Thesis proposal

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F3

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Radio position determination of the flying objects

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Subfield: Radio navigation
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Declaration

Abstract

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Abstrakt

Klíčová slova: slovo, klíč

Překlad názvu: Rádiové určování polohy letících objektů

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Chapter 1

Motivation

Radio position determination of flying objects is standard radio location discipline which led to development of RADAR systems. At the present time the RADAR systems are enough mature to detect almost any radio-reflective artificial flying object in atmosphere or in near space. Therefore technology development is moving from focus on RADAR sensitivity to system stability, reliability and low operation costs. Resulting applied technologies leads to new scientific possibilities of observations and measurement which could bring new discoveries.

1.1 Flying object parameters

From radar point of view where terminology usually uses a term target instead of object. The radar cross section (RCS) and object velocity are limiting parameters of the radar systems. These parameters vary largely depending on measured flying object type.

1.1.1 Artificial airspace targets

A large group of possible radio reflective targets are classical airspace objects as airplanes, Unmanned Aerial vehicles or satellites. These classical objects are usually detectable and localizable with already existing radar systems. Parameters like RCS and trajectory or velocity of these object is also known. Therefore this object category could be used for new system verification.

1.1.2 Natural radio-detectable objects

Several natural atmospheric or near space phenomena are expected to be localized by radio-waves. The list contains Solar system bodies, meteors, ionospheric fluctuations, cosmic rays particles and atmospheric electrical discharges. Not all of these natural phenomenons have confirmed radio detection due to technical or yet uknown physical principles. But observation of natural phenomenons are generally scientifically more valuable than artificial objects. Therefore the work will be mainly focused on methods useful of natural phenomena measurement.

1.1.3 Position determination methods

If we want to find out object position by radio signal reflected or transmitted by the object. We have only a small number of signal features which we could use to obtain information about object coordinates. The best method used for determination of object position depends on type of an object required precision of measurement and application. In most cases for unknown flying object we need to combine several of following methods.

1.1.4 Triangulation

Radio direction finding is the oldest radio localization method.

1.1.5 Distance measurement

1.1.6 Velocity measurement

The key principle is bistatic Doppler shift described by equation 1.1.

$$f = \frac{1}{\lambda}\frac{d}{dt}\left(R_{tx} + R_{rx}\right) \tag{1.1}$$

Where

- f - Received frequency
- λ - Radar tranmitter operating frequency wavelength in meters
- R_{tx} - Distance between transmitter and target
- R_{rx} - Distance between receiver and target.

Chapter 2

Meteor trajectory determination

2.1 GRAVES based detection system

2.2 VOR Transmitters as signal sources

For feasibility study of meteor detection based on VOR beacons a numerical signal model has been created. The spectrum of modeled signal is shown in figure 2.1.

This signal is expected to be reflected from meteor ionized trail and signal reflection will be detected and extracted from the noise using the VOR signal replica. An intensity of received reflected signal was modeled by using standard radar equation 2.1.

$$P_r = \frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 R_t^2 R_r^2 L} \tag{2.1}$$

Where

- P_r — Received power in watts.
- P_t — Peak transmit power in watts.

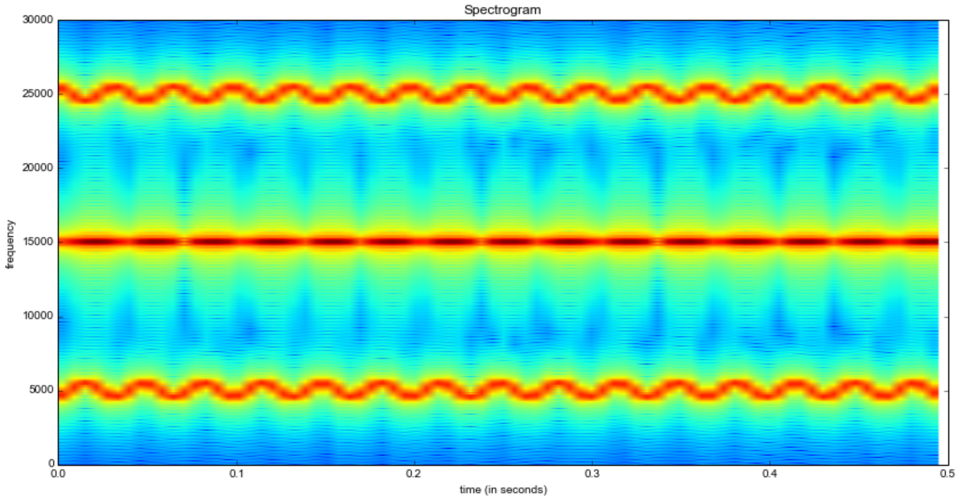

Figure 2.1: VOR signal numerical model

- G_t — Transmitter antenna gain.
- G_r — Receiver antenna gain.
- λ — Radar operating frequency wavelength in meters.
- σ — Target's nonfluctuating radar cross section in square meters.
- L — General loss factor to account for both system and propagation loss.
- R_t — Range from the transmitter to the target.
- R_r — Range from the receiver to the target.

The model generate many meteor trajectories (figure 2.2 and calculate a power level at receiver for point of closest approach. The resulting power histogram is shown in figure 2.3.

