URBISTICS
REDUCTION OF URBAN POLLUTION AND FOREST FIRE FIGHTING AND SURVEILLANCE

J.C. Hadorn, BSI, Bureau de Service et d'Ingénierie, Primerose 27, 1007 Lausanne, Switzerland
Dr. B. Saugy, BSI and EPFL, Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland
B. G. Dürr, Dürr & Partners, Management and GIS Consultants, 57 Punkhorn Pt., Mashpee, MA 02649

ABSTRACT

Studies at the Swiss Federal Institute of Technology in Lausanne (EPFL) and the Municipal and Energy Research Center in Martigny (CREM) have led towards the identification of original town management and complex systems concepts. They integrate planning, cadasters, and real time management under the neologism of urbistics. To illustrate an example this presentation deals with the modeling of pollution reduction strategies based on modifications of heating systems and adaptation of the public and private transportation networks in the Swiss conurbation of Lausanne. It also describes the installation of a system for forest fire surveillance and fire-fighting in the Bouches-du-Rhône in France. The application includes the monitoring of fire-fighting vehicles via satellite communication and alerting the population with automated telephone calls controlled by numeric models forecasting affected areas. These two examples show how to employ map based and urban data for the benefit of the public, the public security and the environment. Starting with the concepts and passing through real applications, this presentation covers the stages right up to final realization in order to explain the limits and advantages of these methods. In fact, the strategies for pollution reduction studied are currently imposed on the communities concerned and the fire surveillance and fighting system is already in use in Aix-en-Provence.

1 AIR POLLUTION ANALYSIS MECHANICS

1.1 Case Study

The study of air pollution reduction measures requires detailed knowledge of all of the mechanisms linking causes to effects, in a way that action may be taken against the most significant causes without relocating the impacts. Figure 1 describes the principal stages for the geographic description of emission sources. The emission model creates the relationship between the processes and their characteristics. Most emissions are linked to energy use (figure 2), hence, a good description of the energy demand of households, workplaces and transportation systems, guarantees the detection and description of the vast majority of pollution sources.

Once established, the model can aid the evaluation of the influence on the impacts of various intervention scenarios. These scenarios would include the study of changes to energy processes such as burners or motors, or to different types of infrastructure usage with traffic flow restrictions or

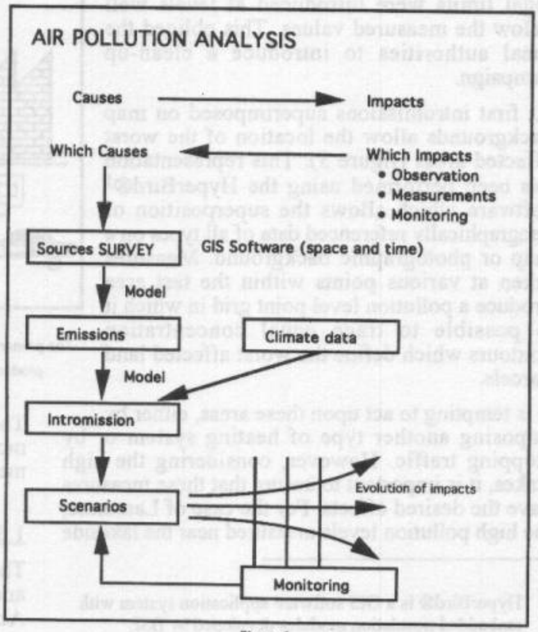

Figure 1

urbanism including the relocation of damaging activities.

At the outset of these intervention scenarios, it is essential to monitor all of the parameters, firstly to calibrate or confirm the models, secondly to verify the success of the measures. Lastly monitoring is required in order to plan for special actions concerning interventions on infrastructures in real-time, such as using cleaner fuels when pollution passes a certain limit, or imposing restrictions on traffic during hot calm weather.

In the wake of smart house concepts which efficiently manage households come urbistics or smart town measures for the optimal functioning of whole communities.

1.2 Intervention Process

Studying the noxious effects linked to air pollution allows us to distinguish the pollution levels observed in order for them to be reduced to within the legal thresholds and, more importantly, below the danger levels.

For the example of Lausanne in 1990, federal legal limits were introduced at levels well below the measured values. This obliged the local authorities to introduce a clean-up campaign.

At first intromissions superimposed on map backgrounds allow the location of the worst affected areas (figure 3). This representation has been performed using the HyperBird®[1] software which allows the superposition of geographically referenced data of all types on a map or photographic background. Measures taken at various points within the test area produce a pollution level point grid in which it is possible to trace equal concentration contours which define the worst affected land parcels.

