Contributions Regarding the Modernization of the Anti-Hail Rocket Launcher Monitoring System

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***Abstract* - The University of Craiova - Center for Innovation and Technology Transfer carried out systematic research on the complementary equipment for the anti-hail system. One of the research topics covered the anti-hail rocket launcher monitoring system. At present, the monitoring system for the launching ramps is composed of slave modules mounted on ramps and a central master module provided with a small display for viewing the parameters of the launching ramps. To view all the parameters, operators must perform several maneuvers at the master module buttons. The paper presents one of the adaptations made this year to take into account the experience gained by those who manage the Romanian national anti-hail system. The optimization of the rocket launcher monitoring system structure is based on the practice of using it and consists of the use of a single piece of equipment for simultaneous display of information in a suggestive form, easily used by human operators under stress in real condition of shooting with rockets. The proposed solution allows displaying all the parameters on the monitor screen and helps the operators in the activity of combating the hail by reducing the number of operations they have to perform. This reduces the intervention time and the stress to which the operators are exposed. The software part of the monitoring system ensures its flexibility and competitiveness.**

Cuvinte cheie: *lansator de rachete, sistem de monitoriare, antigrindină, interfață grafică, software, microcontroler.*

Keywords: *rocket launcher, monitoring system, anti-hail, graphical interface, software, microcontroller.*

I. INTRODUCTION

There have been many talks about climate change recently, but this year, 2019, there have been several hailstorms in Romania that have brought the subject back to the forefront, and the authorities have paid more attention to the national anti-hail system.

In this context, the Innovation and Technology Transfer Centre (ITTC) Craiova carried out systematic researches in the field of complementary equipment through both internal-doctoral research and contractual research. The paper presents one of the adaptations made this year to take into account the experience gained by those who manage the national anti-hail system.

II. ANTI-HAIL SISTEM IN ROMANIA

A. *Structure of National Anti-hail System*

The program for the implementation of the national anti-hail system in Romania was initiated in 1999 [1] and legislated by several normative acts promulgated in the following years [2]. Effective creation has been difficult, but at present, it is a functional system that has proven its worth.

Figure 1 shows the geographic distribution of the national anti-hail system.

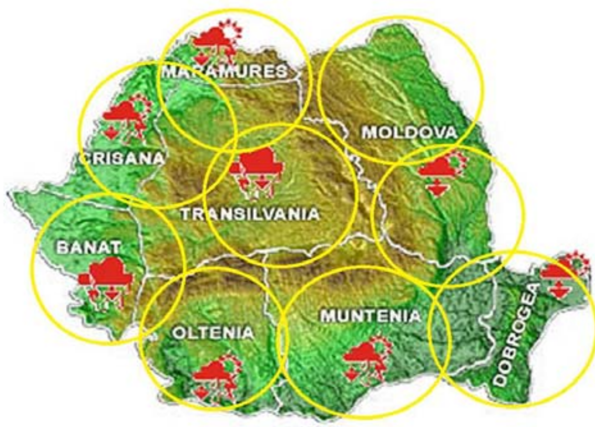


Fig.1. Geographical distribution of the national anti-hail system

Since the founding of the anti-hail system in Romania, research was carried out in the field of anti-hail equipment at S.C. Electromecanica Ploiesti, the equipment supplier, but also in other institutions. Given the complexity of the issues and the legislative issues, in September 2015, the Economic Interest Group was set up "General Designer of the National Anti-Hail and Increase Rainfall System."

Therefore, starting with 2016, the Strategy elaborated by the Anti-Hail Authority in Romania is materialized in solutions developed by the General Designer.

The University of Craiova, Center for Innovation and Technological Transfer CITT has been involved in the design and development of complementary equipment to the anti-hail system [3] and is currently part of the General System Designer (fig. 2).

