MAPPING PUBLIC EXPOSURE TO ELECTROMAGNETIC FIELDS

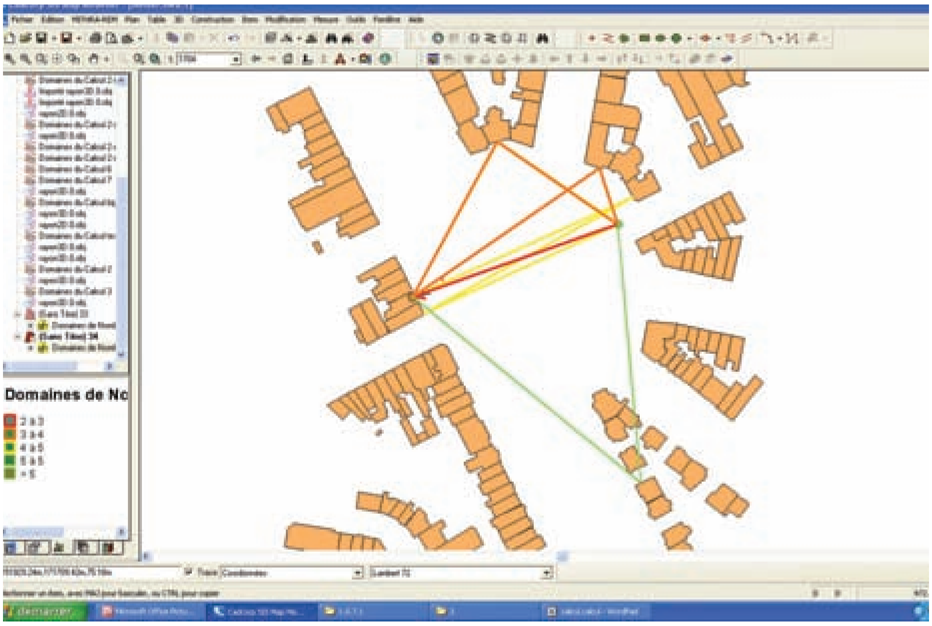
DO THE MANY ELECTROMAGNETIC WAVES THAT SURROUND US CONSTITUTE A REAL DANGER TO PUBLIC HEALTH? OR IS OUR CONCERN MISPLACED?

It seems very difficult to have a rational debate on the subject of the impact of electromagnetic waves on public health. The information just isn't available. Although operators make extensive use of simulation models to predict signal coverage, they tend to have little interest in modelling exposure to electromagnetic waves. Central and local government simply don't have access to the necessary tools to carry out their own modelling exercises. The result is that mobile radio projects go ahead based on incomplete information, and without assessing the risks to the public.

One of Europe's leading research and evaluation centres, the prestigious French Centre for Scientific and Technical Research in Construction (CSTB), is aiming to rectify this. They have been working with the French software house Geomod, to offer a solution – MITHRA-REM.

We are all surrounded by different kinds of waves. They provide us with energy (electric light, and heating), they transmit information (Wi-Fi, telephones, etc.). In fact they underpin many everyday services. However, they also have a less benevolent side: ranging in severity from a nuisance factor (such as noise pollution) through to discomfort, and possibly risks to our health.

The CSTB's acoustics and lighting team is working on ways to predict people's exposure to these different types of waves. To do this, engineers have learned to model not just the wave sources, but also the behaviour of the materials the waves encounter, ranging from simple surfaces (glass), complex objects (windows), to



Cadcorp's SIS Map Modeller offers numerous analytical tools.


A 2-dimensional view of the area of interest

whole buildings, and even entire urban neighbourhoods. Since acoustic and electromagnetic waves behave in similar ways, CSTB's engineers have been able to transpose their original noise transmission models to embrace the modelling of electromagnetism.

This is not the first time that Geomod and CSTB have worked together. Geomod is a specialist French geomatics company, and partner of Cadcorp, the UK based supplier and developer of web mapping and GIS software. The company has worked with CSTB since 2005, as joint supplier of the MITHRA-SIG acoustic mapping package. Putting down the second milestone in what may become a software suite, they have developed the MITHRA-REM application, which forecasts people's exposure to electromagnetic fields. The product clearly fills a gap in the market, since no other software of this kind currently exists, as Olivier Vandenbalck discovered when he was evaluating products for use in the Brussels region, on behalf of the Brussels Institute for the Management of the Environment and Energy (IBGE-BIM).

The MITHRA-REM application is based on Cadcorp's Spatial Information System (SIS), and it operates in three phases. First, users define their input data, which can include digital terrain models, building contours, and emission sources. They then calculate the propagation predictions using a geometric engine and a physical engine. Finally the system processes the data and communicates the results using different methods of representation.

Some basic principles of optics

Electromagnetic waves have some fundamental properties. They propagate at the speed of light. They can be added or subtracted depending on their shape and amplitude. They always travel by the quickest possible route. And they bounce off obstacles (by reflection and/or diffraction), with a force that varies from one material to another. So to be able to model the degree to which different points in space are exposed to electromagnetic waves, we need precise information about both the terrain (buildings, topography, materials, roofs), and the antennae emitting the waves (their height, orientation, the emission wavelength, and other characteristics of the waves).