It is tempting to act upon these areas, either by imposing another type of heating system or by stopping traffic. However, considering the high stakes, it is important to ensure that these measures have the desired effects. For the case of Lausanne, the high pollution levels measured near the lakeside might provoke the initial reaction of banning traffic in that district. However, the indices showed that the pollution could in fact have their source from surrounding neighborhoods, and the concentration near the lake being caused by the topographic and climatic situation. If this is the case, the actions would not have the desired results and would perhaps have caused irreversible economic effects.

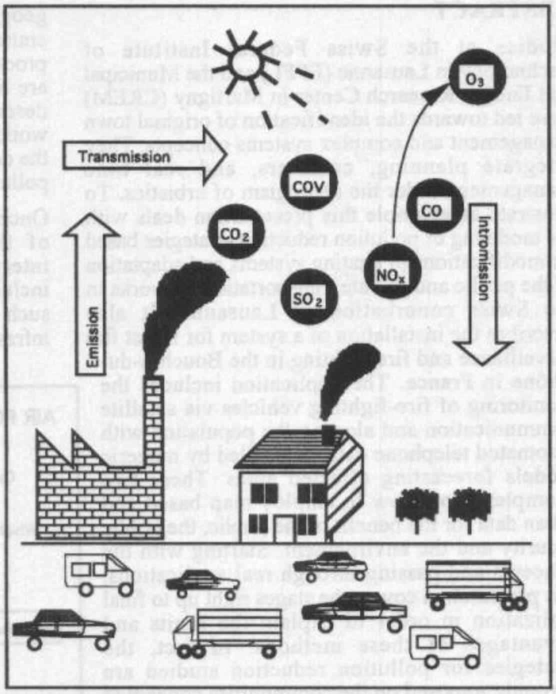

Figure 2
The primary pollutants such as NOx and COV interact under the sun's effect, producing ozone which is a particularly noxious secondary pollutant.

The local authorities decided to build a complete model in order to evaluate the impact of proposed measures.

1.3 Initial Reference State

The three emission generators (heating, industry, and traffic) were modeled using HyperBird®. According to currently available data it is possible to describe the punctual emission levels for known

1 HyperBird® is a GIS software application system with embedded simulation modules developed by BSI, Lausanne

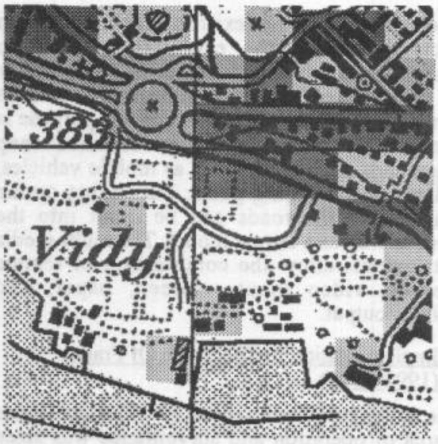

Figure 3:
Pollution levels indicated by the shading of the squares

large scale emitters, linear emission fields for main traffic axes and the emission distribution according to the population density (figure 4).

The emission levels from a combination of heating, industry and traffic were entered into the meteorological model POLYTOX[2]. This model subsequently allowed the study of the transformation and transportation of pollutants in prevailing climatic conditions in order to reconstitute a geographic representation of intromissions. The comparison of measures with simulated intromission allows the calibration of emission and meteorological models. In the case of Lausanne, an acceptable correlation was attained between the measured and simulated intromissions., despite its particular topography including numerous valleys and the thermal effects of the lake

1.4 Construction Of The Intervention Scenarios

The analysis of energetic processes and their improvements allows the identification of the possible emission level changes.

Amongst the processes taken into account are :

- District heating using gas fired co-generation units instead of industrial oil-fired heaters
- Low NOx heaters
- Spread of catalytic converters
- Use of catalytic converters in diesel engines (not yet on the market)
- Offering public transportation enhancements or reinforcement

For each of these processes and rules, it is important to take the market penetration procedure into account

The construction or extension in Lausanne's use of a district heating network can take several decades, whereas, all cars on the road will have catalytic converters installed within the next 10 years, and most of the trucks and heavy equipment presently in service will still be so in 10 years time.

