Mitigating the disruption caused by utility street works

Prepared for The Pipe Jacking Association

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Executive Summary

The New Roads and Street Works Act 1991 (NRSWA), which came into effect in 1993, introduced a new system of managing utilities' street works with the intention of reducing disruption from such activities. This gave new powers to highway authorities to co-ordinate utility street works, backed by new requirements for the utilities to give advance notice of such works and to co-operate with the highway authorities and each other. With its emphasis on reducing disruption, it was anticipated that the introduction of the Act would have led to an increase in the use of trenchless techniques for utility street works, but this has not been the case. The Pipe Jacking Association (PJA) set up a working group to investigate the lack of market growth in the use of trenchless techniques with the aim of obtaining a better understanding of the factors affecting the UK market. PJA commissioned TRL Limited with Jason Consultants Ltd, acting as a named sub-consultant, to review the available information. This report presents the findings of that commission.

Details of the NRSWA are given in the report. A review of its effectiveness in reducing the disruption due to utility street works is also provided through a survey of informed motoring organisations, contractors and highway authorities. The consensus view is that the Act has not led to any noticeable reduction in the disruption due to utility street works. This is supported by changes in the way the Act has been implemented and also by recent Government initiatives such as the planned introduction of pilot lane rental schemes in Camden and Middlesborough.

The importance of utility street works, and the various impacts and associated costs of such works are discussed in the report. The direct cost of trenching and reinstatement work in UK highways for utilities is likely to be in excess of £1 Billion per year. Indirect costs are generated by the impact of utility street works on,

- highway users - largely the costs of delays and accidents;
- businesses - through reduced output and turnover;
- local community - through a reduction or loss of access to amenities;
- the environment - including damage to trees, increased pollution, use of natural resources and generation of waste;
- third party property - damage to buildings, walls etc;
- highway authorities - by the need to repair pavements.

There is a paucity of information on the various indirect costs. Nonetheless, the cost of traffic delays associated with utility street work is likely to be higher than their direct costs. And the total indirect costs arising from utility street works could be about £2 Billion per year. This is a substantial burden for society to sustain. There is a pressing need to collect and validate data on the indirect costs of street works.

Methods for evaluating the indirect costs of street works have been proposed, but they do not seem to have been used in the UK. Elsewhere, cost-benefit analyses of one form or another have been used but these have tended to be overly simplistic. Further work to develop and refine a method for evaluating indirect costs is warranted.

In the UK, selection of the method of undertaking utility street works is based on direct costs, and so trenchless techniques are only used when they are cheaper than the open-cut method of working. Some engineers and their clients have reservations about the risks and costs associated with some trenchless techniques, and indeed such techniques are not the panacea for utility street works. That said, for some street works considerable savings in indirect costs can be obtained by adopting less disruptive, but marginally more expensive, methods of working, and this might include the use of trenchless methods.

A summary of the findings of an international review of the policies and construction practices adopted for street works is provided in the report. Quite a wide range of views were found regarding the 'rights' of utilities to install and repair pipes and cables in public roads. The requirement and use of trenchless methods for utility street works varies according to, for example, the geographical and geological setting, but the most important factor was the existing policy and legislation defining the rights of the utilities and the public. In the countries covered by the review, utilities have far less freedom to undertake street works than they do in the UK. In some countries, such as Japan, some utilities pay a yearly rent on the underground space it occupies, and in others, such as Germany, a permit must be obtained in advance of undertaking any street works.

It is improbable that those currently burdened by the indirect costs of utility street works will continue to do so in the long term. Further changes in UK legislation governing street works seem inevitable. It is essential, for all parties concerned, that any new legislation addresses the prime issues of street works, of all kinds, so that some attempt can be made to optimise the benefit to society as a whole. To do so requires much more information to be collected and analysed on the impacts and indirect costs of street works, followed by an open debate on the options available for introducing new working practices and how they might be implemented.

1 Introduction

In 1985 the Horne Committee completed its comprehensive review of the Public Utilities Street Works Act 1950. This review found that the uncoordinated activities of those concerned with carrying out works on the highway led to unnecessary traffic disruption and significant additional costs to the public. The New Roads and Street Works Act 1991 (referred to hereinafter as NRSWA or as the Act) was introduced in response to this review.

According to the consultation document 'Reducing disruption from utilities' street works', which was issued by the Department of Environment, Transport and the Regions (DETR) in 1999:

> *'The New Roads and Street Works Act 1991 introduced a new system of managing utilities' street works, intended to reduce disruption from them. It came into effect in 1993. There were new powers for highway authorities to co-ordinate works, backed by new requirements for the utilities to give advance notice and to co-operate with the highway authorities and each other.'*

Thus the enactment of NRSWA should have led to a noticeable reduction in the disruption - in all its forms - generated by utilities' street works. This objective does not seem to have been met. Observation and anecdotal evidence from various sources suggest that (at best) the situation has remained much the same since the Act was issued. Indeed, the consultation document stated:

> *'There is no systematic evidence to say whether the problem has got better or worse since 1993. …… And there is continuing concern among road users and others affected by these works.'*

Changes to the conventional working practices, i.e. based on the open-cut method of working, have been proposed and promoted to reduce the disruption generated by street works. The appropriate method of working to minimise disruption would vary according to site conditions, but the benefit of a 'minimum disruption' approach would be a substantial reduction in the impact and associated indirect cost sustained by,

- motorists;
- the community (loss of amenity);
- business (reduction in trade);
- the environment (e.g. reduced pollution, damage to trees and waste);
- highway authorities (in replacing and maintaining pavements and footways); and
- third party property.

The drive to reduce disruption generated by street works might have led, not unreasonably, to an increase in the use of trenchless methods of construction. (Brief details of such methods are provided in Appendix A of the report.) However, again, such expectations have not been met. Indeed, a working group was set up by the Pipe Jacking Association (PJA) to investigate the lack of growth in the use of such methods for installing services in streets. The first aim of the working group was to obtain an understanding of the factors that affect the UK market for both trenchless and open cut methods of installation. A number of areas requiring evaluation were identified and TRL Limited, with Jason Consultants Ltd (JCL) acting as a named sub-consultant, were commissioned to collect and review information on the relative costs and benefits of both methods of working.

The findings of the study have been reported by Burtwell *et al.* (2000) and also by Thomson and Robinson (2000). A launch reception of the latter report was held on 20 July 2000: the reception was reported in both the technical and general press, for example Williams (2000). The launch prompted discussion amongst interest groups, contractors, and utilities. A response to the launch report was received from the National Joint Utilities Group (NJUG), who represent the interests of the utilities, and a meeting of representatives of NJUG, TRL and JCL was held to discuss the report. Public debate has also followed at meetings, such as of the British Tunnelling Society on 21 June 2001, and has continued in print, for example NCE 5 July 2001(a). To provide a stimulus and reference for continued debate, it was decided to make the findings of the study more readily available through publication.

As with the earlier reports, this publication was commissioned by the Pipe Jacking Association (PJA). The content of this published version is based, by and large, on the earlier reports but, with advantage, additional material has also been included, for example on recent changes in practice, and some less important parts have been omitted. The written response of NJUG to the launch report is reproduced in Appendix B.

The report examines the selection of the method of undertaking utility street works and the impacts and associated costs of such works. It also describes the use of trenchless methods that could mitigate such problems: inhibitors to the use of such methods are identified. To provide a broad-based comparison, international experience and practice for undertaking street works are described. The report examines UK practice and legislation governing utility street works and discusses various options for improvements in these areas.

2 Objectives of study

The basic aims of the PJA initiative were to assess the relative costs, advantages and disadvantages of trenchless and open cut methods for utility street works. The specific objectives of the study were:

- To review the literature on research, practice, and the economic and technical benefits of trenchless methods.
- To collect and analyse data on the direct and indirect costs of trenchless and trenched installations.
- To examine whether or not the introduction of NRSWA led to a reduction in the disruption associated with utility street works.
- To review international practice with regard to utility street works and the use of trenchless methods of installation.

- To consider safety aspects of both open cut and trenchless installations.
- To ascertain the perception of UK clients to the use of trenchless methods and their decision-making mechanisms for selecting the method of installation.
- To review how clients took account of indirect and social costs when evaluating methods of installation.
- To review the approach of contractors in selecting the method of working.

To produce a positive contribution to the debate it was necessary to address all types of utility installations. By comparatively assessing open cut and trenchless methods, the economic and technical inhibitors to the wider use of the latter might be identified. Although there are insufficient data to provide a convincing economic assessment, other inhibitors and shortcomings of trenchless installations as *perceived* by clients might be identified in this way.

It might be beneficial to undertake a second phase of work to better quantify the means and benefits of a minimum disruption approach to road works. With this in mind, other tasks for this first phase were to identify:

- organisations who have a concern about the impact of disruption on highways;
- what additional data are required to confirm the benefits of minimum disruption approaches, and the form of analysis required for such data;
- what case studies would best demonstrate the benefits of minimum disruption approaches.

(For brevity not all the above are reported herein, but some information is provided in the earlier reports.)

3 New Roads and Street Works Act 1991

The Act resulted from the review, by the Horne Committee (1985), of the Public Utilities Street Works Act 1950. According to the associated Code of Practice (DETR, 2001) on the implementation of NRSWA, and associated regulations, that review:

> *'highlighted the unnecessary traffic disruption and significant additional costs to the public (apart from those incurred by undertakers, highway authorities and transport operators) caused by the uncoordinated activities of those concerned in carrying out works of all types on the highway.'*

Thus section 59(1) of NRSWA required street authorities to:

> '*use their best endeavours to co-ordinate the execution of works of all kinds (including works for road purposes) in streets for which they are responsible:*
>
> *a in the interests of safety;*
>
> *b to minimise the inconvenience to persons using the street (having regard in particular to the needs of the people with a disability); and*
>
> *c to protect the structure of the street and the integrity of apparatus in it.'*

Section 60 places these same duties on undertakers.

The Act established a notices and registration regime, and gave street authorities powers to issue directions as to when street works may or may not be carried out. Of particular relevance to this study are the following:

Section 54 and 55 - regarding advance notice and notice of commencement of works.

Section 61 to 64 - streets subject to special controls.

Section 66 - avoidance of unnecessary delay and obstruction.

Section 70 - time to complete reinstatements.

Section 74 - charge for occupation of the highway where works are unreasonably prolonged.

According to the Code of Practice, the legislative and regulatory provisions have three supporting pillars:

i The notice system - i.e. concerning the timing of the works.

ii Streets where works are subject to 'special' controls - i.e. 'protected' streets, streets where difficulties would be met with engineering works, and 'traffic-sensitive' streets.

iii Tools to facilitate co-ordination - these include powers to direct the timing of the street works and to restrict such works following substantial road works, and the requirement on undertakers to avoid unnecessary delays and obstruction.

Further, for the Act to be effective undertakers and street authorities must:

i balance the potentially conflicting interests of road users and undertakers' customers;

ii maintain close co-operation and liaison; and

iii acknowledge that work programmes and practices might have to be modified to ensure that the co-ordination provisions are achieved.

It is clear from the above that the Act was drafted with the expectation that co-operation rather than confrontation would be the order of the day. Following the drafting of the Act, the various supply and service industries were privatised and this led to a proliferation of utility companies. The requirements of highway authorities and utilities are more obviously opposed now than they were before. The prime concerns of highway authorities are minimising disruption (in all its forms) and safeguarding public safety, whilst commercial pressures weigh heavily on the utilities and their contractors.

3.1 Effectiveness

It is pertinent to note that the Act was not put in place to reduce disruption *per se*, but to reduce that generated by poor co-ordination of those concerned with street works. This limited aim could be questioned. Nonetheless, an objective of the Act was to reduce the total disruption from utilities' street works and so its effectiveness could be gauged by determining whether such a reduction has occurred.

The need for the 1999 DETR consultation document 'Reducing disruption from utilities' street works' arose from a commitment made in the 1998 Transport White Paper, 'A new deal for transport – better for everyone' (DETR, 1998). This stated at paragraph 3.104:

> *'We wish to reduce the impact on traffic and pedestrians caused by street works for utility companies. We will consult on options for an incentive system, with penalties, to minimise disruption to all road users, and to encourage improved co-ordination on street works.'*

The document set out the problem thus:

> *'There is no systematic evidence to say whether the problem has got better or worse since 1993. It is certainly the case that pressure has increased both from numbers of street works and from levels of traffic. And there is continuing concern among road users and others affected by these works. The problem affects not only vehicular traffic when the works in the carriageway reduces road capacity. It also affects pedestrians when footways are dug up and, at times, they have to use part of the carriageway.'*

To address this 'problem', the document stated:

> *'The Government does not intend, at this stage, to introduce major new legislation on this subject. But it wants to see the powers in the existing legislation used fully where they can be effective.'*

3.1.1 Implementation of section 74

The suggested amendment to the legislation set out in the consultation document is to charge for occupation under section 74 of the Act. An announcement to this effect was made in the House of Lords, in April 2000:

> *'My Lords, the Government intends now to implement section 74 and will work with the highway authorities and utilities to develop such a scheme. … … There was also a widespread feeling that the existing arrangements under the New Roads and Street Works Act could and should be made to work better.'*

(The above seems a clear admission that the Act has not been as effective as it might have been.)

In his address to a meeting of the Highway Authority and Utilities Committee (HAUC) on 25 January 2001, Keith Hill, the (then) Minister for Transport, introduced the changes to section 74 as follows:

> *'The main message I want to get across today is that government takes seriously the challenge of reducing disruption to street users, and we shall not shy away from taking the measures to deal with it.'*

Section 74 of the Act was implemented on 1 April 2001. It requires undertakers to estimate and agree a reasonable time for the works - arbitration is available where the highway authority challenges the estimate. Charges are only made when this period is exceeded: highway authorities are able to charge undertakers up to £2k per day overrun for each works.

In a further development, pilot lane rental schemes for street works are to be introduced early in 2002 in both Middlesborough and Camden. These will be monitored to determine their effectiveness in reducing disruption and inconvenience to the public. With such schemes, utilities will be charged a daily rate of £500 each time a road is dug up to install or maintain their equipment. Such schemes are covered by section 74A of the Act - as amended by the Transport Act (2000). The following statement made by John Spellar, the Minister for Transport, on 14 August 2001 (taken from a DTLR press release) reaffirms the Government's intention to tackle the problem of disruption caused by utilities' street works:

> *'Motorists and residents were fed up with the frustration caused by constant digging up of the road. Disruption caused by utilities digging up our roads and streets causes huge frustration to the travelling public. I am determined to find effective ways of ensuring that works are carried out as quickly as possible. Our decision to mount these trials clearly demonstrates our determination to deal with this blight because frankly the public has had enough. This year we have already brought in powers allowing highway authorities to impose a daily charge on utility companies every time their work overruns an agreed deadline. Over 100 local authorities have or will be taking these powers up. However, the Government has made it clear that if this overrun charging does not reduce disruption sufficiently we shall bring in further powers - 'lane rental' as it is called - to allow utility companies to be charged from the beginning of their works, even if they are completed to deadline. Although no decision has been taken on the national use of lane rental we have decided to use these pilots to test the effect it might have in encouraging utility companies to reduce the overall disruption caused by their works. That is why I am launching this consultation today on how the two pilot schemes will work. The Government will monitor these pilots closely. We will not hesitate to make these new powers available to local authorities throughout England if it becomes clear that this is necessary to reduce disruption.'*

In his statement, the Minister recognised that many street works undertaken by the utility companies were in response to customer demand and included vital work to maintain existing services.