A complex modelling process

CSTB chose to model all the "routes" between pairs of points (antenna and receiver), including interactions with the environment (reflection, diffraction). They then compute the complex vector electric field associated with each point-to-point route, taking account of the radiation pattern of the antenna and of the materials encountered. It is left to the user to choose the density of the reception points (e.g. one point per metre, one every two metres, etc.). It is a decision which affects the speed of calculation. For example, it will take four times longer for each halving of the distance between points. It is also up to the user to set the number of reflections, bearing in mind that each "bounce" reduces the intensity of the wave by a significant amount.

Which data?

GIS has an obvious role in managing the input data, which can include point clouds, grids, and digital terrain models of all kinds. The situation is a little more complex for buildings. They have to be modelled in terms of height, number of storeys, and material. And material can be a represented as composite value - such as 70% reinforced concrete/glass. This kind of information is rarely available in a spatial database. Where spatial data is available, it is sometimes necessary to reformat it. In practice most digital models and 3D databases are easy to convert, and the IGN Topo database can be used directly without conversion.

The software user defines a default material, which can then be modified building by building, or by groups of buildings. The user also enters the ground material (e.g. tarmac in cities, farmland in the countryside, plus lakes, car parks and green areas). The digital model allows for the association of textures with buildings. Although textures are not involved in the modelling computations (which assume only one material per façade), MITHRA-REM does allow you to view them.

The user must then describe the antennae (which can include several transmitters) and the structure that supports them. The first step is to locate antennae geographically and then enter details via an appropriate dialogue box for: azimuth, orientation, beam angle, power, gain, radiation diagram, frequency range, etc.

Users can also retrieve descriptions directly from an XML file and access a library of descriptions created by the manufacturers of the main antennae currently in use. By identifying the characteristics of each antenna and each transmitter, the user can then establish their contribution to total emissions.

Numerous methods of representation

The model is ready to start computing once the number of reflections has been set, along with the area to be modelled, and which antennae to include. The process can take anything from a few minutes to a few hours, depending on the size and complexity of the network concerned. The mapping window then shows a dynamic view, which may be vertical (cross sections, status of façades), horizontal (exposure surface 1.5 m from the ground, 4 m from the ground…), in 2-D or 3-D, or even presented in the form of computation points (with no interpolation between points).

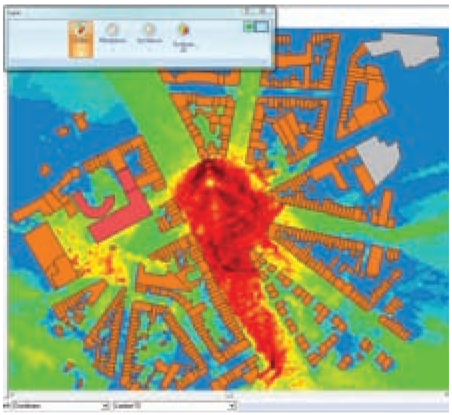
The results can also be displayed as isolines with different degrees of smoothing. The GIS capabilities can be called into play to perform simple calculations such as the percentage of the building's façade subject to a given level of exposure, or to identify hotspots. GIS can also be used for other purposes. If the user knows the population of a block for example, he or she can include this information, just as they can with any location-related data.

Since the model is stored in memory, there is no need to repeat the calculations in order, for example, to change the power parameter of an antenna or to delete a particular antenna from the result. This makes it possible to explore the risks of a project in depth. Each view can be exported to enhanced PDF format, including the descriptions of the buildings and antennae.

The strengths of an application like MITHRA-REM, is that it fills a gap in the information chain. Given that telecommunications operators are reluctant to model electromagnetic waves, other agencies such as local authorities or service companies can step in to offer their services, and contribute information which local people can trust. The software's joint publishers do not intend to stop with a modelling solution for electromagnetism. They intend to capitalise on the investment in interfaces, the data sources and the computation engines, by combining MITHRA and Cadcorp SIS technologies in a complete suite of products. Their future plans are to include applications for calculating solar potential (MITHRA-SOLIS), and pollution (MITHRA-POL).

How Brussels manages its mobile phone operators

Following a royal ordinance which set emission standards for mobile phone



Bringing spatial analysis of GIS into play

antennae, any new installation in Belgium now requires official authorisation. A ministerial order in 2007, set this exposure standard at 3 volts per metre, at any time, and for any publicly accessible area within the Brussels region. It was then decided to share this emission limit between the four mobile network operators present in the Brussels region. The outcome was a limit of 1.5 volts per metre per operator (not 0.75 volts as might be expected, as distribution is not a matter of simple division!). The Brussels Institute for the Management of the Environment and Energy (IBGE-BIM) was given the task of monitoring the exposure of people in the Brussels region when issuing permits to operators, thereby ending a two-year freeze on all projects that had resulted from the lack of information available from the regional authority.

Olivier Vandenbalck and his team at the IBGE had less than a year to set up an effective monitoring process. After going the rounds of the different simulation software, they opted for MITHRA-REM, which met their specifications and passed the tests with flying colours "despite the newness of the product".