Data concerning traffic generation linked to access requirements to residential areas, businesses and

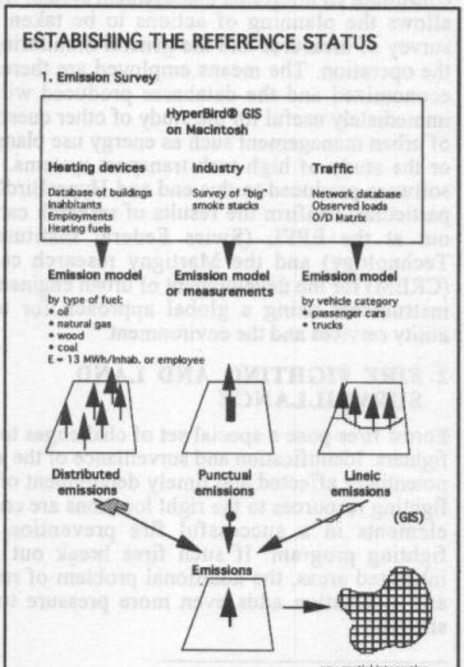

Figure 4

2 POLYTOX is a diffusive-convective 3D concentration model developed by Systems Consult, Bern, with assistance of SEDE SA, Vevey

shopping centers were introduced into the POLYDROM[3] model which allows modal assignment and traffic forecast calculation. An increase in public transportation capabilities, a new freeway exit or a traffic ban changes the traffic distribution and, taking the engine types into account, can produce a new emission state.

Through a combination of technical, legislative or management measures it is possible to construct emission scenarios.

The model POLYTOX evaluates these emission scenarios in terms of intromission. It is then possible to choose the actions which should lead to reduction in air pollution to levels imposed by the law.

This evaluation aids the local authorities in their choice and justification of intervention methods. The system which is set up should guarantee the control of effects and the monitoring of the action.

The combination of these different models, thus constitutes an integrated management system which allows the planning of actions to be taken, the survey of measures and the general monitoring of the operation. The means employed are therefore economized and the databases produced will be immediately useful for the study of other questions of urban management such as energy use planning or the study of high-tech transport systems. The software produced to this end and HyperBird® in particular, confirm the results of research carried out at the EPFL (Swiss Federal Institute of Technology) and the Martigny research center (CREM) for the development of urban engineering instruments using a global approach for town utility services and the environment.

2 FIRE FIGHTING AND LAND SURVEILLANCE

Forest fires pose a special set of challenges to fire fighters. Identification and surveillance of the areas potentially affected and timely deployment of fire fighting resources to the right locations are crucial elements in a successful fire prevention and fighting program. If such fires break out near inhabited areas, the additional problem of rescue and evacuation adds even more pressure to the situation.

3 POLYDROM is a transportation model developed by Systems Consult, Bern

This operation combines existing graphic data with objects describing the essential information necessary to satisfy the given surveillance and/or fire fighting objectives, superimposed onto scanned maps. The system used for this purpose is HyperBird®, which manages scanned map backgrounds and objects such as mobile vehicles, buildings or swimming pools. Depending on the requirements, the roads can be input into the system as well as a terrain model. The multi-media inputs/outputs allow the combination of remote measures, video inputs, screen, paper, and telephone output.

2.1 Implementation In The South Of France (1992-1993)

In the southern French region Bouches-du-Rhône the area of operation and surveillance was sized and defined. Large scale maps covering the entire area, and smaller scale maps, with detailed topographical information, were scanned and entered as background information into the database of HyperBird®. The area of surveillance was then divided into zones. Combustion characteristics and flammability of the vegetation in each zone were also added to the database. Together with wind data, this determines the extent of the different zones in danger.

Information about buildings and residences such as, locations, telephone numbers and the existence of swimming pools equipped with motor pumps also became part of the database.

Fire-fighting vehicles were equipped with Global Positioning System (GPS) satellite receivers/transmitters in order to be tracked and their geographic positions pinpointed and displayed by HyperBird® (figure 5).

Voice messages were prerecorded and included in the database. These messages cover different scenarios, and are to be broadcast in case of emergencies to individuals or organizations by a separate program that communicates with HyperBird®.

2.2 Operations

When firemen at monitoring stations are informed of an outbreak of fire by scouts, they can use HyperBird® to determine the zones of progress of the fire according to wind speed and wind direction. HyperBird® can also employ its database of combustion characteristics and flammability of the vegetation to predict the extent of the fire and the different zones in danger. Figure 1 shows the visual output of these calculations.