No matter what arguments and counter-arguments are put forward by pundits in industry, the foregoing statements should dispel any lingering doubts about the demand for a reduction in the disruption generated by utility street works. The recent changes in legislation are an expression of the political will to ensure that a reduction occurs. Those who argue that these changes were unnecessary are simply not taking sufficient account of the groundswell of opinion that changes to current working practice were essential. And, as stated above, further changes might follow.

3.1.2 Non-compliance

In the decade or so following the introduction of the Act, the number of court cases where councils have sought redress from statutory undertakers for defective or prolonged street works has averaged a dozen or so a year. Given the millions of street openings per year, this might be viewed as evidence that the Act has been particularly successful. In practice, highway authorities have been reluctant to prosecute because this form of redress is not cost-effective. Authorities would much rather resolve problems on the street than in court: prosecution is seen as a last resort - an admission of failure that a problem cannot be resolved by any other means. Thus *the low level of prosecution is not proof that the Act has been applied successfully*.

The co-operative attitude could be changing.

It should be appreciated that (a) court cases are time-consuming and expensive for a highway authority (b) the fines are commonly low, i.e. between £500 and £600, and (c) the fines do not go directly to the highway authorities. The following, attributed by Sherrington (2001) to Mr D Jest - the Environmental Services Manager of Wiltshire - sums up the problem quite well:

> *'We brought a case to court last December where the utility company was fined £1,300. We received costs of £520, but it actually cost us more than £1,000 to bring the case to court - as well as a lot of officers' time.'*

Some authorities might find it difficult to justify the expenditure on what are demonstrably non cost-effective court actions, and it is hardly surprising that some, for example the Royal Borough of Kensington and Chelsea (in 1995), have stated that such court actions are simply not viable. But, despite the cost to local government - and hence the public they represent, court cases might become more frequent, particularly following the implementation of section 74.

In April 2001, Phoenix Natural Gas was fined £750 by Newtownabbey Magistrates Court in Northern Ireland for failing to comply with traffic safety measures. This is thought to be the first time that a public utility has been prosecuted for such an offence. The prosecution followed a pledge from Mr G Campbell - the Regional Development Minister, to get tough on utility companies who break the law whilst carrying out road works. (It is understood that the Roads Service is pursuing other cases.)

Examples of recent cases in England are the prosecutions brought by the London Borough of Bromley against Thames Water, NTL and BT. According to an article in the Surveyor (Sherrington, 2001), the Borough:

> *'had reached the end of the negotiating road with some undertakers, and had no alternative to prosecute.'*

In the same article, the following quote is attributed to the street works manager for the Borough, Mr D Lambert:

> *'We first tried to cajole [utility companies] into carrying out the work properly, but some constantly flout their responsibilities. … What can you do, other than go to court, when a company digs a 1,600m-long open trench and only protects it with three cones, and refuses to implement proper protection procedures?'*

(Details of other prosecutions are also given in the article.)

3.2 Survey

The lack of 'systematic evidence', as highlighted in the 1999 DETR consultation document, hinders the quantification of the problem of 'disruption' (in a wide sense), judging what is required and instituting changes to effect improvement. Therefore, a wide-ranging survey was undertaken to obtain the views of those engaged in planning or undertaking street works, and also those affected by the works. A summary of the results of the survey is provided below.

3.2.1 Motoring organisations

The following organisations were contacted for their views on the disruption generated by street works,

- Automobile Association (AA).
- RAC Foundation for Motoring.
- British Road Federation (BRF).
- Freight Transport Association (FTA).
- Road Hauliers' Association (RHA).

Where possible, meetings were held with representatives of the above organisations. Literature was also obtained, but not all the organisations responded to the request for information.

The results of a survey undertaken by the AA (1997) showed that:

- 76 per cent of drivers consider that more could be done to reduce the inconvenience of roadworks;
- 73 per cent consider that works are undertaken at peak times and so cause unnecessary inconvenience; and
- 78 per cent consider that managers should be more directly accountable for the safety of their roadworks and the delays caused.

The views of the BRF are set out in a position paper 'Utility services and Britain's roads' (BRF, 1999). Although the BRF supported the introduction of NRSWA, they now consider that the benefits gained from it are far less than anticipated. They stated that:

> *'Although utility companies are required to notify highway authorities of the need to undertake routine maintenance they are still entitled to undertake work deemed to be an emergency without approval of the highway authority. BRF believes that there is far too much flexibility in the definition of emergency which enables the utilities to bypass the approval regulations.'*

> *'The formal procedures for co-ordination of street works have still not been put in place and there is still no national register. Although excellent informal arrangements exist in some parts of the*

country there are still many cases of work being approved by neighbouring highway authorities without each of those authorities being aware of the other work being undertaken.'

'There is no mechanism to ensure that work is completed as rapidly as possible. Therefore, a utility may decide it is cost-effective not to work at night or weekends despite the additional cost of disruption to traffic by this approach.'

'Although reinstatement standards have improved, there remains concern in relation to the length of period following reinstatement for which the utility should retain responsibility for the integrity of their work.'

The FTA stated that the delays caused by utility street works were unacceptably long. The evidence backing the complaints and the comments of the members of the FTA and BRF is strong but is, inevitably, anecdotal.

3.2.2 Contractors

Meetings were held with the representatives of contractors engaged in utility street works.

A number of contractors opined that the Highways Agency (HA) made a better job of controlling street works than local authorities, this was particularly so in London. Although one of the aims of NRSWA was to encourage effective co-ordination of street works, many contractors reported that this was the exception rather than the rule. In addition, cases were cited where a utility was told not to undertake work in a particular street or area, because another utility was working there, but the work was declared to be an emergency and started immediately.

3.2.3 Highway authorities

More than half of the highway authorities in the UK was contacted for their overall perception of the NRSWA and specifically on the following:

1 Methods of programming street works, and on the notice periods required under sections 54 and 55 of the Act.

2 Methods used to mitigate inconvenience and disruption to the public throughout the period of highway occupation (section 66).

3 Time to complete reinstatements (section 70).

4 Differences in the approach by utilities to street works in 'traffic-sensitive' and 'normal' roads - as covered by sections 61 to 64 of the Act.

Of a total of 90 requests for information, 34 replies were received. Responses were obtained from a wide range of authorities spread throughout England and Wales and representing a good cross-section of geographical location and experience. Many of the replies were quite detailed and included additional commentaries. The responses to the above are covered in order below, but they are preceded by general comments.

General comments

The replies from the highway authorities on the effectiveness of NRSWA ranged from total satisfaction to total dissatisfaction, but several echoed the following comment, from a respondent in a London Borough:

'… … in the drafting of the NRSWA 1991 the authors were trying to achieve a number of objectives. One of these was certainly an attempt to minimise disruption associated with utility and highway works. However the most important aspect to note is that the drafting of the legislation occurred when the majority of utilities were public bodies and the commercial pressures of shareholders and the boardroom were unknown. The operating environment has now changed. All utilities are in the private sector and the number of utilities able to operate has changed from five to many hundreds if not thousands.'

This proliferation of utilities with rights to install their equipment was a concern to several respondents. There appears to be an increasing awareness that (a) it is the public who are bearing the cost of disruption and (b) there is a need for them to be better represented and protected. On this issue, the Chief Engineer of a Northern Metropolitan Council opined:

'I welcome the opportunity to comment on these matters which rather than being looked at from the point of view of the Act need to be seen from the public's point of view.'

One of the most interesting comments came from a representative of a London Borough:

'The NRSWA was supposed to be dynamic with the Secretary of State being able to introduce change by statutory instruments and HAUC/the Minister able to amend/delete from the associated Codes of Practice. The changing commercial environment that has developed since the legislation was introduced in 1993 has meant that the processes have not been dynamic. The legislation and the associated Codes of Practice have not reacted to change. In my opinion, stagnation has been to the commercial advantage of the private sector utility companies and to the detriment of the travelling public.'

A comment from a technical support manager in a County Council reinforces the above:

'Whilst my experience shows that agreement can be reached between staff in authorities and undertakers discussing the issues in working parties at national level, the agreed amendments are delayed by HAUC and DETR to the point where there is decreasing faith in these apparently remote institutions.'

There was a deep-felt concern that the relationship between utilities and highway authorities was not as represented in the Act. Another concern, expressed in a variety of ways, was that the authorities charged with responsibility for the highways under the Act felt that they had inadequate resources and funds to do the job properly. A few stated that parts of the Act were unworkable in practice.

Programming street works

Although there were wide variations of opinion, a number of respondents expressed the broadly similar view that the choice of the method of installation and its programming were dominated by the cost of the work.

In many cases the utilities did not supervise or manage the site work and, for a contractor working to a tight budget, minimising cost was the main concern. Thus little or no consideration was given to the impact of the works on the public. Although utilities are quite entitled to appoint contractors to act on their behalf, it could be expected that such contractors would concentrate on completing the work to a minimum cost. A few respondents commentated that such arrangements did not seem to be within the spirit of the Act: indeed it could be viewed as a dereliction of responsibilities of the utilities under the Act.

A Principal Engineer of a Southern Council commented:

> *'The utility companies tend to use the method which best suits them and which allows them to undertake work at minimum cost. Minimising disruption for highway users is normally of second priority.'*

Similarly, a representative of a Northern Borough stated:

> *'There is a perception that utility companies carry out their works to reduce their own costs with little regard for the travelling public.'*

A number of correspondents commented on the lack of planning for street works and the inability of utilities to provide advance information even for major works. Similarly a number stated that, in their experience, there was no effort made by utilities to co-ordinate their works with other utilities. But, on a positive note, many respondents, at a local level, had good relationships with utilities and their contractors and could work together to mitigate disruption.

On the issue of notices, many respondents felt that a month was too short particularly for major works. Authorities needed a longer period to co-ordinate works and to put in hand appropriate arrangements for traffic and pedestrians. A technical support manager of a County Council in South East England highlighted a particular problem with notices:

> *'There is one water company in our area who seems to ignore the legislation with opening notices sent in batches of well over a hundred, months after the event.'*

Several respondents commented on the abuse of the emergency provisions, an issue highlighted by the BRF and contractors. One respondent pointed out that it was almost impossible for an authority to counter this abuse because it would need an investigation and expert knowledge to make a judgement. In addition, an authority had little recourse to action even when it was confident that an emergency did not exist.

Mitigation of disruption

Many adverse comments were received about the fact that the utilities, and their contractors, did not take account of the disruption generated by their street work operations. Several respondents felt that the utilities were increasingly reliant on highway authorities to help them achieve the required standards.

A remarkable divergence of views was obtained on 'one-stop reinstatement'. Several authorities stated that it had not found favour with utilities in their locale and that there was little incentive to make progress in this area. On the other hand, others stated that it was standard practice.

The fragmentation of operations, such as the laying of basecourse by one gang with another laying the wearing course, created additional delays to the opening of roads and generated problems with signing, guarding and safety. A highway authority manager for a Northern Council commented:

> *'It has been noted that there appears to be an increase in specialisation or contractual arrangements for the installation of SU* [Statutory Undertaker] *equipment. This works against the one visit principle of the Act. Generally an excavation gang arrives to expose the SU's equipment, followed by a jointing/plumbing crew to make the connection and a reinstatement gang follows these. The process appears to be made worse in that the following crew is not committed to the works until the previous crew has notified that they have completed their works. This means that it is quite common for minor works which could be expected to be completed in one day to be ongoing for six days or more.'*

Similarly, an engineer of a Northern County Council commented:

> *'Excavations are left open for an unreasonable time due to the diversification with the utilities and lack of co-ordination between departments.'*

Section 66 of the Act states the requirement for utility street works to be completed with all such dispatch, as is reasonably practicable. It also covers the procedures a highway authority could take, where this requirement was not being met, to require the utility to take such reasonable steps to mitigate or discontinue the obstruction. On this issue, an inspector from a town in the Midlands stated:

> *'Section 66 is reliant on street authority vigilance. It is as effective as the highway authority procedure for identifying possible problems. Any directions we give to utilities are usually adhered to, however, if they are ignored, there is little the highway authority can logically do.'*

The Director of Engineering of a London Borough gave the following comment:

> *'Occupation and Disruption of Traffic (section 66). A section of the Act that has not been fully developed and only recently the DETR have accepted that there could be merit in developing it.*

In my opinion, in London, it is an essential part of legislation that needs to be introduced to exercise control of utilities who regularly focus on their customer rather than the travelling public.'

Time to complete reinstatement

Section 70 of the Act applies to the duty of the undertaker for reinstatement, but it is fairly loosely worded using phrases such as 'reasonably practicable'. The undertaker has a limit of six months to complete the final reinstatement. Failure to comply with the requirements is an offence.

Many considered that the utilities were unconcerned about the period of occupation and several had to take action to get utilities to fill holes and trenches that had been left open and unattended for weeks.

A frequently made point was that utilities ignored the prescribed time scales for completing reinstatements and also that it was difficult for an authority to monitor such works and even more difficult and expensive to resort to legal action to remedy them. A typical comment was:

'Section 70 is much abused, registration of reinstatements are late 90 per cent of the time, excavations are left open until there is enough work to justify the contractor being in the area.'

Many respondents commented that the failure to reinstate promptly was a common problem. Delays also resulted from the inadequacy of reinstatements to comply with the NRSWA Specification, DETR (1992) and HAUC (1996). The use of coring and other techniques, for checking the quality of the materials and their compaction down to 600 mm or more, have a high failure rate. Counter-claims that a high percentage of reinstatements meet the requirements of the Act appear to be based on superficial methods of assessment. Data on the quality of reinstatements has been provided by, amongst others, Burtwell and Spong (1999). (Section 71 of the Act refers to regulations prescribing materials to be used.)

Traffic sensitive streets

Most respondents stated that utilities differentiated between works in normal and traffic sensitive streets, as required by NRSWA. But several stated that there was no difference of approach in their area and indeed, in some cases, it seemed that some utilities did not know which streets were designated as traffic sensitive.

