Institute Mihailo Pupin
www.pupin.rs

Topic: ATLAS-SST – First Digital Microprocessor-driven Remote Control System

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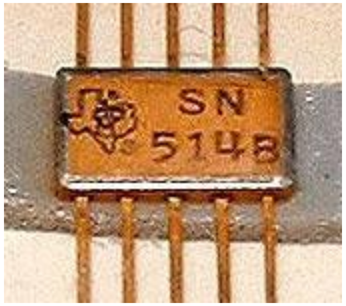
Integrated Circuits - appearance

- **First integrated circuit** (IC) appeared in the **years 1960/61.**
- **Fairchild Semiconductor** and **Texas Instruments**, independently succeeded to integrate a larger number of transistors and supporting electronics components, and packed them together into small-size chip.
- **Better performances** – a parasitic resistance, capacity and inductivity impact was significantly reduced.
- **Lower power consumption.**



Integrated circuit **SN514B** was a NOR/NAND logical gate. Its initial price was cca. $400.-, and in 1963. this IC “travelled” through the space.

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Integrated Circuits - continued

Technology development led to a larger-scale integration and delivery of **LSI** (large scale integration) i **VLSI** (very large scale integration) **integrated circuits.**

- Integrated circuits were packed into **DIL** (dual in line) ceramic or plastic packages – also known as **DIP** (dual in package).
- A common number of IC pins was 14 or 16, dependent of the IC type, and for complex VLSI ICs even larger.
- For power supply voltage **Vcc** and ground **GND**, two IC pins are provided.

Digital integrated circuits include **NAND/NOR** logical gates, **inverters, buffers, shift registers, counters** ... Among analog ICs focus was on the **operational amplifiers**.

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April 1, 1974. – INTEL delivered first 4-bit microprocessor Intel 4004

15 Nov 1971	**USA**	**The Intel 4004, the first commercially available microprocessor, is released.** It contains the equivalent of 2,300 transistors and was a 4-bit processor. It is capable of around60,000 instructions per second (0.06 MIPS), running at a maximum clock speed of 740 kHz.

Advertisement for Intel's 4004

Intel introduces the first microprocessor

Computers

The first advertisement for a microprocessor, the Intel 4004, appears in Electronic News. Developed for Busicom, a Japanese calculator maker, the 4004 had 2250 transistors and could perform up to 90,000 operations per second in four-bit chunks. Federico Faggin led the design and Ted Hoff led the architecture.

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INTEL 8080 TIMELINE

1 Apr 1972	**USA**	**8008 microprocessor released by Intel.**
1 Apr 1974	**USA**	**Introduction of the 8080.** It ran at a clock frequency of 2 MHz and did 0.64 MIPS.
		
1976	**USA**	**Introduction of the Intel 8085 chip.** An improved version of the 8080, with a superset of the 8080s instruction set (only a couple of extra instructions). Single 5V power supply (while the 8080 needed several different voltages).
		

8-BIT MOTOROLA MICROPROCESSOR MC6800

1974	**USA**	**Motorola announces the MC6800 8-bit microprocessor**. It is more easy to implement than the 8080 because it only needs a single power supply to operate and does not need support chips. Unlike the 8080 it is sold not as much as a general-purpose "number cruncher / computer" CPU core but more as a control processor for industrial control and as a peripheral processor.

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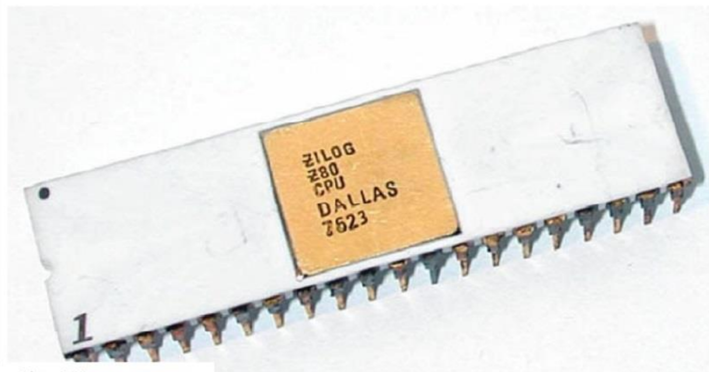
1976 - Intel and Zilog delivered a new mikroprocessor Z-80



Zilog Z-80 microprocessor

Intel 8080 and Zilog Z-80

Computers

Intel and Zilog introduced new microprocessors. Five times faster than its predecessor, the 8008, the Intel 8080 could address four times as many bytes for a total of 64 kilobytes. The Zilog Z-80 could run any program written for the 8080 and included twice as many built-in machine instructions.

