

## MONITORING SYSTEM FOR THE LOCAL LAUNCH POINTS OF THE ANTI-HAIL UNITS

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**Abstract** – This paper presents a system for monitoring an anti-hail system. It is proposed a specific system for anti-hail network in Romania which completes the known systems with information subsystems specific for both to identify the best solutions for the coordination and launch.

The main points refer to the monitoring system structure, sources of information in a local unit launch, the devices master and slave of the monitoring system, the software architecture of the decision support subsystem for launch.

The system comprises two main components: a system for taking the decision of launch and the system for assisting the launch decision.

The hardware architecture of the system for monitoring local point and the hardware architecture of the central monitoring system is presented at point 4, also there are presented the main blocks of the slave module. The input data, output data, the main algorithm of the interface for the decision launch support subsystem, the computerized decision support system interface are presented at point 5 of the present work.

In the realization of the system will be consider all the following: the use of communication via GPRS, monitoring the parameters throughout the all period of operating, log-values, status and alarms, operator actions journals, friendly graphical interface and the generation of tabular and graphical reports for any period.

The integrated system for monitoring the launch anti hail rockets units enables: an increased efficiency by shortening the time for action, a good organization, a high degree of security.

**Keywords:** monitoring, anti-hail networks, informatic system, hail, system architecture

### 1. INTRODUCTION

We are seeing a sharp change in climatic factors often with violent manifestations. In these circumstances, it appears necessary to monitor the climate action and the creation of means of intervention to reduce economic losses caused by such events.

Achievement of an Anti-hail Systems is an important component of a comprehensive means of monitoring and intervention.

In our country it is desired the extension the National Anti-hail System, so institutions were created to conduct this program, namely "The stimulation rain and anti-hail System Administration"

To lead a well-founded and timely decision, any decision process must acquire, process and interpret a growing volume of information, in a time of increasingly shorter. For the time period of the last update of the cloud front, which can provide information about the formation of hail, and time for ordering a shooting to be as short as, it is necessary to integrate various input sizes so that the operator to have as much information to be merged into one "screen", so it is necessary to achieve an integrated monitoring system for the launch points of the anti-hail units. [1]

### 2. MONITORING SYSTEM STRUCTURE

The anti-hail monitoring system is a assembly of hardware, software components, procedures, strategies, activities and people united and organized to process data related to combating hail, to fulfill the task of reducing / eliminating the damage caused by hail and the achievement of through measurable performance criteria established.

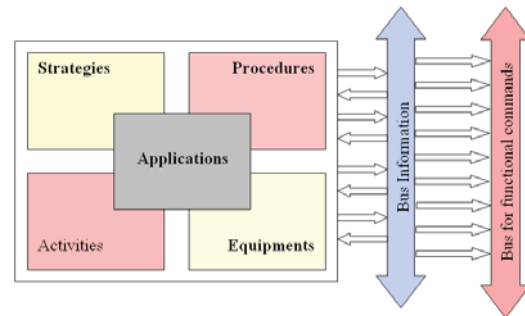


Figure 1: The informatic anti-hail system

In fig.1 is shown, generally, the monitoring system architecture for anti-hail units. The main components of a launching point, necessary for the monitoring system, as is shown in Fig. 2, are represented by a GPRS communication module, the monitoring system, the launching ramps and an optional computer running specific applications. [4]

The GPRS communication module is a terminal identified by an IP address, always connected and available, the GSM network is transformed into a transmission network and packet switched technology like TCP / IP. The monitoring system for the local

point will be described in the next chapters. The main components of the integrated monitoring system for monitoring are two subsystems (fig.3):

- the subsystem for taking the decision of launching
- the decision support launch subsystem