The Act does not apply to motorways - a licence from the Secretary of State is required for street works on motorways. The consensus opinion was that a licence should also be required for undertaking street works in trunk roads. Such roads are by definition 'key routes' and should be protected from uncoordinated street works. Furthermore, there is a strong case to be made, on the grounds of operating safety, for restricting the activities of utilities on the approaches to road tunnels (Clark *et al.*, 2001).

4 Utility street works

4.1 Importance

Given their importance, it is surprising that there are no definitive data on the number of utility street works within the UK. However, the results of a study by the AA (1997) put the number of street openings made on behalf of utility companies at about at four million per year for British roads, with perhaps up to half a million of these in London alone.

The scale of such works can be judged from the results of a study undertaken by JCL (1992) for TRL Limited: the findings of the study have been summarised by Thomson *et al*. (1994). It was estimated that, at that time, the total value of utility construction work was *£2.4 Billion per year*, of which just over *£1 Billion* or so was accounted for by trenching and reinstatement work undertaken in highways. Thomson *et al.* also estimated that, from a relatively narrow database, the traffic delay costs arising from street works were between £1.23 to £1.65 Billion per year. Based on the increasing number of street works and levels of traffic, it would not be unreasonable to assume that the current cost of traffic and public disruption arising from utility installation is about *£2 Billion per year*. This is a very significant sum of money for society to bear. The above figures suggest that *the cost of traffic delays is significantly higher than the cost of construction.*

4.2 Impact

Street works have an impact on a range of community and business issues. Whilst the effects of some issues might be quantifiable, the attribution of a cost to others is particularly difficult. Nevertheless, it is important to appreciate that, under current legislation and regulation, the community meets all the costs of street works other than the direct cost of the works and the damage caused by them, i.e. only part of the total costs is currently borne by the utility companies.

4.3 Direct impacts

The direct impact of the work is the cost of the street works borne by the client for the work. The direct cost components include those due to:

- planning and design;
- material and construction costs;
- supervision of the construction works;
- diversion of existing services, equipment and traffic;
- damage to other undertakers' apparatus and third party property (possibly via insurance);
- interim and permanent reinstatement costs; and
- compensation payments from loss of business/profits.

Normally, the largest proportion of the direct cost will be made to contractors and suppliers - other costs are much smaller but they vary significantly between projects and sites. The more important of the above are discussed below.

4.3.1 Planning and design

Typically, clients only spend one to two per cent of the total life cost of a project on its planning and design (Smith, 1992). In most cases, this is inadequate to properly plan and design the most appropriate solution to a utility scheme in a public highway. Many consultants reported that such design work is very competitive and also that insufficient attention is given to engineering details. Furthermore, it seems that clients are continuing to cut back on expenditure on design, especially on small projects. There is also a trend for a client to move much of the design responsibility to contractors, often through a partnering arrangement.

The results of the survey suggest that most street works are poorly planned with little consideration given to the likely ensuing disruption. It is unlikely that more thought or planning would be given to the use of trenchless methods than to open cut work - in which case the advantages of trenchless methods would not be fully exploited for all concerned.

However, it is encouraging that highway authorities such as Nottingham City Council have successfully pioneered ‘trench-sharing’ between utilities, as reported by Allen (2001). Although it might not be possible for all utilities to share a single common trench, ‘trench-sharing’ should reduce the number of cuts made in roads. This shows, at the very least, that highway authorities are quite capable of organising street works to the benefit of all parties.

There have been a few positive developments with the planning of street works. The generation of the ETON system (Electronic Transfer Of Notification), which was drawn up by highway authorities and utilities, will help co-ordinate such works (see Appendix B). The Ordnance Survey, working in partnership with highway authorities, is developing a National Street Gazetteer that will provide an unambiguous referencing system for any road. This could be used to co-ordinate and publicise forthcoming street works.

A number of initiatives have been put forward to improve the co-ordination of street works, notably within the London area. For example, in June 2000 the Central London Partnership issued ‘Making Streets Work - voluntary guidelines for the enhanced co-ordination of street works in Central London’. A further report ‘Integrated Transport and Environmental Strategy for London’ has recently been released. The Steering Group for the work included Railtrack, developers, consultants and local authorities including those of Westminster and Camden. The fact that Camden Borough are to introduce a lane rental scheme for street works (see Section 3.1.1) implies that such a voluntary code is insufficient.

4.3.2 Contractors and suppliers

The key component costs of open cut installations are:

- labour and plant costs for excavating the trench and laying the pipe or cable run;
- cost of the pipe or cable;
- supply of pipe bedding material and other fill; and
- reinstatement of the trench.

Little data on the cost of utility installations were obtained from contractors - perhaps because such information was deemed commercially sensitive. Nevertheless, estimates can be derived from the limited data supplied and from published information. Data on the cost of installing various types of pipe are given in the previous project report of Thomson and Robinson (2000).

Table 1 summarises the data (with some explanation) supplied by contractors.

According to the data given in Table 1, the cost of installing small diameter ducts and pressure pipes in roads by guided drilling can be competitive with the open cut method. The total installation cost might be governed by other site-specific direct costs but, through proper planning and organisation, trenchless methods can provide savings in construction costs. For example, it was reported by Morgan (1998), for the Midlands Electricity Board, that the cost of installing cable using guided boring was about half the cost of the open cut alternative.

It would seem from Table 1 that some trenchless methods of construction, such as microtunnelling, are not competitive with the open cut method. Unless clients take account of the considerable indirect costs associated with sewer work, only the deeper and more difficult work will be available to the microtunnelling industry. When the cost of all the impacts is taken into account, microtunnelling is indeed competitive: examples are the sewer works in Berlin (Mohring, 1988) and more recently in the USA (Lester and Vedder, 1999).

As described in Section 5, trenchless rehabilitation by either on-line replacement or renovation is extensively used across the world and, in many situations, is cost effective compared to open cut alternatives. A number of studies have tried to produce a simple graphical demonstration to show when a trenchless method, such as microtunnelling, is economically competitive with open cut - see for example Mohring (1988) and Thomson *et al.* (1998). Most of these studies suggest that, in terms of direct costs only, open cut construction is cheaper than trenchless methods for depths of installation to 7 metres or so.

4.3.3 Traffic management

Utilities pay the direct cost of setting up and maintaining traffic management systems but the additional cost of using them, for example through delays and diversions, is borne by the community (see Section 4.4.1). Trenchless methods can, if properly configured, show considerable benefits over the open cut method, because it may not be necessary to close roads or have the extensive single-way traffic flow as usually required with open cut street works.

There is a widely held view in the UK that streets are unnecessarily restricted when no work is being undertaken - see for example the report by the AA (1997). Temporary traffic signals are a major problem at street works: rarely are they properly operated to ensure the maximum throughput of vehicles. Thomson *et al.* (1994) reported on the phenomena that occurs during rush hour periods when there is a lengthy queue in one direction but an empty carriageway in the other. Some countries do not use

Table 1 Data on cost of installing pipes by open cut and trenchless methods as supplied by contractors

Diameter (or equivalent) (mm)	*Excavation method*	*Cost (£ per metre)*	*Comments*
150	Open cut	30	For installing shallow communication duct in a road – includes reinstatement and attendance costs.
150	Guided drilling	25	Installation of a 150 mm diameter polyethylene water main under a road.
4 x 150	Guided drilling	120	Installing 4 x 150 mm diameter communication ducts below a footway.
300	Open cut	45	Installation of shallow multi-way communication duct under a highway: includes reinstatement and attendance costs.
450	Open cut	233	For installing a 2.75 m deep sewer in a road – includes cost of reinstatement. Cost rises to £300/m run when overheads, profit and attendance costs are included.
500	Open cut	70	Installation of shallow multi-way communication duct in highway: including reinstatement and attendance costs.
600	Open cut	363	For installing a sewer in a road – includes reinstatement cost but not overheads or profit.
600	Microtunnelling	380 to 495	Cost varies according to site and specification.
1000	Microtunnelling	1500	For installing pipe at depth of 10 m in wet ground. (No open cut alternative possible). Overheads and profit included.
1200	Open cut	210	Installation of large multi-way communication duct at shallow depth.
1200	Hand-dug pipejack	720	Typical cost for 100 m long length.
1200	Microtunnelling	870 to 1100	Cost varies according to site and specification.
1500	Microtunnelling	1000	Cost of installation only.

temporary traffic lights on the grounds that they are an inefficient means of control. Instead, they ensure that the highway is open to traffic during non-work periods and employ flaggers (or police) to maximise traffic flow when work is in progress (Shibuya *et al.*, 1996).

4.3.4 Third party impact

Third party impacts primarily relate to trench excavation works and fall into two main areas: damage to the apparatus of other utilities and damage to adjacent property.

Although definitive data on the extent of the damage caused to the apparatus of other utilities is unavailable, it is known that the cost of dealing with the problem is significant. For example, Clow (1987) estimated that the number of such incidents in UK was 75,000 and the cost of their repair was £25 Million. Particular examples are:

i A water company in Italy monitored details of leakage and failures over a four-year period: of the 4250 recorded incidents, 2012 (i.e. 47 per cent) were due to excavation works (JCL, 1996).

ii A cable installation contractor commented that a large proportion of their call-outs were to repair ducts and cables damaged by another utility's contractor. (This problem has increased dramatically since cable companies started to lay ducting in UK footways.) The same contractor also reported an example of a call out to a damaged fibre optic cable that was likely to cost £0.5 Million to repair. Here, the contractor who had dug the hole and severed the cable had simply backfilled the excavation and left site before the repair crew from the cable company arrived. (This also shows that reinstatement operations can be done very quickly when needs demand.)

Damage to third party property can occur during the work and also afterwards due to long- term ground movements. Such damage might be little more than an inconvenience to the contractor, but can be a particularly stressful and frustrating situation for those affected by it, and might lead to a lengthy and costly legal battle to gain compensation. Damage might be limited to a fence or wall surrounding a property but ground movement, particularly when generated by de-watering works, can cause severe structural damage to a property. It would seem improbable that a third party could recover the full cost of the damage without recourse to long and expensive court proceedings - even that is no guarantee of success.

Trenchless methods disturb the ground considerably less than open cut working and this must be advantageous because it reduces the risk and the severity of damage to third party property as well as to existing pipes and ducts etc. However, because in some cases the line of existing services is not determined beforehand - indeed in some cases the presence of services is not even suspected, there is a risk that trenchless methods will cause as much disruption to existing services than open trenching. Most of this risk could be removed by adequate site surveys and planning prior to undertaking any site work. However, as stated in Section 4.3.1, this is the exception rather than the rule.

4.4 Highway impacts

For works carried out within the highway boundary, including pavements, there are many additional associated costs. Under current legislation the community pays all these highway-related costs. They include:

- user delay due to traffic congestion;
- operating costs of road vehicles; and
- accident costs.

4.4.1 Traffic congestion

According to Miller and Moffet (1993):

> *'Travel delays due to congestion are widely perceived to be a major indirect cost of transportation. Public concern over congestion drives much of our urban transportation policies.'*

Delays generated by road works represent a substantial part of the total congestion on UK roads. The temporary changes in highway layout, available carriageway width and the activities of the work itself have a number of effects on traffic flow. Some of the factors that cause congestion are discussed below.

Control measures

Congestion is obviously generated by queuing and the need to decelerate/accelerate adjacent to the work area. The delays generated by the latter affect traffic at either end of the excavation/installation works, and can account for as much as 40 per cent of the total traffic delay (Shibuya, 1996). The effect of a single short length of street works might affect the flow of traffic over a significant length of highway. It is perhaps not widely appreciated that what appear to be relatively minor utility works can create substantial traffic disruption with high attendant delay costs.

Flow through street works

Most of the other factors that affect congestion are related to the traffic flow through the street works. The available highway area dictates the maximum traffic flow and so congestion is inevitable where street works reduce the area to less than that required. At present in the UK, there is simply no demand for the methodology for undertaking street works to be based on maximising traffic flow through and around the work area - at best they may attempt to manage traffic through the area.

Traffic will move more slowly where (a) the route around the street works is tortuous (b) the available lane width is narrowed and (c) where road markings are confusing. Studies, by for example Schuurman (1991), Hunt and Yousif (1994) and Dixon *et al.* (1996), have shown that the traffic capacity of a section of highway with street works is less than that of one, of the same width, without the street works. These studies showed that the degree of delay depended upon site-specific factors such as the intensity of the works and its location. Unfortunately, the variability between sites does not allow simple direct comparisons to be made.

An additional factor is the inquisitiveness of the travelling public. As found with accidents on motorways, street works distract the attention of drivers and can slow traffic. It is also an obvious safety risk.

Diversions

In busy urban areas, the congestion built up around one street works will undoubtedly spread as traffic finds alternative routes around the bottleneck. Thus the area affected by a street works can be quite large, particularly during the rush hour. The length of a diversion, and the time required to use it, will vary from site to site and also with the flow of traffic through the day. The cost of delays and diversions are therefore difficult to predict particularly well, but they can be considerable.

Incidents

Incidents, such as accidents and breakdowns, at road works produce congestion, but it is difficult to evaluate the likely effect on a site-by-site basis because no detailed studies have been undertaken on the type and frequency of incident in relation to the type of roadwork or its layout. However, a study in the London area found that 25 per cent of all 'incidents' that led to congestion on roads occurred at street works (Holmes, 1993). Such incidents not only cause congestion but they also generate other human and social costs. Accidents are discussed in more detail in Section 4.4.2 below.

Cost of congestion

A good level of understanding of the costs of traffic delays has arisen from highway maintenance and repair projects. Models have been developed to evaluate the effect of road works on traffic delay and, in some cases, attempts have been made to estimate the cost. However, such models do not seem to have been applied to utility street works in the UK.

In the UK, the QUADRO (Queues and Delays at Road Works) (DMRB 14.1) program is used to evaluate the delay costs to road users due to major highway works: this program has the potential for application to utility works. Other approaches incorporate different delay cost models for example CONTRAM 1 (Webb *et al.,* 1993) in the UK, and QUEWZ (Seshadri *et al.*, 1993) and HERS (McElroy, 1992) in America. These models require inputs for many factors relating to the highway layout and traffic flows. It would seem relatively simple to modify the models to incorporate the data held by local authorities and utilities on, for example, traffic flows on particular street types or on aspects relating to the designation of the street type.

