EVALUATING CONGESTION CAUSED BY ABNORMAL LOADS
SUMMARY REPORT

by N Taylor, T Rees, P Sanger, K Alexander and D Savage

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Evaluating Congestion Caused by Abnormal Loads

Client: AIL Unit, Highways Agency
(Mr. Andrew Cook)

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<table>
<thead>
<tr>
<th>Approvals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
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<td>Quality Reviewed</td>
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</table>
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### CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive summary</td>
<td>i</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2 Approach to and outputs from the project</td>
<td>1</td>
</tr>
<tr>
<td>3 The nature and extent of Abnormal Load traffic</td>
<td>2</td>
</tr>
<tr>
<td>4 Literature Review</td>
<td>3</td>
</tr>
<tr>
<td>5 Consultation</td>
<td>3</td>
</tr>
<tr>
<td>6 Other externalities and ‘Test of Reasonableness’</td>
<td>4</td>
</tr>
<tr>
<td>7 Monitoring on the road</td>
<td>5</td>
</tr>
<tr>
<td>8 Modelling method</td>
<td>6</td>
</tr>
<tr>
<td>9 Monitoring by MIDAS</td>
<td>8</td>
</tr>
<tr>
<td>10 Comparison of Model results with observation</td>
<td>10</td>
</tr>
<tr>
<td>11 Modelling issues and sensitivities</td>
<td>10</td>
</tr>
<tr>
<td>12 Findings of monitoring, analysis and modelling</td>
<td>11</td>
</tr>
<tr>
<td>13 General conclusions</td>
<td>12</td>
</tr>
<tr>
<td>14 Recommendations</td>
<td>13</td>
</tr>
<tr>
<td>15 Acknowledgements</td>
<td>13</td>
</tr>
<tr>
<td>16 References</td>
<td>14</td>
</tr>
</tbody>
</table>
Executive summary

S.1 Congestion on Britain’s roads is an increasing problem and in recent years traffic volumes have increased to such an extent that parts of the network are often operating close to capacity. The Department for Transport (DfT) and the Highways Agency (HA) are committed to reducing traffic congestion by better management of the road network. As part of this commitment alternative modes of transport of large or heavy Abnormal Indivisible Loads (AIL) are being considered. The report summarises the results of a project which has performed a Literature Review related to Abnormal Loads and related issues, conducted a Consultation of Stakeholders and Experts, monitored a number of Abnormal Load movements on the road, and has developed a detailed spreadsheet Model to enable congestion delays and costs caused by Abnormal Loads to be estimated as a function of route, day and time of travel. The report includes details of the impacts of heavy and wide load movements, and recommendations from consultation for improved water transport facilities.

S.2 A Literature Review has provided background information and brought into focus issues of external and environmental impacts and water transport policy. While it has yielded little quantitative data about the congestion effects of Abnormal Loads, and no data on other impacts specific to AILs were found, it has provided the basis for a general quantitative estimate of the cost of external and environmental impacts of road freight transport.

S.3 The Model’s results for congestion costs will contribute to the Highways Agency’s assessment of Abnormal Load applications. Other types of externality cost are recognised, and an estimated externality cost per mile can be input into the model to form part of the overall cost, but based on the Review the effect in cost terms is small and would be unlikely to affect routing decisions. Estimation of externalities for Abnormal Loads would require significant additional research, as no data specific to them are currently available.

S.4 Consultation of members of the Expert Panel and other Stakeholders has aired issues of escorting practice and fair comparison between road and water modes, as well as giving members of the Expert Panel the opportunity to influence the course of the project and in particular the monitoring of Abnormal Loads. Bearing in mind that Water Preference is government policy, Stakeholders have pointed to certain costs and operational factors which tend to make water options uncompetitive, as well as several unfair disadvantages compared to road, and have pointed out the potential for developing new road/water interchanges.

S.5 A number of Abnormal Load moves have been observed directly, and a larger number analysed using data from MIDAS (Motorway Incident Detection and Automatic Signalling) on motorway sections. While neither data set can be said to be fully representative of all AILs, the live observations have been targeted to use limited resources most effectively, and it is believed that a good understanding has been obtained of the possible magnitude of effects of different types of Abnormal Load moving under different conditions.

S.6 A mathematical model, implemented in a spreadsheet, has been developed which embodies the unique characteristics of Abnormal Load movements and takes account of variations by day of week and time of day. Given realistic data, especially on ambient traffic demand, it can produce a description of an AIL’s effect on traffic which corresponds with observation.

S.7 Specific conclusions concerning modelling are:

- The model estimates congestion cost according to specifics of the load’s size, speed and route, and ambient traffic flows, whose results can contribute to the decision-making process. It calculates queuing and delays from traffic and queuing theory, and does not depend on statistical results from monitoring, except to calibrate certain values such as passing speeds and capacities;
The model depends on the data put into it being realistic, which includes correctly identifying the independent sections of the route, inputting accurate time-dependent ambient traffic volumes, and making correct assumptions about diversion. Experience suggests that use of ADTs\(^1\) where TRADS\(^2\) data are unavailable, even if correct for the day of travel, may reduce accuracy, but is unlikely to affect conclusions about the general magnitude of congestion impact;

Congestion caused by a load is most sensitive to its speed, width or lane-take, and the effective capacity of passing lanes, and ambient traffic volume where this is comparable to capacity;