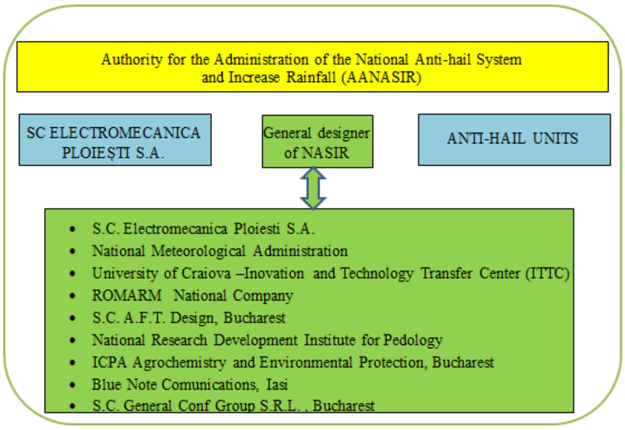


Fig. 2. The administrative structure of the national anti-hail system and increase rainfal

B. *Oltenia Anti-hailUnit Structure*

An anti-hail unit consists of a command center and several local units, often called local launch points for anti-hail missiles. This unit communicates, as a rule, with the regional meteorological center and several local missile launch units. Their number depends on the configuration and size of the protected area (fig. 3).

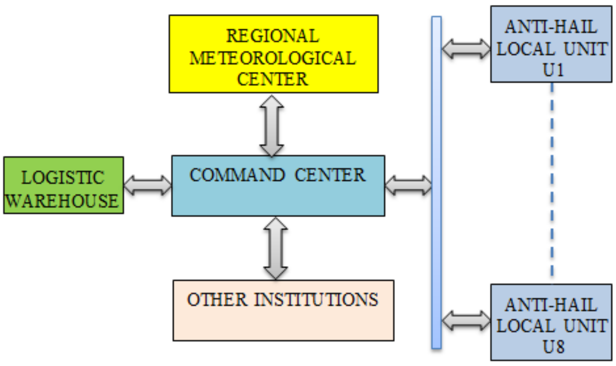


Fig. 3. Structure of an anti-hail unit

The Oltenia anti-hail unit currently comprises three groups for the protection of the vineyard areas of Drăgăşani, Segarcea, Vânju Mare, consisting of 18 local launching points (Table 1)

TABLE I.
OLTENIA ANTI-HAIL UNIT

The Oltenia anti-hail unit	
Command group	*Anti-hail local units*
Drăgă□ani	Mădulari, Orle□ti, Poboru, Sâmbure□ti, Dobroteasa, □u□ani, □tefâne□ti
Segarcea	Portăre□ti, Întorsura, Criva, Calopăr, Padea
Vânju Mare	Pătule, Jiana, Rogova, Padina, Bălăci□a, Opri□or

For security reasons, the anti-hail local units are located outside localities. For example, fig. 4. a) shows the location of a local unit, part of the ″Vânju Mare″ command group.