From a series of surveys of work sites, taken with the findings of other researchers, the best estimate of the ratio of traffic delay costs to construction costs is about 1.3 (Thomson *et al.,* 1994). Others, however, have derived higher ratios - see for example Peters (1984). For a ratio of 1.3, the estimated traffic delay cost of utility installations would be about £1.3 Billion per year (see Section 4.1). However, the number of sites and their geographical spread covered by these surveys were neither sufficiently representative nor large enough to draw firm conclusions on a nation-wide basis. This paucity of data should be remedied by undertaking additional surveys. A point worth stressing is that there will be wide variations in the value of the ratio. For example, Peters (1984) reported that the value for deeper and more technically difficult trenching work can be higher than 3. As stated in the DETR (1999) consultative document, (a) utility installations and traffic volume have steadily increased over the years, and (b) there is no evidence of an improvement or deterioration since NRSWA was introduced in 1993. On this basis it would be reasonable to assume that the current social cost of utility installation to the British public is still at least *£1.3 Billion per year*, but likely to be close to *about £2 Billion per year* (see Section 4.1).

4.4.2 Accidents

Road users

According to Lines (1997), in the 10 years to 1997 there were 46,000 fatalities on the road and 580,000 serious injuries. At present, road accidents in Britain are reasonably stable at around 250,000 per year; this is despite a near-30 per cent increase over the past 10 years in the number of vehicle kilometres travelled. The trends are shown in Figure 1. The decrease in accidents per kilometre travelled is attributed, primarily, to improvements in vehicle safety and legislation, such as the wearing of seat belts.

Davies *et al.* (1998) provided a comprehensive review of cyclist safety at road works in Great Britain: they found that about 200 cyclists are reported injured each year, this includes 40 or so serious injuries or fatalities. The presence of the road works was not necessarily a contributory cause of all the reported accidents but, overall, the severity of the accidents at road works was higher than for ones involving cyclists elsewhere on the road.

There are no data available for the accidents occurring at utility street works in the UK, but Marlow (1994) reported that, for the UK, the incidence of traffic accidents at road works was 1.6 to 1.7 times higher than for sections of highway without them. Studies from elsewhere have indicated that there is twice the risk of a road accident at street works compared to other sections of road, see for example Gundy (1998). Although there is precedence for contractors paying the costs of accident claims related to the way in which the street works are managed, in most cases, the direct costs of accidents are borne by the community or the individuals affected. In addition to the direct costs of accidents, there are psychological costs, such as grief and suffering, experienced by the family and friends of an accident victim. There are also social costs, such as police attendance, as well as losses associated with reduced (or terminated) output, for example in terms of productivity and taxes too.

Over the 11 years to 1997, fatalities and serious injuries associated with highway hazards have decreased, in line with the general fall in accidents on UK roads. Whilst fatalities and serious injuries at highway hazards (other than street works) have fallen by 50 per cent, the decrease over the same period at road works (of all types) was 46 per cent. Thus it would not appear from the data given in Figure 2 that NRSWA has had any significant effect, since its implementation in 1993, on the frequency of personal injury accidents.

Site operatives

Accidents to site operatives might not be viewed as a highway-based impact, but there is a cost to the community due to the attendance of medical aid etc.

The Health and Safety Executive (HSE) has given specific advice and guidelines is with respect to trench excavations. The following quote (from HSE, 1999) is relevant:

> *'In the five years from 1 April 1991 to 31 March 1996, 938 injuries to workers engaged in groundwork activities were reported to HSE, with an average of seven fatalities each year. This carnage is not acceptable and it is about time that the industry organised itself to put a stop to it.'* (Sandra Caldwell, HSE's Chief Inspector of Construction).

Specifically, HSE identify nine major safety aspects related to excavations (HSE Construction Sheet No. 8, Rev 1: 1997). These are:

- collapse of trench sides;
- materials falling onto people working in the excavation;
- people and vehicles falling into the excavation;

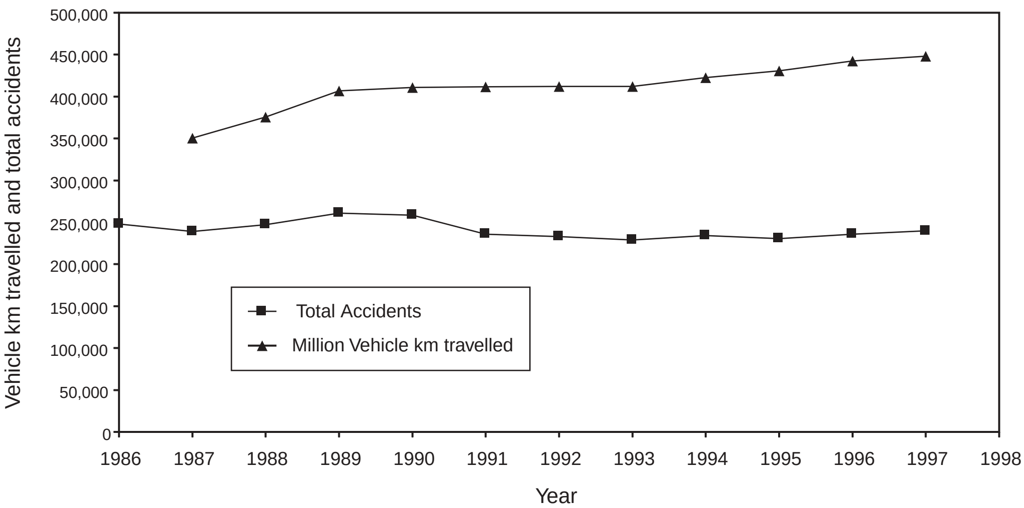

Figure 1 Vehicle km travelled and total number of reported accidents on public roads in Great Britain

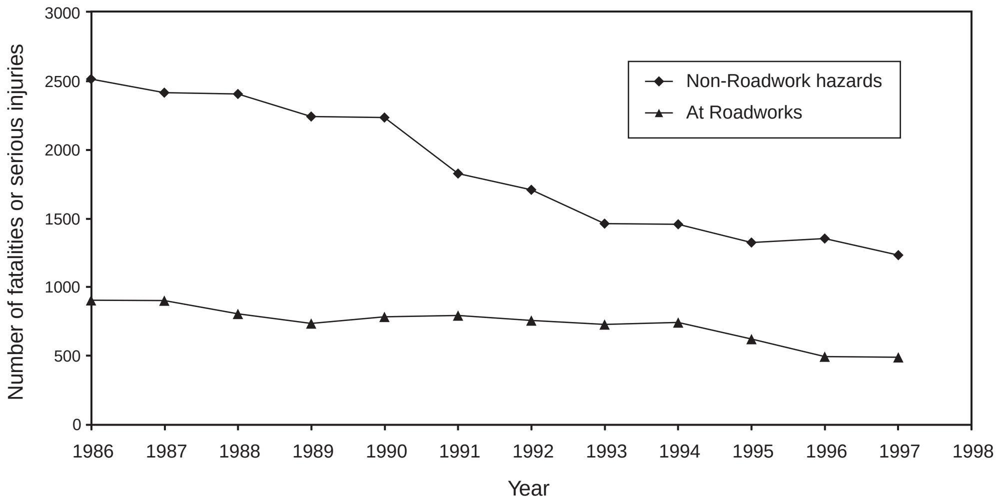

Figure 2 Fatalities and serious injuries at carriageway hazards on British roads

- people being struck by plant;
- undermining nearby structures;
- contact with underground services;
- access to the excavation;
- fumes; and
- accidents suffered by members of the public.

A number of these would be eliminated or significantly reduced by the use of trenchless construction methods.

Cost

The main problem in estimating accident costs is setting the appropriate value for loss of life. Despite a number of unsettled methodology issues, it is widely accepted that the best approach is to measure society's aggregated willingness to pay for safety. The British and Swedish governments, as well as the Office of the US Secretary of Transportation, have adopted this approach, and in doing so more than doubled their previous estimates of the value of life for the purpose of evaluating road safety provisions (Miller and Moffet 1993).

In 1989, the US Department of Transportation placed, for cost-benefit analysis, a value of $1.5 Million on a life. This figure was in the middle of a range of values given by studies undertaken to evaluate the public's reaction to the value of life. The results of a European-wide study estimated that the 45,000 road fatalities in the UE in 1995 had a total socio-economic cost of 162 Billion Euros - this equates to about £2.3 Million per fatality (European Transport Safety Council, 1997).

Assuming a mean cost to society of £0.4 Million per accident, the cost of the 500 serious or fatal accidents per year at road works of all kinds (see Figure 2) would be about *£200 Million per year*. A mere 1 per cent reduction in the number of fatal accidents would, on this basis, result in a saving to society of *£2 Million per year*. It would not seem difficult to justify further studies to examine means of achieving such a modest saving - this might include means of encouraging the use of trenchless methods on sites where there is a high risk of accidents. It would also seem a sufficiently important issue for further data to be collected and collated to determine where work is best directed to reduce such accidents - further discussion follows in Section 6.

4.5 Business and community impacts

Street works affect the business and social lives of the public. The costs for these impacts are primarily borne by the community, but there is precedent for some business costs to be paid by the utilities through compensation. These costs include a reduction or loss of:

- business profit (including municipal revenue); and
- access to public amenities.

4.5.1 Loss of business

Businesses can be seriously affected by congestion from street works; in terms of employee delay but mainly from reduced output, sales or delayed deliveries due to problems of access.

In the UK, water companies have made compensation payments for the loss of profit, but this practice is rare for other utilities. The Water Research Council Investment Appraisal Manual (Glennie, 1991) gives figures based upon the UK Business Statistics, but the figures are generally regarded as being well below the actual loss incurred.

4.5.2 Loss of amenity

The magnitude of the 'loss' through the restriction or temporary suspension of amenities varies considerably. It may be simply a matter that a telephone box is out of use, or that the fear of injury from the works prevents the access to an amenity by the public, particularly children, the elderly and the disabled. Of greater concern are instances where pedestrian crossings have been closed without an alternative safe crossing being provided, see for example JCL (1998). In such cases, pedestrians are left to find the next available crossing, or have to cross without the benefit of lights or where motorists have a restricted view.

Where a local community is consulted about road works, an agreement on working practices might be reached. A utility company, or its contractor, might therefore programme the work accordingly, for instance to ensure that tourist beaches are not affected during summer periods. But, for the vast majority of works, no such consultation takes place.

4.6 Environmental impacts

On occasions, utility companies have had to pay for the environmental costs of their activities, for instance when they lead to noticeable pollution. However, many environmental impacts are not evident at the time the work is carried out and society pays for these. Notable environmental impacts include:

- damage to flora and fauna, mainly trees and shrubs;
- increased air pollution, for example through exhaust emissions and dust;
- the use of natural resources, as backfill material to trenches; and
- the tipping of waste materials at landfill sites.

4.6.1 Tree damage

Trees suffer extensive damage through both surface activities and trench excavation for street works. Whilst superficial damage to the canopy caused by the operation of construction plant might be rectified by pruning etc, damage to the root system can seriously and irrevocably weaken a tree - in the extreme it may kill it. The problem of tree damage has been recognised by utilities, and guidelines are provided to operatives on the mitigation of damage (NJUG, 1995). These set out the precautions that must be undertaken to minimise the risk of damage to trees as well as listing the problems that tree roots and branches can create for the utility services. For example, a ‘literal rule of thumb’ is that roots thicker than the size of your thumb should not be cut. The guidelines are considerably less stringent than, for example, the equivalent German regulations, see Section 5.2.1. The real problem lies in ensuring that contractors and site operatives follow the guidelines.

A number of papers were presented by representatives of utilities and highway authorities, and also by environmentalists and arboriculturists at a conference organised by the National Urban Forestry Unit (NUFU) in 1996. A number of arboriculturists stated that utility street works resulted in the loss of many trees. It was pointed out that it might take some time for the tree to die following such works - by which time the utility contractor had long since left site. Particular criticism was made of the contractors installing cable-TV equipment.

4.6.2 Air pollution

Additional air pollution is generated by traffic queuing at the street works, by it decelerating/accelerating through the works, and also by diversions. Many studies have been undertaken to investigate the pollution that occurs due to vehicle movements, including that generated by queuing but, in all of this, there are no significant data for street works. Given that pollution levels in some urban areas are already a serious cause for concern, see for example NCE (2001b), queuing traffic at street works could raise the pollution in many such areas to an unacceptable level. This is surely a topic worthy of further study. Although the problem has been raised, most concerns are about the increase use of fuel (and its cost) rather than the additional pollution caused.

4.6.3 Import of natural resources and disposal of waste

To meet structural requirements, most excavations in highways require the importation to site of primary aggregates for use as backfill. Some utilities have experimented with modified mixes where construction waste material is added to the backfill that would otherwise be removed from site.

There are significant number of journeys associated with the disposal of excavated spoil and the delivery of backfill material – see UK Water Industry Research (1997). By way of example, consider the installation of a 0.6 m diameter sewer installed at a depth of 4 m in an urban area. With open cut, the trench width would typically be 1.4 m wide, the width and depth of the pavement reinstatement would be 1.7 m and 0.25 m respectively. A 0.8 m diameter pipe could be installed using a trenchless method. The volume of the excavated material would be about 6 m^3 and 0.5 m^3 per metre run respectively, and the former would require the importation of about 11.25 tonnes of aggregate per metre run. Leaving aside the requirements for the shafts and the journeys required to deliver the pipes, a 100 m run for open cut and trenchless methods would, respectively, generate about 130 and 8 journeys of 20 tonne capacity wagons.

Industry now has to pay a landfill tax on the waste it produces, and also on the production of aggregate. However, presently, the costs of removing material from site and replacing it with primary aggregate is, in most cases, the cheapest option. Advantica Technologies is undertaking research on behalf of Transco into the recycling of excavated material with both on and off-site processes - see for example Poole and Faragher (2000).

4.7 Long-term impacts

Some impacts may not materialise until some time after the street works have been completed. Thus, unless specific provision has been made for them, the cost of such impacts is borne by the community. They include:

- reduced highway life; and
- problems generated by ground disturbance.

4.7.1 Reduced life of pavements

Both the reduction in the life of a pavement and the increased cost of road maintenance resulting from excavation works have been studied, but they are contentious issues; see for example Sterling (1994) and Todres and Baker (1996). In addition to the direct damage due to the excavation/installation works, alternative routes may suffer an accelerated deterioration by diverted traffic.

A trench reinstated to the NRSWA Specification should provide a similar life expectancy to that of the original construction. Experience shows that this is hardly ever the case and most engineers responsible for streets are concerned about the impact of open cuts on the service life of a pavement. The main problems with reinstated trenches are:

i poor compaction and finishing which leads to settlement and/or uneven patches with poor ride characteristics; and

ii water ingress through joints in the pavement.

Both of these increase the rate of deterioration and lead to potholing.