Congestion costs are highly variable. Calculations from moves monitored using MIDAS range from virtually zero, to £1600/mile on one motorway section. However, it is estimated that £100/mile is exceeded on only 8% of motorway load-miles. These results are not necessarily representative of all motorways, and not representative of other road types, but may indicate likely magnitudes. The variability of cost not only reflects the familiar way in which delays to individual vehicles vary with place and time, eg between peak periods near cities and night-time on rural roads, but is also magnified by the fact that the heavier the traffic the more vehicles are affected by the Abnormal Load and any queuing it causes;

Directly observed moves, which used a range of road types, are estimated to have average costs intermediate within the MIDAS range. The average delay caused by the most disruptive loads is estimated to be in the range 15-25 minutes per vehicle affected;

Traffic can incur measurable delay even when appearing to flow freely at 30-50 mph, when the presence of a ‘queue’ may not be obvious to an observer;

Diversion may be important only on certain routes, depending on local conditions;

Empty transfer can be modelled in a similar way to loaded moves, with the appropriate route and vehicle characteristic data, but empty mileage is strongly case-dependent;

Other types of externality cost are recognised, and some estimates are made. Detailed estimation of externalities for Abnormal Loads would require significant additional research, as no data specific to them are currently available. An estimated externality cost per mile can be input into the model to form part of the overall cost, but based on the Review and estimates the effect in cost terms is small and would be unlikely to affect routing decisions;

The Literature Review has concluded that there is no other current or relevant research.

S.8 In summary, this project has revisited Abnormal Loads after a gap of 37 years, during which time the quality and capacity of roads, and the performance of transporters, have increased considerably. Although this is a complex subject with a strong component of practical experience on the part of haulage and manufacturing industries and the police, it is believed that an airing and understanding has been achieved of the operational issues of road and water transport. The impact of Abnormal Loads on traffic has been addressed quantitatively, with a new capability of predicting traffic delays and costs, potentially allowing a ‘test of reasonableness’ between road and water modes.

\(^1\) Average Daily Traffic counts, available from DfT
\(^2\) The Highways Agency’s TRaffic and Accident Data Statistics database
1 Introduction

Congestion on Britain’s roads is an increasing problem and in recent years traffic volumes have increased to such an extent that parts of the network are often operating close to capacity. The Department for Transport (DfT) and the Highways Agency (HA) are committed to reducing traffic congestion by better management of the road network. As part of this commitment alternative modes of transport of large or heavy Abnormal Indivisible Loads (AIL) are being considered. The report summarises the results of a project which has performed a Literature Review related to Abnormal Loads and related issues, conducted a Consultation of Stakeholders and Experts, monitored a number of Abnormal Load movements on the road, and has developed a detailed spreadsheet model to enable congestion delays and costs caused by Abnormal Loads to be estimated as a function of route, day and time of travel. The report includes details of the impacts of heavy and wide load movements, and recommendations from consultation for improved water transport facilities.

2 Approach to and outputs from the project

2.1 In Phase 1 a Literature Review (Sanger 2003) was produced covering all modes and their economic and environmental impacts, and a Feasibility Report (Taylor and Rees 2004) primarily concerned with methodology for monitoring and measuring road movement.

2.2 In Phase 2 a consultation was conducted of a number of Stakeholders, some of whom are also members of the Expert Panel set up to advise the Highways Agency directly. This was mainly done by face-to-face meetings, but with some written submissions also.

2.3 In the remaining Phase 3 of the project, there were three main activities conducted simultaneously: live monitoring of selected loads, collection and analysis of data from MIDAS detectors, and development of the mathematical and spreadsheet model.

2.4 A separate Modelling Report (Taylor 2004a) describes the mathematics embodied in the spreadsheet. It uses an example of an actual move to illustrate the relationship between observed, modelled and MIDAS5-derived queue measurements.

2.5 The Model’s results for congestion costs will contribute to the Highways Agency’s assessment of Abnormal Load applications. Other externality costs are identified, but their estimation for Abnormal Loads would require significant additional research, as no data specific to Abnormal Loads are currently available. In the absence of such research, estimated externality costs per mile can be input into the model to form part of the overall cost.

2.6 This Summary Report summarises the results of a project which in calendar year 2004 has performed a Literature Review related to Abnormal Loads and related issues, conducted a Consultation of Stakeholders and Experts, monitored a number of Abnormal Load movements on the road, analysed the traces of loads in MIDAS, and has developed a detailed spreadsheet model to enable congestion delays and costs caused by Abnormal Loads to be estimated as a function of route, day and time of travel, and load characteristics such as speed and take-up of lanes. A separate Modelling Report describes the model and also examines other factors which it would be appropriate to include as part of the cost model.

2.7 The extended Final Report (Taylor et al 2005) includes statistics of load movements, principal results of monitoring, MIDAS analysis and modelling, and results of some sensitivity tests.