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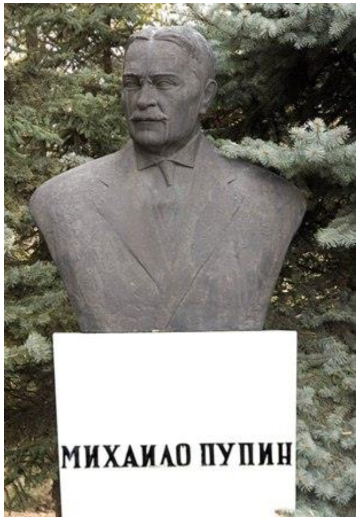
Institute Mihailo Pupin in Belgrade

- Founded in 1959 as an independent scientific and research institute.
- Always at the top in areas of applied electronics, automatics, telecommunications and computer engineering.
- Open for new ideas and challenges.
- Laeder in the IT fields in the country.

Institute Mihailo Pupin in 1970-ties



- Educated and qualified staff.
- Oriented toward industry and its needs (especially toward electric-power industry).
- Worldwide connections – an efficient local implementation of new technologies.

NOTE: First implementation of integrated microprocessor in former Yugoslavia 1975/76 in electric-power industry.

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ATLAS Remote Control Systems

- **ATLAS – standard name for all generations of remote and local control systems (tele-information systems).**
- **More than a half century of development and manufacturing of remote control systems**
- **Transistors and discrete electronic ATLA systems since the year 1968.**
- **First digital microprocessor-driven ATLAS system in the years 1975/76.**
- **Nowadays – fifth generation of microprocessor-driven ATLAS systems.**
- **Complementary projects: SCADA (Supervisory, Control and Data Acquizition) and PLC)Programmable Logic Control) systems.**
- **Development and manufacturing of supporting devices, modules and components.**

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Years of 1974/75

- First commercially available 8-bit microprocessor Intel 8080 (April 1, 1974) – soon followed by Motorola MC6800 microprocessor.
- In the spring of 1975 Intel’s brochure “From CPU to Software“, which described 8080 microprocessor, arrived to the Institute.
- Decision to start with project of designing micro-processor-driven Remote Terminal Unit - RTU and Central Control Unit – CCU.
- Dilemma in a choice between two functionally similar integrated microprocessors: Intel 8080 and Motorola 6800
- The choice of Intel 8080 microprocessor and preparing of a specification to order needed components.
- Start of a hardware design in fall of 1975.

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Why microprocessor Intel 8080

- Technical description of two microprocessors: **Intel 8080** and **Motorola 6800** were very similar. Even MC6800 sounded somehow more comprehensive.
- For software development both manufacturers pointed to large commercial computer networks available at that time, to whom we hadn’t have an access.
- Motorola was a well-known and respected company versus a ”new-comer” on the market INTEL.
- While a choice of Motorola was closer to decide, INTEL delivered a development system **Intellec MDS** – a stand-alone computer that fully supported software development for the mipricessor 8080, making possible a buildup of a development environment in the Institute.

There was no more dilemma – the decision was done: Intel 8080.

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Development System Intellec MDS-80 (first phase)

In first phase the development environment included: Intellec MDS-80 with a connected serial terminal Teletype ASR-33.

ASR-33 served as a console and input/output peripheral device.

Input: keyboard and mechanical paper tape reader (speed 10 char/sec)

Output: Printer and mechanical paper tape punch (speed 10 char/sec)

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Development System Intellec MDS (second phase)

It was obvious that a more comfortable development environment was desperately needed.

Development system **Intellec MDS-80** was extended with **floppy diskettes**, **PROM programmer** and soon with a **video monitor**. **Teletype ASR-33** continued to serve as a printer. Later it was also replaced with another serial printer.

Project Realization: Functional Organization

- Two functional parts: central control unit and process interface
- Central Control Unit == dedicated microcomputer
- Process Interface == dedicated interface toward process
- Modular hardware organization (module = printed circuit board - PCB)
- Program control with Central Control Unit (program stored in non-volatile PROM memory = system firmware).

