DEAD TIME COMPENSATION ON ANTI-HAIL ROCKETS

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ABSTRACT

This paper presents methods of compensation dead time in hail rockets placed in the Anti-hail Combat Unit (AHCU) which can be arranged in Romania in a anti-hail national system.

Keywords: hail combat, anti-hail, anti-hail rockets, compensation of dead time, anti-hail combat unit

1. Introduction

Given the current technological development, the question of control and influence of the meteorological phenomena’s in both military purpose and useful purposes such as anti-hail protection, provoking rain for a peaceful purpose. In his paper Geophysical War [1] col. dr (r) Emil Streinu presents some of the systems and research centers in the meteorological domain. One is located in the northern U.S. at 400 km distance from Anchorage, at the Gakhona military base. A huge field of tundra is planted with a forest of antennas of 25 m height generically called HAARP (High Frequency Active Aurora Research Program). The base is surrounded by barbed wire, the perimeter is guarded by armed patrols of Marines and air space above the research base is closed to all civilian and military aircraft. In response, in Russia there is a similar complex "Sura" which is comparable, in terms of capacity with the current HAARP and is within the central area, in places hidden at a distance of 150 km from Nizhnii Novgorod. "Sura" belongs in the Radiophysics Research Institute where, among other things, once worked the former scientist and current politician, Boris Nemtov. "Today, in the world, there are only three such objectives," says institute director Sergei Sneghiriov. "One in Alaska, second, in Norway at Tromso, and the third - in Russia".

In the field of civil concerns fall on the anti-hail protection, starting with sonic cannons, weather balloons and finishing with anti-hail rockets and with rain provoking rockets.

From historical point of view the first artificial rain was provoked in Bucharest in 1931 by researcher Stefania Maracineanu. Thanks to the data obtained by Stefania Maracineanu, she obtained support from the French government and she repeated these experiments in 1934 in Algeria, being crowned in succes. The next research in this area did not continued until after the Second World War, when in 1946, Vincent J. Shaefer American engineer did an experiment on Mount Washington. Here, in this day heavy clouds where forming over the mountain. He scattered from plane at the base of the cloud, carbonic ice, which gave rise to a heavy rain. The first artificial rain for military purposes was caused in 1963 by the U.S. Army in Vietnam, and in 1966 the Americans provoked torrential rains with disastrous consequences for the provinces of northern Laos. Comparing the effects of the known weapons with those of the Geophysical War especially over the living force, it appears that huge damage can be done; this can be use in a secret war, are stronger than the known weapons and is due to human capacity to know, manage and control the natural phenomena of our planet. Now Geophysical War presents perspectives as possible, but with the mention that such a conflict in the notion of winners and losers might be mistaken, but are able to distinguish between military and civilian victims, between aggression and attack, which emphasizes the fact that scientists can be used in this domain. A try with unexpected effects occurred in China in spring of 2000. Chinese researchers, launched in the atmosphere in an arid region, several rockets with silver iodide in order to obtain rain. Not counting all environmental factors of the area, Chinese scientists found themselves in a very short period in that area with heavy snow. Research to date has been made by small isolated groups, which had a short life due to economic conditions or market demand for equipment, unable to benefit from experiences and previous research. Except are perhaps the military research, where in the same time with the climate disasters there should exists methods and means to combat this effects, but obviously this are not available to the public.

All the achievements to date have been and are built to protect limited objectives (car parks, solar collectors and wind turbines fields, farms) without taking into account global protection through a unique system-wide coordination unit, at local area at least. The beneficiaries are very satisfied by the investment they made.

In Romania was developed a uniform law on national defense against national habitat against hail storms were first steps in this direction have been made, that it was been constructed and it is now working the first hail fighting unit in the area of Ploiesti which is administered by the local production plant called "Electromecanica Ploiesti". From a point of view of anti-hail rocket launching the station is under the control of the Antiair Defence Command. There ware times when this experiments could not be executed but their reasons remain unexplained by the Antiair Defence Command; evan so it is a national project. The National Agency of Meteorology and Hydrology (NAMH), with the meteorological Doppler radar network, does not provide vectorial data; also is not very clear who cover the operating costs of the combat unit (the state or its beneficiaries) there are gaps in financing this activities.