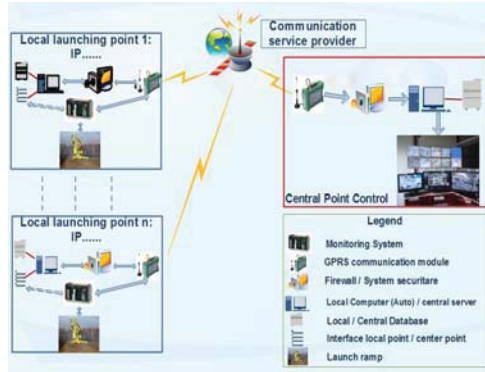


Figure 2: The monitoring system architecture for anti-hail points

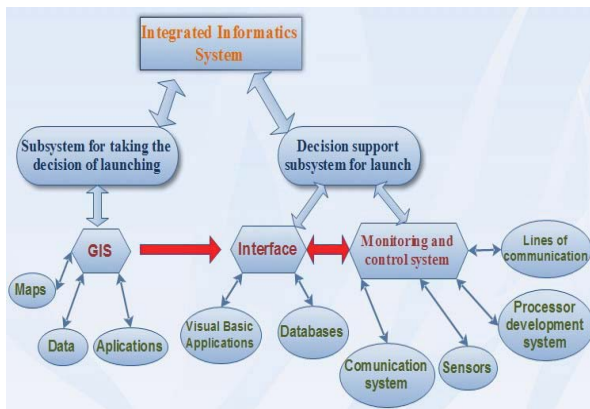


Figure 3: The main components of the system

Monitoring systems for decision support are useful when decision criteria are numerous, conflicting data, when the search is difficult, takes time and satisfactory solution must be given rapidly, like is the case of decision to launch the rockets in the anti-hail systems. The subsystem for taking the decision of launching addresses exclusively to the central control point. The subsystem is a multifunctional GIS which can help the staff of the center point upon the decisions which must be taken in extreme situations. The current weather system from our country allows an update to about each 7-9 minutes, the information of clouds progress come at the central point in about every 15 minutes. As the time between when the last update of the clouds and the time for ordering a shooting to be as short as possible it is necessary to integrate various input sizes so that the operator should have as much information as pooled into a "screen". [5]

The main layers of information - the input sizes are related to: the evolution of clouds, topography and

cultivated areas, launch points and organizational elements.

The cloudy situation of the protected region is very important, intervention will take place only if the weather radar indicates the presence of hail or its risk figure 5.

In Figure 5 are symbolically presented planted areas to be protected, represented by polygons of different colors: green, blue, yellow, orange, red symbolizing the type of each crop (fruit trees, vines, wheat, maize, etc.); the coordinates of the launch point and the central point are represented by specific symbols.



Figure 4: Example of evolution of clouds in Romania

The range of launch ramps is also important, it is highlighted the area which is covered by a central point. The access roads and their types (agricultural, county, national, European) are highlighted for prompt intervention in case of failure.

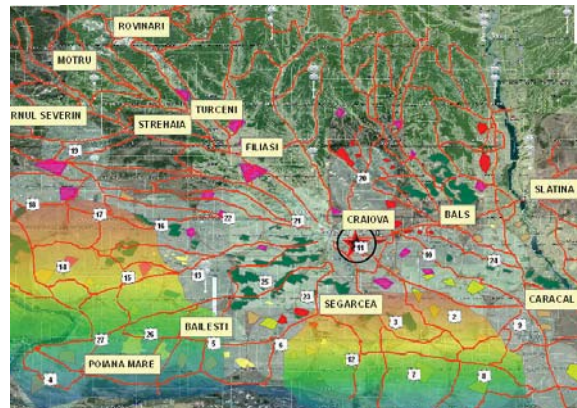


Figure 5: GIS's representation

### 3. SOURCES OF INFORMATION IN A LOCAL UNIT LAUNCH

Based on information received from the NMA is drawn an intervention program in a combat action. Following this action will be established the launch units involved, number of rockets, azimuth and elevation angles. Follow the launch of a number of

missiles in the affected areas and then look at the effect.

A local unit currently contains the following: 2 launchers, live box, rectifier load, ammunition store, two lightning, fire point, generator, ecological toilet, stand with wheels, firing shelter, various accessories.

The main information in a local unit launch is: the hail presence, the rocket presence, the air space open, the elevation, the azimuth, the voltage.

The classification of the information on the types of sources:

- discrete sources without memory: racket presence, tension, elevation, azimuth
- discrete sources with fixed constraints : free air space, hail presence [8], [12]

Consider "hail presence" as a source of information which has two possible realizations.