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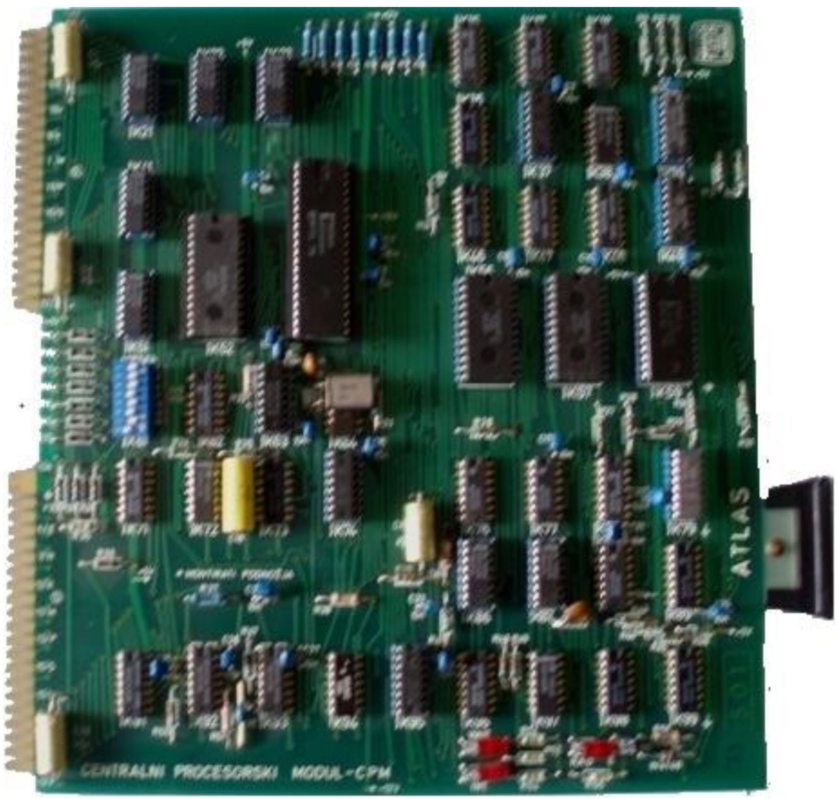
Project Realization:
Hardware – Microprocessor Module



- 8-bit microprocessor Intel 8080
- Nested 8-level interrupt control
- Real-time Watch-dog Timer – WDT

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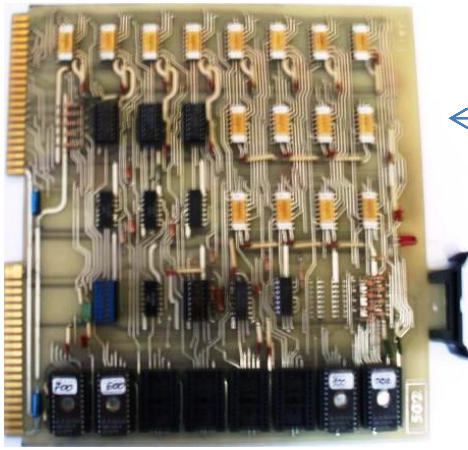
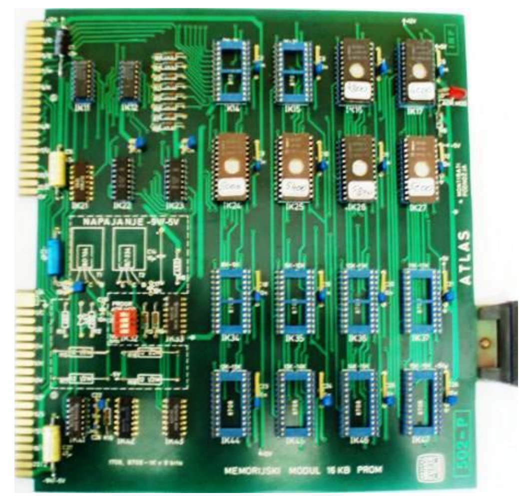
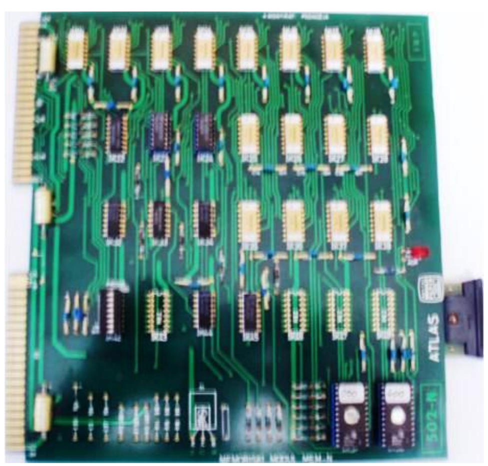
Project Realization:
Hardware – Memory Modules



