

# Installation of the flight data recorder S2-3a on Su-22 and MiG-29 aircraft

Adam Tomyslak<sup>1\*</sup>

<sup>1</sup>Wojskowe Zakłady Lotnicze nr 2, ul. Szubińska 107, Bydgoszcz

**Abstract.** The S2-3a flight data recording system developed at the Air Force Institute of Technology is intended for recording the flight parameters and the operating parameters of aircraft assemblies, as well as to store the recorded data in its memory to evaluate flight safety, piloting technique, technical condition of on-board system and air accident (air crash) causes. S2-3a flight data recording systems are operated on-board the: TS-11 ISKRA, PZL-130 TC-II ORLIK, M-28 BRYZA, MiG-29, and Su-22 aircraft, as well as the Mi-8, Mi-14, Mi-17, Mi-24, W-3 SOKÓŁ and SW-4 helicopters. The paper contains selected information on the installation of the S2-3a recorder on Su-22 and MiG-29 aircraft AT the Military Aviation Works no. 2 S.A. In Bydgoszcz.

## 1 Introduction

The S2-3a/MiG-29 recorder (and S2-3a/S54K and S2-3a/S52 for Su-22 aircraft) is intended for recording during the flight and on the ground parameters of main systems of the aircraft and its equipment, the current flight time and parameters input (data) and to secure recorded information in the event of an aircraft accident. He found the flight control and recording device TESTER U3Ł. The measurement values are directly connected to the inputs of the analog-digital formation and processing systems (S3-1a-2/MiG-29 acquisition unit and BPNK-1 unit for MiG-29, S3-1a-2/S54K acquisition unit and BPSC-22 unit for Su-22M4 and the BSK-22, BPNK-22, BZK-22 and BPSC-22 units for Su-22UM3K aircraft), and then in the form of digital data are recorded in memories of the S3-1a-2K/M maintenance cartridge and the S2-3a-K protected cartridge. The CAN (Controller Area Network) standard was used for data transmission in the S2-3a recording system.

An additional advantage of the modernized system for recording flight parameters of MiG-29 and Su-22 aircraft is the increased level of digitization of the proceeded measurement signals.

The recorder for MiG-29 aircraft consist of:

- a) S3-1a-2/MiG-29 acquisition unit,
- b) BPNK-1 voltage - code transducer unit,
- c) S2-3a-K protected cartridge,
- d) S3-1a-2K/M maintenance cartridge.

The recorder set for the Su-22M4 aircraft:

- a) S3-1a-2/S54K acquisition unit ,
- b) BPSC-22 digital signal processing unit,
- c) S2-3a-K protected cartridge,
- d) S3-1a-2K/M maintenance cartridge,

and for Su-22UM3K aircraft:

- a) BSK-22 control unit,
- b) BPNK-22 voltage - code transducer unit,
- c) BZK-22 power and control unit,

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\* Corresponding author: [atom98@wp.pl](mailto:atom98@wp.pl)

- d) BPSC-22 digital signals transducer unit,
- e) Module M14-01M1.

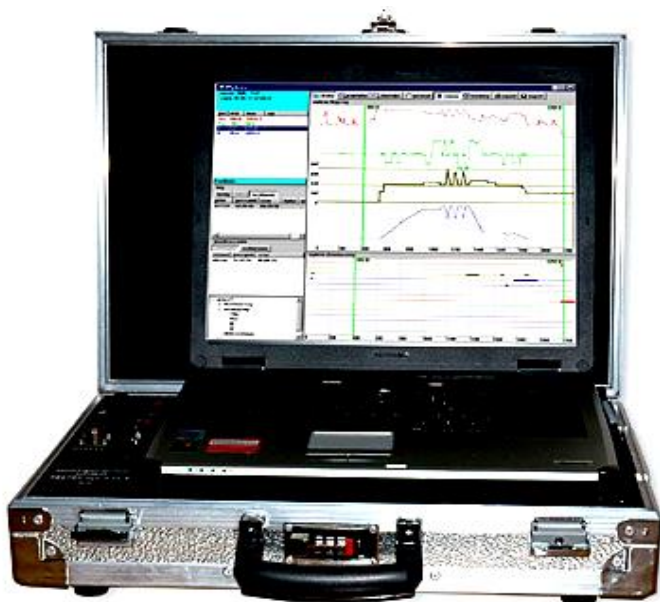
In addition, the recorders include transmitters of parameter and switching equipment.