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5 The Highways Agency’s Motorway Incident Detection and Automatic Signalling system.
3 The nature and extent of Abnormal Load traffic

3.1 Each year the Abnormal Loads Team of the Highways Agency issues 300-400 Special Order\textsuperscript{4} permits for the movement of Abnormal Indivisible Loads (AILs) by road, and also authorises 700-800 VR1\textsuperscript{5} wide loads. Lesser movements are covered by other STGO\textsuperscript{6} and C&U\textsuperscript{7} regulations. Delays caused by Abnormal Loads could be reduced by a better understanding of how they are related to the types of load and the conditions under which they are moved. Movements also involve operational and administrative work by the police and local authorities, such as escorting, road closure and temporary removal of street furniture, and wider costs of maintaining or assessing road structures for their ability to carry the loads. Finally, there may be impacts on safety, and the natural and human environment.

3.2 Alternative modes for large and heavy loads, such as rail and water have their own issues of capacity, accessibility, investment and cost. This project aims to gain a better understanding of the congestion and other impacts caused by the movement of Abnormal Loads and surrounding issues. This will assist the Highways Agency in deciding whether and when to permit the largest and heaviest Abnormal Loads to travel by road, and to promote alternative methods of transporting Abnormal Loads, in particular by water.

3.3 The Special Order specifies the route and special cautions and manoeuvres in detail. It is normally valid for 6 months. SO transports exceeding 150,000kgs are limited to 12 mph, and large slow loads usually require a police escort for all or part of their journey, to close roads and direct traffic, though the police are increasingly charging for this service. SO loads include wide heavy objects like electricity transformers, castings, industrial distillation columns and bridge sections, but can also include lighter loads which are long, like wind turbine blades or girders. Over the long term the number of loads seems to be relatively constant despite changes in industry. Annual statistics on Special Order and VR1 authorisations have been obtained up to mid 2004 (for VR1s from January 2004 only) and are summarised in the Final Report.

3.4 Since January 2004, more routine escorting is being undertaken by the hauliers themselves or dedicated escort companies. Other wide loads exceeding 5.0m (\(16'4''\)) up to 6.1m (\(20'\)) wide are required to be authorised under VR1, about 700-800 authorisations being made every year. Each SO and VR1 authorisation can cover a number of identical moves. Lesser loads are classified under other STGO or C&U regulations.

3.5 The government pursues a Water Preference policy to minimise disruption. Water transport is used or considered for some types of load, especially where water access to facilities is straightforward. Power stations, for example, tend to be sited near sources of cooling water and have slipways installed at the time of their construction. Water transport may be the mode of choice where there is a regular stream of traffic, for example waste of which London alone produces at least 850,000 tonnes per annum.

3.6 The profile of water transport has been raised recently by the transport of a decommissioned Concorde airliner to Scotland aboard the unpowered seagoing pontoon Terra Marique, operated by Robert Wynn and Sons Ltd. The Terra Marique can accommodate up to 1200 tonnes evenly distributed, including the powered waterway barge Inland Navigator with its load, the maximum indivisible load being 400 tonnes. More recently, completed 40m wings for the Airbus A380 ‘super-jumbo’ airliner, unveiled on 18 January 2005, have been transported by barge from British Aerospace’s Broughton plant via the River Dee to Mostyn in Wales, for shipping to the assembly plant at Toulouse.

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\textsuperscript{4} Vehicles over 6.1m wide, or over 30m long (rigid), or over 150,000kgs.
\textsuperscript{5} Vehicle Regulations 1: loads exceeding 5.0m (\(16'4''\)) up to 6.1m (\(20'\)) wide not covered by Special Order.
\textsuperscript{6} Motor Vehicles (Authorisation of Special Types) General Order 2003 (SI 1998) – loads between 44,000kgs and 150,000kgs weight and between 4.3 metres and 6.1 metres wide – includes VR1 category.
\textsuperscript{7} The Road Vehicles (Construction and Use) Regulations 1986 (SI 1078) – loads up to 4.3 metres wide and 27.4 metres long.
4 Literature Review

4.1 The Review (Sanger 2003) embraces about 50 documents whose topics include: costs of transporting loads by road, environmental and socioeconomic effects of Abnormal Load transportation, intermodal transport, potential of waterways, and regulation and guidance.

4.2 No up-to-date information was found on the effect of Abnormal Loads. The last study which monitored the congestion effect of Abnormal Load movements was that by TRL (Dunn 1967). Since then, the nature of roads has changed considerably with the widespread introduction of motorways and dual carriageways, and the speed of many AIL moves has increased with the introduction of more powerful locomotives and sophisticated trailer and suspension systems.

4.3 Some data are available on the externality costs of general road, rail and water freight, including accidents and environmental impacts. When DfT figures are extrapolated to AILs (assuming one AIL is equivalent to 10 HGVs) an estimated externality cost of £3/mile is arrived at (as detailed in Appendix I to the Modelling Report). However, no data are available which relate specifically to Abnormal Loads, and this figure does not take account of externality costs resulting from any queuing or diversion associated with the loads.

5 Consultation

5.1 The Consultation involved the Expert Panel set up to oversee the research, and other Stakeholders from several areas including government, the haulage and water transport industry, and waterway management bodies. The Expert Panel includes Stakeholders drawn from several interest groups, including:

- Water authorities and associations
- Road hauliers and their representative organisations
- Utilities and their representative organisations
- The Association of Chief Police Officers (ACPO)
- Local authorities
- National government

5.2 The Consultation involved members of the Expert Panel and other Stakeholders. Views aired were in many cases frank, and there are some differences of substance or emphasis between those whose main interests lie respectively with road and water transport. The findings of the Consultation with regard to water transport are summarised under General Conclusions.

