Examples of application of the QRA Model (UK, Austria, France)

UNITED KINGDOM

In the UK, the QRAM has been used for a small number of ad-hoc tunnel studies. Attention has been focussed on comparative risk assessments between routes and on the risks associated with HGV fires in tunnels. The QRA study carried out for the proposed A3 Hindhead Tunnel illustrates the approach taken. Currently, there is unrestricted DG traffic and no tunnel on the A3 route. Prior to the Public Inquiry for this new tunnel, the QRAM was used to help answer two questions:

- Should DG traffic be permitted to use the tunnel or diverted along a long distance alternative route?
- Assuming that one bore of the tunnel would sometimes need to be closed for short periods for maintenance or following an emergency, should all traffic from the closed carriageway be diverted along a local alternative route or should the other bore be operated in contraflow mode?

(i) Long term routing of DG traffic

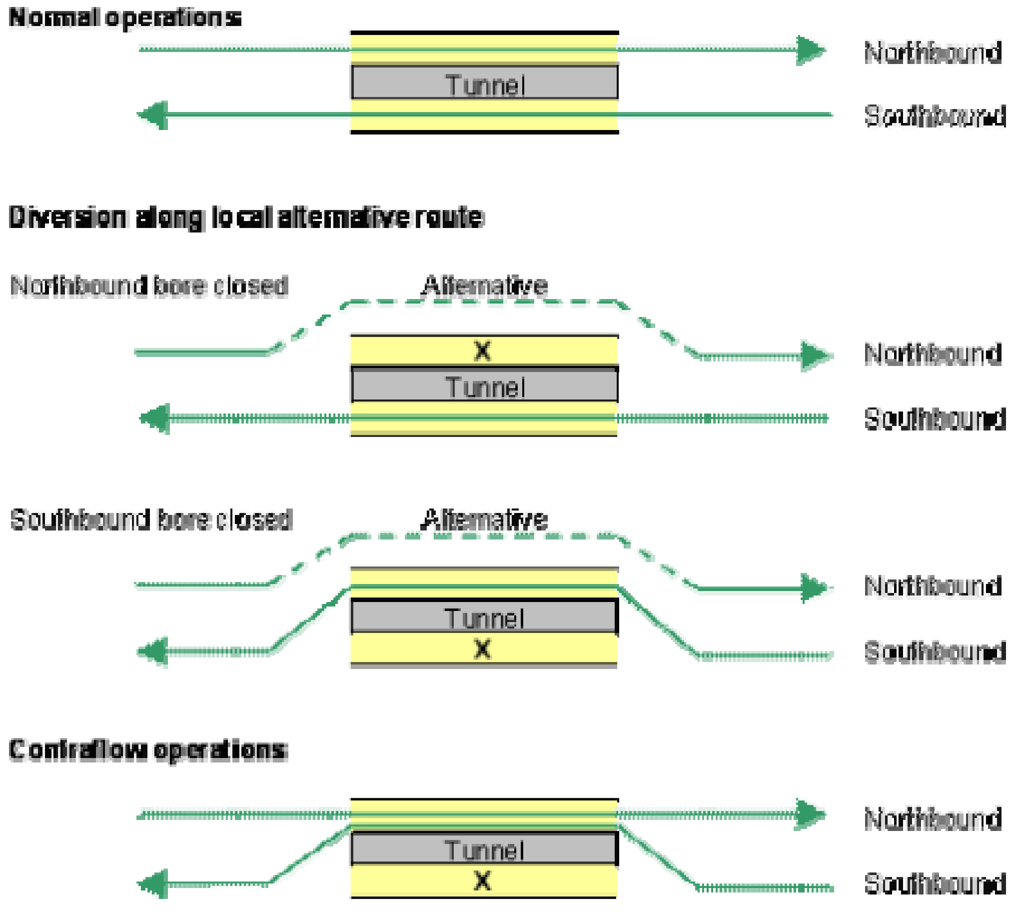
The QRA model was used to calculate the societal risks for the tunnel route (A3) and the alternative route, both with and without the DG traffic currently using the A3. The contribution of HGV fire risks to the overall risk was shown to be important. If the risk of HGV fires is excluded, the overall risk (combining the concurrent risks along the two routes) appears to be significantly greater when DGVs are allowed to use the tunnel route (option a) instead of being diverted along the alternative open route (option b). The Expected Values differ by a factor of about 8. However, if the HGV fire risks are included in the assessment, it can be seen that there is no significant difference between the overall risks for the two options (A and B). This suggests that there would be no safety benefit to be gained by diversion of the DG traffic. Environmental factors also support the view that DG traffic should be permitted to use the tunnel.