## **2 Characteristics of the S2-3a recorder on MiG-29 and Su-22 aircraft**

- S3-1a-2/MiG-29 (S3-1a-2/S54K) acquisition unit through measurement modules analog data convert (convert of analog voltage signals), binary data (convert of binary voltage signals) and special signals (convert of voltage signals with an compound structure, e.g. signals from engine boundary unit BPK-88 – MiG-29 and BDK-89 – Su-22), ensures self-monitoring and registration of the mentioned groups of signals and provides the opportunity to introduce new parameters from the systems navigation, automatic engine starting, control of executive systems for recording and control.
- BPNK-1 voltage - code transducer unit accepts control signals for starting the engines, controlling the operation of the braking parachute, supply voltage of the electric starter and the oil pump in the drive box. The principle of operation is the same as in the acquisition unit.
- S2-3a-K protected cartridge ensures the preservation of registration data in the event of an aircraft accident or crash.
- S3-1a-2K/M maintenance cartridge is designed for quick access to data recorded during each aircraft flight. Transferring data from the cartridge to the description station allows for quick analysis of piloting techniques and diagnose onboard systems. The cartridge is coupled with the aircraft power grid and the acquisition unit through a 4-pole contact connection of the K3-1a-2K pocket. The capacity of the memories enables recording data from the previous 8 hours of flight
- BPSC-22 digital signal processing unit – processed signals from GPS, Navigation, engine operating parameters, air brake and flaps release signals as well as from the autopilot and transmit them to the acquisition unit.
- BSK-22 control unit accepts binary signals from the BZK-22 unit, analog and binary signals from BPNK-22 unit, as well as navigation and GPS signals from BPSC-22 unit and sends them to the maintenance cartridge and protected cartridge.
- BPNK-22 voltage - code transducer unit processes binary and analog signals from the aircraft transmitters forwards them to BSK-22 unit.
- BZK-22 power and control unit processes binary signals and forwards them to BSK-22 unit.
- BPSC-22 digital signals transducer unit processes navigation and GPS signals and forwards them to BSK-22 unit.

In order to operate the S2-3a/MiG-29 recorder on the ground, the following devices are used:

- WTS-5 tester (figure 1) with installed “*Objective Record Analysis*“ (OAZ) software for reading coded parameter value during scaling or inspecting the measurement channels of the acquisition unit and the BPNK-1 voltage-code transducer (BPNK-22, BPSC-22), and to decrypt and analyse the data saved in the memories of the S2-3a-K protected and maintenance cartridges,



**Fig. 1.** WTS-5 TESTER.

- WTS-4/CANUSB interface (figure 2) to transmit data from the CAN bus of the S2-3a recorder to a USB connection of the WTS-5 tester notebook.



**Fig. 2.** WTS4/CAN USB interface.

### **3 Installation of the S2-3a recorder on MiG-29 i Su-22 aircraft**

The flight data recorder S2-3a were installed by Military Aircraft Works no. 2 (Wojskowe Zakłady Lotnicze nr 2 S.A) based on contract with the operator – Polish Air Force. The works carried out in stages. First, the installation was carried out on MiG-29M aircraft (combat), then on MiG-29UBM (training-combat) aircraft.

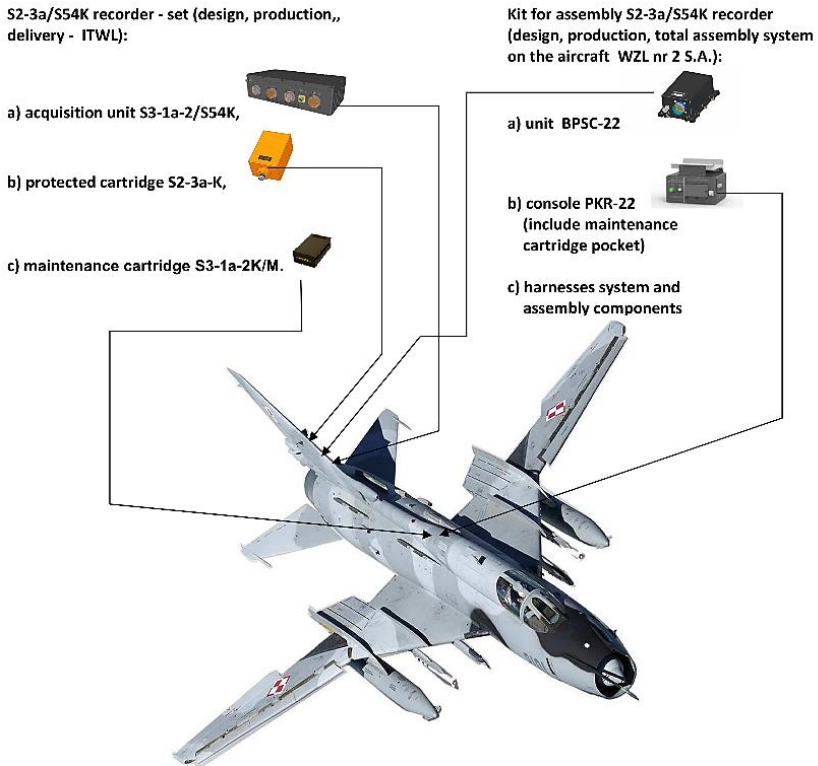
The works related to installing the recorder on the MiG-29 aircraft was carried out by the ITWL, INTOIT and WZL no.2 project teams on a technology demonstrator aircraft withdrawn from flights (so-called HOT MOCK-UP).

