# Studies for development of a system for rapid localization of the guns position in firing fields

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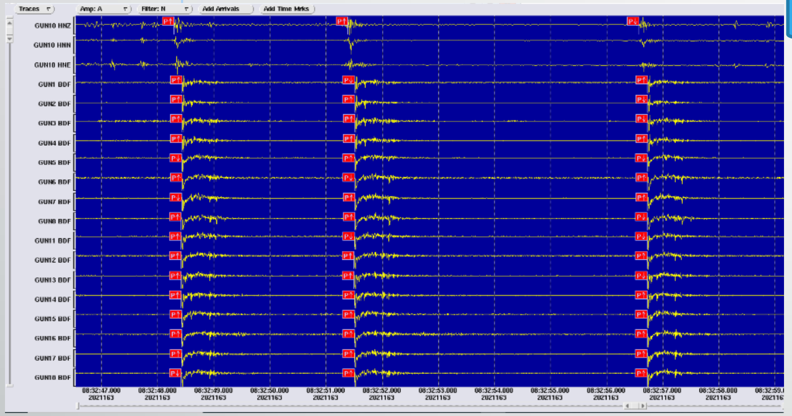
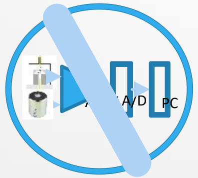
# PURPOSE

Within the PED-2019-0100 project funded by the Romanian Ministry of Research, we intend to develop a system for quickly locating the position of shooting events in time and space in order to aware soldiers of enemy firing position. Multiple tests were performed using different types of portable equipment. We used digitizers with sampling rates between 1 and 50,000 SPS that connect different sensors (MEMS infrasound sensors, infrasound Chaparral M25 sensors, seismic sensors, pressure microphones, audio microphones). The ultimate goal of the project is to identify the signal generating source by quickly calculating the azimuth and distance.

Methods for identification and alarming of sonic events generated by weapons in belligerent areas on the basis of data provided by a pilot facility are to be developed within the project.

# FIRST EXPERIMENT




Recording element using a 24-bit A / D converter to which a MEMS infrasound sensor and a GEOFON seismic sensor were connected

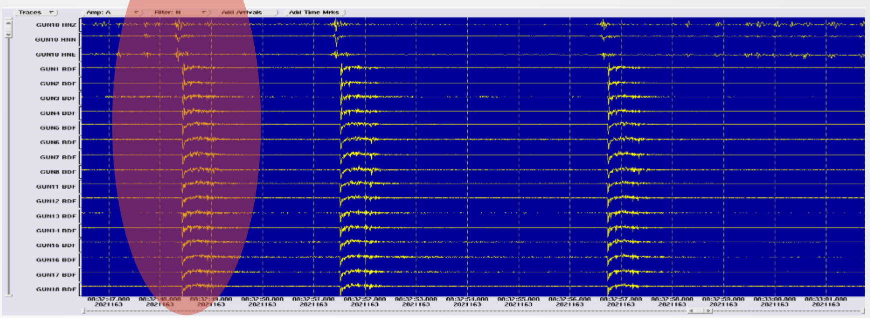

System consisting of MEMS type infrasound sensor, Geophone seismic sensor and 24-bit digitizer, 100sps,

Microphone, Datalogger 24 bits, 200sps,

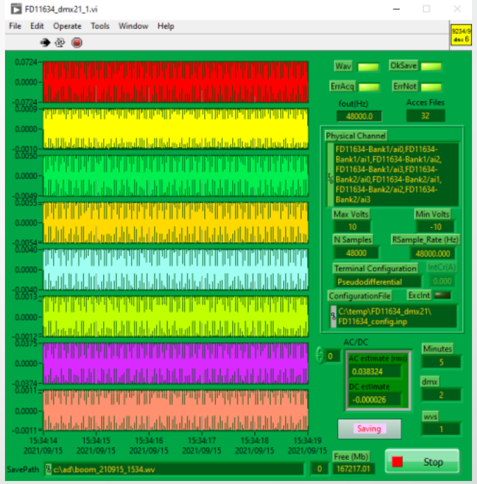
Microphones, Datalogger 24 bits, 50.000sps,