$G = \{g_1, g_2\}$ . Each event corresponds to a probability which is equal to  $1/2$ .

$$G = \{p(g_1), p(g_2)\} \text{ so that } \sum_{i=1}^2 p(g_i) = 1 \quad (1)$$

It turns out that discrete information source is defined as:

$$G = \begin{bmatrix} g_1 & g_2 \\ 1/2 & 1/2 \end{bmatrix} \quad (2)$$

Source entropy

$$H(G) = -\sum_{i=1}^2 p(g_i) \log_2 p(g_i) = 1 \text{ bit/symbol} \quad (3)$$

The maximum entropy of the source  $G$ :  $H_{\max}(G) = \log_2 N = \log_2 2 = 1$

The source efficiency is:

$$\eta_s = \frac{H(G)}{H_{\max}(G)} = 100\% \quad (4)$$

The redundancy of the source  $G$  is the difference between the maximum entropy and the entropy of the sources:

$$R(G) = H_{\max}(G) - H(G) = 0 \text{ bit/symbol} \quad (5)$$

Relative redundancy

$$\rho_G = 1 - \frac{R(G)}{H_{\max}(G)} = 1 \quad (6)$$

Considered "rocket presence" is a source of information which has 6 possible realizations.

$$F = \{r_1, r_2, r_3, r_4, r_5, r_6\}$$

Each event corresponds to a probability which is equal to  $1/6$ .

$$F = \{p(r_1), p(r_2), p(r_3), p(r_4), p(r_5), p(r_6)\} \text{ so that } \sum_{i=1}^6 p(r_i) = 1$$

It turns out that discrete information source is defined as:

$$F = \begin{bmatrix} r_1 & r_2 & r_3 & r_4 & r_5 & r_6 \\ 1/6 & 1/6 & 1/6 & 1/6 & 1/6 & 1/6 \end{bmatrix} \quad (7)$$

Source entropy

$$H(F) = -\sum_{i=1}^6 p(r_i) \log_2 p(r_i) = 2,57466 \text{ bit/symbole}$$

The maximum entropy of the source  $F$ :

$$H_{\max} = \log_2 N = \log_2 6 = 2,585 \text{ bit/symbol}$$

The source efficiency is:

$$\eta_s = \frac{H(F)}{H_{\max}(F)} = 99,6\% \quad (8)$$

The redundancy of the source  $F$  is:

$$R(F) = H_{\max}(F) - H(F) = 0,0103 \text{ bit/symbol}$$

Relative redundancy

$$\rho_F = 1 - \frac{R(F)}{H_{\max}(F)} = 0,996 \quad (9)$$

Consider "free air space" as a source of information which has two possible realizations.  $A = \{a_1, a_2\}$ . Each event corresponds to a probability which is equal to  $1/2$ .

$$A = \{p(a_1), p(a_2)\} \text{ so that } \sum_{i=1}^2 p(a_i) = 1 \quad (10)$$

It turns out that discrete information source is defined as:

$$A = \begin{bmatrix} a_1 & a_2 \\ 1/2 & 1/2 \end{bmatrix} \quad (11)$$

Calculation of entropy related to the source, the source efficiency, redundant source, relative redundancy are similar to those of "hail presence".

Possible values of "elevation" can range between  $44^\circ$  and  $46^\circ$ , so three possible achievements.

$T = \{t_1, t_2, t_3\}$ , each event corresponds to a probability which is equal to  $1/3$ .

$$T = \{p(t_1), p(t_2), p(t_3)\} \text{ so that } \sum_{i=1}^3 p(t_i) = 1 \quad (12)$$

It turns out that discrete information source is defined

$$\text{as: } T = \begin{bmatrix} t_1 & t_2 & t_3 \\ 1/3 & 1/3 & 1/3 \end{bmatrix} \quad (13)$$

Source entropy

$$H(T) = -\sum_{i=1}^3 p(t_i) \log_2 p(t_i) = 0,4248 \text{ bit / symbol}$$

The maximum entropy of the source  $T$ :  $H_{\max}(T) = \log_2 N = \log_2 3 = 0,4249 \text{ bit/symbol}$

The source efficiency is:

$$\eta_s = \frac{H(T)}{H_{\max}(T)} = 99,9\% \quad (14)$$

The redundancy of the source  $T$  is:

$$R(T) = H_{\max}(T) - H(T) = 0,0001 \text{ bit/symbol}$$

Relative redundancy

$$\rho_T = 1 - \frac{R(T)}{H_{\max}(T)} = -1,3534 \cdot 10^{-4} \quad (15)$$

Possible values of "azimuth" can range between  $0^\circ$  and  $360^\circ$  with an increment of  $10^\circ$ , so 36 possible achievements:

$Z = \{z_1, z_2, z_3, z_4, z_5, z_6, z_7, z_8, z_9, z_{10}, \dots, z_{35}, z_{36}\}$ , each event corresponds to a probability which is equal to  $1/36$ .