Societal risk results for different route / traffic options

	EV	EV ratios
Overall risk, excluding HGV fires		
Option **a** - DG traffic uses tunnel	2.0E-02	EV**a** / EV**b** = 7.8
Option **b** - DG traffic avoids tunnel	2.6E-03	-
Overall risk, including HGV fires		
Option **A** - DG traffic uses tunnel	7.7E-02	EV**A** / EV**B** = 1.3
Option **B** - DG traffic avoids tunnel	5.9E-02	-

(ii) Local diversion route for short term closures

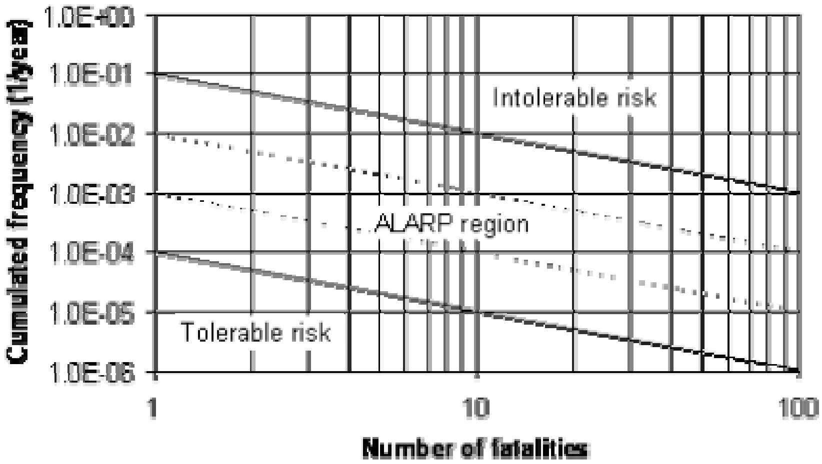
It is expected that one bore of the tunnel would sometimes need to be closed for maintenance or following an emergency. Two options were considered for traffic management under these circumstances. Firstly, all northbound traffic could be diverted along a local diversion route, allowing southbound traffic to operate in uni-directional mode in the open bore of the tunnel while the other bore is closed. Secondly, bi-directional (contraflow) traffic operations could be put in place through the open bore of the tunnel, with a reduced mandatory maximum speed limit of 30 mph. Using the QRAM, it was shown that diversion of all northbound traffic along the alternative route would lead to slightly lower societal risks compared to contraflow operations, but the absolute level of risk would be low for both options.



Comparison of short term local diversion routes

AUSTRIA

In the Austrian case study, threshold values for tolerable and intolerable risk have been used for assessing the results obtained using the QRA model. If the F/N curve of a tunnel is in the tolerable risk region, no action is needed. If the F/N curve touches the intolerable risk region, immediate action is needed, irrespective of the costs of providing risk mitigation measures. Between the areas of tolerable and intolerable risk is the so-called the **ALARP** region **A**s **L**ow **A**s **R**easonably **P**racticable). If the F/N curve is in this region, then additional mitigation measures may be required, depending on their cost effectiveness.