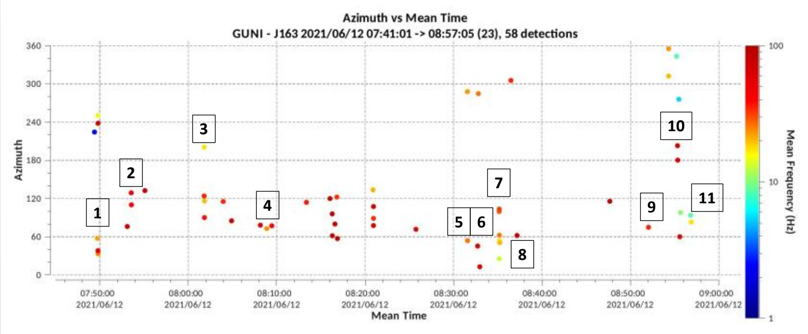
# FIRST RESULTS

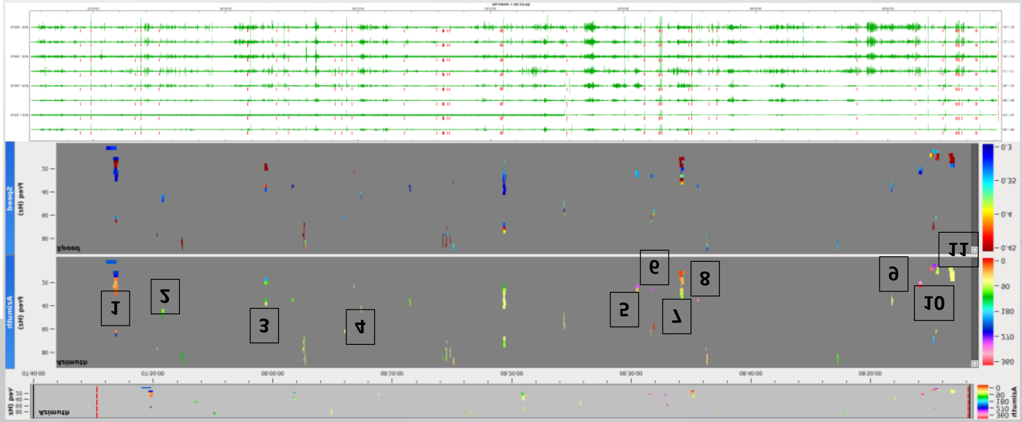
The main parameter is the determination of the infrasonic location for explosions and natural events. It is based on the time of arrival and represents the time at which the monitored event is recorded. Measurements on multiple measurement on multiple channels (8ch) generate the time difference between recordings.