2KB RAM (16x1Kb ICs) +
2KB EPROM (8x256B ICs)

Upon delivery of 1KB EPROM ICs:
16KB EPROM (16x1KB ICs)





2KB RAM (16x1Kb ICs) +
2KB EPROM (2x1KB ICs)

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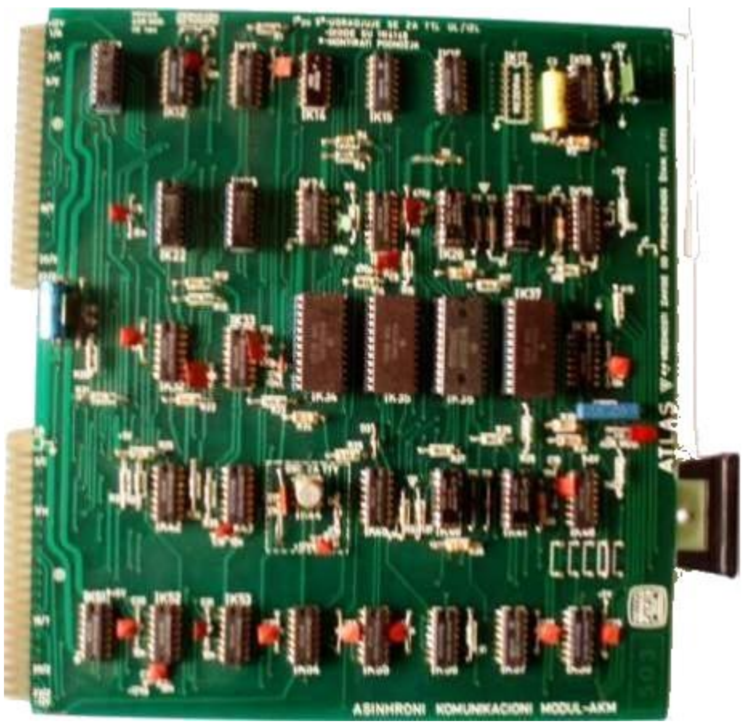
Project Realization:
Hardware – Communication Module



- 4 asynchronous communication channels
- Motorola’s asynchronous communication interface adapter – ACIA was used
- Program controlled byte data transmission (in octets)
- (1 start bit + 1 or 2 stop bits)

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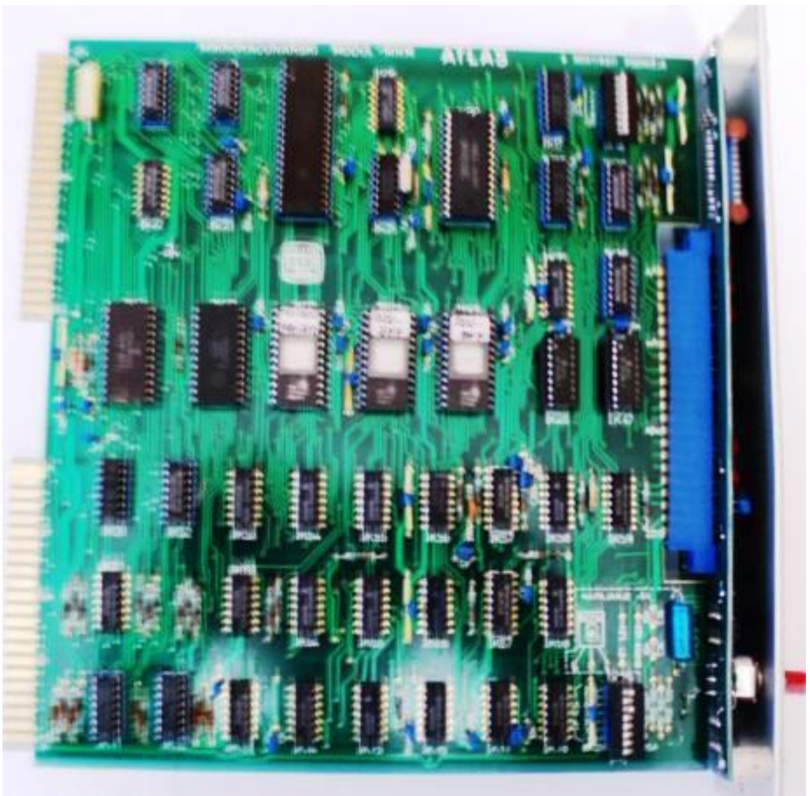
Project Realization:
Hardware – Microcomputer Module



