TRANSNAV International Journal on Marine Navigation and Safety of Sea Transportation
Volume 3 Number 3 September 2009

The Impact of Windmills on the Operation of Radar Systems

M. Dzunda, V. Humenansky, D. Draxler, Z. Csefalvay & P. Bajusz
Faculty of Aeronautics, TU of Kosice, Slovakia

ABSTRACT: The contribution provides solutions to the impact of planned building of windmills exerted on the operation of radar equipment. The major negative factors involved have been determined and considered as to how the planned building of wind power stations influences the operation of radar systems developing a procedure of evaluating their effects.

1 INTRODUCTION

The submitted contribution provides one of the possible approaches of evaluating the impact of building windmills (WE) in a given location exerted on the operational parameters of the radio-location system (RLS). For the reason of providing the required coverage the RLS is protected by a protective zone of determined by the distances and height of plains of the protection zone band. If, in the protection zone, there are any obstacles which overlap with the determined planes, then deformation of the RLS coverage in the vertical plane may occur resulting in the loss of radar signal on flying objects.

2 LOSS OF RADIO-LOCATION SIGNALS RESULTING FROM SHADOWING

The importance and acuteness of the mechanism of any impact will depend on the designation of RLS and its operating environment. Among the most important influences of Windmill exerted on the RLS is the loss of signals as a result of shadowing.

The technical data imply the WE has a great cross-section area. In case when locating the WE in the vicinity of the RLS results in late in its shadowing. This is when the radiolocation shadow is generated in the vicinity of the RLS, see Figure 1. The dimension of such areas depend on the size and mutual distances between the WE, their number, distances from the RLS and the surrounding terrain.

If the height of the obstacle at small distances behind the WE exceeds the height of the WE, then the influence of the WE exerted on the reduction of the direct line-of–sight is to be neglected. If the altitude (height above see level) of the obstacle located before the WE exceeds the height of the WE, than the WE has no effect on the direct lined-of-sight of the RLS, which is entirely determined by the dimensions of the obstacle.

The implications of the shadowing can be quite successfully prognosed applying the methods of modeling and simulation. At performing modeling and simulation of the signal loss resulting form shadowing, a special software can be used which is capable of simulating the direct line-of-sight between the RLS antenna and the planned WE. Advantages may result from the use of such software which enable access into the digital model of terrain and thereby modeling obstacles in it.

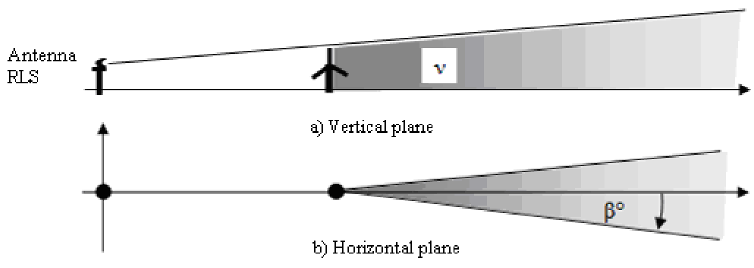

Figure 1. Mechanism of shadowing

The results from the simulation will reveal which windmills cause loss of radiolocation signals resulting from shadowing, thereby discarding them from the construction plan. The success criterion is the minimally acceptable shadowing that must not be present in the areas of interest.

The influence of shadowing of a WE exerted on the RLS is presented in Fig. 2.

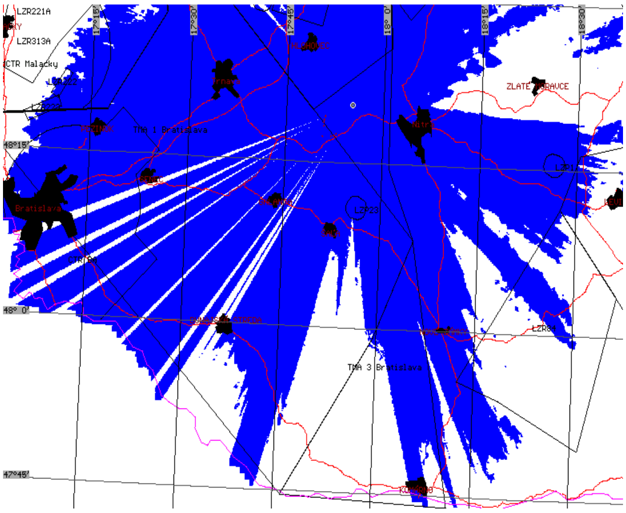

Figure 2. Shadowing of radar signals

3 MEASURED RADIO-LOCATION SIGNALS AS REFLECTIONS FROM WINDMILLS

Everywhere, where, the RLS is used for local airports, and Terminal control areas (TMA), the reflections from the WE are of the highest importance. It is due to the fact that such reflections may divert the controller´s attention and make it difficult for him to monitor further data displayed in the same place on the monitor (Klima trough Bálint). Such an image may also lead to the generation of false tracks of the target which may develop into a more acute problem for air traffic controller. The reflection may cover the targets and the radio-location information on the screen directly over or in the close vicinity of a windmill complex an in some cases may cause the loss of reflections of aircraft.