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GUN1 | 6/12/2021 | 163 | 8:32:48.434 | 117 | BDF | P | c. | dbp:rt:21250 |
| GUN10 | 6/12/2021 | 163 | 8:32:48.290 | 118 | HNZ | P | c. | dbp:rt:21250 |
| GUN11 | 6/12/2021 | 163 | 8:32:48.416 | 119 | BDF | P | c. | dbp:rt:21250 |
| GUN12 | 6/12/2021 | 163 | 8:32:48.416 | 120 | BDF | P | c. | dbp:rt:21250 |
| GUN13 | 6/12/2021 | 163 | 8:32:48.416 | 121 | BDF | P | c. | dbp:rt:21250 |
| GUN14 | 6/12/2021 | 163 | 8:32:48.419 | 122 | BDF | P | c. | dbp:rt:21250 |
| GUN15 | 6/12/2021 | 163 | 8:32:48.421 | 123 | BDF | P | c. | dbp:rt:21250 |
| GUN16 | 6/12/2021 | 163 | 8:32:48.423 | 124 | BDF | P | c. | dbp:rt:21250 |
| GUN17 | 6/12/2021 | 163 | 8:32:48.421 | 125 | BDF | P | c. | dbp:rt:21250 |
| GUN18 | 6/12/2021 | 163 | 8:32:48.419 | 126 | BDF | P | d. | dbp:rt:21250 |
| GUN2 | 6/12/2021 | 163 | 8:32:48.430 | 127 | BDF | P | c. | dbp:rt:21250 |
| GUN3 | 6/12/2021 | 163 | 8:32:48.431 | 128 | BDF | P | c. | dbp:rt:21250 |
| GUN4 | 6/12/2021 | 163 | 8:32:48.430 | 129 | BDF | P | c. | dbp:rt:21250 |
| GUN5 | 6/12/2021 | 163 | 8:32:48.421 | 130 | BDF | P | d. | dbp:rt:21250 |
| GUN6 | 6/12/2021 | 163 | 8:32:48.430 | 131 | BDF | P | c. | dbp:rt:21250 |
| GUN7 | 6/12/2021 | 163 | 8:32:48.420 | 132 | BDF | P | d. | dbp:rt:21250 |
| GUN8 | 6/12/2021 | 163 | 8:32:48.419 | 133 | BDF | P | c. | dbp:rt:21250 |





Example of association of detections with detected events - infrasonic detection detectability diagram (DTK-DIVA); - Graphic detection panel (DTK-GPMCC)

# PILOT FACILITY

After several test were done with different types of equipment and considering the reliability in the field, we selected two pilot installations.

## 1. "Multisensor detection system" using infrasound sensors, seismic sensor (geophone) and microphone – 1000SPS

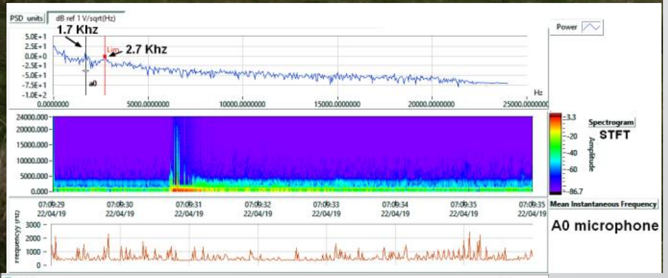
Equipment component: A/D converter 3ch - GPS antenna, Infrasound sensor , Microphone, Geophone, noise reduction elements, power supply

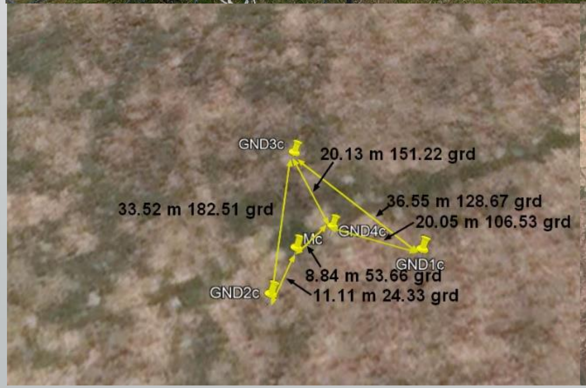
## 2. System using microphone array and high sampling recording system (50000SPS)

The system uses a high speed data acquisition module (100 Khz maximum sampling rate) type FD11634 produced by NI. It has 8 channels and performs the acquisition of high frequency sound and vibration signals.

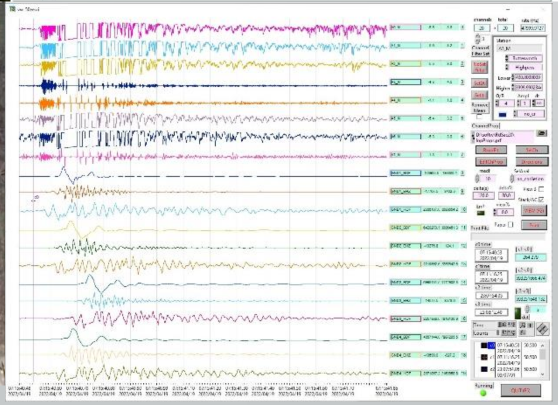
FD11634, 8-channel sound and vibration, 24 bits data acquisition device