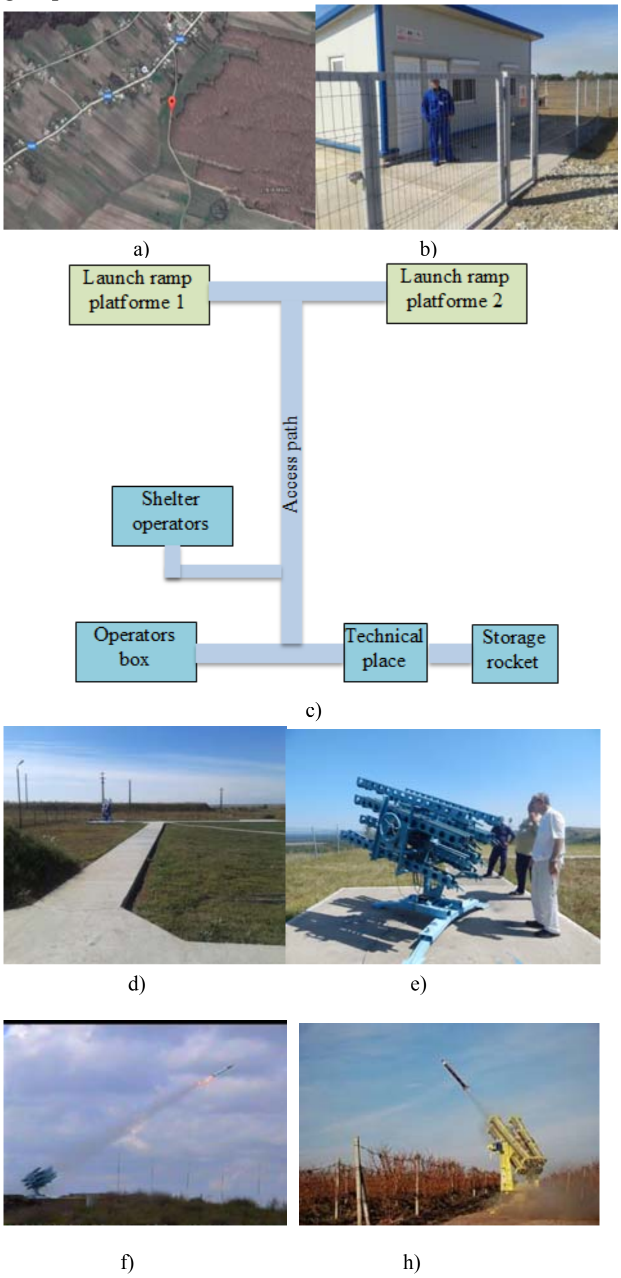


Fig. 4. Location and endowment of a local anti-hail unit

Also, for safety reasons, all local anti-hail units are fence-fenced and equipped with video surveillance systems (fig. 4b).

Figure 4.c) illustrates how the components of a local anti-hail unit are positioned.

In figure 4.d) and 4.e), 4f), 4h) are presented images with access alleyways and experimentation of launch ramps, respectively.

III. THE CURRENT ROCKET LAUNCHER MONITORING SYSTEM [4]

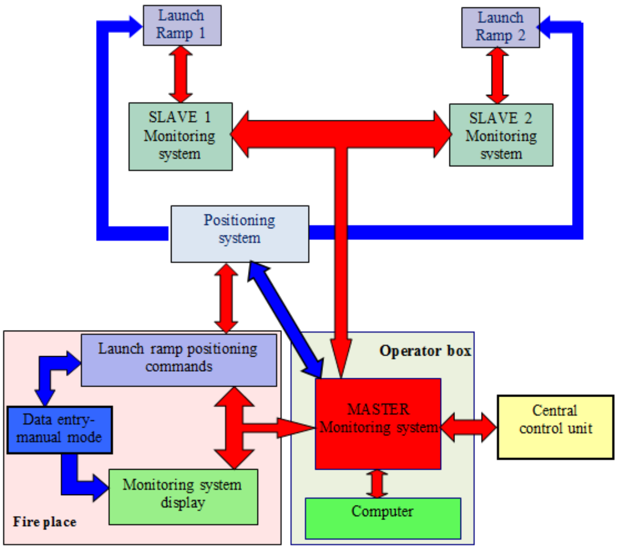
A local missile launch unit, operated by two operators, has two ramps, from which it provides information to local operators and the command center on [5], [6]:

- Azimuth position

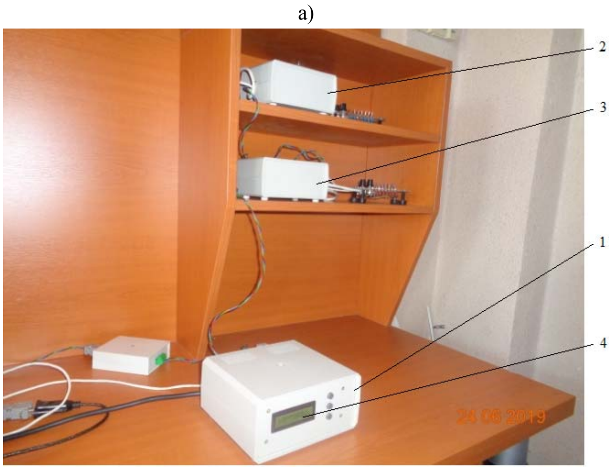
- Elevation position
- Rocket presence

During the launching operation, the following information is transmitted [7]:

- the time and minute of the firing order
- the hour and minute the rocket swept through the ramp.



a)



b)

Fig.5. Current monitoring system structure a) Block structural diagram b) Experimental view: 1- master; 2- slave 1; 3-slave 2; 4-display

Currently, the positioning is done manually, but an automated positioning system has been designed by the research [8]. Also, there is an LCD display [9] (fig. 6) on the fire point where the current position of the ramp is indicated sequentially.

