TOWARDS AN ECO-COMPARATOR FOR ROAD WORKS STEALTH

JM MORIN
Egis, France
jean-marc.morin@egis.fr

ABSTRACT

The external costs incurred by road works congestion in France (20 % of the total road congestion) amount to 0.2% of the GNP (equivalent to 4 billion Euros per year). Among these costs, 20 % correspond to environmental costs.

The *PROPICE-Stealthy road works* collaborative project, co-financed by ANR (French National Research Agency) gave way to an eco-comparator tool helping for the minimisation of road works disturbance (acronym: OPTRA – OPtimisation des TRAvaux).

The paper describes the tool's principles, main features, functionalities and output. It also presents the results of its evaluation on several road works on French motorways.

It promotes the concept of an eco-comparator standard to which the *PROPICE* tool offers its contribution.

1. RATIONALE

Because of ever growing mobility leading to increased road use (despite efforts to promote public transport), it is becoming more and more difficult in France to perform road works without a major impact on traffic flow. Moreover, cost cutting policies together with the pressure of environmental issues are in the long-term slowing down new infrastructure construction, thus entailing more frequent road works on an ageing road network, together with the disruption these cause. In addition, customers feel more and more sensitive to such recurrent travel disturbances that sometimes appear not to be justified or well managed.

The benefits at stake are not negligible: external costs incurred by road works congestion in France (20 % of the total road congestion) amount to 0.2% of the GNP (equivalent to 4 billion Euros per year). Among these costs, 20% correspond to environmental costs (greenhouse gas, emissions, noise…).

This is the reason why the collaborative R&D project *PROPICE – Stealthy road works* was launched, with the aim of designing and proposing tools and methods to optimise the whole process of road and motorway works. The project falls within the framework of the French competitive clusters (*"Pôles de Compétitivité"*) Mov'eo and Advancity and is funded by the French National Research Agency. Coordinated by Egis, *PROPICE* brought together partners from areas of Construction and Civil Engineering (Bouygues, Colas), University (Clermont-Ferrand University), Research Agencies (Laboratoire Central des Ponts et Chaussées, Centre Scientifique et Technique du Bâtiment) and Motorway Operation (Autoroutes du Sud de la France).

Among several other issues like the increase of pavement lifecycle, the reduction of road works duration through optimised procedures and processes (including financial incentives to construction and civil engineering companies), the use of innovative contract engineering, etc, *PROPICE* has developed a tool dedicated to road works optimisation called OPTRA [1].

The following parts describe this tool and its performance, and also open possible perspectives.

2. A ROAD WORKS OPTIMISING TOOL: WHAT FOR?

Several steps must be chained from the design up to the monitoring for road works implementation and for each of them the use of such a Road Works Optimising Tool (RWOT) can prove useful.

2.1. Design phase

At this strategic level, the objective is to complete the works for the lowest cost (contract with the engineering company), the best quality (lowest maintenance costs), the least environmental consequences and the least disturbance to traffic.
Time and space phasing (lane closings, lane shifts, temporary infrastructures, etc) must be defined according to these objectives.
A lot of various parameters intervene in this optimisation. We only address here parameters in relation to traffic, i.e. the congestion volume, travellers' delay, over-consumption and over-pollution.
Provided a forecast of traffic demand at the time horizon of the works is available, the RWOT is able to simulate and assess the traffic impact of each phasing solution and help choose the best *a priori* combination.
At this stage, for example, it can be found out that some or all of the works can be performed during the day with no, or limited (and quantified), impact to traffic. This is of great value to the infrastructure owner (budget savings and best quality works, therefore smaller future maintenance costs) or to the engineering consulting company (proposition of a variant in a tender). Using the RWOT may also allow the road works programme to be optimised by "hiding" disturbing downstream works behind upstream disturbing works, therefore decreasing or even alleviating the downstream congestion ("screen effect").