# Measurements using pilot installations in The shooting range



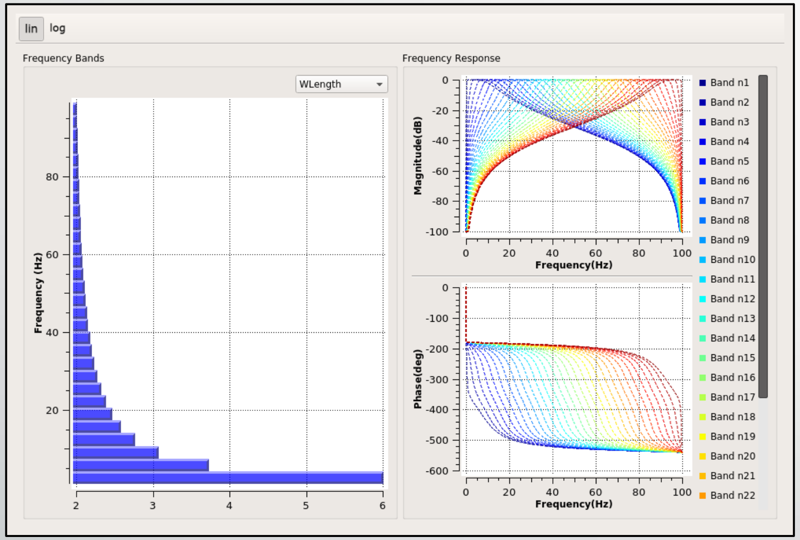







# Results of seismo-acoustic data processing

A four-element seismo-acoustic array (GND) (GND1, ..., GND4) was used to record the signals generated by the large-caliber source test (TSMC) performed in the firing range. Figure 1 shows: (a) the geometric configuration of the measuring array, and (b) the transfer function (array response) in the space of the k-number (rad/m) for the analyzed frequency range (1 - 100 Hz).




a

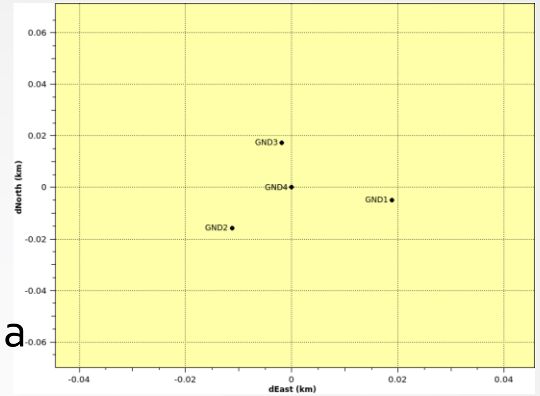
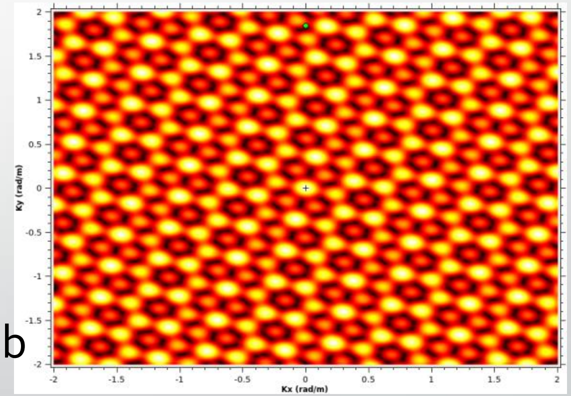