In 1979 an 8-bit microcomputer was designed as a single module:

- 8-bit microprocessor Intel 8080
- Memory: 1KB RAM + 3KB EPROM
- 1 asynchronous communication channel (Motorola ACIA)
- Real-time Watch-dog Timer WDT
- Front panel (console)

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Project Realization:
Hardware – Other System Modules

Other Central Control Unit Modules:

- Front panel with RTC (real-time clock) as MM interface
- Digital Input Controller (signals from process)
- Analog Input Controller with AD converter (measurements from process)
- Digital Output Controller (on-off commands)
- Universal Input / Output Controller (for synoptic control board)

Process Interface Modules:

- Digital Input Scanner (with optocoupler galvanic insulation)
- Analog Input Scanner (with flying capacitors)
- Digital Output Multiplexer (with command relays toward process)
- Digital Signal Multiplexer (for synoptic control board)
- DA Converter Multiplexer (for synoptic control board)
- Digital Command Scanner (for synoptic control board)

Project Realization:
Software – Real Time Programming

Designed hardware required a corresponding program support. There were many restrictions, primarily regarding program execution speed and available storage space (an extremly small-size PROM memory):

- **The only available programming option was to do everything in assembler language (it is not an "user-friendly" option, but it is close to hardware and efficient and economical in its control)**
- **There was no any OS available, especially any RT OS – everything had to be written "from zero"**
- **And the last but the most important: how to debug written software, how to figure-out what is causing a problem if something is going wrong? – how to figure-out between a software bug and hardware malfunctioning.**

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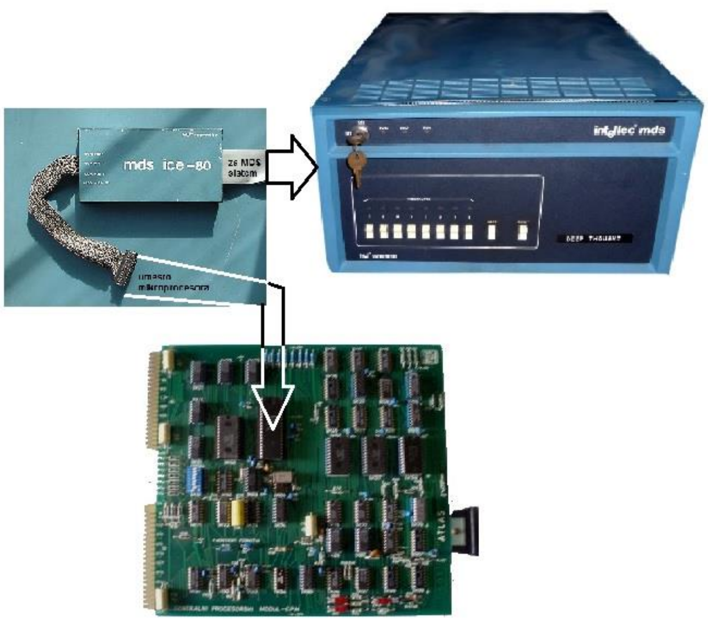
Project Realization:
Software – ICE emulator

Soon INTEL delivered commercially available ICE MDS-80 (in-circuit emulator), „an extraordinary“ tool for efficient program debugging (and much more than the program):



- **ICE emulator connects the MDS development system with designed microprocessor module.**
- **Instead of microprocessor we simply plug in its socket a compatible ICE emulator cable connector.**
- **All processing resources of MDS development system are now used in the microprocessor emulation, providing a “comfortable” debugging of the designed module.**