Egis used recently the tool for the promotion of a variant in a tender (Design Build and Operation of a toll motorway in France from an existing road), proving that the widening works could be made during the day in most periods except some specific ones such as Fridays before holiday periods from 10:00 am at the horizon of the works (2013) (Fig. 1):

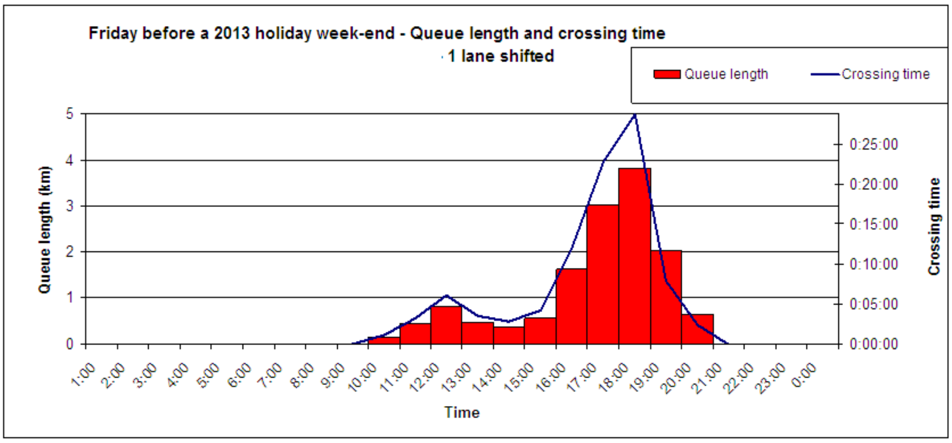


Figure 1: An example of forecast simulation for road works phase design

2.2. Optimal planning

At this tactical level, which is closer to the field, the precise planning is the responsibility of the infrastructure operator, often in charge of week-to-week road works planning and operation. Demand forecast availability is generally more precise than at the time of the design phase.
Simulation and automatic optimisation functionalities of the RWOT allow the generation of optimal planning strategies for individual works, or groups of works, within a cooperation of the respective skills of the operator and tool: the operator is able to introduce corrected parameters or design his own strategies with respect to constraints that the tool is unaware of, whereas the tool is able to do a great deal of runs and scenario calculations with a great stability of results.
The following figure (Fig. 2) presents an example of optimal planning of a group of road works (scenario 1: without upstream works; scenario 2: upstream and downstream works together):

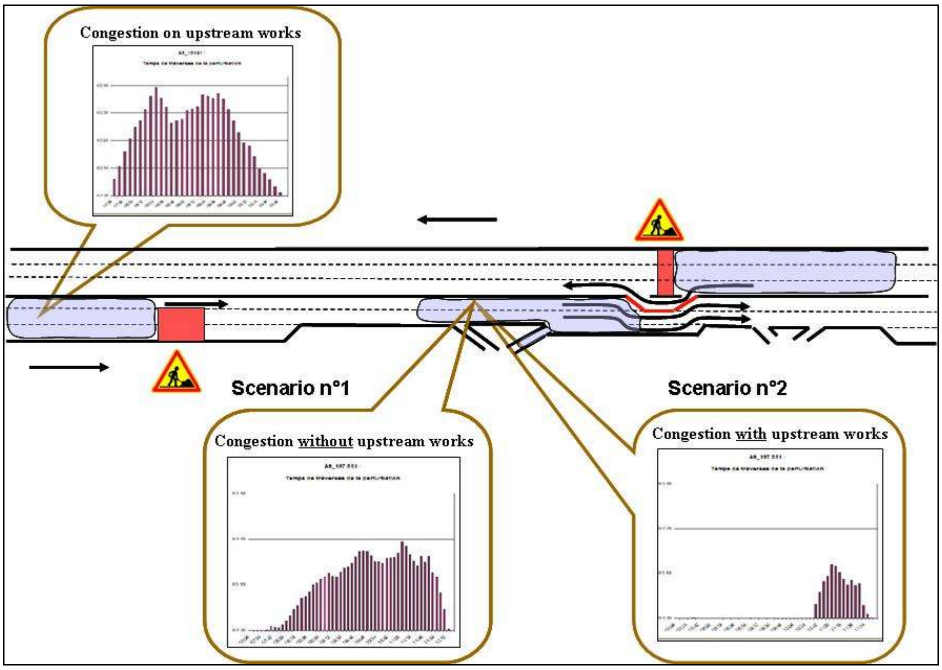


Figure 2: An example of simulation for road works with a “screen effect” with one-another

The RWOT can also be used for the design of Traffic Management Plans: simulation of diversion scenarios, design of equipment on diversion itineraries, and definition of thresholds for opening and closing of the diversion.

