Software for Interference Consideration in a Network of Digital Radio-Relay Systems with Plane Reflectors

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Abstract - **In this paper we described CARRD.net software module for interference consideration in a network of digital radio relay systems with plane reflectors. Since the number of plane reflectors exponentially increases total equivalent interference sources, special attention is paid to calculation reduction based on permanent interfering signal control, and neglecting of insignificant sources.**

Keywords **- interference, plane reflectors, passive repeater, planning of radio-relay networks**

I. INTRODUCTION

With development of high density radio-relay networks, as the most appropriate system for internet and mobile telephony data transport, the interference, as the frequency spectrum usage limiting factor, gain more significance. On other side, with increasing pressure from enviromental lobbyists to reduce the expansion of high sites and the exponential growth of telecom requirements, passive repeater, especially plane reflector, shoud become increasingly attractive too. Growth of plane reflector number in network can have a great influence on interference, since in that case the number of interferers grow exponentially.

With the view to control interference level in the network and obvious need for a specific approach to passive repeater's influence on the network, a specific module has been developed in software package CARRD.net for interference calculation in radio-relay network with plane reflectors, with tools for visualisation, like 2D maps i terrain path analysis. Software usage is limited to territory of Serbia.

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II. PLANE REFLECTORS

Passive repeaters are used for changing the microwave path direction, so we could reduce the number of active repeaters, overcome obstractions and allow usage of locations where active repeaters can't be used. They are enviromentaly friendly and requires minimum maintenance.

There are two main types of passive repeater: back-to-back antenna passives and passive reflectors. In this paper we will pay our attention to plane passive reflectors, since they are mostly used. They essentialy consist of a large flat aluminium plate that reflect signal without distortion. It can also support any frequency band because it is wideband device. Being flat, large and highly conductive means it is 100% efficient. They can archive impressive gain figures due to their efficiency and fact that they can be built to huge dimensions.

Microwave reflector gain in main lobe direction of the reflected signal,with respect to isotropic radiator is given with:

$$G = 42.9 + 20 \cdot \log(S[m^2] \cdot f^2[GHz] \cdot \cos(\alpha))[dBi] \qquad (1)$$

where f is signal's frequency, S passive repeater surface and α incident angle relative to wave normal.

However, to calculate plane reflector's influence on interference, it is necessary to know it's radiation at least in horizontal plane [4]. There is no standard method for interference determination when passive plane reflectors are user, but the method which is describe is suggested for general use in telecomunication industry.

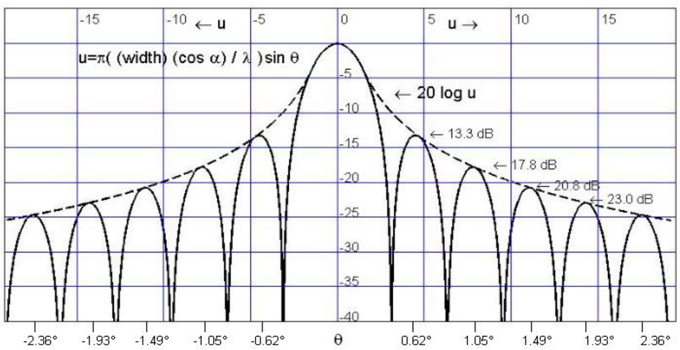

Fig 1. General radio pattern plane repeaters for small angular deviation for a peak of a major lob

The graphical representations on Figure 1 illustrate convenient form of plotting radiation pattern and pattern envelope for plane reflector near main beam (for small angles in far receiving zone). Decibel plots of pattern near main beam axis provides specific value of off axis radiation levels for small angular deviation for a peak of a major lob.

Radiation generalisation of plane reflectors is not limited just for small departure considering main lobe, it is possible for 360 degrees, regarding reflector's width, incident angle and signal frequency (Fig. 2).