Fig. 1 GND seismo-acoustic array used for TSMC. (a) - geometric configuration; (b) - transfer function

b

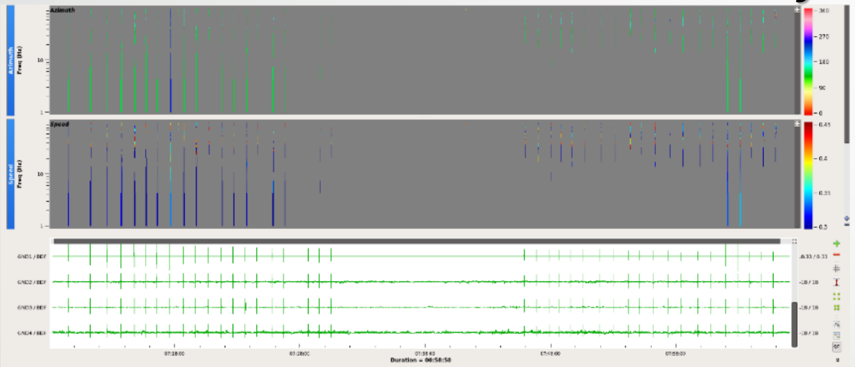


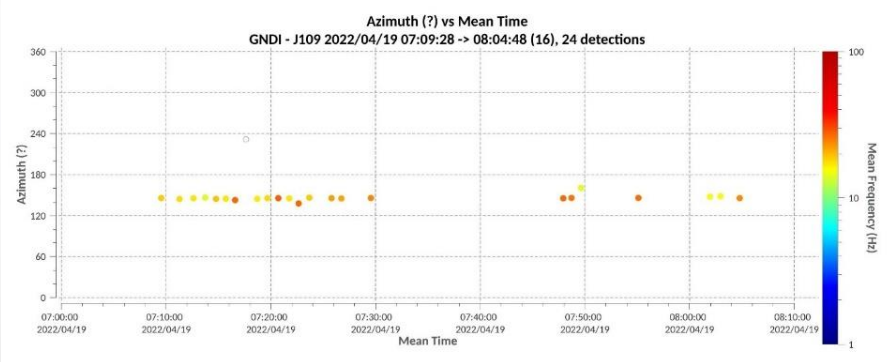

Graphical representation of the frequency bands corresponding to the configuration used in DTK-GPMCC for processing GND records (number of subnets = 4; calculation frequency range: Fmin = 1 Hz, Fmax = 99 Hz; number of frequency bands used for signal filtering (linear variation) = 30, time window length (logarithmic variation with frequency 1 / f): between 6s and 2s

# Results of seismo-acoustic data processing (2)

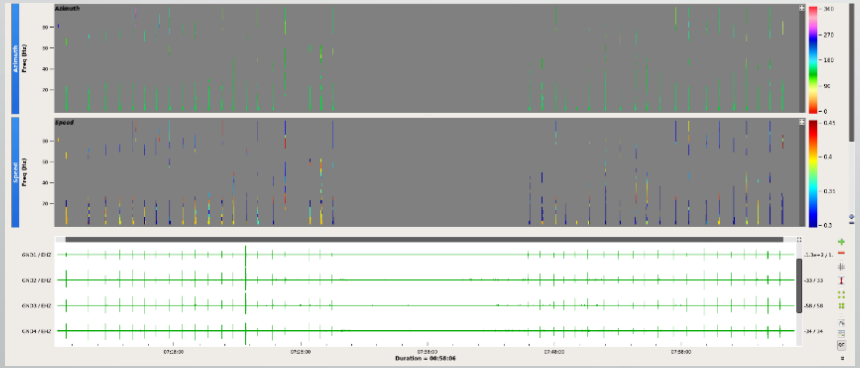
During the shooting with 100 mm antitank cannon with armour piercing fin stabilised discarding sabot projectile, the GND seismic-acoustic sensor array recorded 40 different signals corresponding to the all shooting events. The antitank gun was located in a concreet wall protected shooting lane, positioned 700 m away from the array. The result obtained from the post-processing of the recorded data from the seismic-acoustic signals using DTK-GPMCC program are presented as follow.