$$Z = \{p(z_1), p(z_2), p(z_3), \dots, p(z_{36})\} \text{ so that } \sum_{i=1}^{36} p(z_i) = 1$$

It turns out that discrete information source is defined as:

$$Z = \begin{bmatrix} z_1 & z_2 & z_3 & \dots & z_{36} \\ \frac{1}{36} & \frac{1}{36} & \frac{1}{36} & \dots & \frac{1}{36} \end{bmatrix} \quad (16)$$

Source entropy

$$H(Z) = -\sum_{i=1}^{36} p(z_i) \log_2 p(z_i) = 5,1558 \text{ bit/symbol}$$

The maximum entropy of the source Z:

$$H_{\max}(Z) = \log_2 N = \log_2 36 = 5,1702 \text{ bit/symbol}$$

The source efficiency is:

$$\eta_z = \frac{H(Z)}{H_{\max}(Z)} = 99,72\% \quad (17)$$

The redundancy of the source Z is:

$$R(Z) = H_{\max}(Z) - H(Z) = 0,0144 \text{ bit/symbol}$$

Relative redundancy

$$\rho_z = 1 - \frac{R(Z)}{H_{\max}(Z)} = 0,9973$$

Possible values of "Power" can be between 23V and 25V, so 3 achievements possible.  $U = \{u_1, u_2, u_3\}$ , each event corresponds to a probability matrix as below.

$$U = \{p(u_1), p(u_2), p(u_3)\} \text{ so } \sum_{i=1}^3 p(u_i) = 1$$

It turns out that discrete information source is defined as:

$$U = \begin{bmatrix} u_1 & u_2 & u_3 \\ \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \end{bmatrix} \quad (18)$$

Source entropy

$$H(U) = -\sum_{i=1}^3 p(u_i) \log_2 p(u_i) = 1,5 \text{ bit/symbol}$$

The maximum entropy of the source U:

$$H_{\max}(U) = \log_2 N = \log_2 3 = 1,5849625 \text{ bit/symbol}$$

The source efficiency is:

$$\eta_U = \frac{H(U)}{H_{\max}(U)} = 94,643\% \quad (19)$$

The redundancy of the source U is:

$$R(U) = H_{\max}(U) - H(U) = 0,0849 \text{ bit/symbol}$$

$$\text{Relative redundancy } \rho_U = 1 - \frac{R(U)}{H_{\max}(U)} = 0,9464$$

#### 4. MASTER AND SLAVE OF THE MONITORING SYSTEM

The local point decided is accessed through an application that connects to the decision support system for launch. Once taken the decision to launch, it must be implemented in shortest time possible by using interfaces, communications system, monitoring and control subsystem for assisting the decision. If it is necessary to make a diagram of the decision process, the decision is the central element. To make the right decision we need a system to help us make a decision and another system to help us (assist) to implement decisions in conditions of maximum efficiency.

The decision support subsystem for launch aims: reducing intervention time, better organization, a high degree of security, greater efficiency, reduced operating and maintenance costs, improve performance. In the next figures are presented the main component of the Slave device. This device is located on the launching ramp and monitors: the rockets on the ramp, both the elevation and the azimuth of the ramp.

In figure 6 is presented the hardware architecture of the system for monitoring local point and in figure 7 the hardware architecture of the central monitoring system.