WE, as specified in the basic technical data section, has a great area of the stand, which is manufactured from conducting material reflecting electromagnetic waves striking it. The non-moving WE stands can be considered for a non-moving (fixed) target. Modern radiolocation systems are equipped with circuits for jamming fixed targets, so we assume that jamming the reflections and WE stands will no longer pose problems, provided that the RLS is operating in the mode of fixed targets suppression. The mechanism of RLS signals is presented in Fig. 3. The precondition of generating such reflections is the sufficient amount of reflected signals, received by the receiver antenna.

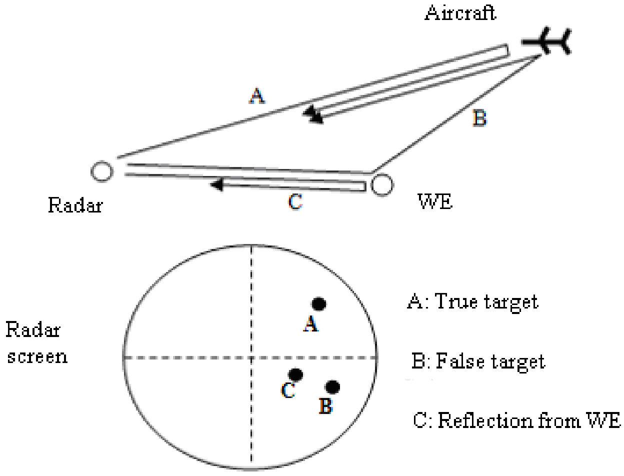

Figure 3. Mechanism of how reflections are generated

We suppose that false targets may result from the reflections from WE which are in direct line-of-sight of the radar. The fact that the WE is situated in the vicinity of the RLS is another precondition.

More complex problems arise in cases when the measured signals are reflected from the propeller blades, which, in line with the technical specifications, are designed to have a big area and built form conducting materials reflecting measured radiolocation signals. Under certain conditions, the signals reflected form the propeller blades may be evaluated by the RLS as moving targets.

This rate is to be probably changed along the entire length of the RLS. One of the ways of determining the maximum way of acceptable reflection is the use of so called protection maps.

At such a simplified map, the scales of reflections are seen in Fig. 4.

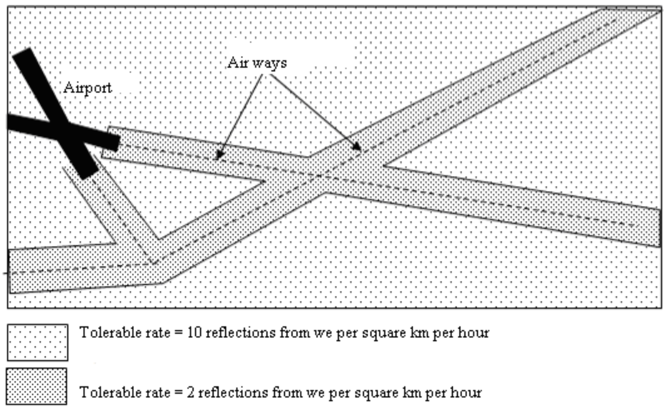

Figure 4. Reflections from windmills

When evaluating the reflections, we will proceed from the equation:

$$P_{odr} = \frac{P_V G_P G v \sigma \lambda^2}{(4\pi)^3 R^4 L} \qquad (1)$$

where L are losses occurring at propagation of the electromagnetic energy in the environment, G_P is the gain on receipt, G_V is the gain in transmission, λ – wavelength, R – distance between the WE and the RLS, σ the effective radar cross-section from which the signal was reflected and P_V is the transmitter performance. The success criterion is termed as the minimum tolerable rate of reflections from the WE per square km in an hour.

4 CONCLUSION

The operation of RLS is negatively influenced by four main factors. Among them are the mistakes in measuring the target azimuth, generation of false targets, loss of signal due to shadowing and degradation of signal as a result of multi-way propagation. When evaluating all the four factors, the key parameter is assigned to the terrain cross section on the connecting line between the WE-RLS and the distance between the wind mill and the radiolocation system. If there is no direct line-of-sight between them, with the distances increasing between them, the effects of building the WE on the RLS are substantially decreasing.

REFERENCES

Klima, J., Klimeš, J.: Výpočet intenzity elektromagnetického poľa v pásmach VKV a UKV (Calculating the intenzity of electormagnetic field in bads of VHF, UHF). Nakladateľstvo dopravy a spojov. Prague 1988.

Greving, G.: Modern Threats to Precision Approach and Landing - The A380 and Windgenerators and their Adequate Numerical Analysis. Paper ISPA 2004 Intern. Symposium on Precision Approach and Landing, Munich 10/2004.

Džunda, M.: Simulation of measuring distance using a DME system under conditions of interference. In: Trans & MOTAUTO '06 : 13. international scientific - technical conference : 25. 28. October 2006, Varna, Bulgaria. Varna : N.Y. Vaptsarov. Naval Academy, 2006. 4 p.

Bálint, J.: Rizikové faktory v bezpečnosti letovej prevádzky. (Risk factors in air traffic safety). Zborník z medzinárodnej konferencie „Letectvo 2006“. Univerzita obrany Brno, 2006.

Bálint, J.,: Možnosti využitia matematických modelov v bezpečnosti leteckej prevádzky.(Possibilites of using mathematical models in air traffic safety.) Zborník medzinárodného seminára „Znižovanie nehodovosti v civilnom letectve – 2003“. Žilinská univerzita Žilina, 2003, pages 37 ÷ 43. ISBN 80-8070-070-2