Fig. 6. Current display for ramp coordinate show

IV. Proposals On Optimizing The Structure Of The Anti-Hail Launch Ramp Monitoring System

A. Hardware part of the monitoring system

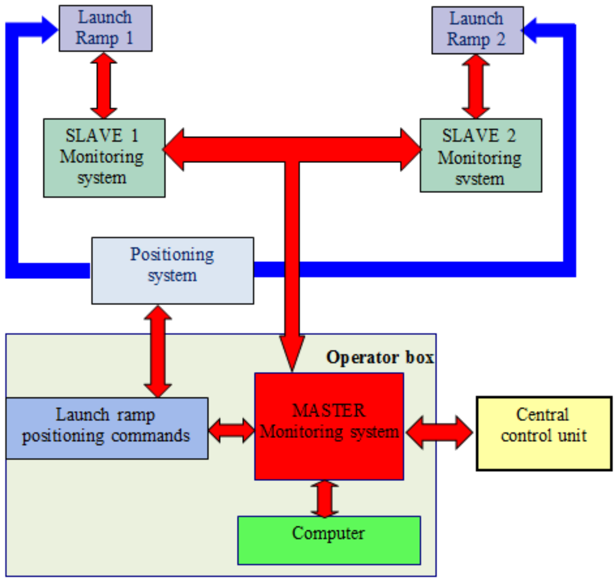
From the experience of the operators of the anti-hail system, SC Electromecanica Ploiesti and SC General Conf Group Bucharest, it was shown that, under the stress conditions the operator is subjected to during actual shooting maneuvers, the sequential display of the coordinates is not efficient.

To view all the parameters the operators must press to the three push buttons of the Master module (fig. 6).

It was also decided that, during the firing operation, the operators stay in one of the compartments of the box from which they automatically position the ramp and give the firing command.

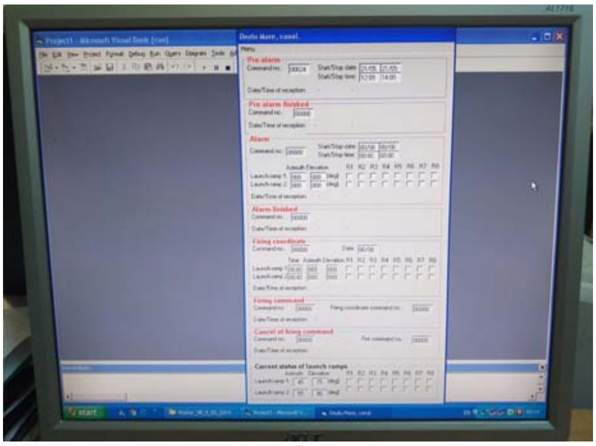
Under these organizational and technical conditions, operators are able to see the monitored parameters on a computer display (fig.7).

Figure 7 a) shows the block structural diagram of monitoring system. Figure 7 b) shows the experimental system developed and figure 7 c) shows the print screen of graphical interface of monitoring system.



a)

b)



c)

Fig. 7. Optimized structure of the monitoring system: a) Block structural diagram; b) Experimental view; c) print screen of display; 1-computer; 2- slave 1; 3-slave 2; 4-display

The proposed solution allows displaying all the parameters on the monitor screen and helps the operators in the activity of combating the hail by reducing the number of operations they have to perform. This reduces the intervention time and the stress to which the operators are exposed.

The hardware structure of the Slave module in the local unit is shown in Figure 8. The role of the Slave module is to transfer information to the Master module, information regarding elevation, azimuth and the presence of up to twelve missiles [10].

As shown in Figure 8, the block diagram captures: digital input block, azimuth scan block, elevation scan block, two analog-digital converters, voltage reference block, power supply block, address selector, microcontroller and an RS485 driver.

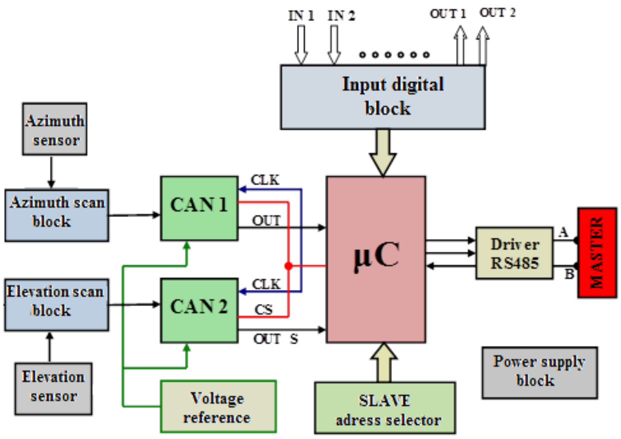


Fig. 8. Block structural diagram of Slave module

The hardware structure of the activity coordination module in a launch unit - the Master module is presented at a general level in figure 9.