Based on the fact that:

- Recent research has shown that breaking ice particles with embedded air gaps 300hPa is need, and that modern sonic cannons have a maximum of 1.3hPa at a distance of 100 m from the muzzle;

- The active condensation substances are spread in the clouds and prevent the growth of ice crystal and therefore fulfilling the conditions so the ice particles leave the cloud in solid state;

- Research by the military concerning the influence of weather;

It can be concluded that research and development resources should be focused on hail prevention training and not combating the already formed hail (by destruction of ice particles where the energy used would be exorbitantly high).

The law of 2009 on intervention on the atmosphere for climate change, in particular the prevention and combating hail, the structure of the national arrangements for implementing and financing the necessary legal framework is created thus, this agreement opens opportunities for the implementation of dedicated private systems.

Within the national anti-hail framework, the local hail fighting stations should obtain the data from meteorological radars of the NAMH, but the intercomunication means are not yet well defined..

In principle, under this law, anti-hail station consists of:

- dispatcher or control point;
- two or more anti-hail rockets launching points (up to 10 stationary launching points and up to 5 aero mobile launch platform);
- own weather station;
- communication system;
- supply and transport system;
- service personnel;

From our point of view this centralized system has the following shortcomings:

- its financing is not clear with the possibility that due to subjective factors that rocket launching may not be executed when the beneficiary wishes so (the farmer pays and the system is not under his direct command);

-is based on local anti-hail rockets because it is administered by the missile manufacturer, Electromecanica Ploiesti, there are premises for creating a monopoly on it and could be a pressure factor in certain socio-political conditions;

- there are failures in terms of communications redundancy, which drastically lowers the reliability;

- responsibilities are not created if the system becomes inefficient because of subjective reasons;

From my point of view, about the hail unitary system coordination, command and control logic is distributed throughout the area and is specific to each sub-process basis, if they differ. Communication between LCD (distributed control logic) is done through messages using a rigorous protocol, information links between them are permanent or temporary depending on the specific needs and can be provided via public communications networks.

In [21] I described a process with distributed parameters, the national anti-hail combat unit, a process identical with one dispatcher station, regional stations and sub-regional stations working as in Figure 1.

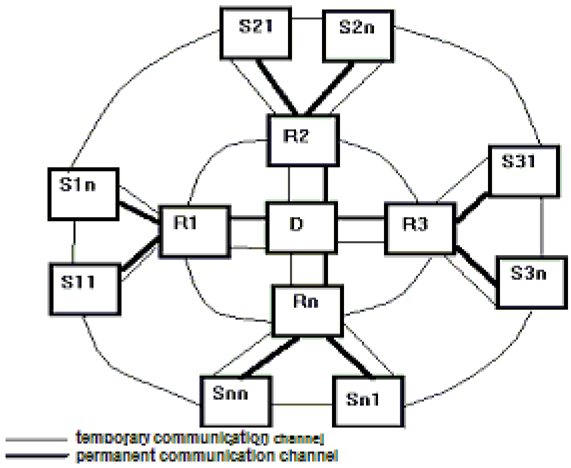

Fig. 1

As said, the links are bi-directional informational, the hierarchical structure has three levels, making information exchange through messages.

Dotted links are informational and circular links (almost parallel) between all substations and all regional stations and represents an alternative to ensure links with high safety information when the connection between the dispatcher station and a regional station is interrupted.

In this case, the dispatcher takes over its tasks, possibly through special reserve equipment for the situation, or sends to the regional stations through another circular channel.

Message routing possibilities are many, but in this case, each station and substation must have an identifier. This fact has a major disadvantage, namely that any Ri, Si and D may send false messages, which endangers the safety system. However, it can be removed by techniques and protocols for authentication, message integrity and encryption (to ensure confidentiality).

In systems with a high risk and where weapons are involved and (in this case meteorological rocket carrying a catalyst) is excluded a human operator, so that the entire security policy will be built around this fact.

