about the date of the establishment of the Computer Center in Ljubljana, stretching between 1962 and 1968, respectively.

[90] Bejek, M., *et al.* (eds.), *FRI 20*…, pp. 13–14.

Conclusion

The history of the development of the CER-10 and subsequent models of CER computers as well as of the attempted establishment of computer industry in Yugoslavia presents a sad story that combines moments of incredible successes, debilitating mistakes and failed opportunities for a continuously desired, yet often illusive technological modernization and scientific development of the country. This research had shown that the CER-10 project fell a victim toa complete lack of careful planning, coordination and consequently, any coherent strategy in building-up of the domestic computer industry. The combined effect of the Regulation for the Acquisition of Industrial Property Rights Abroad (1954), the Law on Model of Financing Scientific and Research Institutes (1961), strict import and export regulations, and the fact that the entire technology was at least to a certain degree under the control of the FNEC and the security sector during the 1960s, was a complete chaos that rendered any attempt of domestic industry to establish serial production of CER computers almost impossible.

The Federal Executive Council was not ready to invest in the production of computers in the country since it required lots of foreign currency they were desperate to keep, but which were continuously disappearing due to uncontrollable expenditures of state companies. Without the support from the state, restricted from 1961 by the Law on Model of Financing Scientific and Research Institutes, the IMP could not afford to invest into serial production of computers independently since it was a research institute much more than a company and did not have that kind of profit that could be easily reinvested. Former IMP engineers admit that it was a general state strategy that the funding for further development would dry-up after each successful CER computer model, the research team would be automatically reduced, and the design of a new model would have to start basically from scratch, but funding for a serial production state would not or could not provide.[91]

Similarly, Yugoslav companies that needed computers were reluctant to purchase them from the IMP since CER machines were not readily available, but instead had to be ordered and paid in advance, at least partly. This produced a waste of time and freezing of assets of potential clients, thus only further complicating the potential start of the serial production of computers at the IMP, or possibly Ei Niš. Even though the IMP stabilized its profits in the 1970s, foreign companies had already made a strong foothold in the Yugoslav market and it would be extremely difficult to replace them. At the same time, companies like Iskra, or a bit later Ei Niš, invested their funds in purchasing foreign licenses, which was much easier, even if more expensive. It was also formally regulated and regularly practiced in the entire industrial sector.

[91] Paunović, V., Hristović, D., "Prikaz i analiza računara CER...", p. 81.

Even if these problems were somehow successfully circumvented, the remaining problem of inadequate number of trained engineers in the field would only further undermine any ambitious strategy. In the given circumstances, a successful serial production of CER family computers as standard machines in Yugoslavia would be equal to a miracle. It seems that the desperate attempt to keep the indigenous computer technology alive was through projects for the YPA, which was the most consistent customer of CER computers, in addition to a handful of big Yugoslav banks and companies for which the IMP constructed unique machines, tailored specifically to their needs (*Table 1*).[92] In fact, this rendered the IMP to the level of a high-tech craft workshop, which points to a conclusion that the state support for production of computers was actually designed to keep the IMP and its production program alive.

Due to all of aforementioned problems, it is a paradoxical conclusion that the country that was on the forefront of development of computer technology in the early 1960s, by the end of that decade relegated their ambitions to only keeping alive projects and companies out of a sheer desire to avoid mass layoffs and potential dissatisfaction among the working class. At the same time, companies that eventually started the production of computers based on foreign licenses were fighting only for their profits on the expanding market, without participation in any ambitious state strategy of the technological modernization.

Finally, the fact that Ranković is regarded as a Serbian nationalist that had full control of the state security sector as well as of the nuclear program during the 1950s and 1960s, it may well be argued that the master plan was to develop the entire set of technologies necessary for the eventual construction of nuclear reactors (and eventually atomic bombs) exclusively in Serbian scientific institutes and companies, thus potentially increasing his own power exponentially, and securing Serbia's advantage in comparison to other republics. This strategy included the electronic computer technology, among others. The "first Yugoslav computer" was developed by the IBK, only to be transferred to the IMP which in cooperation with the Ei Niš was supposed to establish the computer industry in Serbia and Yugoslavia. Each of these institutions was connected to the central scientific hub of Yugoslavia (and Serbia), the IBK, under the direct or indirect control and patronage of Ranković. Even later versions of CER computers were purchased almost exclusively by the YPA and Serbian companies. While further elaboration of this hypothesis is impossible to perform within the confines of this article, it seems evident that the traditional story behind the fall of Ranković in 1966 and his general position in the Yugoslav political establishment deserves to be reevaluated and reexamined with some fresh eyes and from a number of different perspectives.

[92] Paunović, V., Hristović, D., "Prikaz i analiza računara CER...", p. 81.

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Резиме

МА Марко Миљковић,

ЦЕР рачунари као оружје масовног поремећаја: југословенска индустрија рачунара 1960их

Чланак анализира историју развоја ЦЕР-10, првог југословенског рачунара који је конструисан у периоду између 1956. и 1960. године у Институту за нуклеарне науке „Борис Кидрич" у Винчи. ЦЕР-10 је поставио Југославију на листу свега неколико европских земаља које су биле способне да самостално произведу електронске рачунаре (Велика Британија, Француска, Немачка, Пољска и Совјетски Савез). Међутим, иако је овај пројекат представљао изузетан успех југословенске стратегије научно-технолошког развоја, анализа процеса успостављања и изградње рачунарске индустрије у наредној деценији открива читав низ системских проблема Југославије у том периоду; од контрадикторних стратегија економског развоја, до дубоке умешаности УДБ-е и Александра Ранковића у привредни живот земље, која је поред контроле рада научних института и привредних капацитета, подразумевала и преусмеравање средстава из федералног буџета првенствено у српске компаније. Коначни резултат је и прича о судбини рачунара ЦЕР-10 и модела који су касније развијени на основу овог пројекта која представља комбинацију великих успеха и подједнако великих промашаја и пропуштених шанси.

Кључне речи: Југославија, рачунари, ЦЕР-10, нуклеарни програм, УДБ-а, Александар Ранковић