The role of the central controller in the Local Launch Unit (Master module) is to transfer information from the Launchers (Slave module) to the Central Control Unit and display the received orders.

It consists of a microcontroller (μC) as a central element, an RS485 driver, real-time block, output block, input block, an RS232 interface, a serial connector and a power supply block.

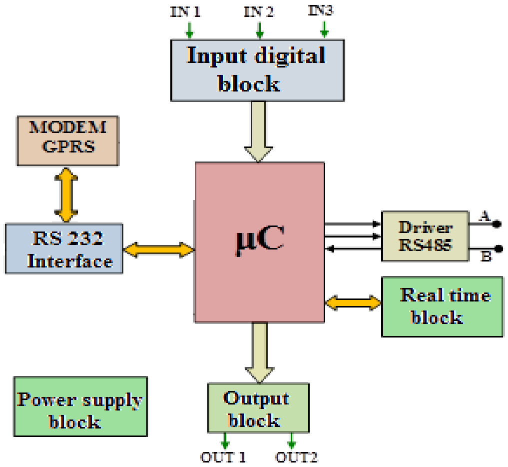


Fig. 9. Block structural diagram of Master module

B. *Software part of the monitoring system*

B1. Graphical interface of monitoring system

A graphical interface has been created to favor monitoring and communication with the Master module and implicitly with the Slave modules in the local launch unit.The graphical interface made with the Visual Basic program [11], (fig. 10) is displayed on the screen.

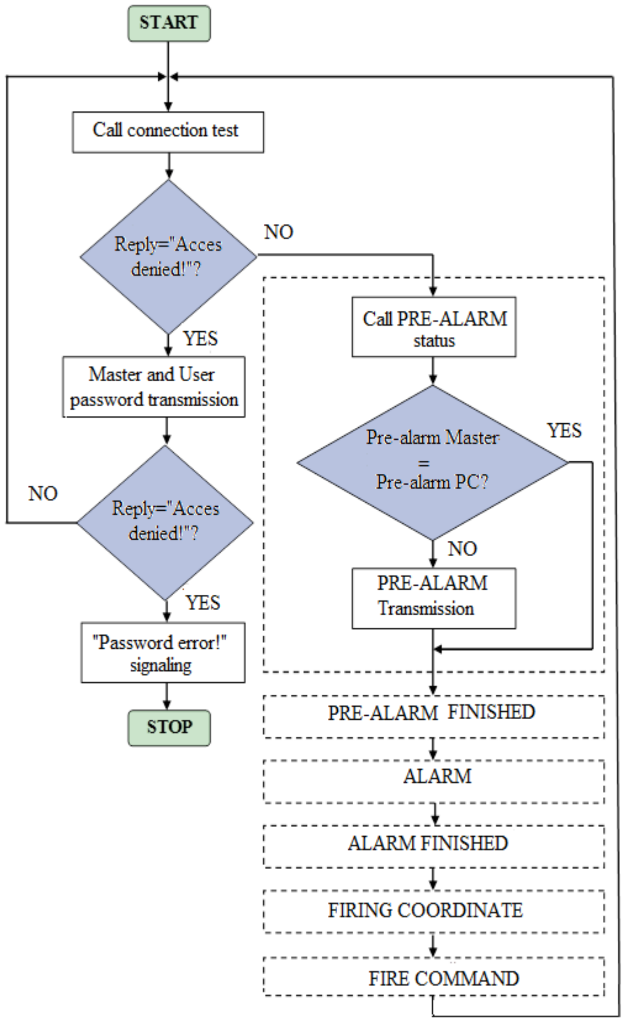


Fig. 10. Algorithm of the anti-hail rocket launcher monitoring system.

A program in Visual Basic was developed to provide an informational connection between the central control unit and the local anti-hail unit. Launching this is done by transferring a parameter, making it possible to run it simultaneously for several local anti-hail units.

