A web-based approach for the evaluation of acoustic performance of development designs and assessment of performance of mitigation elements

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ABSTRACT

Maximising the community's investment in efficient transportation networks is the cornerstone of sensitive development, helping businesses and families thrive. However, meeting the legislative requirements around noise and air pollution issues has significantly increased the workload for national, state and local governments, authorities and industry. Web-based spatial and 3D visualization technology can be used to assist planners, engineers, architects and environmental practitioners to rapidly evaluate the acoustic performance of different development design options and noise mitigation strategies. The ODEN platform discussed in this paper provides an easy to use web-based interface through which a number of noise and air quality issues can be examined and addressed. These include assessment of the acoustic environmental baseline, performance of design options, comparison of mitigation strategies and quantification of impact on population. The system dramatically reduces the time and resources traditionally required to perform such analyses allowing planners, engineers and architects to more effectively deliver projects with an improved acoustic environment.

Keywords: Noise Modelling, Air Quality Prediction, Community Noise, Action Planning, Mitigation Design
I-INCE Classification of Subjects Number(s): 52, 68, 76

1. INTRODUCTION

1.1 Socio-economic background

The rapid pace of urban development and creation of new towns has been the backbone of economic growth in the developed world since the 1950s.

That dense style of development, with vast infrastructure and roadway costs, has been adopted by emerging powers in developing countries to bring billions of people out of poverty.

With brisk economic development come added pressures: an improved quality of life and better care of the natural environment. Indeed these competing challenges are encompassed in the “mission statements” of many countries within the Asia-pacific region in particular as issues which need to be addressed to ensure dynamic and sustainable city growth in the future.

1.2 Technology to the rescue

Fortunately, and in accordance with Moore’s Law(1), information technology infrastructure has grown along with transport infrastructure in the last several decades. Of particular interest is the massive increase in the usage of the internet which as shown in the graph below has soared.

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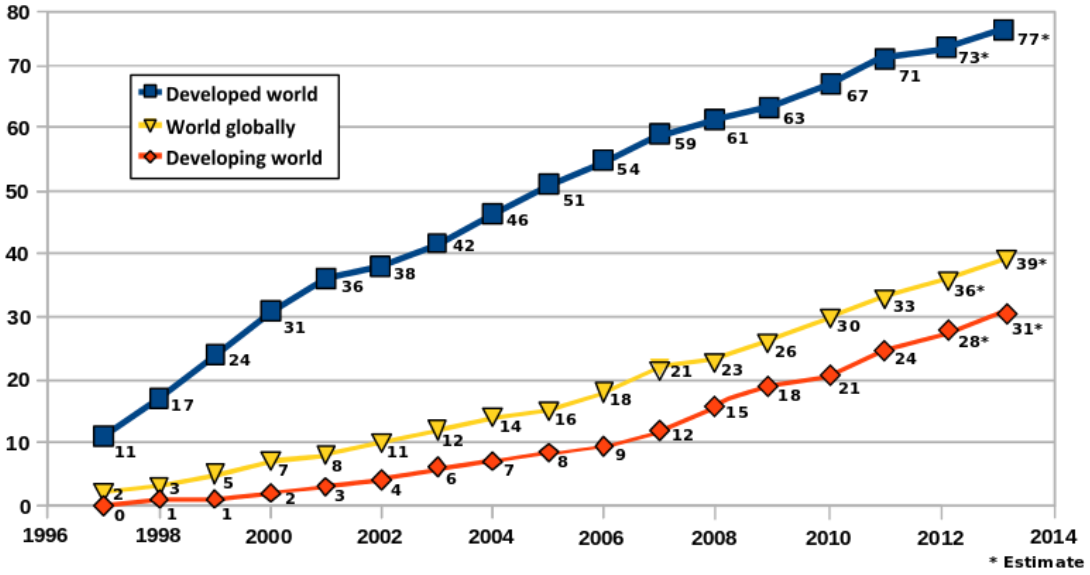

Figure 1 – Internet users per 100 inhabitants (2).