A study of the impact of utility trenching has been completed in Ottawa, Canada. As stated by Lee and Lauter (1999) the results of this study indicate that:

> '*the reduction in pavement lifecycle due to utility trenching, when proportioned back based on the contributing trenched areas, is calculated to be 32.4 per cent.*'

The cost to the road agency of utility trenching was conservatively estimated to be $23.45 per square metre of trenched area for pavements that had been resurfaced for less than two years, to $4.32 per square metre for those resurfaced more than ten years previously. Numerous other similar studies have been undertaken in North America, for example in Burlington, Cincinnati, Kansas City, New York, San Francisco and Toronto. The National Research Council of Canada (1999) has provided a comprehensive summary of the results of such studies. The conclusion of most of them is that no matter how good the repair, *trenching damages pavements*. It seems that trenching can reduce the life of a pavement life by between 15 and 30 per cent. It should be appreciated that a reduction of even 10 per cent represents a substantial cost to be borne by a highway authority.

Recent UK evidence from the coring of reinstatements, and also from TRL investigations, suggest that inadequate compaction and the use of incorrect compaction plant leads to long-term settlement of trenches and reduced pavement life - see for example Burtwell and Spong (1999). Further field monitoring is required to improve or confirm these findings for the UK. This would be preferable to placing reliance on anecdotal evidence from abroad, no matter how convincing that seems.

4.7.2 Ground disturbance

Short-term and major events arising from trenching works can be identified immediately and therefore can sometimes be settled by insurance companies. Clients might wish to devolve the risk for such events to contractors, but this is unrealistic for works in urban areas. Any major collapse will involve a number of third parties and the public who will naturally expect the client and highway authority to rectify the problem.

The disturbance of the ground arising from trenching and inadequate reinstatement can generate long-term settlement. But the elapsed time from the trenching works might make it difficult to identify the source of the problem. That it does occur is evident from (a) the number of reported failures due to settlement in areas of street works, and (b) from the monitoring of movements in and around trenches in roads. The severity of the problem is determined by several factors including the type of soil, the level of the water table, the depth of working and workmanship.

Deep trenching in difficult ground conditions, which requires de-watering and/or the installation of sheet steel piles, carries the highest risk of long-term settlement. The additional risk from deep working is recognised in the NRSWA Specification. An extended guarantee period of a further year is required to cover long-term settlement for trench excavations deeper than 1.5 metres. Any safety assessment should take into account the increased risk to the public of deep open cuts in urban locations.

4.8 Evaluation

A means of measuring the impact of street works is fundamental to any discussion on installation methods but there has been a reluctance to develop any such assessment tools. From a number of viewpoints this reticence is unfortunate. It is widely accepted that the total cost of street works is an aggregate of direct, indirect and social costs, but for substantive conclusions to be drawn it is necessary for each contributory cost to be calculated on an equitable basis.

A methodology for undertaking a cost-benefit analysis of utility installations has been developed by JCL. The model has not been used in the UK, but it has been used elsewhere. It considers the following factors:

- user delay;
- additional road fuel;
- loss of business;
- accident and insurance claims;
- reduced parking revenue;
- environmental pollution;
- additional highway maintenance; and
- damage to other utilities and property.

These are not, however, the only issues. Other indirect social costs may arise due to the overall impact of a project on a community. Putting a value to these costs is difficult because discussion resides in a political rather than an economic arena. Furthermore, different communities place different values on the various social impacts.

This uncertainty and variance makes it difficult to reach objective conclusions, even where the aim is to compare different ways and means of completing an installation. However, it is possible to re-analyse the problem in a way that is both justifiable and takes into account all the restrictions, limitations and concerns raised by the community affected. This requires the simple assumption that the work is required and so what is of issue are the relative impacts of the different ways and means of completing the work. Whilst this approach may be unacceptable for large infrastructure projects, it is viable for most street works. From this basic assumption, analysis moves away from the calculation of 'true cost' to one based upon the comparative costs of various construction methods, locations and programming. The model can thus be used to determine the comparative impacts on urban communities and business life. It enables clients, and their regulatory authorities, to justify the proposed methodology, whether in terms of impact alone, or by way of an assigned cost to impact criteria.

For an accurate analysis, the models require reliable and comprehensive data on the following:

- traffic volumes and types;
- population aspects;
- highway characteristics and pavement quality;
- restrictions on highway activity (junctions etc.);
- street furniture and trees;
- types and usage of adjacent private property;
- types and use of public amenities;
- ground conditions;
- risks to private land and property;
- existing utilities and other underground facilities; and
- specific criteria related to the various construction methods.

Much of the required data can be collected either from existing sources and records, low-cost monitoring or simple visual inspections. Data alone are insufficient. It is necessary to introduce weightings to express the relative importance of some impacts. These are best developed from discussions with the community, road administrations and other bodies responsible for infrastructure. By way of example, where a pipeline is to be laid through a wooded area, the community may place a high weighting on tree impact or loss. Similarly, a high weighting value might be given to the area of newly laid highway affected by street works, and the period over which it is affected. In a wider scenario, it is possible to make decisions at an appropriate political level that could apply to the whole of the UK.

Having collected the data and established the weightings it is possible, using a matrix network, to analyse various options for route alignment and construction method, sequencing and programming.

The results of the analysis are based on a point scoring system with the weightings applied to each particular impact. The output will be a total relative score for each option, or part of an option. The lowest score should be obtained by the option that would have the least impact overall and, where basic cost information is included, the least overall cost to the community.

In summary, because most utility street works are required, either due to community demand or municipality/ governmental decree, analysis can be limited to comparative aspects. Such an analysis requires the establishment of community and road network impact weightings. Those affected by the work can often supply weightings but local or national governments could provide them for some factors. In utilising numerical information and local community knowledge and views, the results of such an analysis provide the basis of a justifiable and logical decision-making process for a project, and one in which the community has an involvement.

5 Experience and practice

Highway authorities in various countries have quite different policies regarding the rights of utilities in public roads. In many, there is an understanding that (a) the underground space beneath public right-of-ways is a valuable resource, and (b) the use of this space on a first-come first-served basis or as a utility corridor can restrict future developments - and reduce the value of this resource.

Some form of cost-benefit approach is commonplace but, in many cases, the approach is overly simplistic. Many are derived from highway works and do not take into account all the indirect costs. Furthermore, valuations of environmental impact vary widely from one country to another. It is not uncommon to find that utilities are required to spend substantial sums on mitigation measures to avoid disturbing flora and fauna but, often, the disturbance to the local population does not attract the same investment or attention.

The full range of trenchless methods is available to all the countries reviewed in this report but different trade names may be associated with a particular method. Significant differences arise in the way that each country applies the technology and, more importantly, in their attitude to disruption and regulation. The techniques are described in Appendix A.

5.1 UK

In the UK, the ‘rights’ of the utilities to gain access to the road to lay, repair or maintain their equipment are essentially contained in various Acts passed in the middle of the 19th century. These ‘rights’ are always at the forefront of any negotiations. It might be thought that, some 150 years following their introduction, such wide-ranging rights are inappropriate particularly given the development of modern society around road transport. The automobile did not come into common use until nearly 80 years following the passing of several of the Acts. The conflict between the rights of the utilities and the public in the use of the highway has escalated dramatically in the last 20 years.

HAUC oversees the working of NRSWA and develops Codes of Practice. This Committee is formed from representatives of the Local Government Association (LGA), the Department of Transport, Local Government and the Regions (DTLR) - the successor to DETR - and NJUG. The last named is funded by utility companies and so it would seem to be reasonable for their representatives to have a vested interest in ensuring that measures taken to reduce the impact of street works do not add to the operating costs of the utilities. This seems an unbalanced, inappropriate, if not invidious, closed shop arrangement: it could hardly be argued that HAUC represents the interests of all those affected by street works. Respondents to the survey, see Section 3.2, questioned the role of NJUG and accordingly treat the advice issued by HAUC with scepticism. It would seem necessary to widen the membership of HAUC to counter the charge that it is unrepresentative.

5.1.1 Trenchless technology

The UK has been at the forefront of many of the developments in trenchless technology, for example in pipe rehabilitation and on-line replacement, and the full range of equipment and contractors are available to undertake all types of trenchless work.

Trenchless methods have been used by a number of utilities but, whilst this is laudable, in virtually every case they were used because they were the cheapest option for the utility - the reduction of disruption was an unplanned bonus to the public. Also, some of the claims for using ‘trenchless’ installations are, in fact, maintenance operations, for example the cleaning and relining of pipes.

Over the last decade, the use of pipe jacking and microtunnelling have declined. Guided drilling is taking an increasing, albeit small, market share, but the technique has taken longer to establish in the UK than elsewhere. Renovation and on-line replacement continue to be the major uses of trenchless technology in UK. This is primarily due to the direct costs savings that can be achieved compared to open-cut replacement.

Because of the lack of incentives to minimise disruption, the potential market for new sewer installation has not been fully realised in the UK. This is not due to any shortcomings on the part of contractors.

From the survey, less-than-enthusiastic comments were received from some UK highway authorities on the use of trenchless methods. The experience of several was that the bursting technique, which is commonly favoured (on cost grounds) for replacing cast iron pipe, often generates surface heave which is detrimental to the overlying road pavement. In addition, the replacement of lateral connections by open excavations means that often a section of road is closed to traffic for periods of time as long as, or even longer, than that for open cut trenching. With guided drilling methods, it was opined that the working pits and open cut for completing connections (after the line has been installed) could be just as disruptive for road users as if the whole scheme had been trenched. Clearly, trenchless methods are not the panacea for all street works and problems will undoubtedly arise when such methods are used inappropriately and also where the work is poorly planned.

5.1.2 Factors determining the method of installation

The following summarises the issues that influence the choice of the method for installing services in roads.

- *NRSWA.* The introduction of the Act has not led to a reduction in the disruption due to street works. The Act does not insist on the adoption of a minimum disruption approach to street works.
- *Planning and implementation.* In general, utility installations are not planned or managed to mitigate the impact of the works. This favours the open cut option.
- *Contractual arrangements.* Large utility companies let work to one or more contractors who might not have experience of trenchless methods. Partnering can unwittingly be a barrier to innovation. The benefits of trenchless technology might not known at the top level of management where strategic decisions are made.
- *Client/engineer relationship.* Where designers are unsure of the level of risk, conventional construction techniques are used. The pressure on fees also affects the level of engineering input to a project. These reduce the utilisation of newer technologies and innovative methods.
- *Lack of confidence.* Many clients are cautious of trenchless methods: the common perception is that jacked installation is a high cost activity and almost a last resort.
- *Cost trends.* There have been few changes in the costs of jacking and microtunnelling methods over the last 10 years that would make them more economically attractive, but with other trenchless methods, such as guided drilling and sewer renovation, efficiency has improved and costs reduced.
- *Industry trend.* A key area for all types of jacked installation is the renewal of sewers. Between 1991 and 1993 more sewers were replaced than renovated but since then this has reversed.
- *Potential damage to existing equipment.* For shallow installations it is perceived that there is simply too high a risk of damaging other utility equipment when drilling in congested urban corridors. In many cases the location of utility pipes and cables is unknown.
- *Capped budgets.* To control price increases to consumers, the regulator caps the budgets for capital expenditure in the water industry. Unless cheaper alternatives to open cut can be realised, the potential for trenchless methods in this sector is limited. Since relining of existing pipes can be undertaken more cheaply, this methodology is likely to remain a key factor in limiting the volume of sewer replacement by trenchless methods.

From the above, the main factors that inhibit clients in UK from making greater use of trenchless methods are:

- Clients are not well informed, or even interested, in alternative installation methods that might carry a higher cost.
- The use of ‘partnering’ arrangements can be a barrier to innovation – mainly because of the implication of a higher risk.
- Because of uncertainties about the position of existing utility apparatus, there is still a widely held belief that the shallow installation of pressure pipes and cables is only feasible by open cut.

5.2 Other European countries

5.2.1 Germany

As a Federal Republic, considerable autonomy is delegated to the 16 Lander who can pass their own regulations in areas such as environmental protection and highway operations. The possible adverse effects of street works on the environment and on the community are given much greater prominence in Germany than in the UK.

Many of the Lander have environmental regulations which limits the use of open cut works and encourages trenchless methods. Hence crossings of even moderately trafficked roads are installed by trenchless methods. It is forbidden in some Lander to carry out open cut trenching work below the canopy of a tree. And to limit ecological damage, Hamburg and other regions restrict the lowering of the ground water table - in practice this eliminates the use of deep trenching with de-watering.

The highway authorities in Berlin have developed solutions to utility installations that do not create environmental damage or disruption to the community. The ‘Berlin Method’ for installing sewers radially from a manhole position rather than directly on to the sewer is an example. Works are planned and designed to take full advantage of the benefits of microtunnelling in minimising impact on the community. The authorities have found that not only does it reduce disruption but provides easy maintenance and repair access thereby also eliminating future excavations.

The authorities in Hamburg have long been at the forefront in the development of pressure balance jacking methods for use in granular soils and where there is a high water table. Guided drilling for pressure pipe and cable installation is used extensively and is increasing its market share. Sewer renovation by lining is less favoured because many clients view the solution as less technically good as a new pipe, and on-line replacement by bursting is seen by some to have environmental drawbacks.

Germany is the leading user of trenchless methods in Europe, and has been a world leader in the development of sewer installation based on microtunnelling and pipe jacking. Unsurprisingly, it has a number of leading manufacturers of equipment and many experienced contractors. Although the populations are similar, the use of microtunnelling and jacking methods in Germany is some 10 times greater than in the UK.

5.2.2 France

In France, the regulations controlling pipe laying vary between the various Departments, but, commonly, utilities are forbidden to install apparatus in cuts in newly-laid roads: the embargo can extend for two, three or five years. In addition, every municipality can establish its own regulations for its roads. For example, in Prefecture de Hautes-de-Seine, transverse crossings of roads by open trench are forbidden, whilst the Prefecture de l’Isere forbids such crossings where the road carries more than 2000 vehicles per day.

The City of Paris has regulations for street works, including those for utilities, covering:

- co-ordination;
- scheduling;
- methods of construction; and
- standards for finished work.

A small department in the City administers the regulations. This reviews all proposed street works and has the power to request changes to scheduling methodologies and materials to reduce the disruption to the community. To aid co-ordination, quarterly meetings are held with the various utility companies.

An investigation in Toulouse showed that the life of a road could be reduced from 30 to 10 years by trenching works for the installation of utility services, Audouin (2000). In Toulouse, a road reinstatement charge is levied according to the width of the trench plus a 500 mm wide strip on either side. A typical charge for a 300 mm wide trench would be £150 per metre run.

France has a relatively low population density, relatively small communities and rather unfavourable conditions to the use of trenchless methods. However, the companies who operate the water and wastewater systems have led the development and use of such methods. Of these, guided drilling and pipe renovation methods are more commonly used, but microtunnelling has also been used in the larger conurbations.