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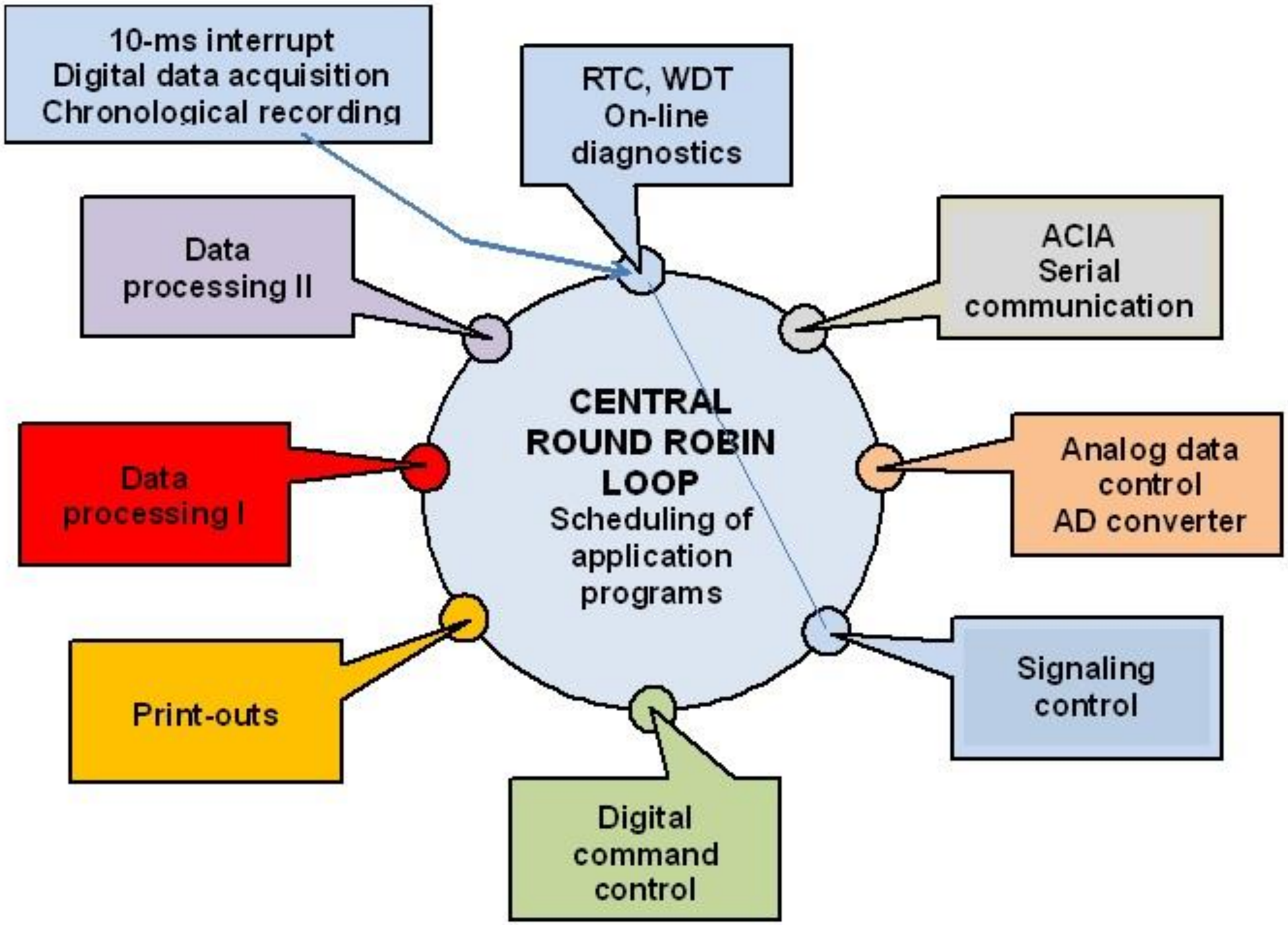
Project Realization: Software – Concept



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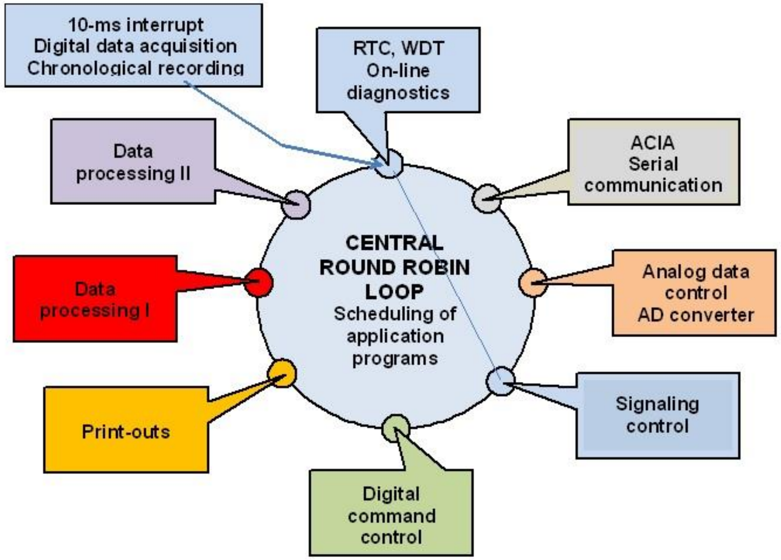
Project Realization
Software – Concept (commented)



- Central round-robin distributor with connected points for application programs and WDT control (watch-dog timer).
- 10-ms high-priority interrupt program controls RTC (real-time clock) and enables real-time program execution and remote communication.
- Application data acquisition and data delivery programs control process interface hardware.
- Application data processing programs, program for printing, etc.
- On-line diagnostics programs.