5.3 Stakeholders concerned with roads argue that costs of planning, surveys, fees, craneage, and special civil works (eg to strengthen landings), as well as some actual transport costs including those of road journeys to landings, tend to make water options uncompetitive.

5.4 Stakeholders concerned with water transport argue that it suffers from a number of unfair disadvantages compared to road, for example underinvestment, divided responsibilities and levying of tolls, as well as specific problems like guaranteeing of adequate channel depths in canals and navigations. On the other hand, ‘hidden subsidies’ and efficiencies of scale tend to favour road transport.

5.5 Water Preference is government policy, but it is argued that action is needed if water facilities are to be ready for a future in which road movement may become increasingly costly, and environmental constraints increasingly severe. Opportunities may also exist for developing new road/water interchanges to take advantage of the modern road network, eg between the River Thames and the M25 motorway near Chertsey.

5.6 The police are concerned mainly with the practical issues of escorting and safety. They are content with self-escorting by hauliers or their contractors where there are no major safety issues, but consider that conferring any additional powers to replicate those of the police could cause difficulties.
The police wish in particular to remain involved in any traffic management duties related to AILs, though some forces now carry these out on a contract basis.

5.7 Local authorities take the view that most AIL movements are well planned, but are concerned that route planning does not place enough emphasis on the restrictions and impacts on local authority roads, a situation which if true should improve with the introduction of ESDAL.

5.8 Costs of transport by water are less directly dependent on distance than road transport and involve a large, sometimes dominant, component of intermodal transfer costs, especially craneage. Roll-on-roll-off operation can reduce this.

6 Other externalities and ‘Test of Reasonableness’

6.1 The idea of a ‘Test of Reasonableness’ is to compare the likely total costs of alternative moves by road and using water, to determine whether a move using water is a reasonable alternative.

6.2 For road moves, the estimated congestion cost per mile needs to be based on analysis of the actual moves, as it is not possible to use a general figure for all loads on all roads. Sensitivity tests detailed in the Final Report show that congestion cost can vary over a wide range depending on the characteristics of the load, its route and timing.

6.3 Operational costs specific to each move include, for road moves:

- escorting and police
- disruption and inconvenience from removal, restoration or protection of street furniture
- planning costs
- costs of bridge and other structure assessments

6.4 Other costs to be factored into road moves include, in approximate order of importance:

- damage to infrastructure
- pollution Including impact of diverted traffic
- climate effect diverted traffic
- additional accidents
- damage to the environment, including removing vegetation to make way for the load
- impacts of ‘upstream processes’ such as additional fuel production, where relevant
- noise

6.5 There are no AIL-specific data on these costs, but estimates (see Section 8 of Final Report) of the more important externalities for the 11 moves observed and modelled, which travelled a total of 2201 km (1368 miles) with an average load of 197 tonnes, but were more than averagely heavy and therefore not necessarily representative of all AILs, yield the following comparative total costs, showing that those besides congestion are unlikely to be sufficient to affect decisions about moves:

- congestion £256.5K (as modelled)
- road wear and damage £0.7K (based on mileage)
- health <£18.9K (additional, related to queuing)
- accident-risk £5.9K (mainly related to queuing)
- noise <£1.9K (related to mileage)
- water move ~£8.4K (inland vessel over same distance)

ESDAL - (Electronic Service Delivery for Abnormal Loads) is an internet portal being set up by the Highways Agency which will help hauliers carrying Abnormal Indivisible Loads plan their journeys. It will be launched later in 2005, and will eventually provide near-real time route planning assistance (see Platt 2004). This on-line system will contain information on structures, for example weight and height restrictions, as well as comprehensive network information including names of local authorities who need to be consulted or notified.
6.6 When comparing a road move with a water alternative, each case will have an individual set of circumstances, so the costs will need to be evaluated on a case-by-case basis. These should include vessel costs, dredging\textsuperscript{9} and civil works, transhipment costs etc. Because these costs can vary over a wide range, as detailed in the Final Report, it is not possible to set a fixed point at which a water move becomes advantageous. Although assessing each case individually may expose initial high infrastructure investment costs, if repeat moves are likely over the longer term, then this should be taken into account.

6.7 Moves using water may involve road segments to and from transhipment points, which need to be evaluated in the same way as full road moves. For some movements, it may be appropriate to assess whole-journey costs (from load origin) rather than just the final leg to the destination.

6.8 Water transport is much less polluting than road transport (estimates\textsuperscript{10} vary from 3 to 10 times less, per tonne-km) so externality costs are likely to be even less important than for road moves.

7 Monitoring on the road

7.1 Dunn’s analysis (Dunn 1967) is limited to comparison of average speed with and without the presence of the load, assuming no overtaking. Today, many loads move on multi-lane dual carriageways where there are opportunities for overtaking and the combination of queuing and passing makes analysis of the delay effects more complex. It is also no longer practical, for cost and safety reasons, as well as the higher speed of loads, to station a large number of observers along a whole route as Dunn did.

7.2 A monitoring team was mobilised for seventeen AIL moves. These particular moves were chosen for the information they could yield about different types of Abnormal Load under different conditions, not as a representative cross-section. Three moves were cancelled at the last moment, for various reasons – eg high winds, unexpected height restriction, wrong type of crane on site.