Use HOT MOCK-UP aircraft made it possible to arrange the recorder elements determine the dimensions of the electronic units, and determine of the length of the recorder's electrical harness cables without withdrawing flying aircrafts from production, which did not generate delays in current production.

The same method was used to install recorders on subsequent types of aircraft. Then the recorders were installed on the Su-22M4 aircrafts.

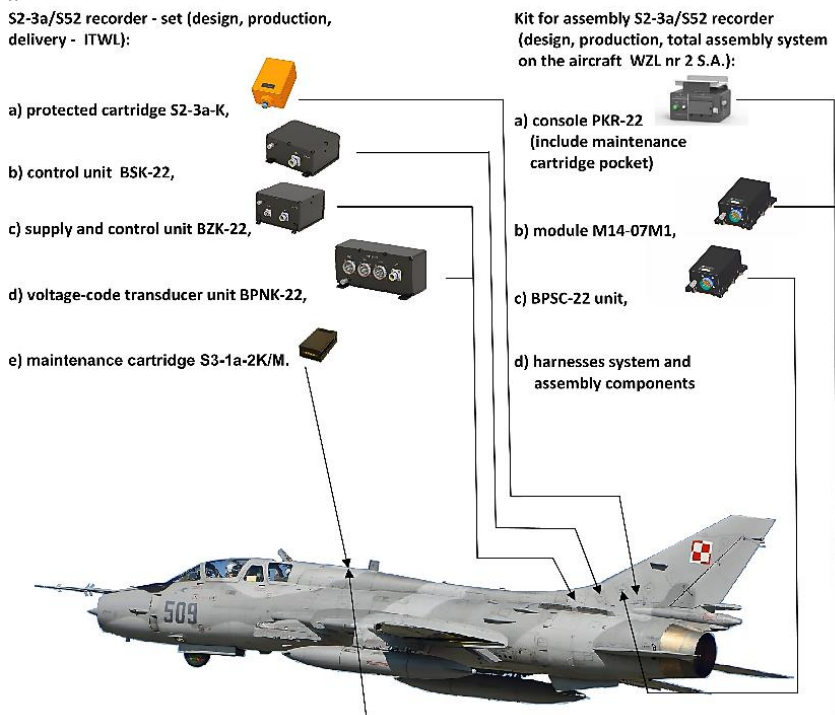


**Fig. 3.** Assembly of the S2-3a recorder on MiG-29 aircraft.



**Fig. 4.** Assembly of the S2-3a recorder on Su-22M4 aircraft.

The works was completed by installing the recorder on Su-22UM3K (combat-training) aircraft.



**Fig. 5.** Assembly of the S2-3a recorder on Su-22UM3K aircraft.

The construction project was carried out by a team of specialists from Military Aircraft Works no. 2 (Wojskowe Zakłady Lotnicze nr 2 S.A) in cooperation with a team from the Air Force Institute of Technology (ITWL) in Warsaw – the recorder manufacturer and with INTOIT from Gdańsk.

Pursuant to the contract, ITWL was responsible for the design, production and supplier of: the acquisition unit, maintenance cartridge, protected cartridge and voltage - code transducer unit, while WZL no. 2 S.A. designed, produced and delivered the maintenance cartridge pocet, BPSC-22 unit, system of electrical harnesses and mounting elements and assembled the system recorder on the aircraft. Moreover, WZL no. 2 S.A made housings for electronic units produced by ITWL.

The S2-3a recorder was installed on aircraft in place of the previously used TESTER U3-Ł recorder (TESTER U3 for the Su-22UM3K aircraft). The intention of the project creators was to interfere as little as possible with the existing electrical installation of the aircraft – the existing electrical installation of recorder was used and modified. The design teams determined the scope of recorded parameters in cooperation with the representatives Polish Air Force. WZL no. 2 specialist S.A:

- analyzed the electrical diagrams of light data recorders,
- developed a diagram of the arrangement of recorder elements on the aircraft,
- developed a detailed new electrical diagram integrating the new recorder with existing systems,
- provided information on the form and value of electrical signals of flight parameters for recording,
- prepared construction documentation of electronic units housings and assembly elements as well as electrical harnesses.
- made a prototype assembly on technology demonstrator (so-called HOT MOCK-UP),
- performed prototype scaling of flight parameters,
- prepared the prototype aircraft for test flight,
- developed documentation for test flight,

- developed a design and maintenance bulletin introducing changes to aircraft maintenance documentation.