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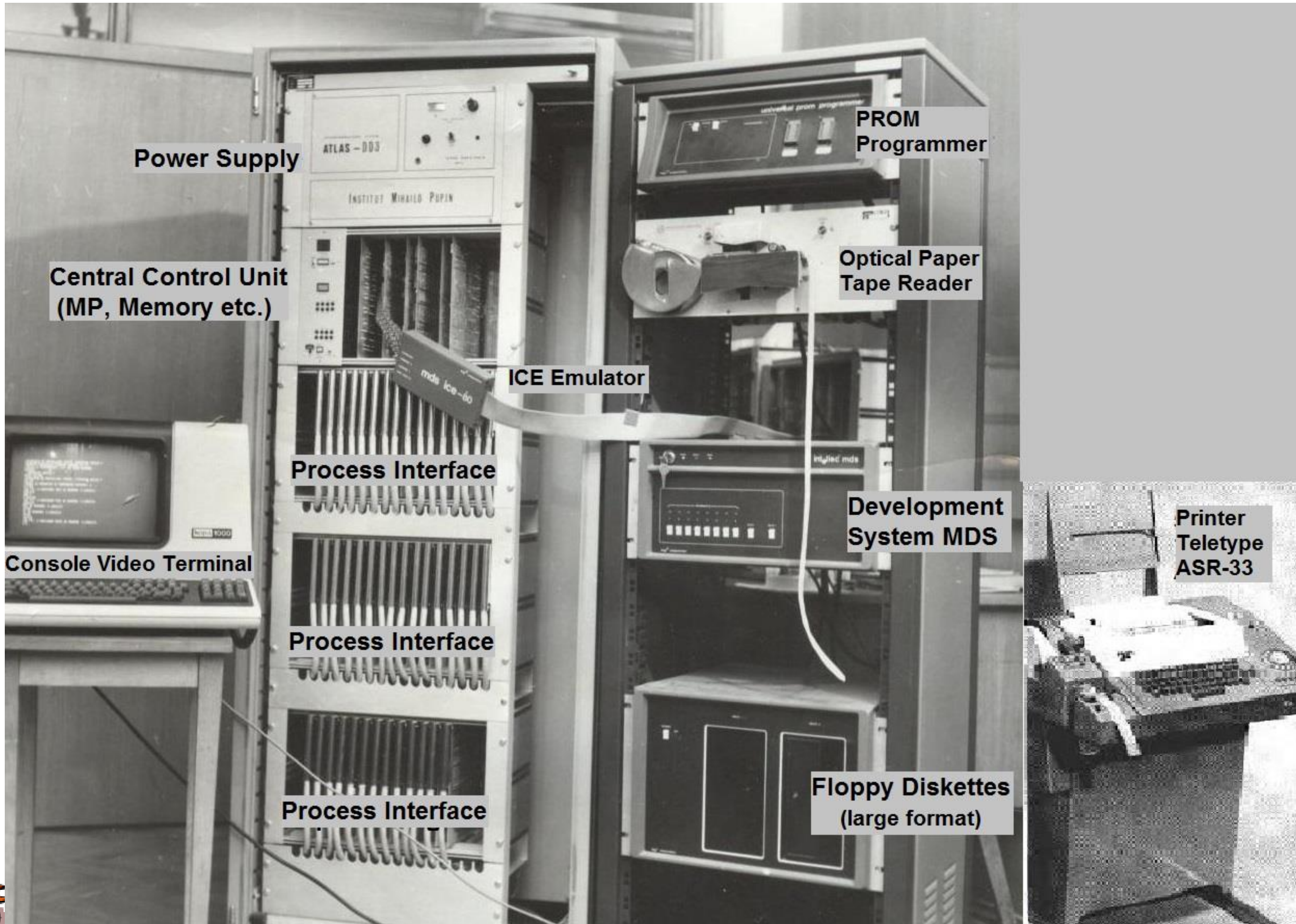
Project Realization: Digital Workshop