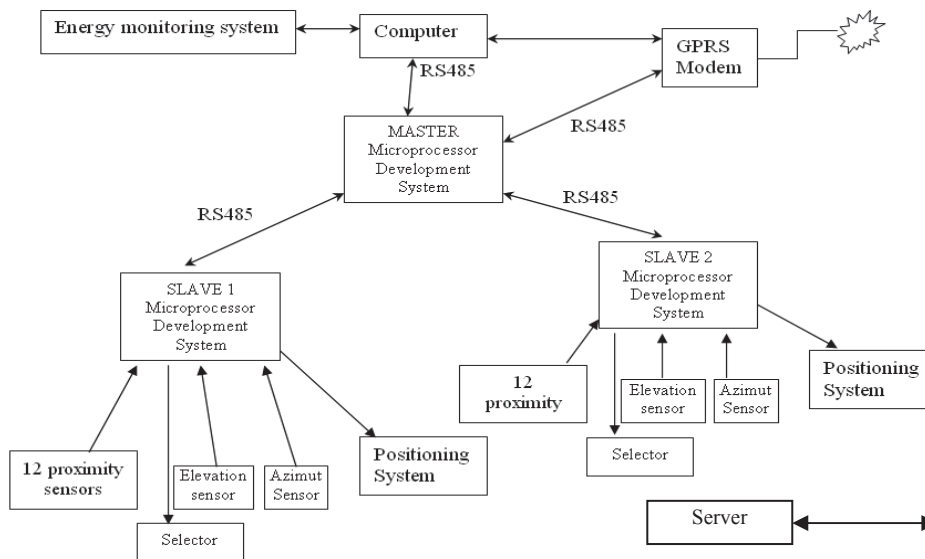


Figure 6: Hardware architecture of the system for monitoring local point

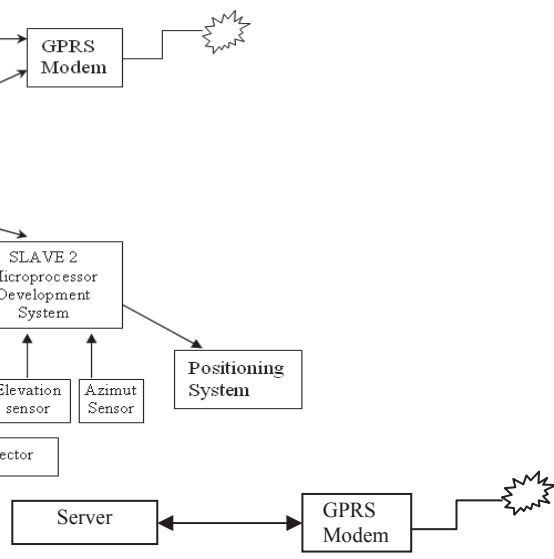


Figure 7: Hardware architecture of the central monitoring system



In the following are detailed the blocks for the differential amplifier stage for azimuth (figure 8), differential amplifier stage for elevation (figure 9), the slave address selector and the Atmega8

microcontroller with Pin Assignment (figure 10) and also the rocket block that help on reading information regarding the rockets loaded on the ramp (figure 11).