7.3 The remaining 14 moves for which data were obtained consisted of 11 SO, one VR1 and two other STGO. Of these, four were affected by delays or equipment failure en route, but completed their journeys. VR1 moves are clearly under-represented. This was the result of some difficulty of obtaining reliable information in advance from hauliers about when and where such loads would travel, because the Highways Agency does not plan the routes. C&U moves up to 4.3m wide, with their higher travelling speeds, are likely to have less of an effect on traffic, and probably not significantly more than that of ordinary HGVs, so it was not considered cost-effective to pursue them.

7.4 Methods of monitoring used included:

- Observer travelling with the convoy, as a passenger with an escort or police vehicle.
- ‘Flying car’, driving to various vantage points where timing of arrival, and flows before and after the passage of the load could be measured.
- Stationing several observers at key points to measure timings and queue lengths, and to estimate speeds and flows.

7.5 Video camera recording was used in some cases. CCTV coverage was available for one load from the M6 to the M40, However, any resulting delay was not noted because traffic appeared to remain free-flowing (at around 30 mph).

7.6 These monitoring exercises have yielded useful information allowing the Model estimates and MIDAS results to be compared with observation. The method of monitoring depended on the nature of the move, its speed and the type of roads it would use, and did not necessarily cover the entire journey, concentrating on the points where the most useful data were expected.

\textsuperscript{9}This may be dredging undertaken to allow the Abnormal Load to pass, or dredging of inland waterways and some ports which British Waterways have a statutory duty to carry out, to maintain depth at the 1967 level.

\textsuperscript{10}Based on sources identified during the Review and Consultation, and reported in Taylor (2004a)
8 Modelling method

8.1 The Excel Spreadsheet Model developed consists of four main worksheets, as follows:

- The Inputs worksheet contains a list of the road sections along the load’s route and their characteristics such as section length and load speed, and source for volume data.

- The Model worksheet itself is generated from the Inputs worksheet, and also contains the working and results for each section of the route. Some data are user-modifiable.

- The Summary worksheet receives certain important common data and displays certain overall results, including total cost, cost-per-mile and other statistics.

- The Defaults worksheet holds some common data including cost/vehicle-hour and characteristics of various road standards such as capacity per lane, based on advice by ITEA.

Macros invoked from an Excel menu generate the Model from the Inputs data and enable the model to be run automatically for a range of start days and times. Figure 1 shows the three main worksheets.

8.2 The modelling approach is to estimate queuing, delays and cost deterministically\(^{11}\) on each of the road sections into which a load’s route is divided. Since Abnormal Loads tend to move slower than the ambient traffic and make predetermined stops, the speed of a load on each section can usually be estimated in advance. A full description is given in the separate Modelling Report (Taylor 2004a).

Estimation of delay is more complex than for an incident which temporarily closes a road, because the ‘bottleneck’ is moving. While there are similarities to the moving block model developed for Convoy Control (Taylor 2004b), it is also necessary to allow for some traffic being able to overtake.

8.3 To define the normal traffic flow on each section at the time when the load is present, a TRADS\(^{12}\) ‘Hourly Variation’ table, or if this is not available an ADT\(^{13}\) value, must be provided. The most detailed data on section traffic volumes are found on the Highways Agency’s TRADS web site where it is possible to get 24h hourly veh/h flow profiles for different days of the week aggregated over a specified period (eg a particular month). TRADS data are available for most motorways and many trunk and major A roads, and can be downloaded as Excel files, the form which the model requires. The data month selected should be that most similar to the month of travel – eg the same month in the previous year if available. Otherwise, an ADT (Average Daily Traffic) figure may be obtained from DfT or some other source. The coverage provided by TRADS and ADTs is indicated in Table 1. All sections have available Site Coordinates (OS Easting and Northing) which can be used as an aid to locating the relevant road section or site.

<table>
<thead>
<tr>
<th>Road class</th>
<th>TRADS sections(^{14})</th>
<th>ADT sections</th>
<th>ADT miles(^{15})</th>
<th>Total miles in GB(^{16})</th>
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\(^{11}\) The deterministic approach does not consider random or other probabilistic variations in variables such as load speed, traffic demand and capacity.

\(^{12}\) TRaffic and Accident Data Statistics database maintained by the Highways Agency.

\(^{13}\) ADT=Average Daily Traffic collected by local authorities and the DfT.

\(^{14}\) Only sections for which an AADT is available, representing about 39% of total sections defined.

\(^{15}\) Estimated from ADT tables by adding up section lengths in kilometres, so there may be accumulated errors.

<table>
<thead>
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<th>Only Compulsory of Volume</th>
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<th>Compulsory Inputs</th>
<th>Voluntary Inputs</th>
<th>ONE WAY ADT (v/h) or ( \text{v/h}) if applicable</th>
<th>Duration of one Step to allow Passing (minutes)</th>
<th>Maximum Time on Section (minutes)</th>
<th>Fraction of Demand Deviated</th>
<th>P(Queue to End Section) (0-1) (Linking Factor of Tails)</th>
<th>Tidality: Opposite Way Flow proportion of forward direction (Jones et. al)</th>
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### Figure 1. Example of main Spreadsheet Model worksheets (as at time of reporting)
8.4 The core of the model on each road section consists of the five elements listed below, supplemented by secondary effects of which the most important and common is queuing of opposite direction traffic as a result of road closure:

- Section description, including road capacity, traffic volume, load characteristics and timing
- Economic cost of delay\(^{17}\)
- Queuing behind the load and resultant delay
- Delay resulting from speed drop when passing the load, assuming passing is possible
- Diversion

8.5 Important factors in the delay calculation include:

- The normal capacity of the road section, and the ambient traffic volume
- The speed and lane-take of the load
- The capacity for traffic passing the load
- Number and duration of breaks on each road section
- The amount of diversion and proportion of queuing delay incurred by diverted vehicles.

