Exposure to Air Traffic Control Systems

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INTRODUCTION

A wide range of air traffic control (ATC) systems exists for air traffic surveillance, communication and navigation purposes. Exposure to these ATC systems is only rarely investigated up to now. Operators of these systems and the general public being and living closely in the neighborhood of these systems are exposed to the electromagnetic (EM) fields of these systems. Moreover, the EU-Directive 2004/40/EC [1] will result in new requirements on employers in the European Union concerning the exposure to electromagnetic fields. This directive will also affect ATC systems where workers are exposed. To our knowledge, only very limited procedures for exposure assessment in the vicinity of most ATC systems have been developed up to now.

MATERIALS AND METHODS

Fourteen types of ATC systems are here identified and categorized according to their functionality. The following sources of electromagnetic (EM) radiation are considered:

- category I "**Communication**": (i) Very High Frequency/Ultra High Frequency (VHF/UHF)-transmission centers and (ii) trunking antennas
- category II "**Navigation**": (iii) Instrument Landing System (ILS), (iv) Non-Directional Beacon (NDB), (v) Distance Measuring Equipment (DME), (vi) VHF Omni-directional Range (VOR), and (vii) radiolink
- category III "**Surveillance**": (viii) primary radar, (ix) secondary radar, (x) surface radar, (xi) multilateration, (xii) microwavelink, and (xiii) beacons
- category IV "**Meteo**": weather radar (xiv)

For each type of source, mostly 3 to 5 sites (installations) are investigated. In our study, a total number of 50 sites and 1073 locations are investigated.

The fields are measured using appropriate electric- and magnetic-field probes and analyzers in the frequency range of 255 kHz to 24 GHz. For each type of equipment specific measurement procedures are developed and applied. Duty cycles have been determined experimentally and from the specifications of the ATC installations.

Max-hold measurements as a function of distance to the ATC equipment are executed. For *occupational* exposure assessment, the measurements are done close to the considered equipment such as control panels, antennas, cable connections, etc. For *general public* exposure assessment, measurements as a function of the distance from the antennas and outside the fence of the different sites are executed. "Minimum distances" are then defined as the distances outside which the electric and magnetic field levels of the systems do not exceed the ICNIRP reference levels for occupational and general public exposure, respectively. In this paper we will compare exposure values and exposure ratios with the ICNIRP 1998 guidelines [2].

RESULTS

Figures 1 and 2 summarize the ranges of electric field strengths and investigated frequency bands for all 14 categories of ATC installations for general public and occupational exposure, respectively. A data set is shown as a rectangle, its boundaries give the frequency and ranges of field strengths. Most systems are compliant with the ICNIRP reference levels except NDB (up to 881.6 V/m) and DVOR (up to 92.3 V/m) installations, for which minimum compliance distances are defined (see further). The reference levels are not exceeded for locations accessible to the general public.

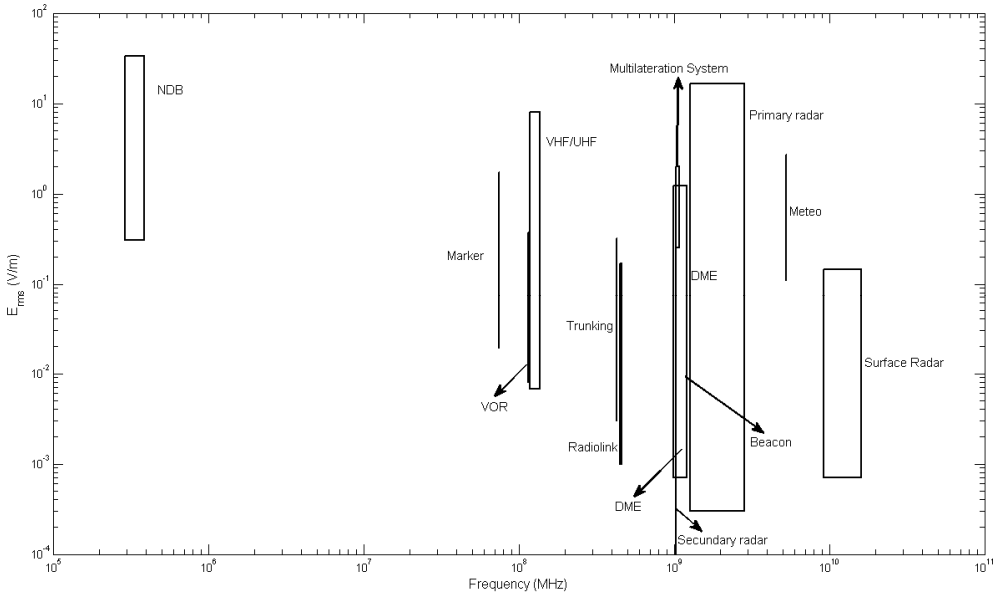

Figure 1: Ranges of electric field strengths for all 14 categories of ATC installations for **general public** exposure.