2.3 Experimental detection of other objects

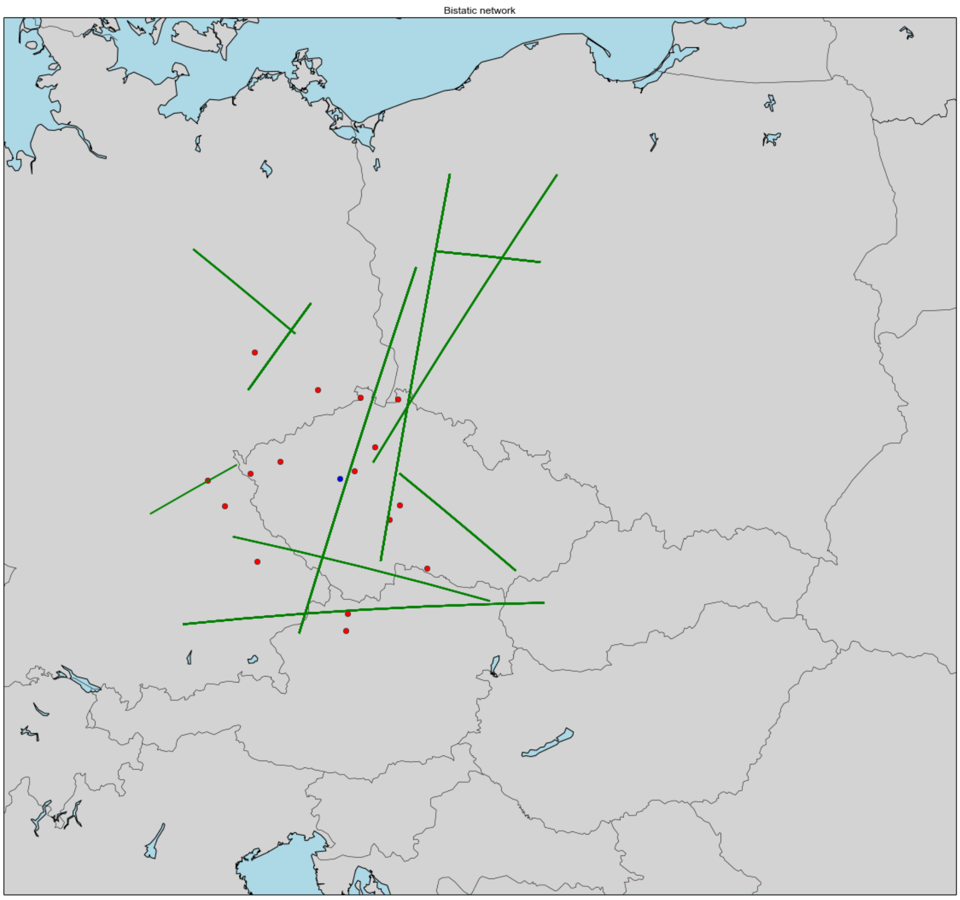

Figure 2.2: An examle of random artificial meteor trajectories

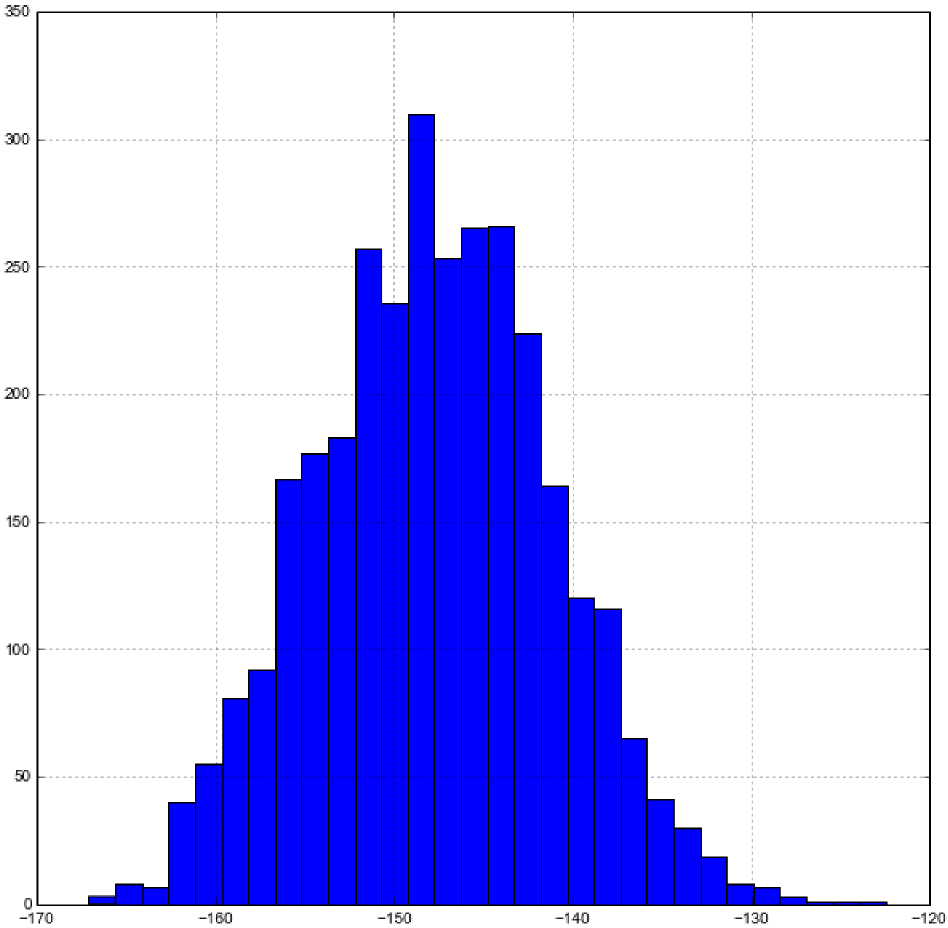

Figure 2.3: Distribution of expected signal power on receiver [dBm] on horizontal axis and meteor count on vertical axis.

Chapter 3

Future work

3.1 Meteor signal model improvement

3.2 Expansion of used methods to more objects