8.6 Model results can be particularly sensitive to some inputs, especially the above. This is discussed in the Final Report.

8.7 The Model’s results for congestion costs will contribute to the Highways Agency’s assessment of Abnormal Load applications. Other externality costs are identified (see earlier in Section 6), but their estimation for Abnormal Loads would require significant additional research, as no data specific to Abnormal Loads are currently available. In the absence of such research, estimated externality costs per mile can be input into the model to form part of the overall cost.

9 Monitoring by MIDAS

9.1 In addition to the ‘live’ monitoring, nearly 60 moves have been monitored on motorway sections of their routes using MIDAS detector data, selected from a total of 575 moves identified. This is somewhat fewer than was originally planned, because of a lack of moves taking place, and the need to select current or recent moves (March-October 2004 in practice) so that hauliers would be likely to be able to provide details of route, timing and any significant events. It also depends on the moves using route sections covered by MIDAS, which are limited to certain motorways. Sections covered by MIDAS are limited to certain motorways, and therefore may not be representative of all motorways, nor of other types of road including single carriageways, which can be studied only by direct observation or modelling.

9.2 MIDAS provides 1-minute-average flows, speeds and other variables, by lane, at a number of detector sites on certain motorways, spaced at intervals down to 500m. Currently MIDAS is installed on the following road sections which are 3-lane motorway unless otherwise stated:

- M1 Junctions 11 and above (Luton and northward)
- M5 Junctions 1-4a (Birmingham ‘box’)
- M6 Junctions 4-20
- M25 Junctions 6-16 (including Controlled Motorway where 4 lane)
- M42 Junctions 1-7 (Birmingham ‘box’)
- M62 Junctions 4-30
- M60 Manchester ‘box’ (not all 3 lane)

\(^{17}\) The DfT’s on-line portal WebTAG (2004) provides information on the cost of delay time. It is considered sufficient in the present study to adopt an average figure of £11.28 per vehicle-hour (the range across different vehicles classes and journey purposes being about £10-12.50)
9.3 Analysis of MIDAS data is aided by a TRL-developed software package called MTV\textsuperscript{18}. This enables traffic speeds on a stretch of motorway over time to be visualised (see below), and also allows total vehicle-hours of delay to be calculated relative to a ‘reference speed’ of 65 mph determined from MIDAS data. Available coverage of MIDAS was variable, being affected in some places by temporary network bandwidth constraints. Overall, about 55\% of coverage was considered good.

9.4 A series of Saturday daytime moves of large slow girder-frame loads up the M6, expected to produce heavy queuing, was identified as ideal for comparing observation, modelling and MIDAS results. It was not appreciated until afterwards that MIDAS coverage of the main queuing region would be very limited. MTV plots still yielded useful information from the visible geometry of the queuing regions, allowing the queuing model to be validated.

9.5 Figure 2 plots the total travel distance identified against estimated cost-per-mile bands. The results, which are necessarily limited to a subset of motorway sections in England, show that the delay cost per mile on motorways is highly variable, so it would be misleading to suggest an average delay cost. The median delay was only £2.50/mile, consistent with most delay being caused by a small number of loads. The highest figure measured was about £1600/mile on one section, but only around 8\% of motorway load miles were associated with delay costs over £100/mile. These results are not necessarily representative of all motorways, and not representative of other road types, but may indicate likely magnitudes.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Total mileage in cost-per-mile bands of moves on motorways monitored by MIDAS}
\end{figure}

9.6 The variability of cost not only reflects the familiar way in which delays to individual vehicles vary with place and time, e.g. between peak periods near cities and night-time on rural roads, but is also magnified by the fact that the heavier the traffic the more vehicles are affected by the Abnormal Load and any queuing it causes. It is emphasised that the Model does not depend on such statistics since it calculates delays from traffic and queuing theory. The only use made by the Model of MIDAS results is in calibrating certain values such as passing capacity and speed (see below). On the other hand, the MIDAS results cover a broader range of moves than those directly observed and modelled.

9.7 Analysis of MIDAS/MTV data on traffic passing speed and flow has enabled an approximate relationship to be established between passing speed and load speed, and an estimate of passing capacity per lane to be made. The latter appears to lie in the range 50-80\% of normal lane capacity.

\textsuperscript{18} Motorway Traffic Viewer – developed originally by Dr B Williams and P Still, who have since left TRL.
and it is recommended to adopt a figure of around 1300 veh/h, around 65% of normal capacity, similar to that measured from counts on the M6 when the traffic was known to be saturated.

10 Comparison of Model results with observation

10.1 In the course of the project spreadsheet models were constructed for several moves observed. The average cost of the moves observed was £177/mile, but this is certainly not representative of all moves, since monitoring was deliberately aimed at those likely to cause congestion. According to the model, the most disruptive loads delayed other traffic by on average in the range of 15-25 minutes.