5.2.3 Scandinavia

In Scandinavia, the utilities do not have rights of entry and have to obtain permission to install new equipment from the owner, i.e. the highway/road authority. All costs associated with the work have to be met by the utility, but it is not thought that any of the social costs are charged. Inspections are undertaken both before and following the street works.

Most trenchless methods are used widely in Scandinavia, but in some regions, like much of Norway, the geographical conditions do not favour their use. This is, however, balanced to some degree by the high level of environmental concern. The use of guided drilling and renovation using ‘closefit’ liners are relatively common (see Appendix A).

5.3 USA

The approach in America to regulation and evaluation of utility works varies widely according to the attitudes, location and circumstances of the individual States and/or cities. However, the National Environmental Policy Act (1969) legally mandates public participation in the planning process. It gives the public the right to be given information about proposed schemes and potential impacts and mitigation measures. This contrasts sharply with the attitude in the UK where it is claimed that such information cannot be given because it is commercially sensitive.

The indirect costs associated with street or highway projects are already well established as an appropriate component of investment planning. The Highway Performance Monitoring System (HPMS) provides simulated ‘user’ costs. The Highway Economic Requirements System (HERS) utilises the HPMS database, but provides an analysis with more emphasis on user-cost considerations. This recognises reductions in travel time, incidents, vehicle-operating costs, maintenance costs and residual value. Although it was developed for assessing public works projects it can provide estimates of indirect costs for utility street works.

The level of indirect and social costs and, particularly, disruption of traffic varies widely across the country. It has a population density of about a tenth of Europe and so space is at less of a premium. The majority of cities in

America were laid out on a grid pattern with wide streets, and this makes for less impact and easier diversions when street works are undertaken. Nevertheless many cities, including New York, San Francisco and Boston, have similar problems to those in Europe.

Sterling (1994) provided a detailed review of policy issues: this concentrated on:

- the value of the space beneath public rights of way in making decisions on its allocation;
- methodologies for assessing the full costs to society of utility street works;
- implementation of contractual practices and fee structures to mitigate disruption; and
- impact of open cut working on pavement life and costs.

He argued that the underground space beneath a public right of way has an intrinsic value of its own that should be taken into account when decisions are taken about how such space should be allocated and charged. Also, that the 'free for all' in the utilisation of underground space and the giving away of the right to occupy space by utilities needs reconsidering. A figure of 30 per cent of the commercial value of the adjacent land provides a basis on which to calculate the value of rights of way. Sterling (1998) further developed the case for determining the value of land beneath a right of way.

Sterling (1994) notes that permits are issued, at a charge, to utilities cutting trenches in a street, but also that most highway engineers thought that the permit charges did not recover the full costs. It was recognised that it is difficult to devise suitable bidding arrangements and contractual practices so that the goal of minimising social costs is reflected in the method of working. A form of lane rental charge was proposed.

The method for calculating traffic disruption costs has been further developed by McKim (1998). His analysis is based on well-established traffic analysis techniques, see for example Transportation Research Board (1991). Evaluation is based on calculations from a 'Traffic Control Plan' that incorporates delays due to (a) slowing, (b) queuing and (c) detours.

Over the years, individual authorities have used various approaches to try to minimise disruption and costs. For example, the New York Authority gives notice to all utilities of its intention to repave a section of street in Manhattan. Once the work is completed, the utilities are denied access for several years. Likewise, other cities impose 'penalties' in disguised forms such as the requirement that the utility will pay for complete resurfacing of the dug up section of the road. From 1 January 1999, the San Francisco City authorities adopted a 'street-cut fee': this was strongly opposed by the local Gas Company. Other cities that impose street-cut fees include Phoenix and St. Paul. The fees range from about £10 per linear metre to £700 per square metre, and there is a minimum fee of £650 per cut. In Sacramento, California, utility fees have been charged from January 1998. These range from about £2 to £15 per linear metre depending on the age of the pavement and whether the cuts are transverse or longitudinal to the street. Fees are not charged where trenchless methods are used.

Despite the relatively low density of population, and the greater space normally available for working, some non-disruptive installation methods have been pioneered in America. It is estimated that the directional drilling market in North America has a value of over $1 Billion per year; this represents an installed length of 250,000 km per year. The rehabilitation of sewers and, to a lesser degree, pressure pipes by renovation and on-line replacement is also a major market with a turnover of the order of $1 Billion. On the other hand, microtunnelling and pipe jacked methods have a small market share.

5.4 Other countries

5.4.1 Japan

Japan has, by dint of its congested cities and historical lack of sewer systems, turned to trenchless methods of installation; and more than 1000 km of sewers is installed annually by microtunnelling and jacking methods. It is 'accepted wisdom' by clients and utilities that it makes no sense to damage the Japanese economy by using installation methods that create additional costs to the community.

The main reason for this extensive use of trenchless methods is that construction in roads has to comply with the Road Act, which is dealt with by street authorities, and the Road Traffic Act, which is the responsibility of the police. It is clearly established that roads are for transportation, but for other purposes it has to be restricted, or even prohibited.

There are three categories of road usage:

- Free use for pedestrians and vehicles.
- Permitted use - when specific permission is given for an installation that is normally prohibited. An example would be some form of obstruction in connection with road safety.
- Concessive use - when permission is given for construction works in the road. This is called 'road occupancy' and covers utility installation.

The road authority has the following rights:

- To prohibit re-excavation - for periods of up to five years in the important roads.
- To co-ordinate construction.
- To give occupancy permission only when the scheme is approved by the Co-ordination Committee for Road Construction.
- To ensure that construction is prohibited during key periods in the year.

An annual charge is made to utilities that install their equipment in or on the road. For example, an electricity pole is charged at £11 per year. Pipes up to 200 mm diameter are charged at £0.67 per metre/year; from 200 to 400 mm at £1.30 per metre/year; and 400 to 1000 mm at £4 per metre/year. However some utilities, including those dealing with waste and fresh water, are given exemption. In Tokyo, the gas utilities alone pay more than *£12 Million per year* occupancy charge.

The police through their powers from the Road Traffic Act also give conditional permission for street works. Detailed proposals have to be submitted well in advance with measures to mitigate the disruption and nuisance. In addition, detailed proposals have to be provided for signing and barriers for the protection of the public.

On heavily trafficked roads, daytime construction is not permitted. Night working is required with the road returned to traffic use for next day. In the suburbs, construction may be permitted in the period between the morning and evening rush hour but again construction has to be arranged to return the road to traffic each day.

The work of the two Acts is brought together under Co-ordination Committees on Road Construction where the police, highway administrators meet with the utilities. The meetings are as follows:

- An annual meeting to discuss long term planning (three to five years) - this has up to 200 attendees and lasts five days.
- An annual meeting to co-ordinate the planned activities in the highway in the following year.
- A bi-monthly meeting at a local level to co-ordinate and control the planned works in the next four weeks. No construction can be included unless it has been submitted in the annual plan, but provision is made for emergencies.
- Once the co-ordination committee has passed a scheme, a formal request for road occupancy permission can be made to the Police and the Highway Authorities.

Japan has been the pioneer in developing pressure-balance tunnelling equipment and its adaptation to pipe jacking and microtunnelling. With a massive home market, there are, at present, several thousand microtunnelling machines in service with contractors. Up to 10 to 15 per cent of all sewers are installed by these methods. In comparison, guided drilling is only beginning to have a significant market share.

The Cured in Place (CIP) lining (see Appendix A) of gas lines was pioneered in Japan, but this was initially done to provide a flexible lining to a rigid pipe to mitigate against seismic damage rather than for more normal renovation reasons. Moderate use is made of pipeline renovation techniques.

5.4.2 Hong Kong

Hong Kong is one of the most congested regions in the world. The highway authority issues construction permits with severe restrictions on times and methods of working. Night working is frequently required and the road must be fully open to traffic by next morning. Plating is widely used to achieve this even though it adds substantially to the costs of the open cut method.

Despite unfavourable soil conditions, pressure-balance tunnelling and microtunnelling are extensively used for, for example, sewer rehabilitation.

5.4.3 Singapore

The Singapore Government has issued a complete ban on trenching work in busy streets. Although a small country, Singapore leads the world in the percentage of utility work that is undertaken by trenchless methods. Much use has been made of microtunnelling, often in difficult soil conditions. However, the use of rehabilitation techniques has been limited.

5.5 Summary

The common thread that runs through the foregoing is that the various technologies for non-disruptive installation of utilities are readily available and common to a wide range of countries. The wide variations in the use of these technologies are due to a number of factors including:

- specific needs of each country in terms of utility installation or rehabilitation;
- geographical setting, in terms of population density and age of infrastructure;
- geological setting; and
- business activity and prosperity.

However, the most important factor in the use of trenchless methods is the attitude of the government towards the rights of the utilities and the public and in developing legislation which protects the environment and community from the impacts of street works.

The requirement for utilities and contractors to obtain a permit in advance of undertaking any street works seems to be an effective approach in several countries including Germany, France and Japan.

6 Discussion

As stated in the title, this report is concerned with the disruption generated by utility street works. Although there is a shortage of confirmatory evidence, the cost of such disruption could be about *£2 Billion per year*. Under present arrangements, the cost of disruption is borne by the public rather than by the utilities, and their contractors, who generate the disruption. The adoption of a minimal disruption approach, which might include the use of trenchless technology, could greatly reduce the impact and cost of road works to society, but the use of such an approach will only increase when indirect costs are taken into account. The debate on how this could be best achieved is bedevilled by a paucity of sound data. This in turn leads to ill-founded and perhaps misleading statements by protagonists on all sides. Some of these issues are discussed in the following.

6.1 Sources of disruption

Disruption to traffic and pedestrian movements can be generated by various agencies. According to Linskey (2001) - the chairman of NJUG:

> *'Congestion is caused by many factors, including:*
>
> - *Our roads carry traffic volumes with which they were never designed to cope.*
> - *Public transport is often inadequate (where it exists).*
> - *Road users add to the problems, for example by parking inconsiderately.*
> - *A wide variety of work takes place in the road.'*

All but the last is hardly germane to a discussion about the congestion caused by agencies other than the motorist, and certainly not about the effectiveness of the NRSWA. These broad social issues concern the limiting parameters of the current road network and traffic flows and fall outside the remit of this report, and of the utilities. The third concerns the motorist but, at the risk of understating this issue:

i the threat of being towed away in an urban area tends to reduce the time scale of the disruption generated by inconsiderate parking;

ii unlike street works, where court action is necessary, on-the-spot fines are available, and commonplace, for illegal parking - including unauthorised extended stays; and

iii through a variety of means, motorists contribute a substantial sum of money to the Exchequer.

It is essential, however, that all works that takes place in or around a road are considered when assessing how the consequences of disruption could be reduced. Disruption is generated by construction work undertaken for private developers, and also by highway authorities carrying out repairs and improvements to the highway and its surrounds. Such works often have a severe impact on pedestrian access. In this respect, there is no over-riding reason why private developers should be treated differently than utilities.

It has been suggested, by for example Linskey (2001), that the congestion generated by utility street works is less than that due to the combined effects of private developers and highway authorities. However, again, despite its obvious importance, there is little verifiable information to confirm any such claim. It would seem essential to determine the level of disruption (in all its guises) on public roads generated by various agencies to check that the legislation introduced to control it is properly directed. It is of note that, in the same article, Linskey opines that the enactment of section 74 of NRSWA will have little effect on the problem of road congestion. Section 74 was not however introduced to deal with the (seemingly) intractable problem of traffic congestion on the nation's roads, but had a more modest (but nevertheless important) aim to minimise the unnecessary disruption due to utility street works.

6.2 Costs and charges

At present in the UK the general public, but principally road users, pay for all but the direct costs of most utility street works. Evidence shows that the indirect costs are substantial - perhaps approaching £ 2 Billion per year (see Section 4.1). These indirect costs are borne in numerous ways, for example through the reduction in productivity and amenity, higher insurance premiums, local and central government taxes, duties etc., but not necessarily through increased utility charges. What is clear is that the premise 'the polluter pays' is not followed here as it is elsewhere. Some of the indirect costs of congestion due to street works could thus be viewed as a surcharge on the public - and principally road users. The transference of costs/charges from utility user to the public at large - who after all are users of some of the utilities - *might* be more acceptable were street works planned and organised efficiently. But, as accepted by the Government (see Section 3.1.1), it is clear that this has not been the case and so the public pays for what are, in terms of disruption, inefficient working practices.

Commercial pressures should ensure that street works are not undertaken where they are unnecessary and also that they are completed to a near-minimum cost to the utility and their contractors. But this is not the same as minimising the 'total cost' to all concerned: some street works will be left open for longer than absolutely necessary because it reduces the cost to the contractor (see Section 3.1). Quite simply, there is no compulsion for a utility or an contractor to consider most of the indirect costs of their work and, given the current legislation, it would be naive to expect them to do so as a matter of course.

Unless the total impact of street works is assessed, the method of working that might generate the minimum disruption will not be identified and used. The development of some form of impact assessment tool for determining the total impact would not appear to be an unduly difficult task. The calculation and collection of disruption charges due to all street works seems much more complex and fraught with practical difficulties. Equally so, is the introduction of a compensation scheme for utilities undertaking more costly methods of completing street works, than they would otherwise do, to reduce indirect costs. Neither, however, should be dismissed out of hand.

It is self-evident that forcing utilities to adopt more expensive methods of working than they would otherwise use, but which could substantially reduce indirect costs, will alter the current balance of payment. It would seem more equitable for some, if not all, of the indirect cost to be borne by the users of the utilities. This will increase household bills. A substantial increase might not be welcomed by the Government or even allowed by the overseeing regulator. This has been put forward as a reason for maintaining the status quo, but it is not a sustainable argument.

A large percentage of utility street works generate little in the way of indirect costs - particularly those that are completed within a working day. It would seem from the available data that about 75 per cent of the total indirect cost to society is generated by about 25 per cent of street works, with the majority of these costs being directly proportional to the period of occupation. Using round figures, for the sake of argument, the 75 per cent could represent an indirect cost of £1.5 Billion per year and the 25 per cent a direct cost of £250 Million per year (see Section 4.1). If the adoption of less disruptive methods of working decreased indirect costs by 80 per cent (i.e. £1.2 Billion) but increased direct costs by 10 per cent (i.e. £25 Million), the ratio of the savings in indirect costs to the increase in direct costs would be about 50 to 1. Even a reduction of indirect costs of only 50 per cent brought about by a 20 per cent increase in direct costs gives a ratio of 15:1. Whilst the data are rather sparse and the method of calculation is open to different interpretations the conclusion is robust and compelling: *for 'major' street works substantial savings in indirect costs can be secured by adopting less disruptive, but only marginally more expensive, methods of working.*

However, the current situation is unlikely to change until it is necessary for utilities to take account of the indirect costs associated with their work or, more forcibly, they are charged for disruption: it would seem that change will only come through legislation. On the basis of the above analysis, the question should not be whether new legislation is required but what form the new legislation should take to best address the issue. Given the large sums of money involved, it would seem relatively simple to justify further work to collect and collate additional data, validate assessment methods so that the above can be quantified. Such investigations should be jointly funded and co-ordinated by a range of interested parties.