The form performed allows permanent testing of the information from the anti-hail launch unit and ensures rapid updating of the information from the operator of the central control unit. The program performs every 60 seconds a complete scanning/ programming of the allocated Master module. First, the information connection is tested (fig. 10). If the answer is "Access Denied", then the master and user passwords are transmitted. If the same answer is received, then the passwords are invalid, and the program ends here; otherwise, it returns to the test sequence. If connection testing is successful, then a call is dialed to request stored pre-alarm status data. If received data is not identical to the one from the PC, then updated data is sent to the allocated Master Module.

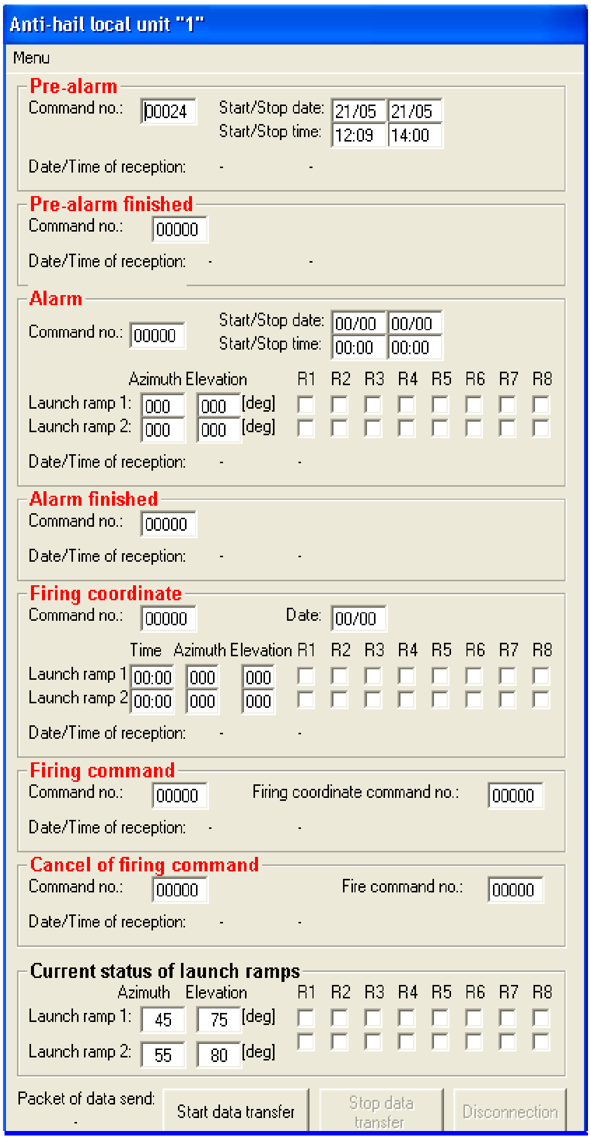


Fig. 11. Proposed graphical interface for the operator of the local anti-hail rocket launch point.

This sequence is then repeated for "pre-alarm finished", "alarm", "alarm finished", "firing coordinates", "fire command" and "cancel fire command". After the treatment of the last type of anti-hail warfare order, the organizational chart presented above is repeated again.

The window projected in Visual Basic (fig. 11) captures the seven battle orders, the current state of the launchers (azimuth, elevation, and presence of the anti-hail missiles) and a control button. If the operator starts editing a parameter, then the data flow to the assigned Master ceases and activates the button that resumes the data transfer.

The Visual Basic program checks the data in the allocated Master Module and updates the anti-hail work orders in accordance with the operator's settings.

The new interface has the following advantages:

- the background image is static;
- displays all specific information;
- the information remains on the monitor all the time.

B2. Software structure of monitoring system

At a local point of launch of the anti-hail rockets, the transfer of data between the Master module and the modules placed on the rocket launchers is done through a RS485 full simplex data bus. The data transmitted are organized in the form of packets (telegrams), and the Master module emits a serial packet in the form presented in table II.

TABLE II. DATA PACKETS EMITTED BY MASTER MODULE

Byte no.	b7	b6	b5	b4	b3	b2	b1	b0
1	1	0	0	0	0	0	a	b
2	0	0	0	0	0	0	a	b
3	0	c6	c5	c4	c3	c2	c1	c0

The first byte has bit b7 always set to "1". This byte is also called a header and is used to identify a packet start. All other bytes have bit b7 set to "0".