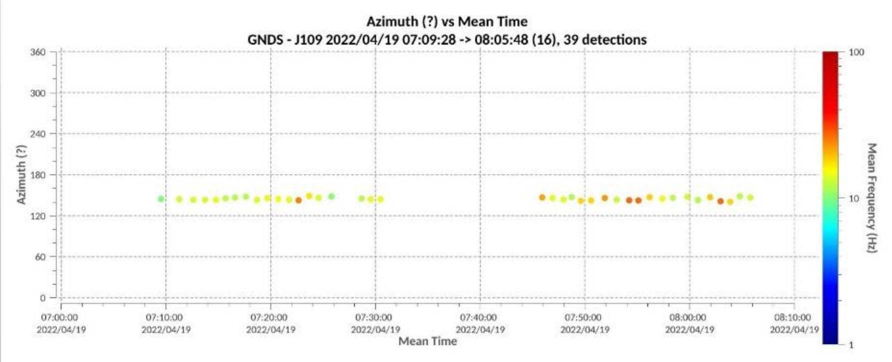
*Infrasound data*






*Seismic data*





# Results of seismic-acoustic data processing (3)

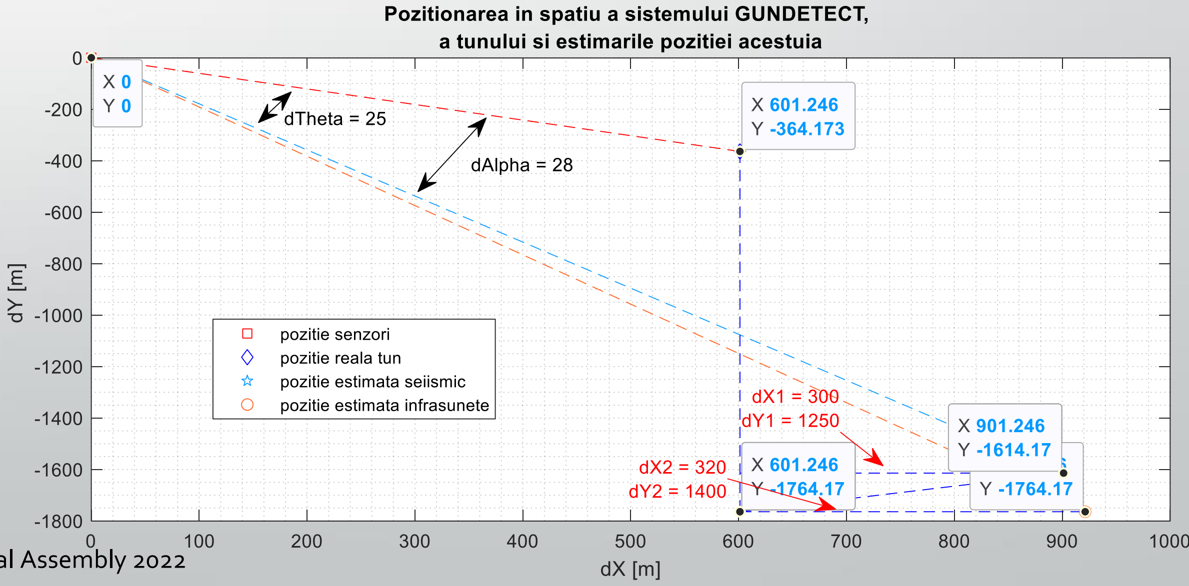
The main results of seismic-acoustic data processing with the DTK-GPMCC program

| | Infrasound data | Seismic Data |
|---|---|---|
| Azimut invers mediu (°) | 145,9 | 145,0 |
| Viteză medie (km/s) | 0,315 | 0,365 |
| Frecvență medie (Hz) | 19,1 | 17,1 |
| Amplitudine PP (Pa) | 11,0 | N/A |


Polar histogram of TMSC-associated seismic-acoustic array infrasonic detections represented over Google Earth map (green - infrasonic data, yellow - seismic data)

Possible causes that generated positioning error:

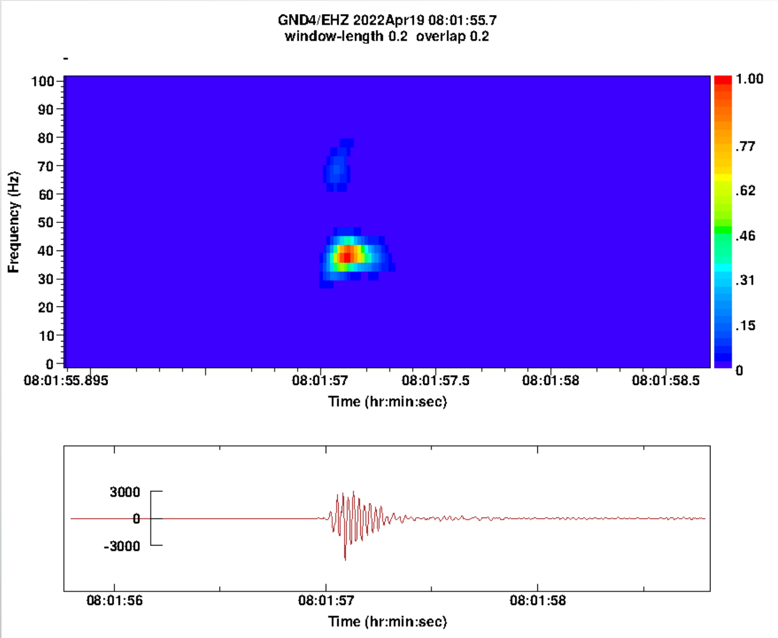
- Shockwave reflection caused by positioning the antitank gun in a concrete wall protected firing lane;
- powerful gusts wind that blew from North to South direction and west to east with speeds reaching 1.44m/s NS and 1.38 m/s WE;
- Heavy clouds at low altitude that increased atmospheric pressure;
- Not enough sensors nodes in the array;
- To close positioned sensors node in the array.



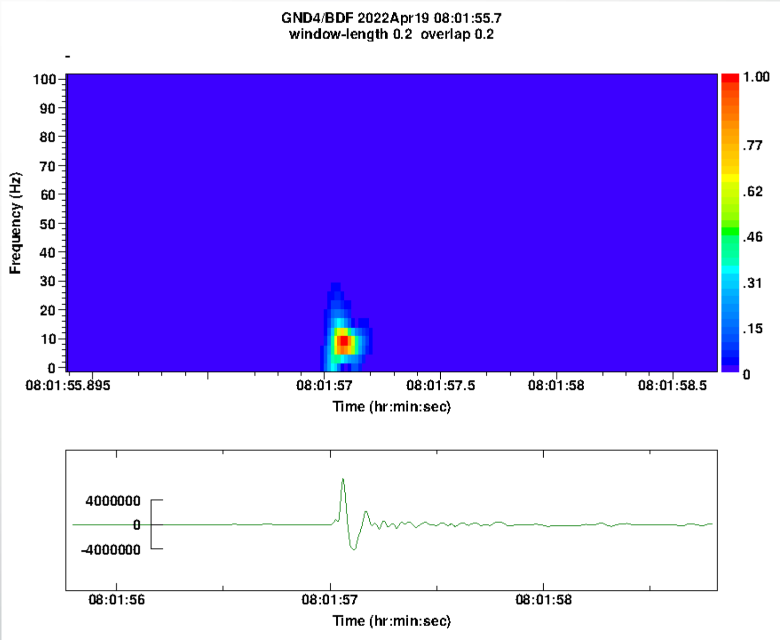
# Conclusions (1)

- System permit extracting of acoustic signature by means of spectral analysis;
- Acoustic signature permit identification of the shooting event trough comparing with a data base;
- Acoustic signature should be processed in order to reduce white parasitic noise;
- Calibrated data base of acoustic signature of artillery and infantery shock wave sources should be created.