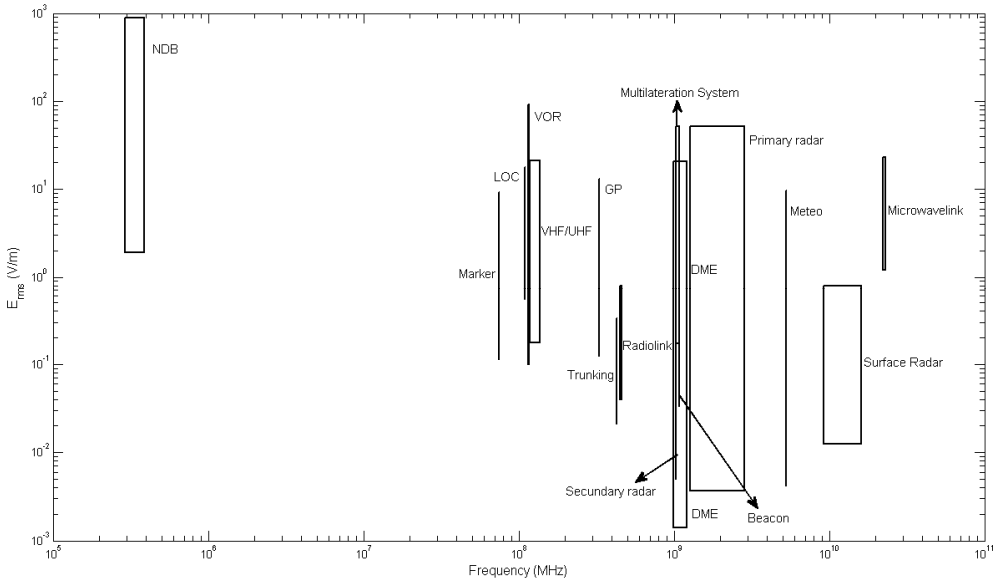

Figure 2: Ranges of electric field strengths for all 14 categories of ATC installations for **occupational** exposure.

For most ATC installations (VHF/UHF, trunking, ILS, DME, radiolink, radars,

multilateration, microwave links, beacons, weather radar) no additional measures are needed as the ICNIRP reference levels for workers and the general public are satisfied. The following additional measures are needed for the other ATC installations.

- A minimum distance for workers of 1.6 m from the NDB antenna and 0.5 m from NDB signal cable connection is advised for occupational exposure. For the general public a minimum distance of 10.6 m is advised. A fence should be installed around the antenna. When adaptations to the antenna have to be made, the antenna should be switched off.
- For NDB, the field levels exceed mostly the reference levels for opened control panel inside the control house. When closed, these field values are much lower (Joseph et al. 2011b) and satisfy the ICNIRP reference levels. Therefore it is advised to install controllers on the panel to enable control by workers with closed panel.
- A minimum distance for workers of 1 m from the central DVOR antenna is advised for occupational exposure. A fence should be installed around the antenna. When adaptations to the antenna have to be made, the antenna should be switched off.
- Different ATC installations (NDB, DVOR, roof of radars and weather radar, multilateration) should not be entered by visitors (general public), as the reference levels of ICNIRP for the general public can be exceeded near the antennas of these installations (e.g., minimum distances from the NDB antenna up to are 10.6 m possible).
- For radar towers, sensors which switch off the radar when entering the roof (where the radar antenna is placed) are often installed. These are very important as fields near the radar antenna might exceed reference levels.
- If possible, the power of some transmitters could be lowered (NDB, DVOR). This is not always possible as certain field levels have to be present to ensure safe air traffic navigation.

CONCLUSIONS

Electromagnetic exposure (occupational and general public) to air traffic control (ATC) systems is investigated experimentally at 1073 locations in the frequency range of 255 kHz to 24 GHz for 50 different sites. For all installations the ranges for the exposure values for workers and the general public are provided. For NDB and DVOR systems minimum distances outside which the field levels of the systems do not exceed the ICNIRP reference levels are presented.

ACKNOWLEDGMENTS

W. Joseph is a Post-Doctoral Fellow of the FWO-V (Research Foundation - Flanders).

REFERENCES

[1] Directive 2004/40/EC. Directive of the European Parliament and of the council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC); 2004.

[2] International Commission on Non-ionizing Radiation Protection, “Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up 300 GHz),” Health Physics, Vol. 74, No. 4, pp. 494-522, 1998.