As most are well aware the medium permeates our daily lives in part due to cost and availability and partly due to the delivery of entertainment content and applications. While the internet has for a long time been used to disseminate the results of scientific endeavours, harnessing the technology for the provision of scientific and engineering user applications is still relatively new.

The ODEN system described in this paper is such a web-delivered application providing the capability to model and assess environmental noise and air quality issues. The technology allows for:

- Rapid assessment of noise and air pollution from man-made structures;
- The flexibility to handle a near limitless number of infrastructure design options;
- Support of noise mapping for road, rail, industrial and air transport;
- Support for road and industrial air quality modelling; and
- Comparison of results to a number of global best-practice sets.

The system cuts planning and modelling time from days to minutes by allowing for rapid iteration through design options as well as easy-to-use edit tools. The system is preconfigured to support the regulations of those countries in which it is deployed.

2. ABOUT THE SYSTEM

2.1 Infrastructure Works Planning Tool

ODEN is an online application, that is simple to use, requires little operator training, and utilises preconfigured baseline data to assist government planning bodies, engineering and construction companies and environmental consultants in rapidly and effectively dealing with ever-increasing requests for environmental assessments. ODEN provides organisations with the capability to carry out:

- Large-area strategic noise mapping;
- Broad-brush assessment and quick scenario iteration during preliminary planning or scheme design of road infrastructure, housing or building development projects;
- Detailed noise assessment of finalised designs of road infrastructure, housing or building development projects including statistics on exposure to population;
- Noise assessment for future traffic flow conditions predicted for transport projects such as road widening, speed change or road network expansion;
- Review and assessment of noise environment with short turnaround time;
- Design and comparison of different mitigation measures e.g. noise barrier, and their comparison; and
- 3D presentation of noise assessment results enabling public engagement

2.2 System Architecture

ODEN has a flexible multi-tiered architecture comprising a Presentation Tier, Logic Tier and Data Tier. The Presentation Tier revolves around a rich internet application (RIA) web client, a 3D web client and an HTML web client. The Logic Tier is comprised of the Oden Application Server (the heart of the system) that handles the project management, job control, spatial data I/O and modelling logic.

The Oden Application Server is web services based, allowing integration into different packages across just about any computing platform. Oden consumes and houses data in a spatial RDBMS.

3. MODELLING BASICS

3.1 Model Creation

The first step after logging on to the system is to generate a project in which assessments are carried out. This is as simple as naming the project and defining an area of interest. The following figure shows the resulting view for the user.