2.3. Real-time operation

During road works, the RWOT is able to generate real-time estimation of current and forecasted crossing times to transit the works area. This information can be used in two manners: for driver information, thus making this delay less onerous, and for control purpose when a diversion itinerary is available.
As a number of investigations made in various service domains show, the provision of information helps the customer to accept delays he is facing. Given that the infrastructure operator wants to keep the user satisfaction above a certain level, it clearly appears that a systematic user information policy will help achieve either a better image of the road service by users, or alternatively realise a greater number of road works with unchanged perceived service level.

When a diversion is necessary and possible, the tool helps to manage the road system optimally. With RWOT, the opening and closure of the diversion itinerary is done in an anticipated manner, assuring diverting drivers that they will follow a quicker route at any moment. At present, this is generally not the case because of late opening and closure due to the lack of anticipation.

This is illustrated in the following figure (Fig. 3):

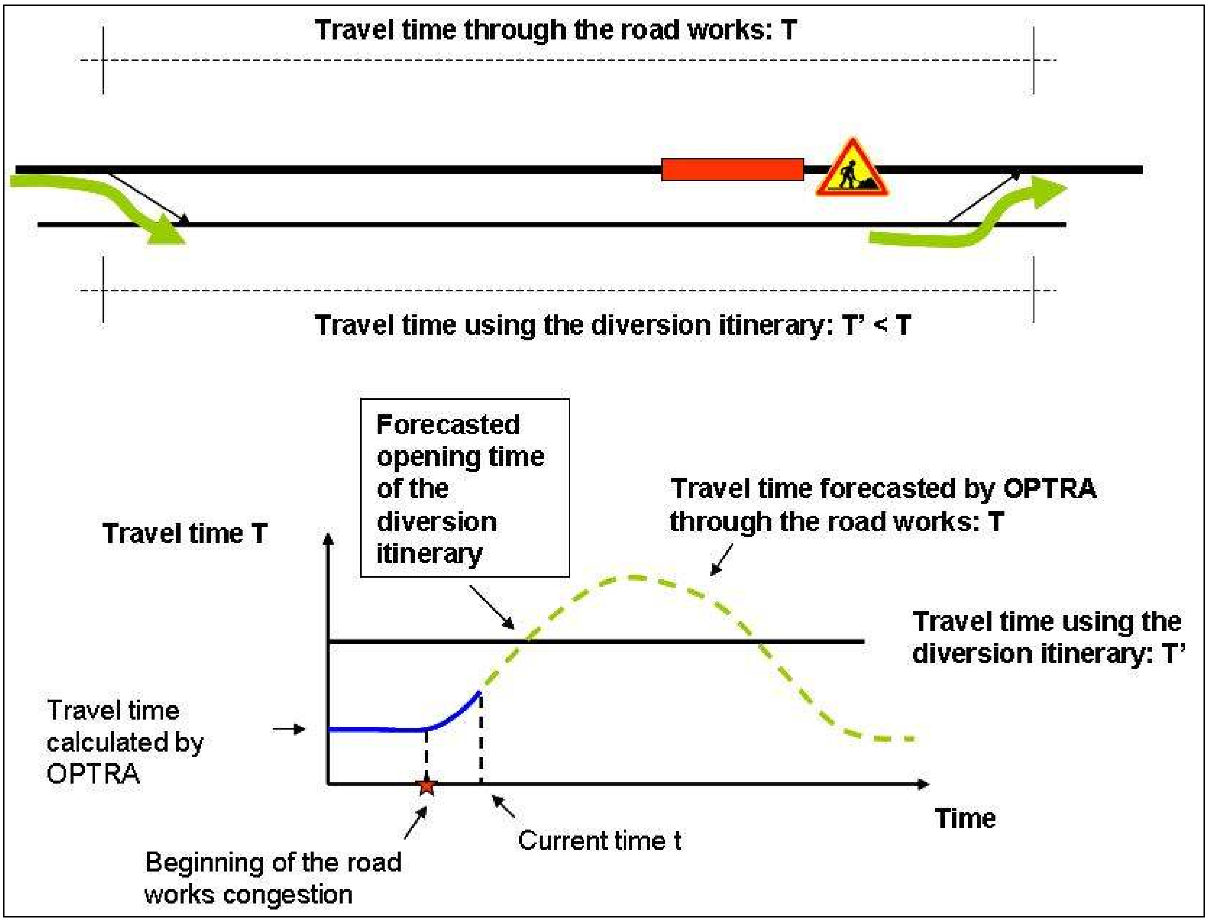


Figure 3: The use of the RWOT for optimal diversion strategy management

3. PRINCIPLES AND FUNCTIONALITIES OF THE RWOT

3.1. Principles

The Road Works Optimisation Tool makes use of a traffic model based on the stock method. This method relies on the estimation of the number of vehicles present at any moment in the road section, calculated from an initial number of vehicles (easy to estimate in a fluid situation from the mean density given by counting stations and the length of the section) updated from that moment onto the current time with cumulated traffic volumes entering and leaving the section. This stock is then divided by the traffic density for queue length calculation and by the traffic volume exiting the section for travel time calculation.