The Air Force Institut of Technology designed and delivered:

- recorder set,
- software,
- software for descrypting saved data OAZ.

### 4 Flight data description system OAZ

The “Obiektywna Analiza Zapisów [Objective Record Analysis]“ (OAZ) software was developed in DELPHI5 and is intended to read, archive and image the waveforms of flight parameters recorded in the maintenance and protected cartridges of a S2-3a recorder. The software enables:

- reading a selected record from recorder cartridges,
- archiving records and other data in a database,
- reading archived records from a database,
- graphically imaging (on graphs) flight parameter waveforms,
- reading selected parameters in real time. It can image and analyse the following parameters:
  - analogue (parameter values are determined based on scaling graphs);
  - computational (parameter values are results of calculation procedures);
  - binary (bi-state).

Analogue parameters can be depicted on a graph as the following values:

- coded (obtained directly from the recorder memory);
- physical (calculated based on scaling graphs).

Computational parameters are depicted on a graph as physical values, calculated based on coded values through the procedures of a selected dll module. A record read from a recorder cartridge (protected or maintenance) can be divided into any number of time intervals, defined as flights with a possibility to identify overruns in each of them. The architecture of the software enables displaying windows of the main bar, as well as imaging and editing windows for the implemented functions. The main bar buttons open and close the windows, sized and positioned by the user. Window coordinates are saved prior to closing the software and restored after restarting it. User interface is tailored to her/his needs.

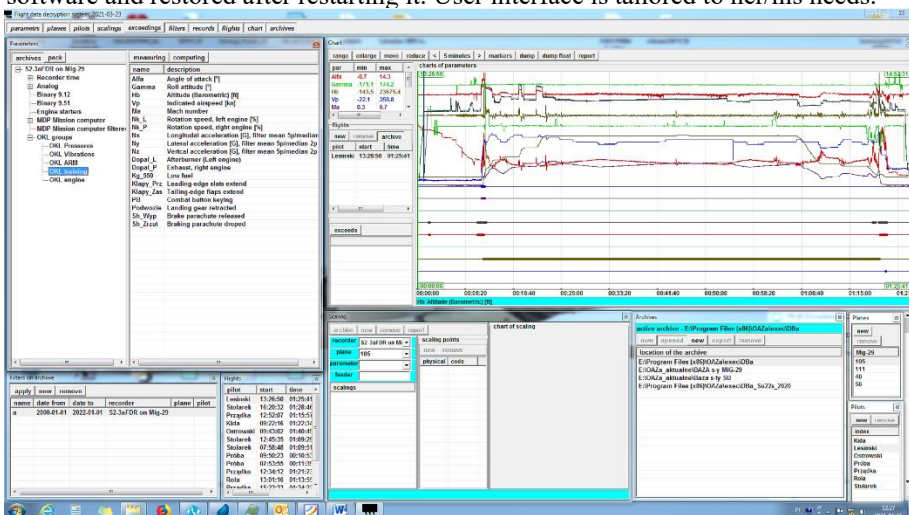


Fig. 6. „Objective Record Analysis“ (OAZ) software – sample screen of pilot parameters.

## 5 Summary

The purpose of replacing the registrator was:

- introduction of a modern, fully electronic form of information recording,
- storing data in electronic form in a protected cartridge and an maintenance cartridge,
- ease scaling parameters of aircraft system transmitters,
- ease of archiving scaling of aircraft system transmitters,
- use one flight parameters description system used on others aircraft of Polish Air Force, for example: TS-11 ISKRA, PZL-130 TC-II ORLIK, M-28 BRYZA and helicopters: Mi-8, Mi-14, Mi-17, Mi-24, W-3 SOKÓŁ and SW-4,
- improving the work comfort of ground staff,
- reducing aircraft operating costs,
- increasing the aircraft maintenance capabilities.

Thanks to the use of the S2-3a recorder, the time needed to analyse flight parameters was shortened. This results in the possibility of a faster next departure the plane, because the next flight is only possible after analysis the recorded data.

The use of the OAZ description system allows installation the program on any PC computer and analyse data not only by Objective Flight Control staff, but also by specialists in particular specialties. This allows great opportunities to diagnose the technical systems and also makes it very easy to analyse malfunction.

## References:

- [1] *Mechanik* nr **4** (2020)
- [2] *Autobusy* nr **6** (2019)
- [3] [www.wzl2.mil.pl](http://www.wzl2.mil.pl)