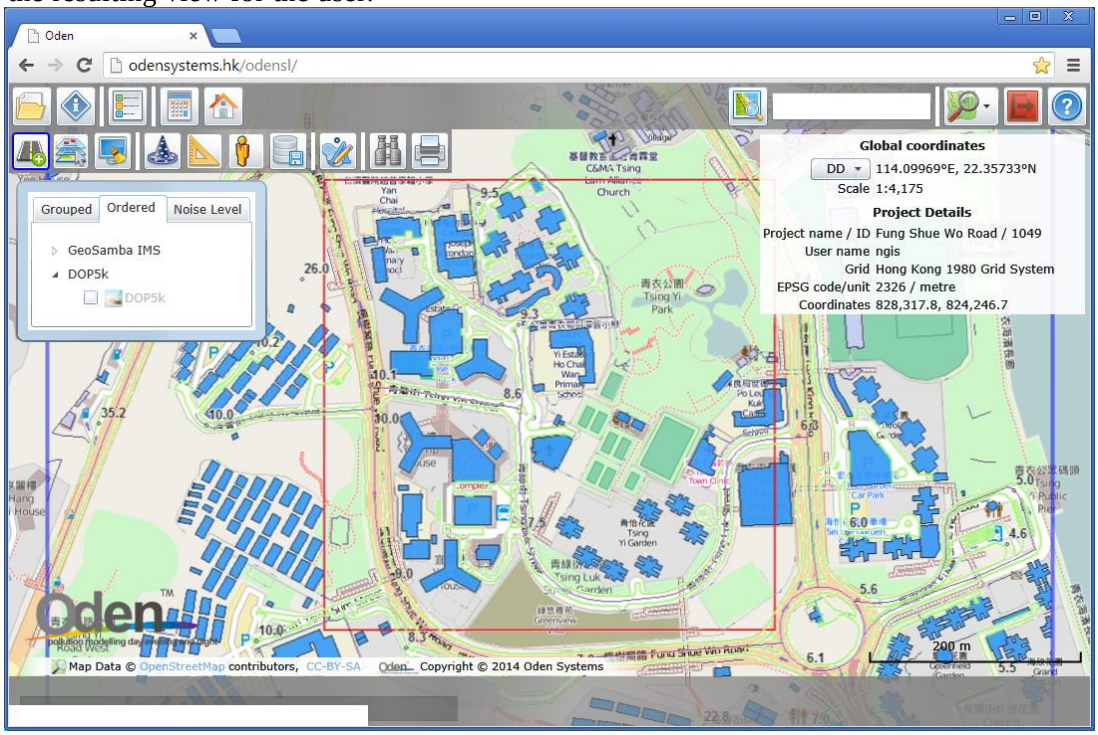

Figure 2 – ODEN initial project view.

3.2 Editing Data

Editing the base data is simple and very importantly it is validated upon input. This eliminates much of the manual error which can arise as a result of desktop editing of base data sets. This is achieved through the use of wizard like interfaces and validation routines to streamline data input. In the figure below a barrier entry wizard is used to place a cantilevered barrier next to the road in question. The process takes about 30 seconds.

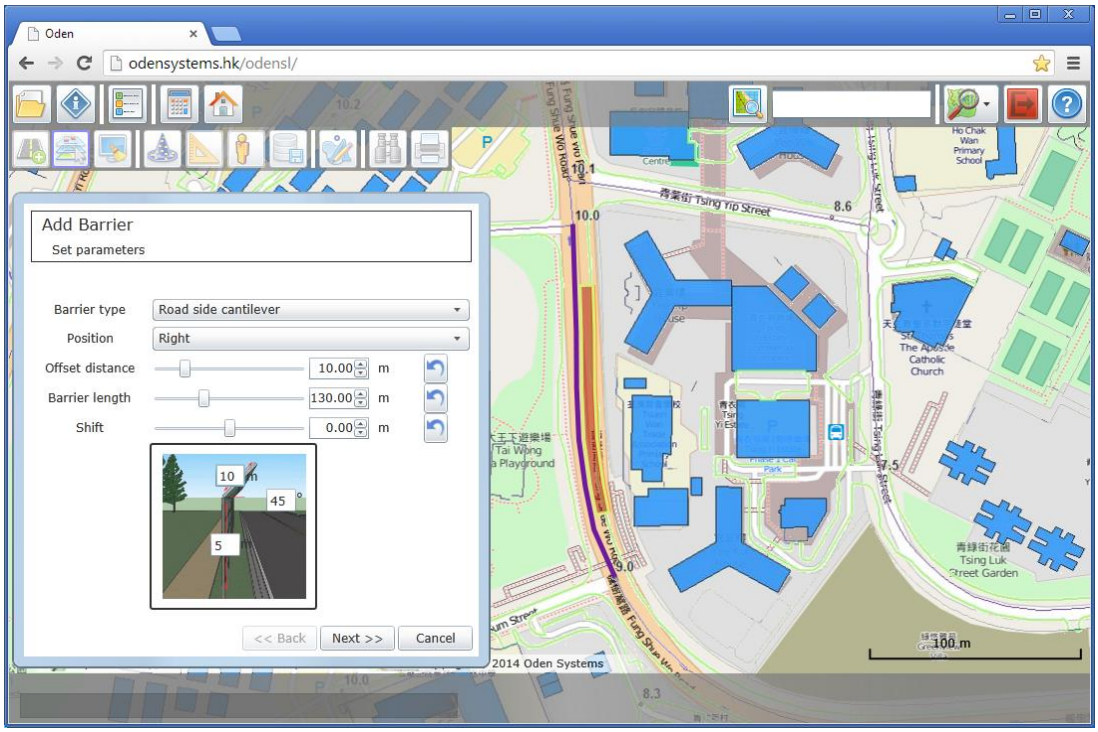

Figure 3 – "Add Barrier" wizard.