The RWOT then calculates the over-consumption and the over-pollution (greenhouse gas, chemical pollutants, particles) coming from the congestion (compared to the situation without road works). It makes use of a set of formulas provided by the ARTEMIS European research project and of a 20 year-ahead modelling of the French motor vehicle fleet

provided by INRETS (IFSTTAR). These effects are then translated into environmental costs using standard values (for further details, see JM MORIN and C. PÉROT [2]).

3.2. Functionalities

The RWOT offers several functionalities:

3.2.1 Help to programming through two different modes (ex ante)

- The user can ask the tool to simulate the impact of the road works with a pre-defined time period or
- The user can define the duration of the works and a larger time period during which he wants the works to be done and ask the tool to automatically find the time window within this period which produces the minimum impact on traffic.

In both cases, the tool is able to manage for a group of several road works and for their mutual influences.

Input data is the demand forecast during the road works period, and the so-called remaining capacity, i.e. the maximum traffic volume that can exit the road works according to the number and types of the remaining lanes left to traffic.

3.2.2 Monitoring of the level of service provided to users over time (ex post)

The tool can be used for monitoring the actual impact on traffic produced by planned road works after their implementation. The same model is used to reconstruct congestion by using actual traffic measurements (upstream and downstream the road works) instead of forecasted demand and remaining capacity.

3.2.3 Help to real-time traffic management

This functionality is being developed. Input data is the real-time upstream and downstream traffic volumes. The RWOT will produce the current crossing time and queue length together with their anticipated values 2 hours in advance thanks to a real-time demand forecast function. Figures 4 and 5 below show two screen displays of the RWOT.