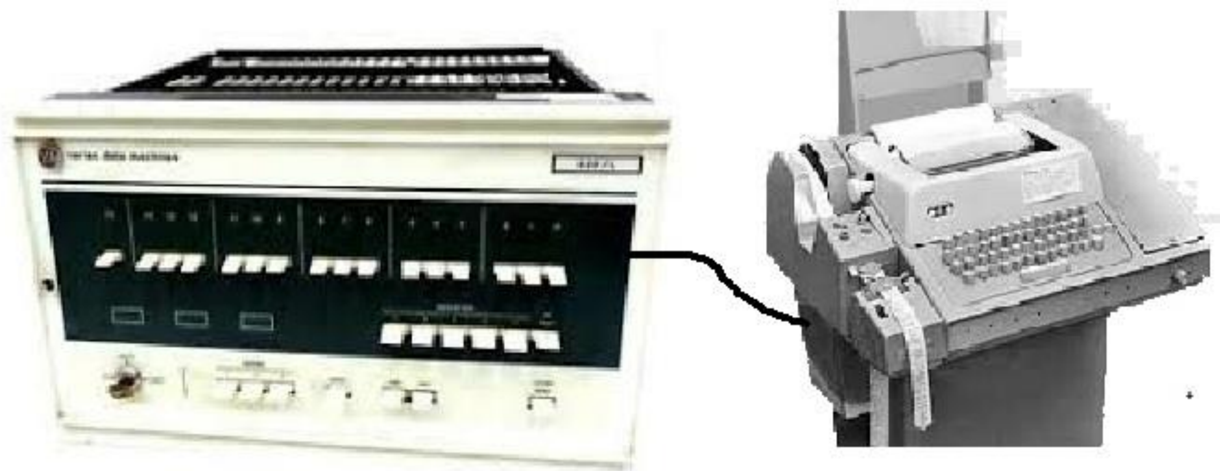


CONCLUSION

- Project “**Microprocessor-driven Remote Control System ATLAS**“ turn to be very successful.
- A significant number of this generation ATLAS systems were built-up and delivered to customers (mostly to electric-power industry).
- At the same time, **ATLAS** triggered other compatible development projects in Institute: **SCADA (Supervisory, Control and Data Acquizition) Systems**, **PLC (Programmable Logic Control) Systems** and others ...

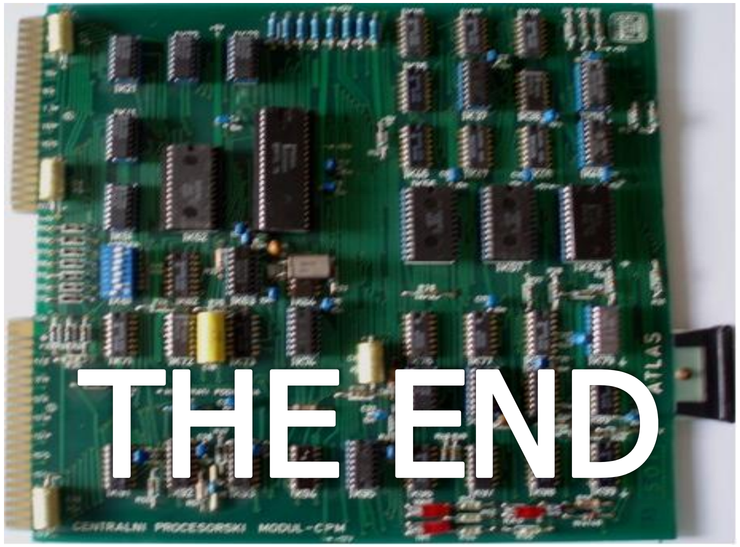
And last but not the least, there were several important pre-conditions for a successful project completion. These were, for sure, the accumulated knowledge and experience from previous similar projects: **Monitoring and control of the Danube left bank pumping stations** (hardware-wise) and **System for monitoring and chronological event recording in HP Djerdap 1** (software-wise).

System for Monitoring and Chronological Event Recording in HP Djerdap 1



- First process mini-computer VARIAN 620i in an electric-power site in former Yugoslavia.
- The slide presents the system computer part in both, development and operational environment.
- Installed and put in operation in 1970/71.

Topic: ATLAS-SST – First Digital Microprocessor-driven Remote Control System



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