3.3 Running Calculations

Once the user has checked that the base data meets requirements or has added in modified elements, a calculation request may be issued. Multiple regulations are supported and the system is CNOSSOS-EU ready. Standard calculation types include: single or multi-storey assessment point calculation, 2D assessment grid calculation, 3D at façade calculation and vertical screen calculation. The process is simple and job status is reported back to the user as in the figure below.

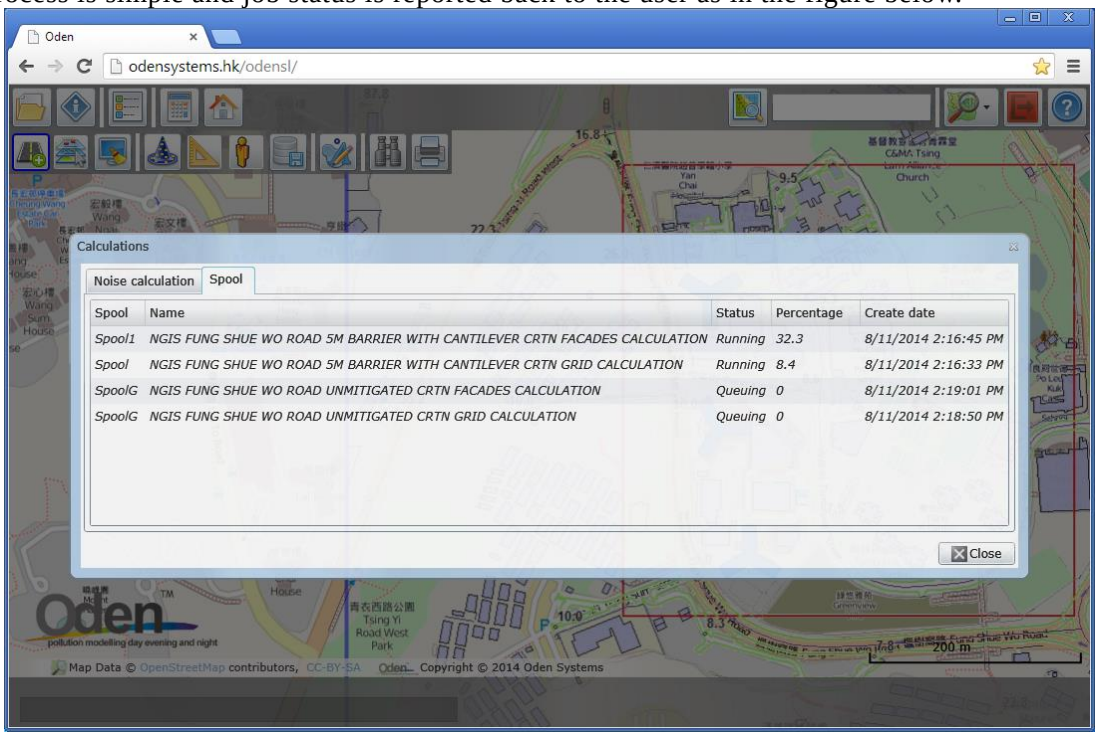

Figure 4 – Calculation management in ODEN.

3.4 Presentation Outputs

A number of presentation formats are available within the system including 2D and 3D views as well as charts and graphs. The figure below shows a selection of these.