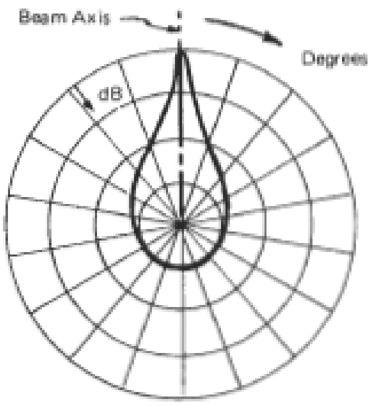

Fig. 2. Generalisation of horizontal plane passive reflector radiation diagram

III. Algorithm for Interference Calculation in RR Network with Plane Reflectors

Every radio-relay link is defined with link class, that is quality norms and unavailabilty norms that must be satisfied. Before interference calculation, for every link quality calculation and system parapmeters dimensioning can be done with respect to latest ITU-R recommendations [5] or Digital radio – relay link calculating manual from CYPTT [6] and determine maximum allowed threshold degradation due to interference.

Interference analysis in radio-relay network requires special approach when near zone interferers and far zone interferers. Near zone is area in range of less than 300m away from receiver and is thought to be not possible to mathematically calculate, because there is reflection from near objects. In this case, usually all the transmitters are allocated in the same subband.

Far interferers are signals from all the transmitters not placed in near zone (except, of course, useful signal) and plane reflectors radiation (Fig. 3). Plane reflector is broadband, so it is taken that all signals in reflector's subspace reflects in every direction in horisontal plane. So, with the upgrowth of plane reflectors, the numbers of interferers rise exponentially.

Receiving filed level of interfering signal on antenna connection when the transmitter jamms are calculated under receiver and jammer coordinates, terrain path, azimuth, antenna radiation pattern and transmitter's output power, in addition to plane reflector coordinates, its radiation pattern and appropriate terrain paths when calculating plane reflector's influence.

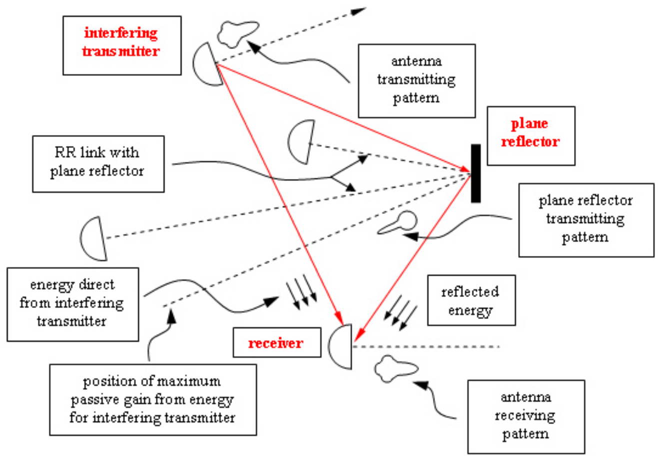

Fig. 3. General plan of system with potential interfering in RR network with plane reflector

For angle and distance calcultation it is desirable to project the whole network in rectangular coordinate system. The Gauss-Kruger system, which is governmental authorised, and Hermannskogel local datum (Bessel's ellipsoid) are uses in software [7][8]. Antenna and reflector's elevation influence are not investigated.

Interference level at the receiver is diminished by filter chain (consisting of microwave and interfrequency filters) rejection.

In case of narrowband interference (unmodulated carrier, low capacity link etc.) the whole rejection is gathered by superposition of given filter characteristics. In case of broadband interference (for instance next channel with the same modulation and capacity – *modulation like* signal), energy rejection depends also on disturbance spectrum.

The whole interference level is calculated when all interferers' level assemble by power and it can be seen as augmentation of noise level in receiver, so that it degrades threshold. After the calculation is finished report can be made about interference level and threshold degradation on every receiver in the network and influence of every interferer specially, while in case of high interference it is possible to mark the main source of interference. If allowed degradation criteria are not fulfilled, redistribution of subbands, channels and polarisations is demanded.