The application telephones inhabitants of threatened buildings and residences in priority order based on the degree of threat. It relays a prerecorded message to the inhabitants according to their situation. Residents in dwellings with swimming pools equipped with pumps can also be informed about actions to be taken.

The operators responsible for coordinating the fighting of an incident, monitor the progress directly on video terminals. HyperBird® controls three screens simultaneously in order to facilitate supervision of interventions. The information displayed is:

Screen 1: The control panel or file information.

Screen 2: A large scale color map to coordinate the overall intervention.

Screen 3: Detailed information about known resources and risks (swimming pools with motor pumps, water reservoirs, surveillance vehicles, fire trucks, schools, hospitals, etc.) projected onto a color map (scale 1:25,000). This map may be replaced by an aerial photo that indicates detailed topography and the ground coverage.

Information from aerial photos can be complemented by other photographic data, or even recorded or real time films can be accessed via QuickTime™ within the object files concerned.

The operators can determine zones affected and the time required for interventions from the available data such as, the fire front and the positions of fire trucks or rescue vehicles. They can guide the vehicles to their destinations even through areas obscured by smoke. They inform the drivers of the routes to take between their current location and their target site, by monitoring the positions on the 1:25,000 scale map displayed on screen 3.

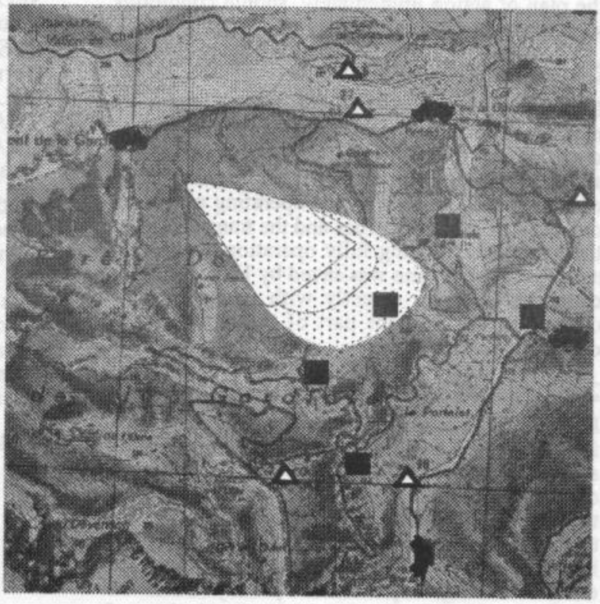

Figure 6

HyperBird® application for the surveillance of incidents in the South of France. Propagation model of fire - Location of fire trucks and dwellings with pools.

2.3 Benefits

Clearly, the actual forest fires are ultimately put out by fire fighters. No high tech system will replace this part of the mission. But fire prevention as well as fighting can be greatly assisted by a system such as HyperBird®. It significantly improves the logistics and the effectiveness of interventions. It cannot only better guide fire trucks and rescue vehicles to the most critical destinations but also guide them out of danger areas, thus greatly improving the safety of fire fighters. By letting the system communicate with residents in potential danger zones, the operators can focus on the task of minimizing the spread of a forest fire. The system lets them select optimal intervention areas. Once an area is secured, personnel and equipment can quickly be redeployed to another strategic location. The system also lets the operators change the plan of action immediately, should conditions such as, wind direction change.

2.4 Implementation Time Frame

Implementation was accomplished in about 12 months. Some extensions to HyperBird® were made during this time and are now a part of the standard product. Because of the user friendliness of the system, training of the operating personnel did not pose any difficulties and the transition from the test phase to being fully operational was very smooth. A lot of time was saved by Hyper Bird®'s capability to work directly with scanned maps, circumventing a major part of the cumbersome digitizing process.

2.5 Financial Considerations

Payback for this investment in high technology is a function of the frequencies of forest fires and the areas affected. At current timber prices, a reduction of the burnt area by less than a hundred acres over the lifetime of such an installation already pays for the incremental investment. Potential saving of human lives, and of livestock through improved early warning capabilities justify such an installation in many areas. Reduction in loss of property will not only benefit those affected directly, but the entire area through reduction of insurance rates.

3 CONCLUSION

The two examples highlight the possibility of developing scientifically advanced applications or, more directly, those centered around real-time management of buildings and infrastructures. They contribute towards materializing the urbistic concept which allows the use of geo-addressed data to be employed within a system of better resource management, using simple methods which also exploit numerical databases presently being collected as well as graphic documents which are already available for numerous applications.

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