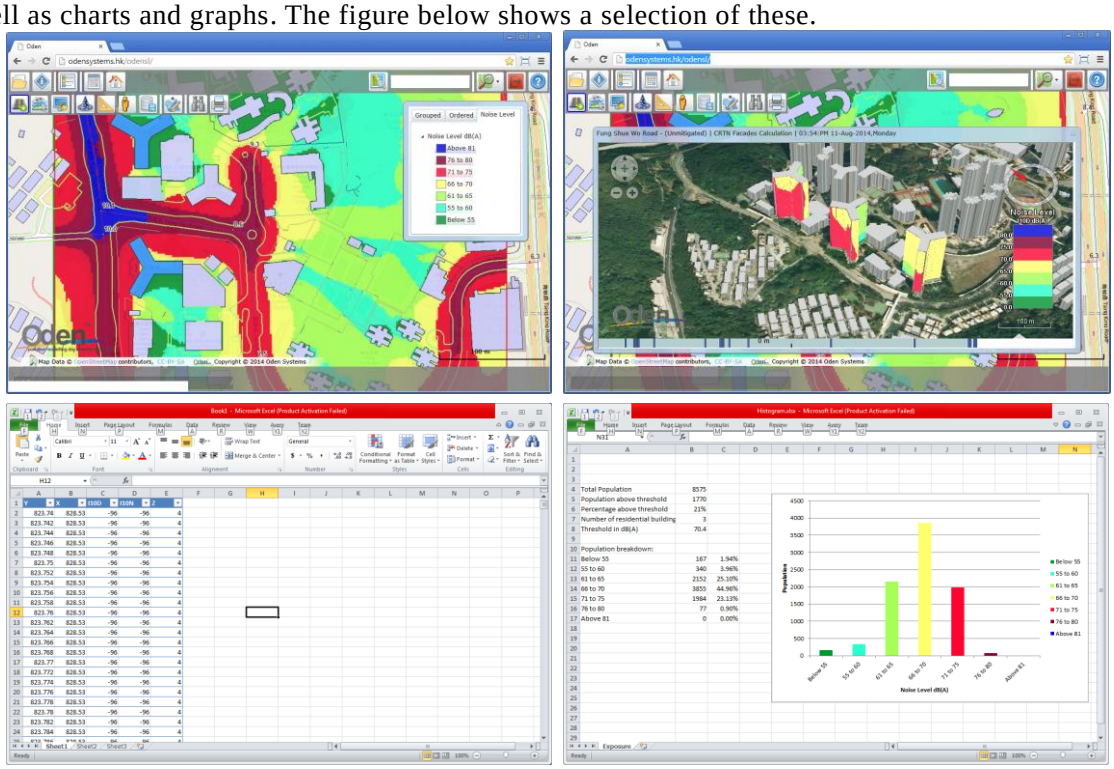

Figure 5 – Presentation Outputs from ODEN.

4. PERFORMANCE ASSESSMENT

4.1 Comparing Mitigation Strategies

One of the main system uses is that of comparing different mitigation strategies in terms of number of people protected verses cost.

Strategies that can be examined include fitting of measures such as noise barriers and enclosures, treatment with low noise road surfacing, introduction of architectural fins as well as changes to the layout of new building structures to be developed.

For ease of management, different options to be tested can be stored in project. A simple Project Manager interface assists with this task