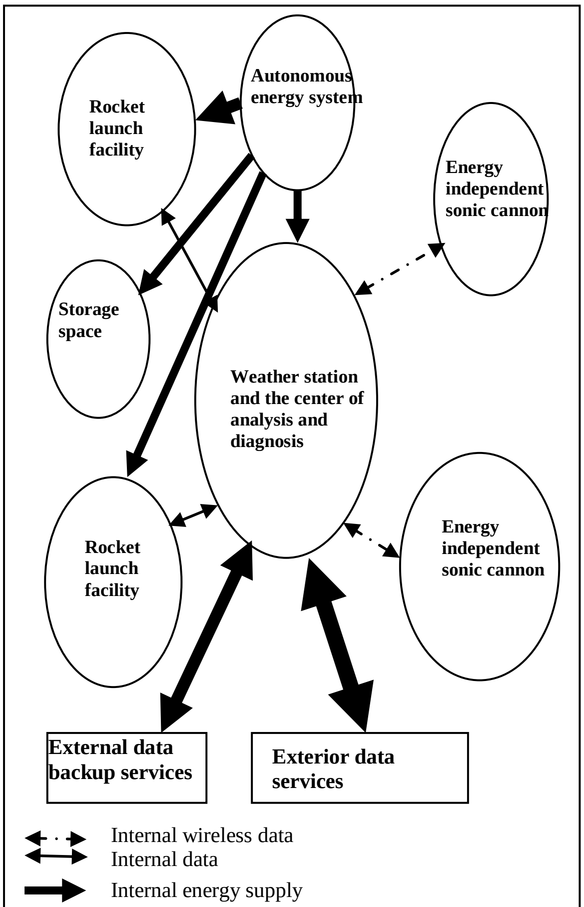

Fig. 2 – AntiHail Combat Unit

2. Communications Subsystem Defining

Within the national anti-hail, are defined a number of combat units (AHCU) can be substations to S11 to S1n in Figure 1,Repeating units are R1 to Rn and the National Center for Analysis and Diagnosis that is connected (or is even a constituent part) to NAMH (National Agency of Meteorology and Hydrology). In our view, a hail combat unit can have the structure in Figure 2.

The external data services to be provided with its own radio relay communication network with a capacity of 2 Mb / s, constituted in a semi-grill network type and related Repeating points.

External data backup services will be provided over the Internet with VPN connections (Virtual Private Networking).

Both external data services are provided through symmetric encryption data security with embedded hardware encryption devices to the radio relay network routers with IPSec built VPN. Both solutions are on the market in different variations and in this paper, I deal with security issues that transit communication subsystems.

Communication between control center and anti-hail control units it is based on data vectors with well-defined fields. Data vectors are *control vectors, state vectors, timing vectors.*

Data vectors are all the same length to prevent the possibility that an alleged attacker to differentiate based on their length.

At any time the command center may issue to any AHCU and begin with a synchronization vector followed by a command vector after that, it waits for a state vector and another timing vector from AHCU.

Data vectors have two fields called data field and the authentication field. The authentication field is actually a hashing function applied to the data field and has a bit length of N1 bits (N1 is sized depending on the type of hashing function used and data field length).

Data field is a string of n bits of the first two bits define the vector type (01 for control, 10 state, 11 for timing and 00 unused), the next 32-bit contain the message moment of time in universal format, on 6 bits is encoded the AHCU number, the next 128 bits contain symmetric encryption key, followed by the actual data through which the commands are sent or parameters to be adjusted, this field can be sized according to the necessities. In control vector the command Center adds AHCU number on 6-bit, to which he addresses; and in the state and timing vector both AHCU and control center inserts the AHCU specific number with which they share data.

The algorithm used to encrypt the data field is 128-bit AES key, the initial key is generated by the command center being unique across the system.

The uniqueness of this algorithm is that the key is initially distributed to AHCU by human operators, on the portable information media, changing at every session without human intervention.

At boot time message exchange, the first timing vector is sent from command center and it will contain the new key (randomly generated by the command centre but kept until the next session) that AHCU will use to encrypt the data field content of status and timing vector. The key is included in key field on vectors before encryption.

AHCU decrypts the first timing vector and command vector with initial key distributed from command center, it separates the new key from timing and control vector sent for a new session, keeps them inserted into the timing vector and status vector, encrypts them with a new key and sends them to command center.

Command Center uses to decrypt timing vector and status vector received in response from AHCU, the key that himself had generated previously, making data authentication in the same time.