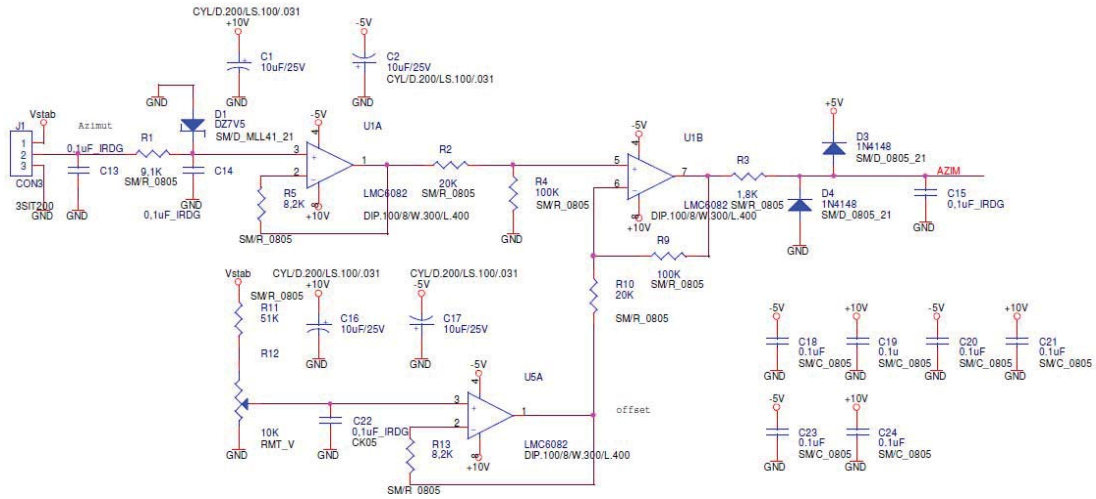


Figure 8: The differential amplifier stage for azimuth

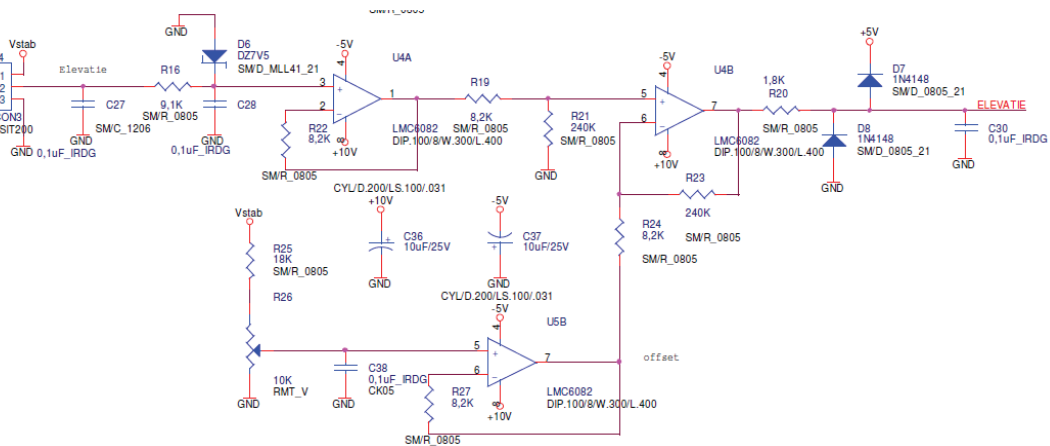


Figure 9: The differential amplifier stage for elevation

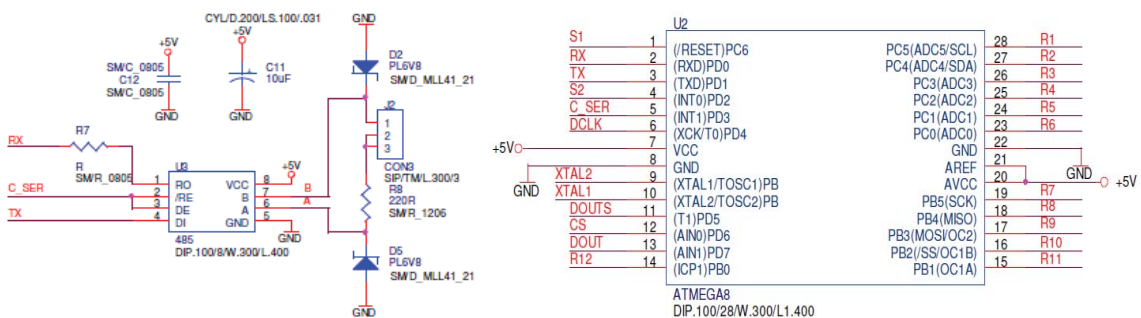


Figure 10: Slave address selector and Atmega8 microcontroller

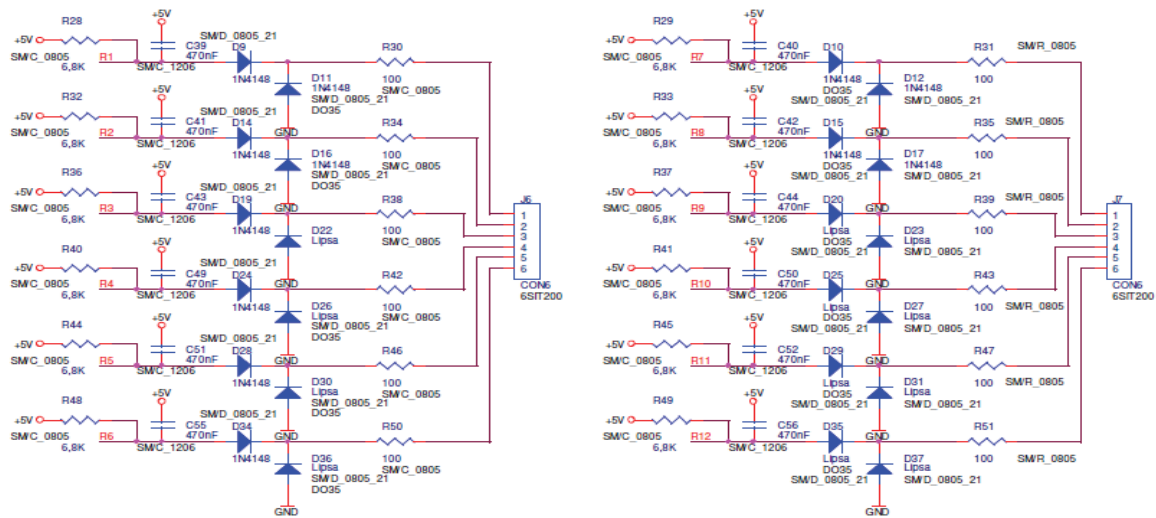


Figure 11: Rocket block

## 5. SOFTWARE ARCHITECTURE OF THE DECISION SUPPORT SUBSYSTEM FOR LAUNCH

The main input sizes for this system are:

- the ramp launch number - for a secure identification by the operator
- the battery voltage – the checking the available of the energy supply system; due to prioritization system of the consumers it will always be ensured the minimum energy for positioning ramp and release heat [1].
- Confirmation of the presence hail clouds - an element of safety before launch
- Confirmation of the free air space - a safety element before launching
- Opening / Closing inside ramp - an element of security and protection of the launch ramp
- Positioning elements: azimuth and the elevation
- Number and position of presence the rocket on the ramp - thus ensuring control over the activity of launching and loading ramp
- The choice to missile for launching
- The altitude of explosion – for a higher efficiency of fighting against hail fall it is important the place of seeding in the cloud and this is achieved by positioning a ramp and by programming rocket altimeter.

The main output data will be represented by positioning the ramp, by firing order and by the daily-monthly shooting report.

Interface shown in figure 12 was made with the help of Visual Basic 6.

At the central point are ensured:

- Centralization of data, storing them in databases or journals of values;
- friendly graphical interface that allows quick viewing of the status of items represented by standard symbols or suggestive drawn so that it can be easily identified

by any operator and colored according to the state (normal or alarm);

- determining the state of alarm and reporting their location (symbols, colours, flashing), the bubble element associated text, sound alarms and table and display instructions for remedying the situation, if the problem solving requires the participation of the operator or of the intervention team and can't be solved the with control loops;
- reconfiguration by the operator or administrator of the control loop parameters, alarm thresholds, etc.
- management control system: activation / deactivation of the sensor or execution elements, archiving logs and reports, creating / deleting accounts operators, etc. In the figure 13 is presented the algorithm of the interface for the decision support subsystem for launch

The connection is initiated from the point of order and the transmission is automatic at the rate determined or when one of the parameters change, as follows: the number of the launch installation, the type of the launch installation, the azimuth, the elevation of the two groups, the presence of the rockets on the installation, the time of purchase data for each part of the launch installations. The equipment located at the point of order provides the following facilities:

- the possibility of selection the launch points for establishing the connection;
- ability to enable / closing the communication channel;
- console for sending specific commands;
- the possibility of automatic transmission of the launch coordinates with the help of an adjacent application;
- console for displaying the monitored data;
- console for voice communications;
- the possibility of recording data.

Equipment located at the point of launch provide the following facilities:

- Voice communications interface;
- Audible and visual signalling prealarma signal;
- Audible and visual signal alarm signal;
- Release data display, automatic transmission of monitored data.