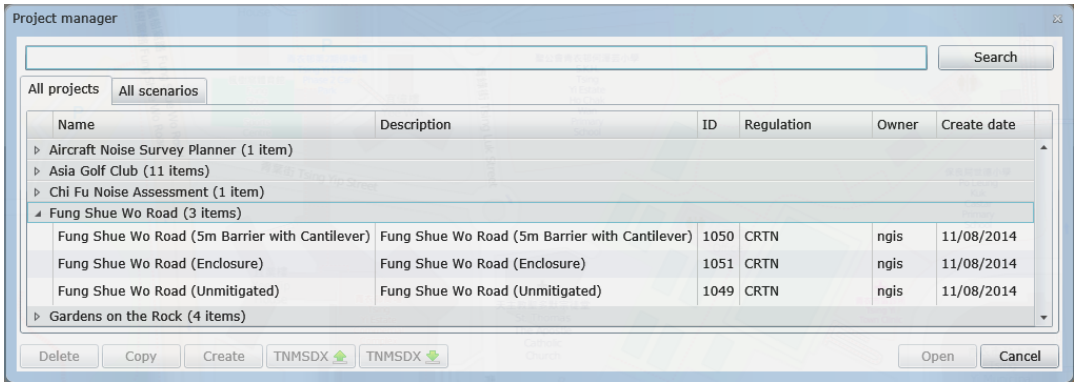

Figure 6 – Project Manager.

In the following example we can see the effect of a cantilever barrier compared with a full enclosure. The baseline case is also shown.

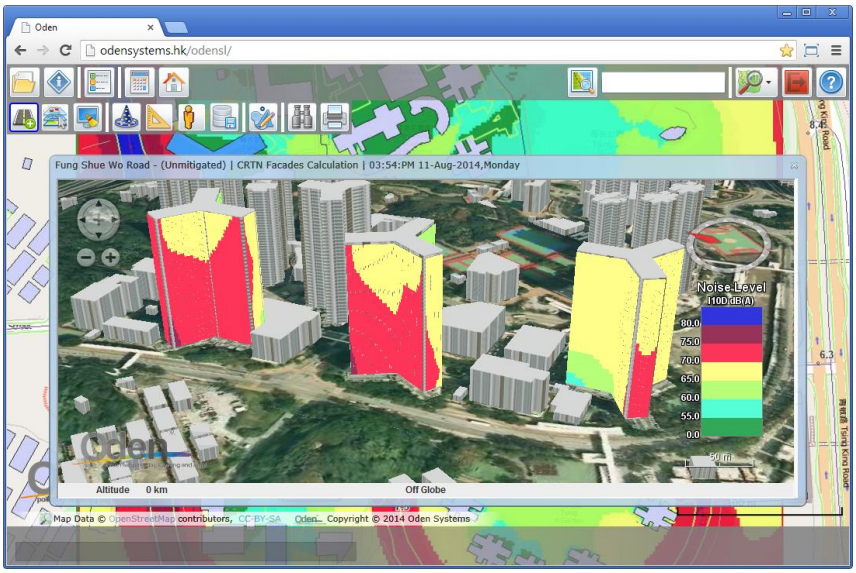

Figure 7 – Baseline Noise Exposure Levels.

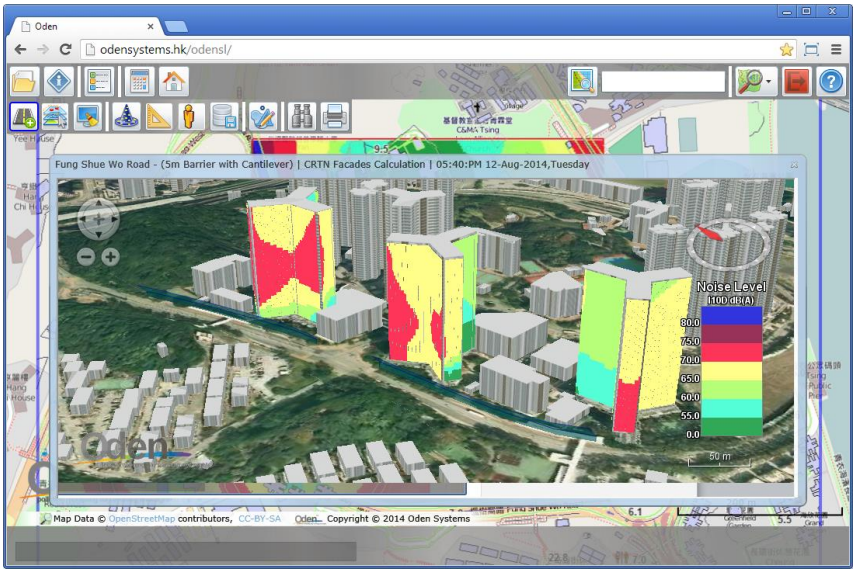

Figure 8 – Cantilever Option Noise Exposure Levels.