(a)




(b)

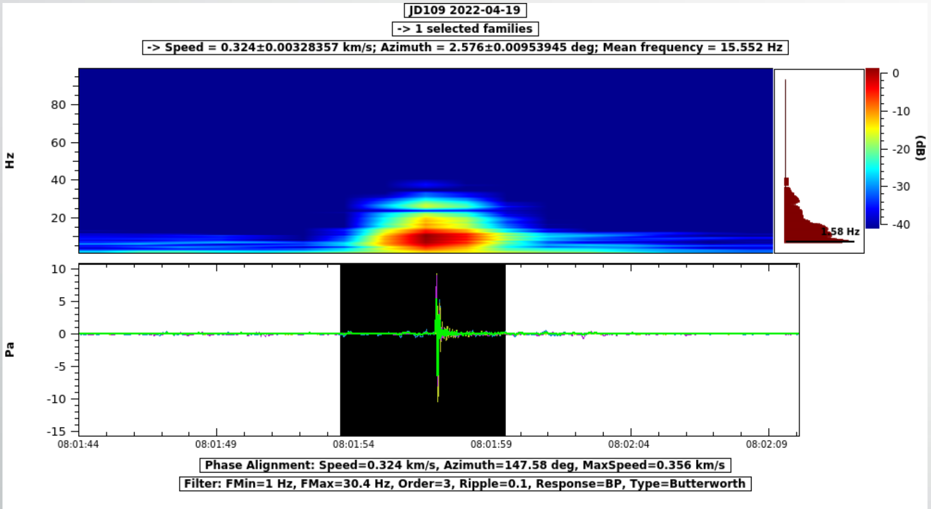



Example of normalized spectrograms and waveforms associated with the considered infrasonic signal. (a) - infrasonic data; (b) - seismic data

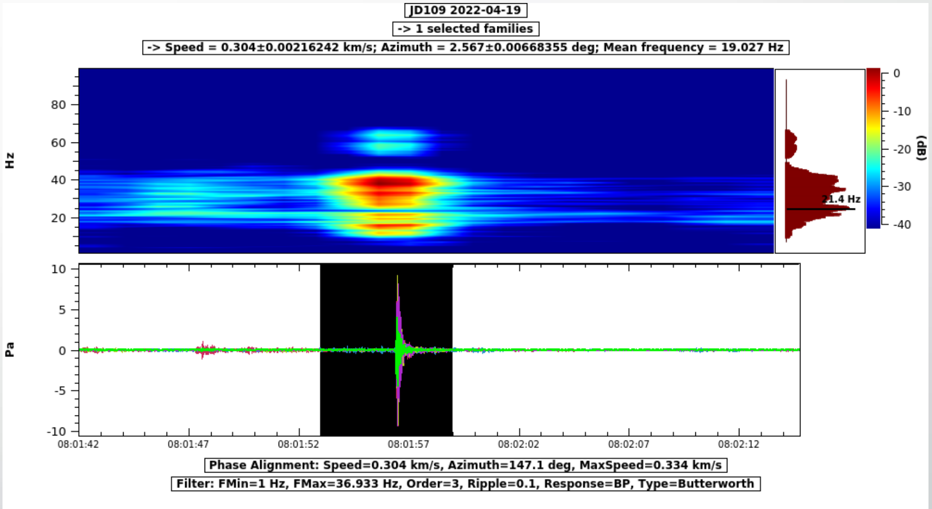
# Conclusions (2)

Due to the significant low energy content observed at low frequencies, it can be assumed that under certain favorable atmospheric conditions, the infrasonic signals emitted by these sources can be detected at much greater distances than in the present case.

The infrasonic signal detected by the sensor system contains a combination of the power spectrum of the acoustic source and the propagation effects (distortions introduced by the behavior of the propagation medium, respectively of the atmosphere).




(a)




(b)

Example of beam shape spectrograms of the recordings of the four sensors associated with the infrasonic signal (a) - infrasonic data; (b) - seismic data

# THANK YOU !