10.2 Observed and modelled moves made use of general purpose roads as well as motorways, but the MIDAS analysis provides a cost distribution only for motorway sections. The costs estimated for motorway sections monitored are not necessarily representative of all motorway sections, and are not representative of other roads.

10.3 The Final Report compares results of observation and modelling for seven moves on four different routes. This includes the large girder-frame moves on the M6 referred to earlier. In that case, despite some uncertainties, the model results show good agreement with observation and can be considered to validate the model. There is good agreement on two other routes also, but on one it was not possible to reconcile the observed volumes with the observed queues without assuming diversion. This occurred on a rural route with a rich local minor road network.

11 Modelling issues and sensitivities

11.1 Variations in haulier, police and escorting practice may have an effect on load speed, lane take and passing capacity. For example, observers judged that during moves on the M6 and M62, traffic could have passed safely at 40-45 mph, but the presence of police brought occasional passing speeds down to 30 mph or even as low as 20 mph, potentially reducing passing capacity, though there is no definite evidence. MIDAS had set 40 mph signs, but traffic speeds within the queue were always well below 30 mph, so the main effect of the signs may have been to protect the back of the queue.

11.2 Add to this the site-specific hourly variations in traffic demand and it is clear why predicting the effect of Abnormal Load movements on traffic delays is not straightforward. The availability of the delay model allows the sensitivity of traffic disruption to movement characteristics to be investigated, both at the generic (typical) road section level and for route-specific movements.

11.3 The variables that have the greatest effect on traffic delays on individual sections are traffic volume, lane take, length of haul before queues can be dissipated, and load speed (which affects both the time the load is present and possibly the ‘effective capacity’ of passing lanes). Day and time of movement can have a major effect on local and total delays through the variation in traffic volumes. Although the delays can also be affected by the speed limit of the road, the speed of traffic passing the load and the proportion of Heavy vehicles, these do not have a major effect directly. Indirectly, the proportion of Heavies could tip the balance between capacity being sufficient or insufficient to avoid queuing. Their presence could in principle affect the effective passing capacity even more by modifying traffic behaviour in the vicinity of the load, but how often this occurs is unknown.

11.4 The Final Report contains a section devoted to discussing the sensitivity of the traffic delays to the assumptions made in the planning of Abnormal Load movements. Tests are based for the most part on 3-lane motorway sections and the results given are designed to indicate the effect of parameters on the results under ‘typical conditions’. The numbers are unlikely to be reproduced exactly on specific links.

11.5 More specifically, the Model includes facilities to estimate the benefit of breaks which allow queues to clear fully or partially, and also to recommend the number and location of these breaks. Limited tests suggest that the cost saving of breaks is fairly consistent (in the range 40-50%), though more breaks are likely to be recommended for moves which are inherently more costly, and also that most of the benefit may be on just a few road sections where queuing and congestion are heaviest. More details can be found in the Final Report and the Model User Guide.
12 Findings of monitoring, analysis and modelling

12.1 Abnormal Loads have unique characteristics which call for particular approaches to monitoring and modelling, and raise particular issues.

12.2 Several issues concerning the limits of modelling have arisen from the monitoring work:

- Accurate traffic volume data are needed for each section of the route. Construction of the spreadsheet model is aided by macros, but a time-dependent volume profile or ADT value needs to be obtained ‘manually’ for each road section;
- Results are sensitive to the behaviour of passing traffic, and the effect of ‘tactical’ manoeuvres by hauliers and police to allow traffic to pass. The results of this study from MIDAS data have shown what the range of passing speeds and capacities is likely to be;
- When the convoy and traffic are relatively quick moving, the delay caused is not obvious, although this does not present a problem for modelling;
- Estimating the extent and impact of diversion requires additional information about where opportunities for diversion exist along the route.
- Neither modelling nor MIDAS analysis is an exact science. The model depends on many variables which can only be estimated, derived from historical data or samples, or in extreme cases guessed on the basis of professional experience, while MIDAS analysis depends on detectors being available and on the correct choice of parameters such as the reference speed of ‘normal’ traffic.

12.3 As explained earlier in Section 6, a ‘test of reasonableness’ must take into account the highly case-specific nature of operational and planning costs associated with Abnormal Load moves by road or water, as well as the estimated congestion cost of road moves. On the other hand, it is possible to rank moves according to the magnitude of their likely congestion costs, which are highly variable.

12.4 There are no data specifically relating to the safety and environmental impacts of Abnormal Load movements. Research on these costs for HGVs reveal them to be relatively small in relation to congestion costs. Using these figures, estimates have been made for these externality costs for Abnormal Loads as no specific data are available. The best available information has been assembled in Appendix I to the Modelling Report.

12.5 The congestion costs produced by Abnormal Loads are highly variable, measured values for moves monitored on motorway sections ranging from virtually zero to £1600/mile in one case, though only about 8% of motorway load miles exceeded £100/mile. While it is not meaningful to suggest an average value, the median congestion cost on motorways of £2.50/mile (ie that exceeded on half of load-miles measured) is unlikely to affect decisions about whether, when and how to permit a load to move. For the moves observed, which are not representative of all moves but were chosen to give the maximum information, the most disruptive moves delayed other traffic by on average 15 to 25 minutes.