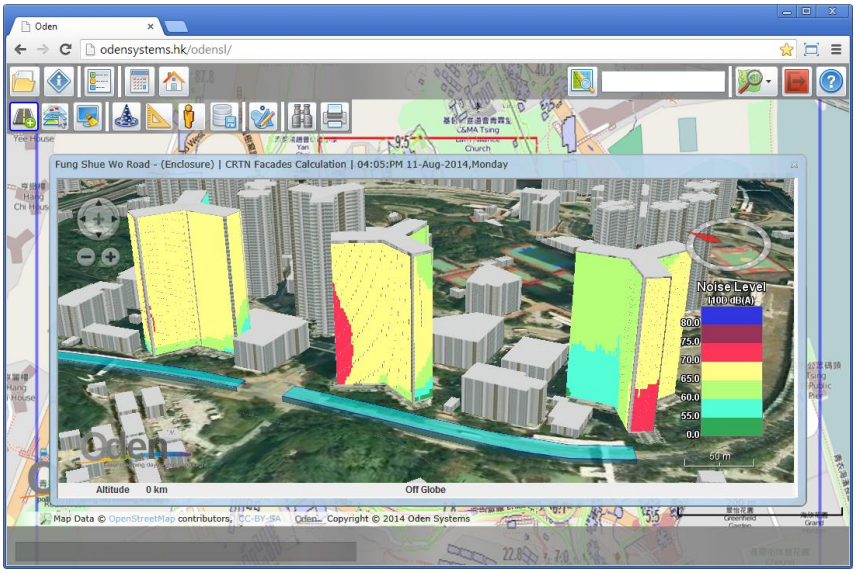

Figure 9 – Enclosure Option Noise Exposure Levels.

4.2 Quantification of Impact on Population

For the example above, we can also use the system to generate a summary set of population exposure statistics as shown below.

Metric	Baseline	Barrier Option	Enclosure Option
Total Population	8,575	8,575	8,575
Population above threshold	1,769	756	406
Percentage above threshold	21%	9%	5%
Number of residential buildings	3	3	3
Threshold in dB(A)	70.4	70.4	70.4

While it can be seen that more protection is afforded by the enclosure, justification would need to be given as to whether the cost was indeed worth the reduction.

5. AIR QUALITY MODELLING

5.1 Leveraging Noise Modelling Base Data

During development of the system, it became apparent that many of the underlying datasets used to support noise modelling would also be suitable, with some manipulation, for use with air modelling. The system was thus extended to do so and is now regularly used to carry out air quality "hot spot" assessment.

5.2 Air Quality Modelling Capabilities

The system is integrated with two air quality models AUSTAL2000 and MISKAM. AUSTAL2000 is a Lagrangian particle model in compliance with the German guideline VDI 3945 Part 3. MISKAM is a three-dimensional non-hydrostatic numeric flow and dispersion model for small scale forecasts of wind behaviour and emission concentrations. This provides a capability to model air pollution from road and industrial sources and for modelling around complex building situations.

As with the systems' noise capability, users may input and modify source data for input to the models.