3. Hail Detection Methods

Theories about the formation of hail in convective clouds are complex and therefore incomplete, that is why it is prevention and detection is difficult in operational tasks. In addition, the prevention techniques used in real-time are not directly targeted for this purpose. On the other hand, precise data cannot be provided in real time, and verifications are quite hard to achieve. Areas where local climatic data and studies are strongly conditioned by the interests for damage occurring on certain goods (i.e. agriculture). In addition, it should be noted that the area where hail falls is a small area compared to the size of the active area of the "mother" storm.

Excluding military research into issues where detection, provoking and combating weather phenomena are not necessarily related to cost and economic efficiency in the civil domain are limited because very few resources are available to the researchers. However, over time several acceptable hail detection methods have been developed using Doppler Effect weather radar depending on Z - degree of reflection of radar waves measured in dBZ, which determines what form is water present in the atmosphere. The first techniques were based exclusively on the detection of very intense, intense or extreme reflectivity on PPI (Plan Position Indicator = radar display), maintained over a period. Thresholds that were recommended at the time ware based on local studies, limited in time, with different radars, etc. Thus, for guidance, there have been established different work thresholds in different parts of the world:

- Alberta, Canada, there is always hail if $Z \geq 50$ dBZ;
- Switzerland, and other places in the world, nuclei with $Z \geq 55$ dBZ that persist more minutes;
- NEXRAD algorithms believes that between 53-55 DBZ signals can be generated by the presence of hail in the storm (this is not a technique itself, but requires that the first instance, but means that large values of Z can be considered safe to hail). There ware echoes measured with Z greater than these thresholds and they certainly not guaranteed hail detection (Dye and Martner, 1978). Setting thresholds for detecting the existence of Z has strong seasonal variations, regional variations and even daytime variations.

Echo height above the zero isotherms: environment variables. In these techniques, we must take into account the environmental variables as significant elements to predict the presence of hail, radar data analyzed based on 3D. ***Waldvogel's method***: one of the most simple and effective methods for estimating the probability of the existence of any size hail in a cloud, was developed by Waldvogel (1979). Based on the results of sowing techniques on hail cells, it demonstrates that the probability of hail falling on the surface depends on the difference between the $\mathbf{H_{45}}$-$\mathbf{H_0}$, where $\mathbf{H_{45}}$ is the echo height of **45dBZ**, and **H0** melting band hight. Keeping these two parameters, and a single criteria, it was possible to probabilistic separate, cells with rain from those with hail. A cell is potentially generating hail if: $\mathbf{H_{45} - H_0 = 1.4}$ **km**

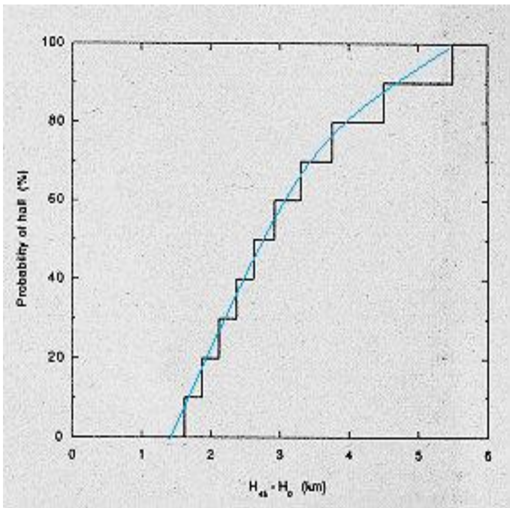

Fig. 3 Probability of hail on the ground according to $H_{45} – H_0$

In fig. 3 as seen above we realise that when the difference is as big as 6 km the probability of hail is 100%. Waldvogel's study was performed with a 3 cm radar, calculating the height of $\mathbf{H_0}$ based on radio data. The theory behind this relationship is based on the fact that hail is formed in areas where the drops temperature is under -10 ° C: as more drops are at these temperatures, the higher the amount of supercooled water is available to generate hail. Once formed, the difference in heights between 45 dBZ echo and melting band height is critical for hail falling on the ground. Waldvogel's method may be useful for discriminating clouds with and without hail in terms of probabilities. **Indirect evidence of hail in conventional radar data:** VIL the product obtained from three-dimensional radar data is of great importance at the operational level. VIL is a radar measure of the potential of liquid water content per m^2 precipitated inside a cloud (Greene and Clark, 1972). Measured in Kg/m^2.

$$\mathbf{VIL = SUM\ 3.44 \times 10^{-6}\ [(Z_i + Z_{i+1})/2]^{4/7}\ dh}$$

Where SUM is the integral from the bottom to the top of the radar volume considered, $\boldsymbol{Z_i + Z_{i+1}}$ are reflectivity values in layers of thickness **dh**. At higher liquid water content and greater height, we have greater VIL, and therefore, larger ascending currents to maintain high reflectivity values at higher levels. We see that VIL is the mass of suspended liquid water per unit area of a cloud.