IV. Software Description

CARRD.NET software is realised in GIS environment, so it joins all kind of data (graphical, visual, descriptive, numerical …) in functional unit and assures their selection by various criteria. It has four database about nodes, RR links, equpment and antennas.

Node is an antenna tower or plane reflector location, defined with its coordinates (geographical or Gauss-Kruger and altitude) and its indicator. Node with passive repeater as a special type of node must have data about its orientation in horisontal plane and its dimension. RR links are described by its configuration (1+0, 1+1, 2+1 and 3+1), channels used, equipment and antenna type, link class (quality and unavailabilty norms, allowed degradation due to interference, sizing), indicator for easy infrastructure inspection and marked plane reflector (if used).

Equipment data (capacity, channel spacing, output power, threshold, resistance to interference from the same channel, etc.) and antenna data (gain and hh, vv, hv, vh and radiation patterns) are placed in independent database. Word, PDF or Excel files containing parts of project can be attached to every node, RR link, type of equipment or antenna. By specifying RR link and calling of algorithm, calculation of link quality and *sizing* of system parameter can be done.

Software background is geographical map 1:600 000 for common orientation and two terrain models, the first less precise, 1km x 1km resolution and the latter 8" x 10" resolution (approximately 200 m x 200 m).

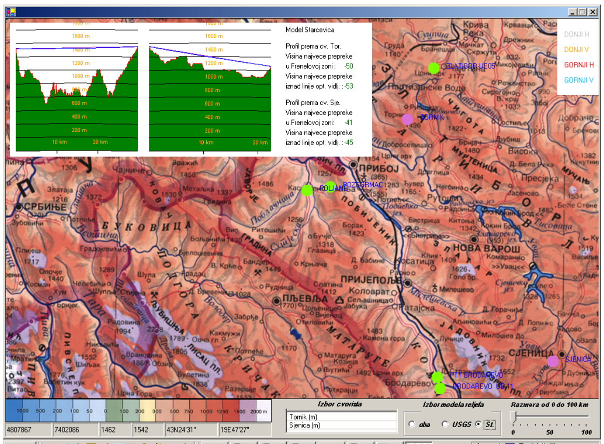

Fig. 4. Online terrain path profile analyses for determening radio repeater location

Geographical map is used for common orientation, while 3D terrain models are used for interference calculaton and terrain path drawing (Fig. 4).

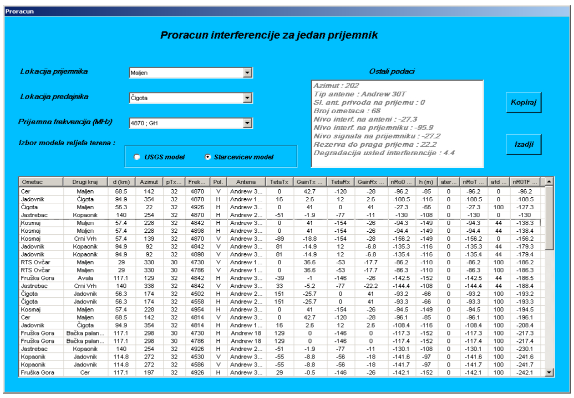

Fig. 5. Calculation results (for each receiver separately)

Interfering level in antenna is calculated upon data inputed for every receiver in the network (for instance 2+1 link configuration consists of 6 receivers). The other variable is interference level in demodulator, calculated upon threshold degradation, which is compared to maximal allowed for every RR link (Fig. 5 and 6). If interference reduction is not satisfactory, the solution is looked upon thorough channel distribution and antenna polarisation, and after that checking is done by recalculating. Possible solutions are in system redimensioning and further iterations.