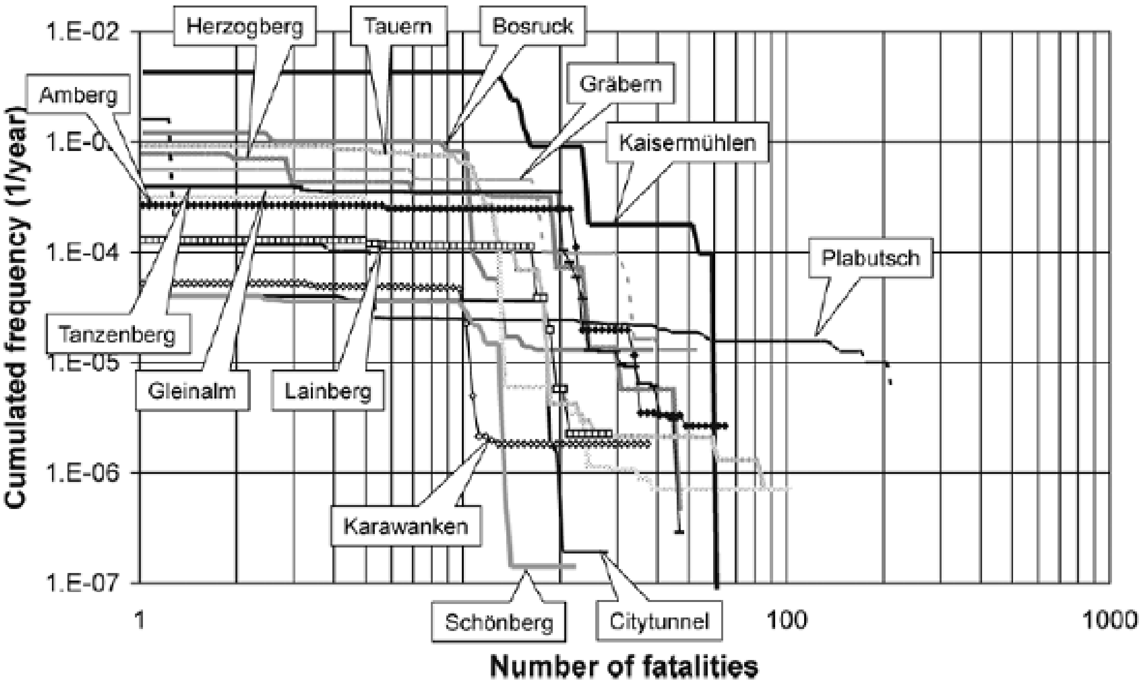


Tolerable risk as suggested by the Austrian Commission for Tunnel Safety for a 1 km road tunnel

However, these threshold values used have no official status and in future the QRA model will probably be used in a comparative step by step procedure, more or less similar to the framework for use of the QRA-model in France:

- Step 1: check the relevance of the problem
- Step 2: investigate the tunnel
- Step 3: investigate alternative routes

The next Figure shows a compilation of the F/N curves for the 13 tunnels. The highest societal risk was calculated for the Viennese Kaisermühlentunnel, which has a traffic volume of 85000 vehicles per day (the highest of the 13 tunnels). The lowest societal risk was calculated for the Schönbergtunnel, which has a traffic volume of approximately 8500 vehicles per day. None of the F/N curves for the analysed tunnels was found to touch the area of intolerable risk. All of the F/N curves lie partly or wholly within the ALARP region. A range of risk mitigation measures were considered, including diversion of DGVs, regulating the spacing between HGVs to a minimum distance of 150m and ventilation system enhancements.



Comparison of F/N curves for 13 tunnels in Austria

FRANCE

In France, so far, quantitative risk analysis of dangerous goods transport is required for all new tunnels, except for non-urban tunnels less than 500m if bi-directional, and less than 800m if uni-directional. A simple qualitative approach may be used in other cases. For tunnels in operation, a QRA study is required only when modifications are planned for the dangerous goods traffic, or if asked by the French authorities.

However, after having performed a number of QRA studies, it was concluded that a criterion based on tunnel length is insufficient to define whether detailed risk analysis is required (QRA study) or not (qualitative study). Other parameters such as the traffic characteristics are also important. This can be illustrated by considering a past case study where tunnel was long enough to require a QRA study, but the DGV traffic was too low to constitute a significant level of risk.

An Intrinsic Risk (IR) criterion has therefore been defined, based on past experience gained using the QRA model. This criterion corresponds to an Expected Value of 0.001 fatalities per year. The Intrinsic Risk is calculated by applying the QRA model to the tunnel itself, taking no account of the adjacent open sections of the route. Only the eleven dangerous goods scenarios in Table 1, and not the two HGV fire scenarios, are considered.