Binding resource and results targets

The outcome is a process which administrations in other countries can only dream about. The strategy adopted by the IBGE obliges the four mobile operators to use MITHRA-REM in preparing their applications, which are then forwarded to the IBGE. In return for this commitment to provide modelling outcomes, the regional authority provides operators with the 3D database of the region (Urbis 3D) on which to carry out their simulations. The model results are then checked by the IBGE and, once accepted, the reports are made available to local authorities to publicise to their communities. "In the first phase, we have concentrated on mobile phone operators. Communications networks run by the emergency services, the police, the fire brigade and the army will follow", explains Olivier Vandenbalck.

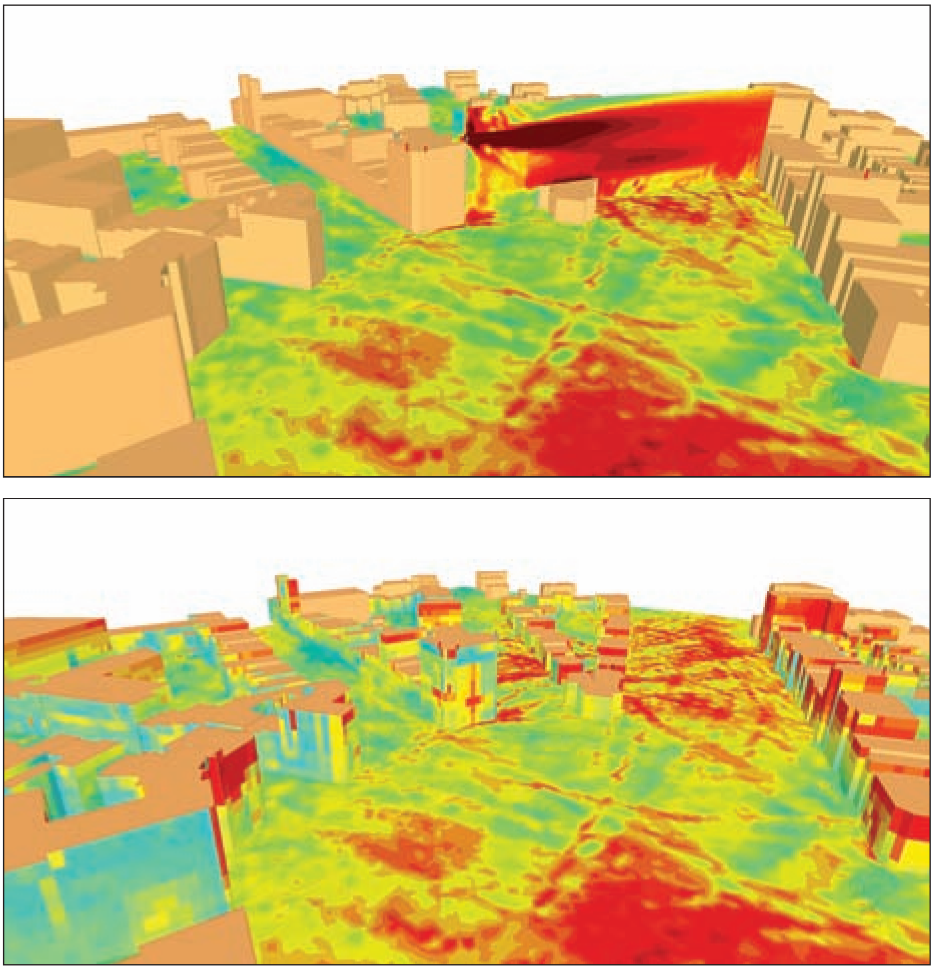
Although a simulation exercise provides valuable results, it can never give a full account of reality. "The actual emission levels always have to be calculated, because they vary in line with variations in network usage by time of day, and day of the week, for example." adds Olivier Vandenbalck. "The calculations are not based on the maximum level but on a "mean" level (the nominal maximum level minus a certain number of decibels) which has been set on the basis of academic research." What matters above all, is the ability to identifying places where there is a high concentration of exposure – "hotspots" – even at normal times.

By extending the use of this type of analysis, the Brussels region hopes to influence the strategy of the operators towards an antenna network that is both denser (and better suited to service provision), and also less powerful, in order to limit the exposure of its citizens to electromagnetic radiation.

Links:

Cadcorp – www.cadcorp.com
Geomod – www.geomod.fr
Centre Scientifique et Technique du Bâtiment – www.cstb.fr
A version of this article originally appeared in SIG La Lettre, as 'Cartographie de l'exposition aux champs radioelectriques'. SIG la Lettre is a monthly GIS newsletter published by the independent publishing company Rouge Vif. See their web site at www.sig-la-lettre.com for details on the annual GIS conference organised by SIG la Lettre, which will be held at the l'Ecole Nationale des Sciences Géographiques (ENSG), 17-19 May 2011.

Article by Françoise de Blomac – SIG la Lettre – e-mail: deblomac@sig-la-lettre.com



The area of interest displayed in 3 dimensions