12.6 Abnormal Load hauliers may require lay-over sites, of adequate capacity, for temporary or overnight use for several reasons: long journeys requiring two or more days, avoidance of peak traffic periods, and limitations on drivers’ daily working hours. Currently, they rely on experience to find and secure these sites, planning and timing their moves accordingly. Use of motorway service areas is limited and they need to be on the agreed route.

12.7 In order to maximise the amount of information gathered, the results of this study have been obtained by analysing SO (loads over 150,000kgs, or 30m long, or 6.1m wide) and VR1 (loads exceeding 5.0m up to 6.1m wide) moves, but the modelling principles and general findings apply equally well to other types of load covered by STGO and C&U (smaller and lighter loads).
13 General conclusions

13.1 A Literature Review has provided background information and brought into focus issues of external and environmental impacts and water transport policy. While it has yielded little quantitative data about the congestion effects of Abnormal Loads, and no data on other impacts specific to AILs were found, it has provided the basis for a general quantitative estimate of the cost of external and environmental impacts of road freight transport.

13.2 The project has allowed the Expert Panel the opportunity to influence the course of the project, and in particular the monitoring of Abnormal Loads. Consultation of members of the Expert Panel and other Stakeholders has aired issues of escorting practice and fair comparison between road and water modes. Stakeholders raised various specific concerns such as divided responsibilities for managing waterways and uncertainty about dredged depths, imposition of tolls, ‘hidden subsidy’ for roads, and the benefits of targeted investment, eg new motorway-waterway interchanges.

13.3 A number of Abnormal Load moves have been observed directly, and a larger number analysed using data from MIDAS on motorway sections. While neither data set can be said to be fully representative of all AILs, the live observations have been targeted to use limited resources most effectively, and it is believed that a good understanding has been obtained of the possible magnitude of effects of different types of Abnormal Load moving under different conditions.

13.4 A mathematical spreadsheet model has been developed which takes into account the specific characteristics of each Abnormal Load movement including the load’s size, speed and route, and variations in ambient traffic by day of week and time of day, so its results can contribute to the decision-making process. It calculates queues and delays from traffic and queuing theory, and does not rely on statistical results from monitoring, except to calibrate certain values such as passing speeds and capacities. Given realistic data it can produce a description of an AIL’s effect on traffic which corresponds with observation.

13.5 Specific conclusions concerning modelling are:

- The model depends on the data put into it being realistic, which includes correctly identifying the independent sections of the route, inputting accurate time-dependent traffic volumes, and making correct assumptions about diversion. Experience suggests that use of ADTs where TRADS data are unavailable, even if correct for the day of travel, may reduce accuracy, but is unlikely to affect conclusions about the general magnitude of congestion impact;

- Congestion caused is most sensitive to load speed, load width or lane-take and the effective capacity of passing lanes, and ambient traffic volume where this is comparable to capacity;

- Congestion costs are highly variable. Estimates from moves monitored by MIDAS on some motorway sections ranged from virtually zero to £1600/mile on one section. However, it is estimated that £100/mile is exceeded on only 8% of motorway load-miles. These results are not necessarily representative of other motorways or other types of road. Overall costs of moves observed directly are estimated to be intermediate in the MIDAS range.

- Based on modelling results, the average delay incurred by individual vehicles because of the most disruptive loads is estimated to be in the range 15-25 minutes.

- Traffic can incur measurable delay even when appearing to flow freely at 30-50 mph, when the presence of a ‘queue’ may not be obvious to an observer;

- Diversion may be important only on certain routes, depending on local conditions;

- Empty transfer can be modelled in a similar way to loaded moves, with the appropriate route and vehicle characteristic data, but empty mileage is strongly case-dependent;

- There are no data on externality costs specific to AILs. However, some costs (other than congestion) can be estimated, and are unlikely to be large enough to affect decisions;

- The Literature Review has concluded that there is no other current or relevant research.
13.6 When estimating costs of transport by water, it must be kept in mind that water transport can also involve substantial road segments, but that water costs are less directly dependent on distance than road transport and involve a large, sometimes dominant, component of transshipment costs, especially craneage, although roll-on-roll-off operation can reduce this.

13.7 In summary, this project has revisited Abnormal Loads after a gap of 37 years, during which time the quality and capacity of roads, and the performance of transporters, have increased considerably. Although this is a complex subject with a strong component of practical experience on the part of haulage and manufacturing industries and the police, it is believed that an airing and understanding has been achieved of the operational issues of road and water transport. The impact of Abnormal Loads on traffic has been addressed quantitatively, with a new capability of predicting traffic delays and costs, potentially allowing a ‘test of reasonableness’ between road and water modes.

14 Recommendations

It is recommended that:

- Abnormal Loads occupy the minimum number of lanes possible without jeopardising safety, and that the shortest possible closures of roads and side-entries be made;
- Better information be gathered from practitioners on the actual operational costs of both road and water moves so that the uncertainties in comparing road and water modes can be reduced;
- A study be set up to determine the specific externality impacts and costs of Abnormal Loads, much of which may be related to the congestion and delay caused by them;
- An inventory of lay-over sites and their capacity be compiled, with clarification of the responsible authorities;
- Where necessary, bandwidth for MIDAS data be increased to facilitate more wide-ranging monitoring.

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16 References