6.2.1 Lane rental

Some form of lane rental could be charged for the reduction in road or footway capacity due to street works. Because the impact of street works varies widely, the charge could be a function of the class of road/footway or the normal level of flow that it carries: it should recognise that some street works cause little disruption. Lane rental is now an accepted part of the road works on trunk roads and motorways, and so the case for its introduction for street works seems compelling. Indeed, as stated in Section 3.1.1, lane rental schemes for street works are to be introduced in Middlesborough and in Camden. According to an article in the Surveyor (Anon, 2001), there are about 25,000 excavations per year in the roads in Camden and the pilot scheme is intended to help the Council achieve a 10 per cent reduction in delays caused by such works on key routes by 2004. The income from the scheme will pay for additional street works enforcement, help meet administrative costs and, possibly, fund research into other congestion-beating measures.

There are a number of drawbacks to the introduction of a lane rental scheme for road works - most obviously that administration costs might be disproportionately high compared to the resulting benefits. Presumably, the costs of lane rental will ultimately be borne by the consumer. It might also be a rather blunt instrument because, unlike motorway works, street works are numerous, and most are relatively small-scale, short-lived exercises. (Nonetheless, it might still prove to be an effective instrument.) Furthermore, the commercial pressure to reduce the time of occupation, thereby minimising lane rental charges, must not compromise the quality of a reinstatement. The cost of introducing and implementing a system for checking the quality of reinstatements to all road works might be high and recourse to legal action might still be required. For efficiency, the latter requires a clear, accurate and acceptable method for assessing the quality of a reinstatement.

At this stage it is not clear that the introduction of lane rental will effectively force the co-operation of different utilities and undertakers carrying out street works, or reduce the disruption due to street works. For this reason the pilot schemes in Middlesborough and Camden are to be monitored. Some thought could be given to applying such a scheme to all activities that reduce the capacity of roads and footways. For planning purposes, some form of internal charging could be introduced to assess proposals for road works by the highway authorities themselves.

6.2.2 Licences and permits

As described in Section 5, in some parts of the world an organisation wishing to occupy a street for any length of time requires a licence and/or a permit to do so. A permit is only granted on receipt of a detailed breakdown of the work - this includes a time scale, method of working, and traffic management arrangements etc. In the UK, a local highway authority could issue such permits. And, given a remit to minimise disruption to the community, the authority would have the right to challenge, and perhaps modify, any particular aspect of the work. The cost of a permit could cover the administration of the system, including checking that the work was done to time and quality. The charge might vary according to the level of disruption generated by the works, or the length of time the works are undertaken for, i.e. much as a lane rental system. Again, such a system should be applied to all activities that reduce the capacity of a street or footway, or reduce the level of services available.

This system has been shown to work well overseas, for example in Germany but, as shown in Section 5, there are substantial differences in the attitude of society, government and industry there and in the UK to the disruption generated to street works. Such differences might hinder the introduction of such a system in the UK - and such a system would have to be introduced through legislation.

6.3 Policy and legislation

At the risk of over-simplification, at present:

- i policy matters relating to the construction and operation of roads in the UK are the responsibility of the DTLR;
- ii HA are responsible for the operation of the motorway and trunk road network in England;
- iii Transport for London are responsible for the management of all roads in the capital;
- iv other roads are under the aegis of the local highway authority - some of which are members of the CSS (mainly for county and local roads) or the Technical Advisers Group (TAG) (mainly conurbations); and
- v utility regulators have a considerable influence of a wide range of utility operations, but they have no remit to control the impact generated by street works.

Over the past 50 years or so, there have been a number of Ministries and Departments responsible for roads in the UK. (In that time the Departments of Transport and Environment have been wedded and divorced twice.) Ultimate responsibility now rests with the DTLR but, at present, there is no single body responsible for all roads in the UK. It could be argued that the appointment of a national co-ordinator for all roads would ensure that rights-of-way, congestion, the road infrastructure, public transport, speed cameras and a whole host of other issues would receive the attention that, for example, motoring organisations and the press claim they deserve. What is required is more akin to a regulator (as for the utilities) or a ‘Tsar’ (as for illegal drugs) than an ombudsman.

Discussion regarding the appointment of a national co-ordinator (and the brief, budget and manpower for the office) falls outside the scope of this report. But, according to the details of the arrangement, by acting as a focus such a post might improve the implementation of Government policies on transport (see below). For example with regarding to issues of sustainability, construction of new roads, congestion charging in urban areas and on integrated transport. There would seem to be little point in such an exercise were it merely a reorganisation of the current bureaucracy.

Whilst the initiatives in Nottingham, on trench-sharing, and Camden, on lane rental, are to be applauded it seems that the implementation of either of these schemes, or others - such as the issue of permits for all road works - on a nation-wide basis will require legislation. This, again, might be better formulated, implemented and monitored through a ‘roads regulator’. There is a danger that various schemes introduced on an ad-hoc basis will lead to confusion in the industry, and such schemes might not be particularly efficient or effective. This should not be used as an argument against the introduction of pilot schemes.

It would seem necessary for those involved in undertaking street works and representatives of those affected by them to have some forum for exchanging information, ideas etc. and it would seem best that such a forum should be chaired by DTLR. The results of the survey (see Section 3.2) show that the make-up of HAUC is *seen* by some to be biased, and it does not provide such a facility.

There is plenty of evidence to show that there is scope for reducing the disruption due to road works of all kinds, including utility street works. The reduction of indirect costs at street works will, inevitably, increase direct costs, which will be borne by the utilities and ultimately their customers. Only if there is a political will, can this charge/cost balance be changed. It seems unlikely that, by itself, the implementation of section 74 will lead to a substantial shift in the current balance. The maintenance of the status quo will continue to ignore the substantial indirect costs resulting from utility street works that are borne by the public - but in the main by motorists. The introduction of lane rental charges, as in Camden, will recoup some indirect costs, but it remains to be seen whether or not this scheme will become commonplace.

Recent statements by the Government (see Section 3.1) backed by changes to the existing legislation should be sufficient to show that the status quo cannot be defended or maintained indefinitely. If this is accepted, the best way of ensuring that changes to existing legislation are appropriate and acceptable is for all those concerned with street works to co-operate by, for example, pooling data and ideas. The trench-sharing scheme at Nottingham is a good example of what can be done, and the results of the survey, see Section 3.2, show that there was no lack of co-operation between engineers concerned with street works. Any new legislation needs to be fine-tuned to optimise the benefit to society as a whole. There is a danger that new legislation might be drafted rather too quickly, perhaps as a need to be ‘doing something’ or in response to a particular ‘newsworthy’ incident or disaster. Despite the forthright comments of the Government, some in industry regard the implementation of section 74 as an example of ‘gesture’ politics.

Over the past few years, UK transport policy has increasingly taken account of sustainability issues and prominence has been given to making the best use of the existing infrastructure. Thus it has become increasingly important to ensure that the maximum highway space is available for use by the travelling public, and hence that the disruption caused by road works is minimised. With regard to street works, the introduction of new legislation would enable the Government to meet some of its stated objectives for transport in the UK (DETR, 2000). These include:

- reducing transport emissions;
- improving transport safety, in particular a 40 per cent reduction in the number of people killed or seriously injured in road accidents and the provision of safe cycling and walking routes; and
- reducing congestion on roads, particularly in urban areas and at bottlenecks.

It is accepted by the Government that such improvements require an increase in the investment in the transport industry - Transport 2010 (DETR, 2000) envisaged an expenditure of around £180 Billion over the next ten years. The findings of this study show that there would be an excellent return on investing a small share of this investment to reduce the disruption generated by street works.

7 Conclusions

General

1 Utilities have a legislative ‘right’ dating back to the mid-nineteenth century to occupy the road for the purpose of installing, repairing and maintaining their equipment.

2 Utility street works, which involve excavations, conflict with the free use by pedestrians and vehicles of the street.

3 Street works can damage pavements and third party structures, and adversely affect the environment, the quality of life and the operation of businesses.

4 The utilities provide essential services, but the impact and indirect costs of utilities’ street works are borne by the community.

NRSWA

5 The privatisation and proliferation of utility companies and re-organisation of local government has resulted in a totally different commercial state to that envisaged when the NRSWA was drafted in the early 1980s.

6 Because of higher levels of traffic and increased activity of utilities, the conflict between road users and utilities has probably increased since the Act was introduced. The low level of prosecution for defective or prolonged street works is not proof of the effectiveness of the Act.

7 The fundamental aim of the Act to reduce disruption arising from street works has not been achieved.

8 There is evidence that the Emergency Powers of the Act are being abused.

Planning and installation methods

9 Utilities are under no obligation to consider less disruptive, but perhaps more expensive, methods of working, and there is no compulsion for street works to be undertaken in such a manner as to minimise the disruption or the period of occupation.

10 The selection of the method of installation is dictated by the direct cost of the work.

11 The delegation of responsibility from the utilities to their contractors for selecting and planning the method of installation seems contrary to the spirit of the Act. This delegation is unlikely to lead to other than the use of the least costly method of working.

12 There is room for improving the co-ordination of street works and the forward planning of work programmes.

Impact of utility street works

13 Utility street works are disruptive to the economic and social fabric of the country. The indirect costs of such works have been estimated to be of the order of £2 Billion per year. Traffic delay is the major component, but major costs are incurred due to disruption of businesses, damage to pavements and to third party equipment and property and increased numbers of accidents. In addition, environmental impacts and loss of amenity are involved.

14 A major barrier to any sensible dialogue and evaluation of social and third party costs is the paucity of data on such issues.

15 For some street works, a substantial saving in indirect costs could be obtained by adopting less disruptive, but only marginally more expensive, methods of working.

Trenchless methods

16 Trenchless methods are only used where their direct cost is lower than for open-cut working. Thus the use of trenchless methods is unlikely to increase substantially until the indirect costs of street works are taken into account.

17 Many highway engineers do not appreciate the benefits of trenchless methods. There are reservations about the risks and costs associated with microtunnelling and pipe jacking methods.

18 The use of trenchless methods varies according to the geographic and geological setting and the specific needs of a particular country or region, but the most important factor determining their use is the attitude of Central or Local Government towards the rights of the utilities and the public.

Further measures

19 Pilot lane-rental schemes for street works are to commence in the UK in 2002. However, it seems likely that further legislation will be necessary to satisfy the Government's stated objective 'of reducing the impact on traffic and pedestrians caused by street works for utility companies'.

8 The way forward

Investigation

To move the debate on, reliable data are required on the impacts and indirect costs of street works, in particular:

- traffic delays;
- effect of trenching on the life of a pavement, adjacent third party equipment and property;
- incidence of accidents at street works;
- pollution generated at and around street works; and
- other environmental effects, such as damage to trees.

Long-term data are required for some of the above, such as the effect of trenching on the life of a pavement. Reviews are to be undertaken of the effect of enacting section 74 of the NRSWA and of the various pilot schemes, for example the lane rental schemes to be operated by Middlesborough and Camden. The PJA is one of many organisations that could play a pivotal role in such reviews and in the collection and assessment of additional data.

Models of analysis

The data from the above should be used to develop and refine various models for evaluating the impact of street works.

Promotion of trenchless methods

The PJA and others involved in trenchless methods of working need to make engineers, in highway authorities, utilities and contractors, more aware of the benefits of such methods. However, perhaps more importantly, those in local and central government should be more appreciative about how these methods could bring real benefits to the people they represent. The problem might lie with the extent of current coverage rather than the quality of existing promotional literature. A follow-up programme of research could involve support for the collection of data, as proposed above, but in particular,

- safety and economic aspects of street works;
- collection and assessment of data from trenched and trenchless schemes; and
- detailed case studies to compare the advantages and disadvantages of trenched and trenchless methods of construction.

Legislation and representation

The need for new legislation might emerge from the findings of the above. This will however take some time to complete, if it is ever done, and it would seem useful to initiate discussion among interested parties to assess the need for further legislation and the practicality of various options, such as lane rental. It might also be worthwhile establishing a standing committee of representatives of organisations, not currently represented on HAUC, to promote the interests of the public and motorists, and to lobby Government on all aspects concerning road works. To be of any value, such a committee must be active: it should be involved in the organisation of public meetings, of meetings with local and central Governments, and be intimately involved in the promotion and completion of research work.

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Appendix A: Trenchless installation techniques

A1 Trenchless installation techniques

The following trenchless techniques can be used for the installation of new pipes and cables:

- impact moling and pipe bursting;
- guided boring and directional drilling; and
- pipejacking and microtunnelling.

Trenchless methods can also be used for the repair and/or rehabilitation of existing pipelines.

The following provides a definition and a short description of the above methods. More detailed explanation of trenchless technologies can be found in publications issued by the International Society for Trenchless Technology (ISTT): see Bibliography.

A1.1 Impact moling and pipe bursting

Impact moling

Definition - The use of a tool that comprises a percussive hammer within a suitable casing, generally having a torpedo shape. The hammer may be driven pneumatically or hydraulically. The term is usually associated with no-steered or limited steering devices without rigid attachment to the launch pit, which relies upon the resistance (friction) of the ground for forward movement. During operation the soil is displaced, not removed. An unsupported bore may be formed in suitable ground, or a pipe drawn or pushed in, behind the impact moling tool: cables may also be drawn in.

Because impact moling is, by and large, unsteered the technique is most suitable for short lengths of bore, but a straight bore can be maintained for long lengths at a larger diameter. Diameters range from about 45 to 200 mm depending on the pipe or cable being installed.

Impact moling can be a very cost-effective method of installing small to medium sized pipes, and ducts and cables for a broad range of utilities including gas, electricity, water and telecommunications. The technique is commonly used for simple road crossings for the installation of service connections between main lines and individual properties. Moles are relatively easy to use, monitor and maintain in the field, and many utility companies carry moling systems as standard equipment on all installation and service vehicles.

Pipe bursting

Definition - A technique for breaking an existing pipe by brittle fracture, using mechanical force from within: the remains are forced into the surrounding ground whilst, at the same time a new pipe, of the same or larger diameter, is drawn in behind the bursting tool. The pipebursting device may be a pneumatic impact moling tool that converts forward thrust into a radial bursting force, or a hydraulic device inserted into the pipe and expanded to exert a radial force.