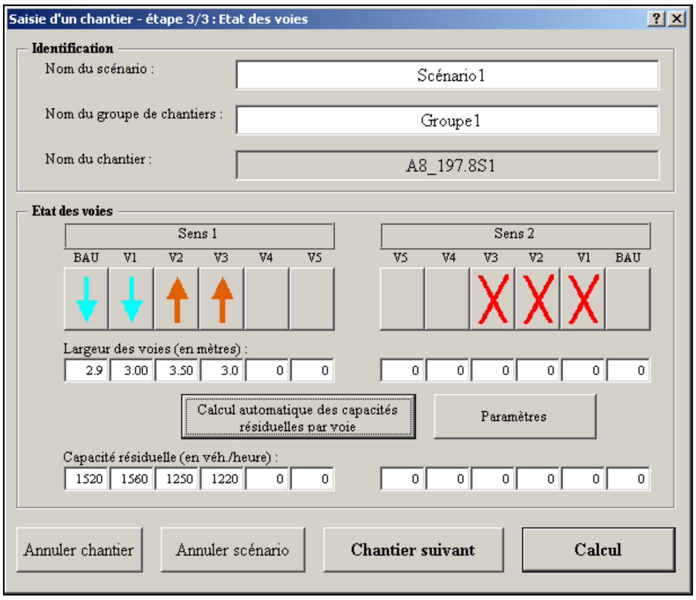
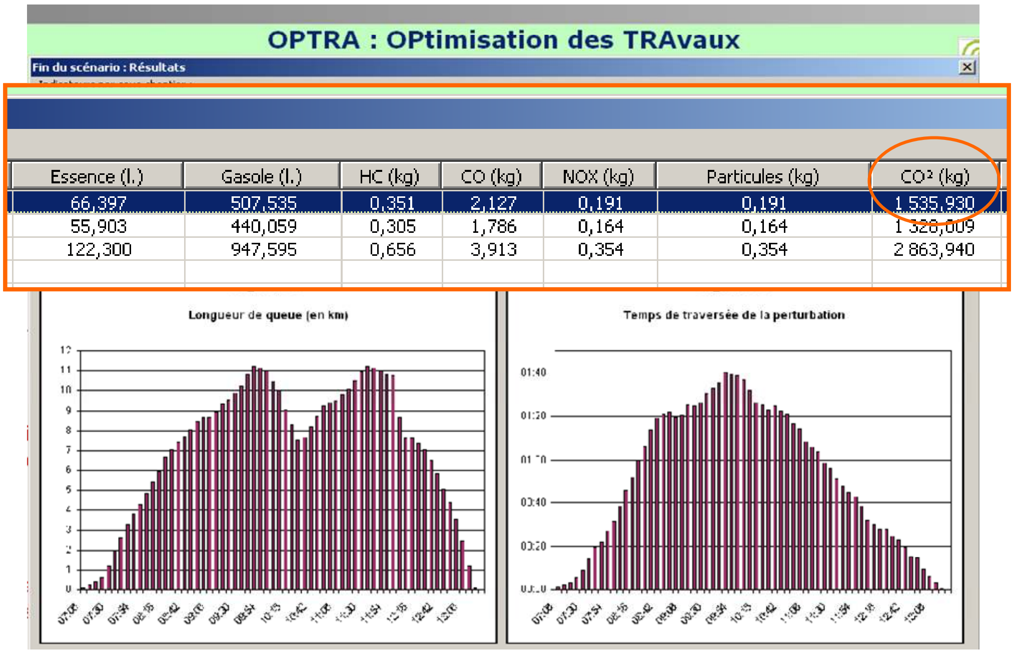


Figure 4: Screen display for road works spatial definition

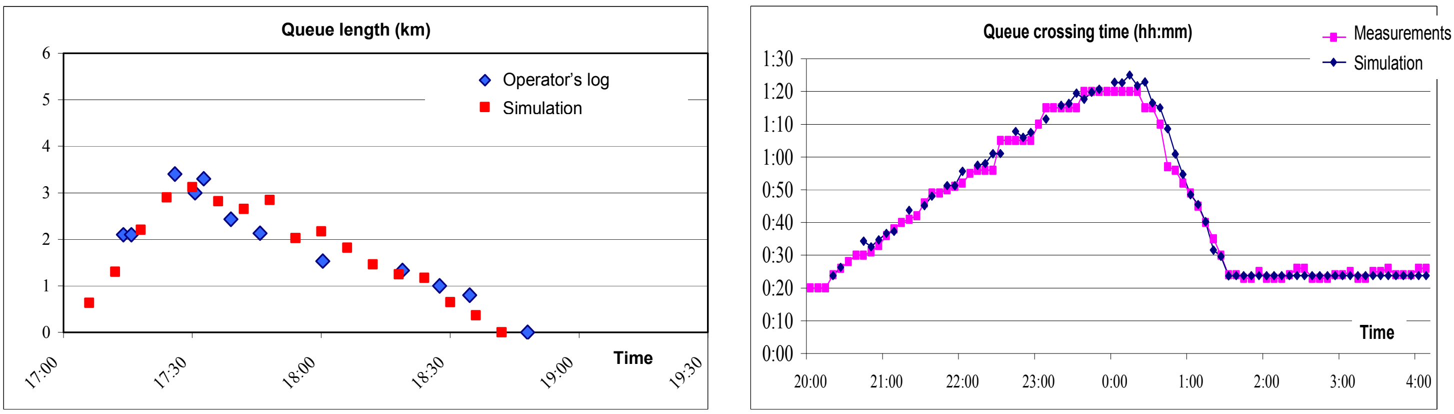


Essence (l.)	Gasole (l.)	HC (kg)	CO (kg)	NOX (kg)	Particules (kg)	CO² (kg)
66,397	507,535	0,351	2,127	0,191	0,191	1 535,930
55,903	440,059	0,305	1,786	0,164	0,164	1 328,009
122,300	947,595	0,656	3,913	0,354	0,354	2 863,940