Vil-grid and VIL cellular

VIL, which vertically integrates values of Z, may take two forms: VIL grid and VII cellular, if each point is calculated vertically on Cartesian volume (X, Y) or based on 3D analysis of convective cells.

VIL grid integrates vertically all values of Z, and to VIL-cell, the convective cell is identified first, and reflectivities which constituted it are integrated.

4. Dead time in antihail rockets

At the moment the dead time, when fighting hail with dispersion method of active substances in the probable formation area, it appears because data is so much delayed on the feedback loop because NAMH updates data every 10 minutes, also because of large times on the execution loop, respectively the probability of hail rocket explosion in the formation of hail is low (and in case of "failure" the target relaunch procedure must be repeated). Therefore, dead times are minutes long, and they can be compensated by launching several anti-hail rockets in an enlarged area.

5. Proposed dead time compensation methods

Since the formation of hail is detected by indirect methods (low accuracy) and the process is unpredictable (practically, an acceptable mathematical model of this phenomenon cannot be described). Generating and implementing of a prediction function to compensate for dead time on the feedback loop, and especially of dead time on the execution loop would involve the allocation of large research resources.

A first method to reduce dead time on the reaction circuit is to equip AHCU with a weather-radar, integrated into the Center for analysis and diagnosis of AHCU as in fig. 2 which will provide real-time Cartesian coordinates of the probable area where hail can form. In this way the missile launch point, can implement a prediction function, which can infer the future position of the area, depending on thermodynamic parameters and the state of the atmosphere of the area covered, making the necessary corrections for the rocket launch. This does not guarantee to reach the target.

The second method, which requires that the first method is implemented, is to change the vector rockes or anti-hail projectiles with guided rockets making the whole system a tracking system. There are currently wired missiles, guided rockets and projectiles that use the GPS system. Choosing the type of rocket is strictly dictated by the resources allocated, the possibilities of producing the anti-hail charge and missile in the country and the demand from the beneficiaries. By using guided missiles, dead time is reduced to an order of magnitude equal to the time required to reach and explode the rocket cargo in the dangerous zone, but it is not fully compensated (basically, is not needed to launch more rockets to annihilate a cell with large probability to form hail).

The short time (5-10 sec) from the moment the hail starts forming to the moment the hail is completed, it imposes complex analysis strategies on a large area, so a zone prone to hail storms will be "protected" by AHCU from its neighborhood. There should be analized, especially in the likely areas of hail formation, and intervene on to those because once hail is formed, combat posibilities are none. In Romania there are eight large weather radars covering the whole territory.

The most extensive areas with high frequencies (60-75, 75-90 and 90-105 cases) are grouped in Salaj counties, Cluj, Mures, Alba and Hunedoara. Peripheral areas where these values fall between 45-60 cases: highly region of Satu Mare, Mures, Bistrita Nasaud and Maramures, including Lapus depression. Areas with over 75 cases in these districts overlap: Salaj County, Almas-Agrij depression, Cluj County, Gilau Mountains and eastern slopes of Muntele Mare, Cluj and Dej sub-mountainous hills, Capusul hills and Feleac hills which distinguish with over 90 cases, Hasdate and Iara depressions, Transylvania Plain (which extends to the counties of Mures and Bistrita Nasaud), Alba county area that overlaps with the Trascau Mountains, with extension in Hunedoara county over the Metaliferi Mountains and Mures passage. The way this areas are aligned, meaning from NW to SE ofer the Silvania hills and Meses indicates the maner in which the oceanic air masses meets the warm and humid mediteranean air masses that enter from the SW on the Mures passage over the Metaliferi mountains.

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