Pipebursting is used for the renewal of gas and water mains, and for the replacement of old and undersized sewers. Significant increases in size are possible. Sewer bursting operations are typically in the diameter range 150 to 375 mm, but larger pipes have been replaced by this method. Pipebursting using a pneumatic mole relies on a percussive fracture mechanism, and is therefore aimed at brittle materials such as cast iron, spun iron, clayware and unreinforced concrete. The technique is by far the most popular method for size-to-size replacement and for upsizing of pressure pipes, and has been used for diameters of less than 100 mm to over 500 mm.

Hydraulic bursting has been used primarily for the on-line replacement of sewers and gravity pipelines, rather than for pressure pipelines. Pipelines up to one metre in diameter have been installed by this method.

Summary

- Moling is one of the simplest and most widely used no-dig techniques, especially for the installation of small diameter service installation over relatively short distances.
- With a few exceptions, moles are not steerable and rely on launch orientation and frictional forces to follow the desired route.
- On-line replacement offers a means of replacing or upsizing existing pressure or gravity pipelines economically and with minimal or no excavation. A wide range of techniques is available, based on pneumatic, hydraulic or microtunnelling systems.
- Most pipe bursting techniques are limited to the replacement of brittle pipe materials such as cast iron, clayware and unreinforced concrete, but some are designed to deal with ductile materials including steel.

A1.2 Guided boring and directional drilling

Definition - A steerable system for the installation of pipes, conduits and cables in a shallow arc using a surface-launched rig. The direction of the drilling head can be adjusted at any stage during the bore to steer around obstacles under highways, rivers or railways. Traditionally, directional drilling has been applied to large-scale crossings with guided boring used for shorter and smaller diameter work. More recently, the use of the techniques has tended to overlap, and it is probably unwise nowadays to infer anything about the scale of the operation from the terminology.

The installation of the pipe or duct is usually a two-stage operation. A pilot hole is first drilled along the required path, and the bore is then back-reamed to a larger diameter to accommodate the pipe. During this pullback stage, the pipe is pulled into the enlarged bore as the drill string is withdrawn.

Guided boring and directional drilling have traditionally been used for the installation of pressure pipes and cable ducts, where gradients are not critical, rather than for gravity pipelines which demand close tolerances in vertical alignment to meet hydraulic design criteria. Most drilling techniques, rely on accurate bore location and guidance systems. Advances in electronics technology have resulted in a high degree of accuracy.

A typical mid-range, surface-launched guided boring machine is capable of installing a pipe of 250 to 500 mm diameter over distances of between 100 and 350 m, depending on ground conditions. The installation of larger diameter pipes is generally only achievable over short lengths of bore.

The largest directional drilling rigs can develop a thrust of over 100 tonnes, and are used primarily for long or large diameter crossings beneath rivers, estuaries, or major highways. At the bottom of the scale, compact rigs with a thrust and pullback of around 4 tonnes can install pipes up to about 160 mm diameter over distances of up to 100 m.

Summary

- Guided boring or directional drilling can be used for the installation of pipes, ducts and cables, in most diameters and over distances of up to a kilometre or more.
- Equipment ranges from compact rigs suitable for small bores and operation in restricted spaces, to large units designed for large diameter, long distance crossings.
- Guided boring and directional drilling is arguably the fastest growing new installation technique in the world.

A1.3 Pipejacking and microtunnelling

Definition - A system of directly installing pipes behind a tunnelling or shield machine by hydraulic jacking from a drive shaft such that the pipes form a continuous string in the ground. Microtunnelling is the remote controlled method of pipe jacking and, although it originally applied to diameters below 1 m, can now be utilised for almost any pipe diameter.

In recent years, technology has enabled both methods to be applied to a wide range of ground conditions from waterlogged sands and gravels, through soft or stiff, dry or waterlogged clays and mudstones, to competent rock.

Both pipejacking and microtunnelling are well suited to situations where a pipeline has to conform to close line and level tolerance, because the guidance and control systems allow accurate installation within close limits. One of the more common applications is for gravity sewers, for which microtunnelling was originally designed, where not only are the line and level critical but so is the depth of installation: in such cases both techniques can be more cost-effective than open-cut installation.

Summary

- Pipejacking and microtunnelling are cost-effective methods of installing new gravity pipelines through most soil types and at virtually any depth.
- Precise control of gradient and alignment is possible, and the techniques are particularly suitable for medium to large diameter gravity sewers.
- With microtunnelling it is possible to install pipes in very poor ground conditions with minimal risk of surface disruption or settlement.

A1.4 Pipe rehabilitation

There is now a large variety of different relining systems for the rehabilitation of short sections of pipe as well as complete pipeline runs. Systems are available for relining pressurised and unpressurised pipes.

There are four generic types of relining systems:

- sliplining;
- close fitting liners;
- sprayed lining systems; and
- Cured-in-Place pipe (or lining).

Specialised renovation systems are also available for completing localised repairs.

Sliplining

This is possibly the simplest technique for renovating non-man-entry pipelines: it basically entails pushing or pulling a new pipeline into the old one. Although, in theory, any material can be used for the new pipe, in practice polyethylene (PE) is the common choice. Not only is this material well established in the potable water and gas industries, it also has good abrasion resistance and is sufficiently flexible to negotiate minor bends during installation. Furthermore, it can be butt-fused into a long continuous length prior to being winched into the host pipe.

Close-fit lining

The use of liners that are deliberately deformed prior to insertion, and which revert to their original shape once in position so that they fit closely inside the host pipe, is often known as ‘close fit lining’ or ‘modified sliplining’. This technique is a logical development of sliplining and can be applied to both gravity and pressure pipes. The technique takes advantage of the in-built ‘memory’ of polymeric materials.

Spray lining

Often, it is often necessary to remove scale and corrosion from water pipes, and then apply a coating that will inhibit further deterioration, and perhaps also seal minor leaks. The most common materials used for this are cement mortar or epoxy resin, and these are applied by a robotic spraying machine that is winched through the pipe at a steady, predetermined rate.

Cured-in-place pipe or lining

The main alternative to sliplining (and its variants) is Cured-in-Place lining, which is sometimes referred to as ‘in situ lining’, ‘soft lining’ or ‘Cured-in-place-pipe’ (CIPP). This method has dominated the non-man-entry sewer renovation market in many countries for more than twenty years or so.

Although several competitive systems are now available, their common feature is the use of a fabric tube impregnated with polyester or epoxy resin. This is inserted into the existing pipeline and inflated against the pipe wall, and then cured either at ambient temperature or, more commonly in all but the smallest diameters, by re-circulating hot water or steam. Some variations use ultra-violet light to cure the resin.

As well as minimising bore reduction, an inherent advantage of cured-in-place liners is their ability to conform to almost any shape of pipe, making them suitable for relining non-circular cross-sections.

Appendix B: NJUG response to report by JCL

NJUG response to TRL report 'Factors affecting utility installations and the mitigation of distruption in the street' by Jason Consultants Ltd. August 2000

General

It is regrettable that the authors of the report did not consult NJUG or its members for an input. Those commissioning the report, the Pipe Jacking Association, will be well aware that Utilities use trenchless methods whenever these are appropriate since the benefits are well known. However there are a great number of factors that influence the choice of type of construction of infrastructure in streets and it has to be borne in mind that in the great majority of cases trenchless techniques are entirely inappropriate. This is only one example of how consultation with the Utility industry, either directly, or via NJUG would have led to a more balanced, less biased and accurate report on the issues.

NJUG would also have wished to comment on the statement that ‘it is invidious that the body charged with overseeing the working of the Act and developing Codes of Practice and draft regulations is the Highway Authorities and Utilities Committee (HAUC) with the NJUG being funded by and representing the Utilities’. NJUG, through its association with HAUC, has a remit from the Secretary of State to advise on street works legislation. This body has the expertise in street works matters and is best placed to advise on appropriate and practicable legislation. HAUC is seeking to expand its remit to liaise with other road users to assist the DETR in this process.

The following comments relate to the main conclusions section of the report but specific points in the body of the report are made also where relevant.

Conclusions

NJUG notes that the primary aim of the study was to obtain a better understanding of the factors that affect the choice of the method of installing utility apparatus in roads and streets (and incidentally excludes Highway Authority works). The Utilities have to make these choices and a balanced study would have aided this process. However, the report fails to address these issues and instead goes beyond its implied remit into broader issues surrounding traffic disruption, the effectiveness of legislation and socio-economic costs.

General

Reference is made to Utilities’ statutory right to use the street for installation, repair and maintenance of their apparatus. Their statutory rights are given in order for them to install and maintain the infrastructure of energy, telecommunications, data and water/sewerage services that are essential to the wider economy and society. These services are required by residential and business customers which include many of the road users highlighted in the report.

Whilst Utilities accept that their essential works can unavoidably contribute to traffic disruption to some extent, the substantial bulk of Utilities’ works pass without comment, or attract very little public attention. It is only a small element that elevates the occasional problem that unfairly weights the public’s perception of what we do, and how relatively well we go about doing it.

The New Roads and Street Works Act (NRSWA) had five main objectives as follows:

- Those carrying out street work should be fully responsible for their excavations and for their reinstatement to proper standards.
- Street authorities should be responsible for co-ordination of all works in the street: for this purpose they must maintain a public register of street works recording all significant events in the life of each job.
- In order to minimise traffic disruption, highway authorities should be empowered in certain cases to impose restrictions on the times for carrying out street works.
- Street works should be executed by competent operatives under proper supervision.
- Improved procedures and financial arrangements should be introduced to avoid delay and waste where diversionary works are required on account of major road, bridge or similar works.

Two of these relate to the powers and duties of Highway Authorities to co-ordinate and direct the timing of works. The Utilities co-operate with the Highway Authorities to assist them in these duties.

The Electronic Transfer of Notifications System (ETON) introduced in April 1999, and drawn up by the Highway Authorities and Utilities jointly, provides the authorities with a better tool for this purpose. Your report does not refer to this system which, given time, could improve co-ordination nor does it refer to other initiatives throughout the country seeking to improve co-ordination, such as in the City of London and within a group of London Boroughs.

The effectiveness of the NRSWA legislation has been mentioned since its implementation through the Highway Authorities and Utilities Committee (HAUC), various TRL reports and the DETR reviews. General improvements have been noted throughout the period but ways to improve co-ordination are actively sought. The references to ETON and co-ordination codes of practice are examples of this. It should be noted that the Highway Authorities have only rarely had to resort to the use of Section 66 notices available to them within the existing regulations (to penalise Utilities for unnecessary delays or obstructions).

We believe that NRSWA has been effective in creating the basis for a fair balance between road users and in minimising disruption bearing in mind the duties and constraints on both Utilities and Highway Authorities.

Disruption arising from street works

The report states that Utilities are under no obligation to consider less disruptive methods of working and will not consider installation methods that will add to their costs. Under the NRSWA co-ordination arrangements, Utilities and Highway Authorities discuss arrangements for conjunctive working, the optimal timing of works, their effect on traffic and appropriate techniques and arrangements for major projects. Where appropriate Police officers are involved in these arrangements to agree safe and effective operations.

The Utilities, whilst not obliged to by statute, use a number of installation methods and seek to introduce new technology in the interests of lessening disruption, damage prevention, increased efficiency and cost reduction in the interests of their customers and road users. Indeed many advances in new technology have been made by Utilities themselves through research and investment leading to a significant increase in trenchless technology. However, we have to recognise that these techniques are only appropriate in certain circumstances.

There is no evidence to support your statements that emergency powers are being abused.

Planning and installation methods

To suggest that the delegation of responsibility from Utilities to contractors (and also from Highway Authorities to contractors) is a dereliction of Utilities' responsibilities under NRSWA is extraordinary. Utilities may lawfully appoint contractors to act on their behalf and the scope of their responsibilities is spelt out in the relevant contracts. Contractors have to comply with legal requirements.

Whilst cost must be a factor in determining operational methods, Utilities are mindful of the need to reduce disruption and use techniques to minimise disruption such as first time reinstatement, trenchless technology and pipejacking where it is practical to do so.

Environmental impact of utility operations

Whilst the report states that Utility operations in highways are disruptive to the economic and social fabric of the country, it has to be recognised that those same operations, in providing essential, secure services, provide the infrastructure for an efficient economy.

Regarding strengthening legislation, the Government has recently announced measures aimed at reducing disruption by charging for unnecessarily prolonged delays in street works which should discourage a poorly performing Utility from over-running on street works. This scheme has been drawn up with the assistance of HAUC. NJUG considers that this measure, together with the revisions to the NRSWA Codes of Practice and the introduction of a Best Practice document provide the best way forward.

Trenchless methods

NJUG Members are sufficiently aware of the trenchless techniques that are available and the range of benefits associated with them. A session at the recent HAUC 2000 Conference was devoted to new technology and a paper was presented on trenchless technology by one of the Utilities

Abstract

The report is primarily concerned with the impacts and associated indirect costs generated by utility street works. A questionnaire survey was carried out amongst interested parties, including highway authorities and motorist organizations, to determine whether in their view the New Roads and Street Works Act, which came into effect in 1993, had led to a reduction in the disruption generated by street works. Their responses are included in the report. The impact and costs of street works are also considered in some detail, along with methods for their evaluation. An international review was also completed on the legislation governing street works and on the use of trenchless construction methods: a summary is provided in the report. It is concluded that, in the UK, the disruption generated by street works could be much reduced, but substantial benefits might only come from changes to existing legislation. It is also concluded that further research is required to better evaluate the impacts and indirect costs of utility street works, which are currently borne by the community and not by utility companies.

Related publications

TRL370 *Cyclist safety at road works* by D G Davies, T J Ryley, G A Coe and N L Guthrie. 1998 (price £25, code E)

TRL324 *The effectiveness of the utility reinstatement specification* by M H Burtwell and C C Spong. 1999 (price £35, code H)

PR81 *A study of the safety performance of major motorway roadwork layouts* by M R Hayes, P J Taylor and H C R Bowman. 1994 (price £50, code N)

PR37 *A review of the accident risk associated with major roadworks on all-purpose duel carriageway roads* by M R Hayes and P J Taylor. 1993 (price £50, code N)

CR342 *The frequency and importance of incidents which cause congestion in urban areas* by G N Holmes and D R Leonard. 1993 (price £25, code E)

CR283 *A study of traffic capacity through the various features of motorway roadworks* by J G Hunt, J D Griffiths, T S Moses and S Y Yousif. 1991 (price £20, code D)

CR150 *Accidents at roadworks on all-purpose rural* by R D Coombe and D R Turner. 1989 (price £25, code F)

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