Figure 5: Screen display for results presentation

4. ASSESSMENT

The intrinsic model accuracy of the RWOT has been assessed on several road works situations where traffic data were accurate enough in order not to mix inaccuracies coming from the model and from the data. Some results are displayed below (Fig. 6).



Road works on A61 motorway at Carcassonne (ASF) **Road works on A1 motorway at Roye (Sanef)**

Figure 6: Evaluation results (queue length and crossing time)

The quality of input traffic data is not as critical when using the planning functionality as when using the monitoring or the real-time functionality of the tool.

In planning use, forecasted traffic demand generally comes from specific statistical tools which are able to provide good quality forecasts (better than 10 % accuracy). These forecasts come from 1-hour based historic traffic volumes which the RWOT transforms into 6 minute-based data for better results. Remaining capacities are also well known from measurements made downstream during past real road works classed into types.

For monitoring and real-time use, a good quality of data (accuracy and completeness) is necessary in order to avoid the shift of the stock estimation. As it appeared that traffic data sometimes does not meet these requirements, the development of a "robustification module" has been planned. It is based on the use of historical traffic data and on fusing techniques using additional available data such as operator's log (queue length observations) or FCD (Floating Car Data) when available.

5. CONCLUSION: TOWARDS A STANDARD ECO-COMPARATOR?

Stealthy road works are of interest for various actors (infrastructure operator, civil engineering companies, users) pursuing various objectives. Each of these actors will all the more promote such innovative planning and execution of works as they will expect a financial interest from it:

5.1. Infrastructure operators

The RWOT is able to provide cost reduction (example: secured work during the day instead of at night) and a better management of the level of service perceived by users.

5.2. Users

Reduction of congestion means reduced gasoline costs, increased safety through reduced traffic hazards (fewer sudden braking situations) and reduced stress.

5.3. Construction and civil engineering companies

For companies, improving stealthy road works would mostly imply increasing work costs. This issue would play a significant positive role for them only if it were introduced within criteria for contracts granting. The RWOT will then provide help for sound submissions to tenders.

5.4. Public organisations

The logic of public organisations is based on a multi-criteria approach of community benefits some of which are not easily quantifiable. Monetarisation of environmental, consumption and time gains allows comparison between competing solutions.

As a conclusion (see JM MORIN [3]), tools like the RWOT significantly contribute to the promotion of stealthy road works through helping:

- Infrastructure owners setting reasonable objectives in tenders (incentives to shorten the duration of works) and evaluating subsequent bids
- Construction and Civil engineering companies testing alternative solutions and justifying their relevance
- Infrastructure operators reducing road works impact, informing the users, monitoring and optimising the actual level of service over time.

It becomes clear from above that an eco-comparison standard tool or method would ease the "rules of the game" between the various actors of the road works domain, offering a common, objective and accepted communication basis.

This would imply several consequences:

- Using the same referential (tool or method) for all actors

- Including a precise definition of the stealth criterion into road works contracts: parameters forming the criterion, with their weights and monetary values
- Weighing the stealth criterion to a significant level compared to other criteria
- Defining bonus-penalty rules according to works planning compliance
- Providing forecast traffic data to civil engineering companies (from infrastructure owner or operator).

And what about the creation by the public authorities of a “Stealthy Road Works” accreditation?

There is probably still some way until these objectives are met. In our mind, the most efficient way for impelling this change would certainly be the introduction at the tender level of quantitative stealth criteria.

REFERENCES

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2. Morin, JM, Pérot, C. (2009). “Améliorer la furtivité des chantiers perturbants par une programmation optimale : OPTRA », ATEC – ITS France Congress, February 2009.
3. Morin, JM (2010) « Un éco-comparateur et un optimiseur de la furtivité de chantiers : OPTRA ». Revue Travaux, n° 876, November 2010.