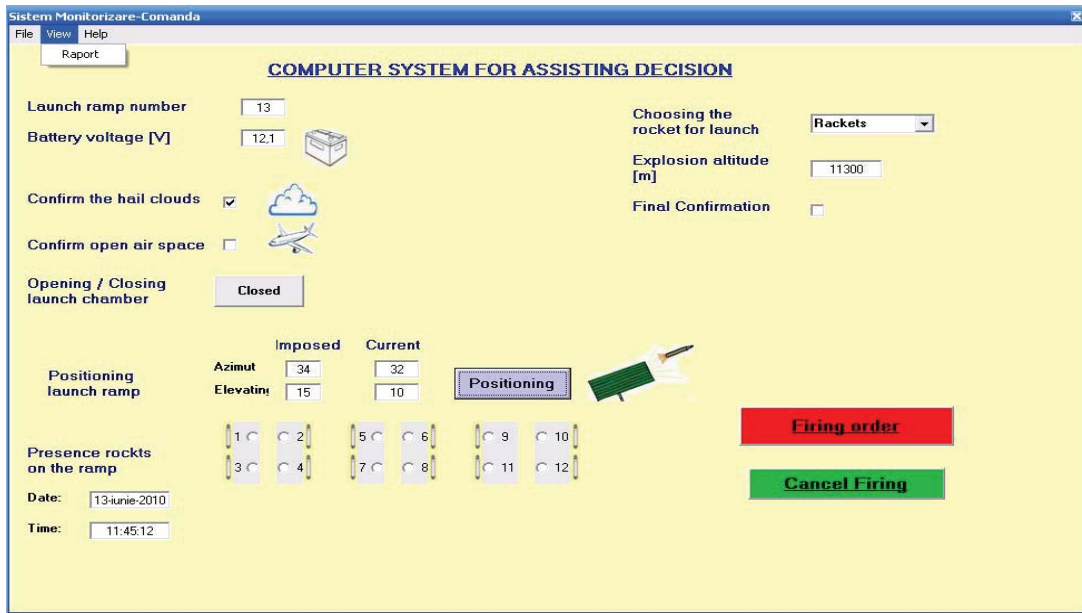


Figure 12: Computerized decision support system interface

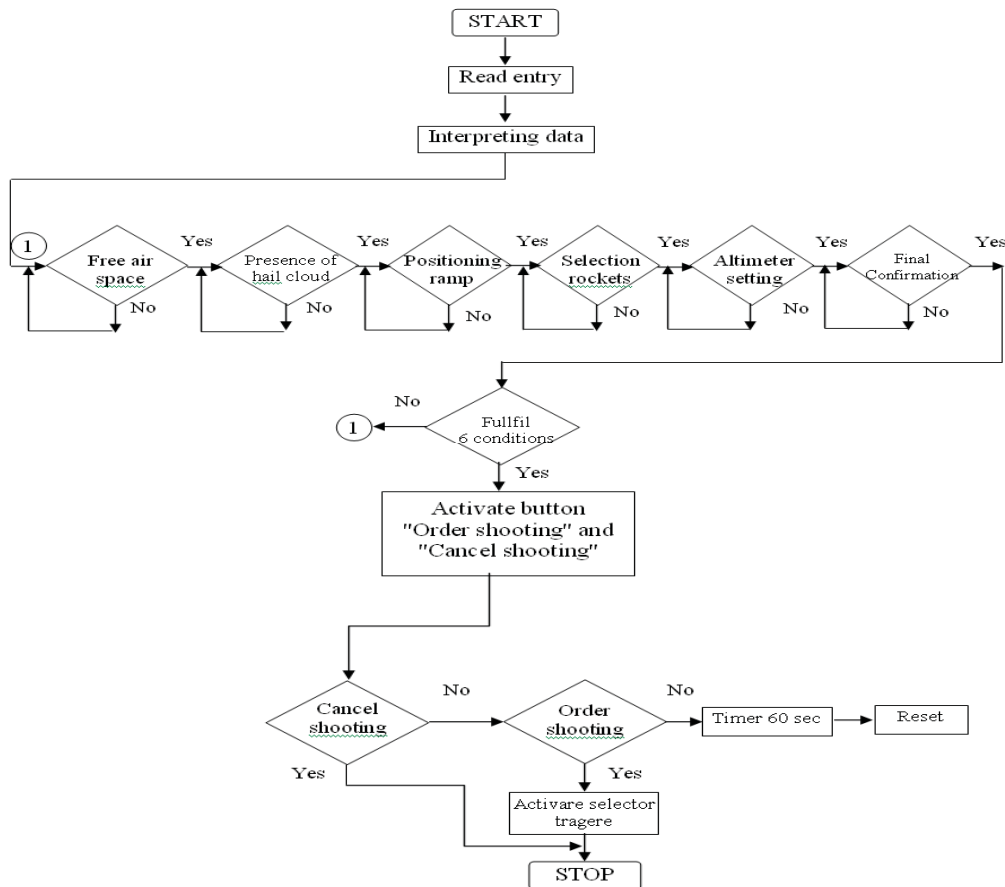


Figure13: The main algorithm of the interface for the decision launch support subsystem

## 6. CONCLUSIONS

The systems of risk management have begun to have an increasingly higher importance, mainly due to the devastation caused by climate change. Thus, the anti-hail systems have seen a great evolution in the late twentieth century.

The anti-hail systems with increased efficiency are based on the principle of seeding clouds both in the air and land. Due to the evolution of the radar systems and of the dedicated software, the cloud is no longer perceived as an object but as a physical-chemical process in which are important the exact areas of intervention in order to produce favourable changes.

The informatic system for the Romania anti-hail network comprises two main components: the subsystem for taking the decision of launch and decision support subsystem for launch.

In the realization of the system will be consider the use of communication via GPRS, is a cheap communication, monitoring the parameters throughout the all period of operating, log-values, status and alarms, operator actions journals, friendly graphical interface and the generation of tabular and graphical reports for any period.

The integrated information system for monitoring the units launch of anti-hail rockets will increased the network performance and efficiency by estimating both the entropy and the efficiency of information sources. The application of information system leads to an increasing efficiency by reducing the intervention time, a better organization, reducing operating and maintenance costs, degree of security.

## Acknowledgments

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