The ab sequence of bytes 1 and 2 specifies the address of the Slave module to which the respective package is addressed.

If the slave module identifies a packet that is addressed to it then it will respond with a packet (telegram) of the form of the one in table III.

TABLE III. DATA PACKETS REPLIED BY SLAVE MODULE

Byte no.	b7	b6	b5	b4	b3	b2	b1	b0
1	1	1	0	0	0	0	a	b
2	0	0	0	0	0	0	a	b
3	0	r7	r6	r5	r4	r3	r2	r1
4	0	a7	a6	a5	a4	a3	a2	a1
5	0	e7	e6	e5	e4	e3	e2	e1
6	0	0	r8	a8	a12	a11	a10	a9
7	0	0	0	e8	e12	e11	e10	e9
8	0	c6	c5	c4	c3	c2	c1	c0

The first byte has bits b7 and b6 set to "1" and in b1 and b0 its own address is encoded. Its own address also occupies the next byte. In octets 3, ...,7 information about rockets, azimuth and elevation is stored. The package ends with a checksum.

The program was written in C, under StudioAVR4, [12]. for an ATMEGA8 microcontroller. It starts with the inclusion of libraries and the declaration of the variables used. The actual code realizes the configuration of the ports, the initialization of the serial communication, the initialization of the variables in the program and the identification of its own address. There follows an infinite loop in which the program waits for a serial packet to be received and then prepares and transmits a serial packet containing information about the rockets, azimuth and elevation.

Next, program sequences relevant to the monitoring system are presented.

Initialization sequences of the variables in the program:

```
----------------------------------------------------------------------
#include <avr/sleep.h>
#include <avr/interrupt.h>
unsigned int k;
unsigned char i, CRC, Buffer, Additional Buffer;
unsigned char Contor Caracters, Buffer Serial[26], Slave Address, Received Address;
unsigned char AzimuthH, AzimuthL, ElevationH, ElevationL, S1, S2, Data, DataS;
void Transmite(void), Reset WDR(void);
extern void Azimuth Elevation Scan(void);
int main(void)
{
    SREG=SREG & 0x7F; // Disabling general interruption system.
        //Ports initialization 1– input byte , 1 – output byte.
    DDRB  = 0x00;PORTB = 0xFF; DDRC  = 0x00;PORTC
        = 0xFF; DDRD  = 0x5A;PORTD = 0xFF;
        //Initialization UART0 to baudrate 9600
   UCSRB   = 0x00;UCSRC   = 0x06;UCSRA   = 0x00;
   UBRRH =   0x00;UBRRL =   0x67;UCSRB   = 0x18;
   MCUCR = 0x00; GIMSK = 0x00;TIMSK = 0x00;
   SREG=SREG | 0x80;     // Enabling general interruption system
   UCSRA &=0xA0;         // The serial flags are cleared
   PORTD &=0xF7;         // Cross line 485 in high impedance.
    ContorCaracters=0; AzmuthH=AzimuthL=ElevationH=
   ElevationL=0;
----------------------------------------------------------------------
```