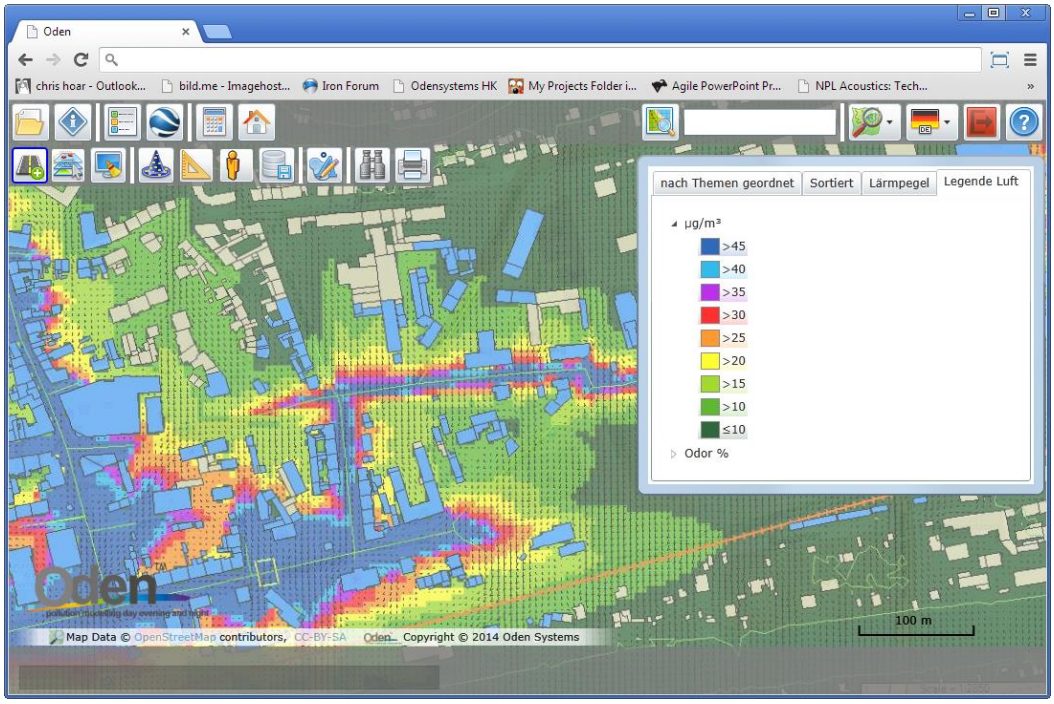

Figure 10 – Results of MISKAM numerical airflow model showing total maximum NOx over all wind directions.

5.3 Mutual Effects of Mitigation Planning

There are obvious benefits if action planning for both noise and air pollution reduction is conducted in such a way that mutual effect of measures can be evaluated. While in some cases a measure might be mutually beneficial, in some cases it may not. For example, a traffic routing strategy might improve air quality by reducing congestion but at the same time introduce road noise problems elsewhere.

As noise and air calculations can be carried out within the same project and with the same input data, the system thus allows for the examination of these mutual effects.

6. OTHER ASPECTS

While the above discussion focuses on the capability of the ODEN system and its technical operation, there are a number of other non-tangible technical benefits the system brings to organisations. By providing repeatable workflows with standardised data sets and modelling parameters, modelling is repeatable and defensible ensuring transparency and accountability in noise assessment exercises.

Because it has been designed as an easy to use web application, it can be accessed by hundreds of users with generalist skills as opposed to specialists using specialist desktop software. While clearly there is a need for the latter expertise in complex cases, the system can reduce heavy workloads by distributing simpler tasks to a large user base. Similarly, as the system is simple to use, training costs are greatly reduced.

Finally, as the system is scalable and utilises loosely coupled web architecture, it is relatively easy to integrate with organisations existing spatial infrastructure.

7. CONCLUSIONS

The ODEN system was developed in response to the observation that a large number of organisations involved in noise modelling and assessment activities had similar problems to solve in terms of the technical issues to be addressed as well as the problem of often limited access to expertise and specialist software and the pressure of ever increasing workload.

The system has been successfully deployed in a number of organisations worldwide and is now relied on for activities ranging from the assessment of acoustical performance of planned housing developments, planning of local scale noise mitigation measures through to regional studies supporting such activities as compliance with the European Noise Directive. The reason for this success is that the system leverages web-based technology to allow for a large number of generalist users to access air quality and noise modelling functionality and workflows simply and effectively. This has allowed for more even distribution of workloads and has thus increased organisations environmental assessment capability.

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