If IR > 0.001 for a given tunnel, then a QRA study is carried out to compare the tunnel and alternative routes. When comparing two routes, with Expected Values, EV1 and EV2, three situations have been defined:

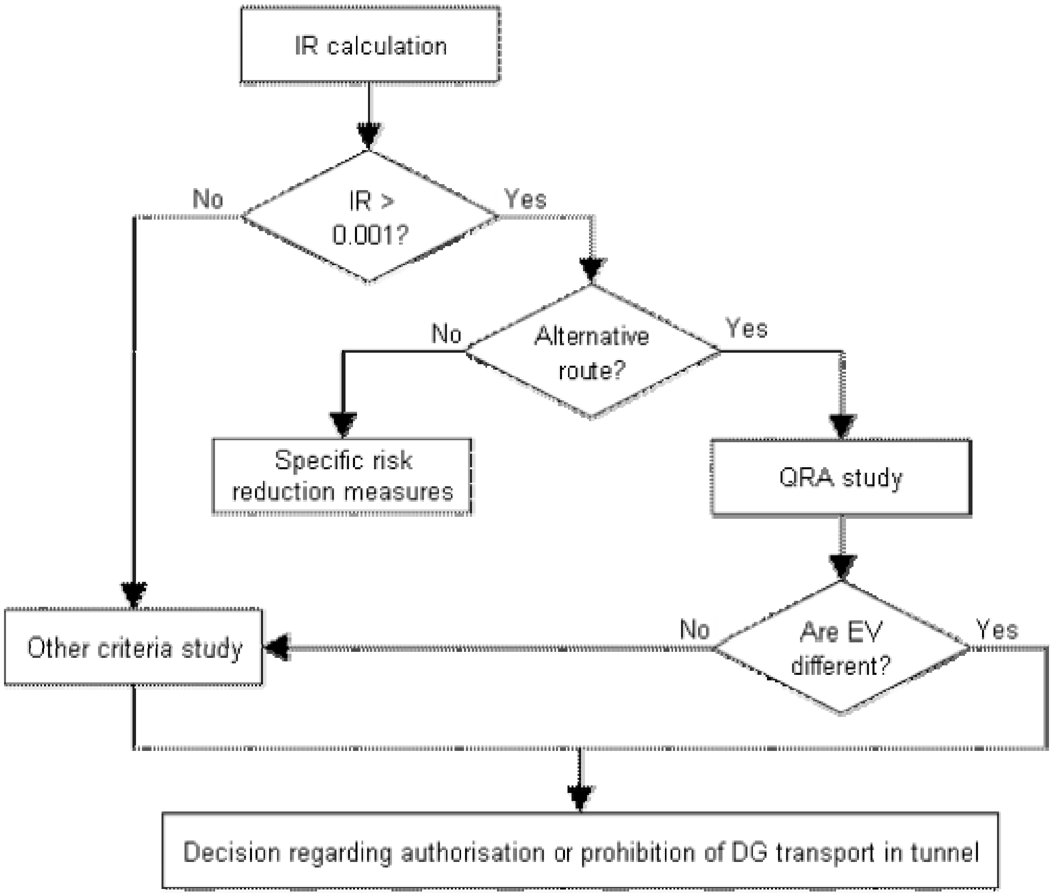
- EV1/EV2 < 3 — Other criteria are required to make a decision
- 3 < EV1/EV2 < 10 — A sensitivity study is required
- EV1/EV2 > 10 — Route 2 should be favoured

When EV1/EV2 < 3, the following other criteria are considered:

- risk aversion;
- accidents without involvement of hazardous material; and
- route vulnerability from economic and environmental points of view.

QRA studies have now been carried out for about 30 tunnels. Of these, there were 5 cases (19%) with IR < 0.001, 4 cases (15%) with IR » 0.001, and 18 cases (67%) with IR > 0.001. Of the QRA studies with IR 0.001, there were significant differences between routes in half of the cases (11 out of 22 cases). Of these, the tunnel route was found to be less dangerous in 2 cases (18%) and more dangerous than the alternative route in 9 cases (82%).

Drawing upon the experience gained in the previous studies, the approach shown in the next Figure has been defined for risk analysis for dangerous goods transports.



Framework for use of the QRA model in France