Setting the address; Possible values: 1,2,3,4:

```
   if (PINC & 0x40){S1=1;}else{S1=0;}
    if (PIND & 0x04){S2=1;}else{S2=0;}
    if (S1==0) {   if (S2==0){AdressSlave=1;}
    else{AdressSlave=2;}     }
    else {          if (S2==0){AdressSlave=3;}
    else {AdressSlave=4;}   }
//-------------------------------------------------------------------
while(1)
{
back:WDTCR |=0x04;        //260 ms –watchdog attack.
//----------------- Receiving serial request -------
       if (!(UCSRA & 0x80))goto back;          // It is tested if a serial character has been received.
       UCSRA &=0x7F;        // The serial reception marker is deleted.
       Buffer =UDR; if (Buffer >127)ContorCaracters=0;
           // The heder is identified.
       if      (ContorCaracters>2){ContorCaracters=0;goto back;}   // Buffer space test.
       BufferSerial[ContorCaracters]= Buffer; ContorCaracters++;
       if (ContorCaracters>2)
       {
           ContorCaracters=0;
           //------------------------- The CRC is tested ---------
           CRC=BufferSerial[0]+BufferSerial[1];
           CRC ^=0xFF;CRC++;CRC &=0x7F;
           if (CRC !=BufferSerial[2])goto back;

           //----------------- The address is tested ---------
           AddressReceived=BufferSerial[0] & 0x03;
           if  (AddressReceived!=AddressSlave)goto  back;

           //-----------The redundant address is tested ----
           AddressReceived =BufferSerial[1] & 0x03;
           if  (AddressReceived!=AddressSlave)goto  back;

           //-------- Azimuth and elevation reading ---------
           Azimuth elevation scan();
           //-------------Serial package preparation -----------
           BufferSerial[0]=0xC0| AddressSlave;BufferSerial[1]=0x0F & AddressSlave;
           //-----------------
           BufferSerial[2]=0; Additional Buffer =PINC;
           if (Additional Buffer & 0x20)BufferSerial[2] |=0x01; //Rocket no. 1.
           if (Additional Buffer & 0x10)BufferSerial[2] |=0x40; // Rocket no.. 2.
           if (Additional Buffer & 0x08)BufferSerial[2] |=0x20; // Rocket no.. 3.
           if (Additional Buffer  & 0x04)BufferSerial[2] |=0x10; // Rocket no. 4.
           if (Additional Buffer & 0x02)BufferSerial[2] |=0x08; // Rocket no. 5.
           if (Additional Buffer & 0x01)BufferSerial[2] |=0x04; // Rocket no. 6.
           Additional Buffer =PINB;
           if (Additional Buffer & 0x20)BufferSerial[2] |=0x02; // Rocket no. 7.
           //-----------------
           BufferSerial[3]=AzimuthL & 0x7F;//AzimuthL
           BufferSerial[4]=ElevationL & 0x7F;//ElevationL
           BufferSerial[5]=AzimuthH & 0x0F;
           //AzimuthH
           if(AzimuthL & 0x80)BufferSerial[5] |=0x10;
           //AzimuthL.7
           if (Additional Buffer & 0x10)BufferSerial[5] |=0x20;// Rocket no. 8.
```

```
        BufferSerial[6]=ElevationH & 0x0F;///ElevationH
        if(ElevationL & 0x80)BufferSerial[6] |=0x10;
//ElevationL.7
        //--Calculare CRC--
        CRC=0;  for (i=0;i<7;i++){CRC +=BufferSerial[i];}

        CRC ^=0xFF;CRC++;CRC &=0x7F; BufferSe-
rial[7]=CRC;
        //--------------The serial packet is transmitted ---
        for (k=0;k<8403;k++){ResetWDR();}
        //Temporizare 20 ms.
        PORTD |=0x08;  // Cross line 485 in low im-
pedance.
        for(i=0;i<25;i++){UDR=BufferSerial[i];Transmited
();}
        for (k=0;k<840;k++){ResetWDR();}
        //Timing 2ms.
        PORTD &=0xF7;  // Cross line 485 in high im-
pedance.
        }
        else {goto back;}
    }}
    //---------------------------------------------------------------
    void Transmited(void)
    {
    UCSRA &=0xDF;        // The emission flag is erased.

    while(!(UCSRA & 0x20)){ResetWDR();}
    }
    //---------------------------------------------------------------
    void ResetWDR(void){asm volatile ("WDR;"::);}
    //---------------------------------------------------------------
```

The Reset (WDR) function provides the impulses needed to operate the watchdog system. If these pulses are no longer generated, the program is blocked and a microcontroller reset mechanism is automatically initialized.

V. CONCLUSION

The continuity of the research carried out since 1999 has enabled a strategy to be developed in the field of complementary equipment for the national anti-hail system.

The establishment of the General Designer of the National Anti-Hail System as a Group of Economic Interest, consisting of institutions that have demonstrated experience in the field, and who have competence in research as well as in the manufacture of the proposed equipment, is an example of good practice for the development of equipment in the system domain anti-hail from Romania.

The optimization of the rocket launcher monitoring system structure is based on the practice of using it and consists of the use of a single piece of equipment for simultaneous display of information in a suggestive form, easily used by human operators under stress in real condition of shooting with rockets.

The software part of the monitoring system ensures its flexibility and competitiveness.

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Fourth coauthor - 10%

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