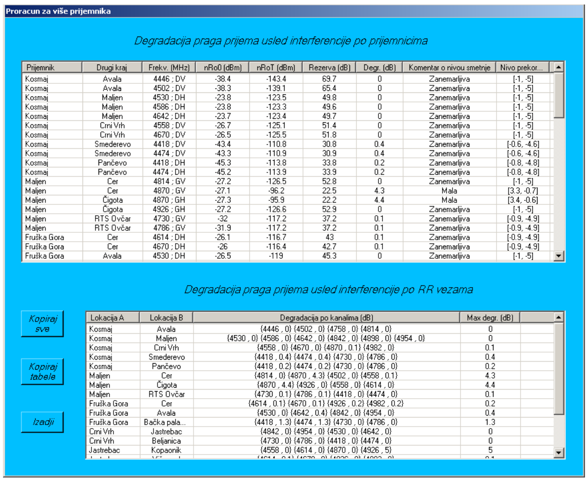

Fig. 6. Calculation results (for all RR links collectively)

In this phase of link calculation different tools can be of help: main interferers selection, spectrum spacial invasion description, node invasion by azimuth and channels, as well as the whole network topology, interactive terrain path analysis, node selection and selection of links by indicators. These applications are of great significance for interference control in near field. CARRD.NET allows fast and easy project documentation creation (Fig 7. and 8.).

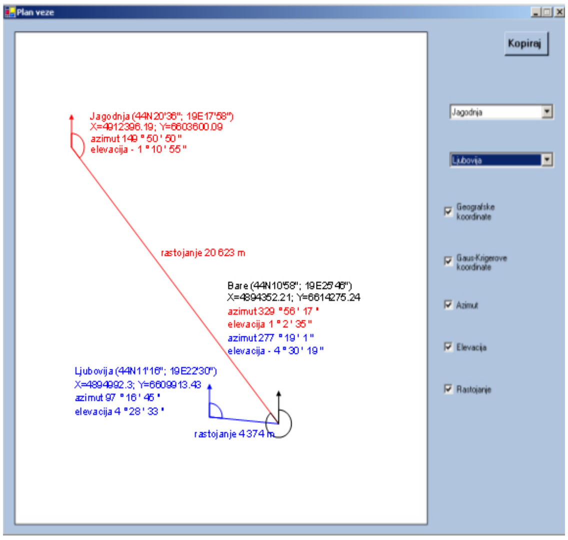

Fig 7. Plan of RR link with plane reflector

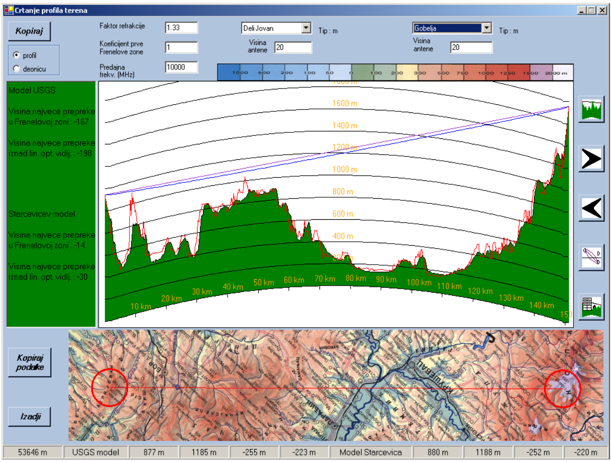

Fig 8. Terrain path analysis

V. CONCLUSION

CARRD.NET deliver series of functions which significantly speed up and lighten RR networks planning and their expansioning in Serbia. It has very efficent tools for analysis and elimination, respectively its reduction by calculating not only direct interference from interferers in far zone but also plane reflector influence in the network. Regarding this problem, which demands software backup, both 3D terrain models implemented in this program prove themself very satisfactory, while higher resolution model is more reliable for terrain path analysis.

Still, critical parts on terrain paths have to be checked on the field, and implementation of topographical maps 1:25 000 is next step software improvement, since its functionality, regarding this problem, would be at higher level.

This software assures integrity and accessibility of all data for RR networks, automatic creation of complete project documentation, as well as link quality calculation and system parameters sizing.

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