

Harpur Hill, Buxton  
Derbyshire, SK17 9JN  
T: +44 (0)1298 218000  
F: +44 (0)1298 218590  
W: [www.hsl.gov.uk](http://www.hsl.gov.uk)



**Pilot study of the Causes of Third Party Pipeline  
Infringement**

**HSL/2007/23**

Project Leader: **Rachel Cummings**

Authors: **Rachel Lee, Rachel Cummings, Jennifer  
Lunt and Christine Daniels**

© Crown copyright (2007)      Science Group      **Human Factors**

## **ACKNOWLEDGEMENTS**

Researchers at the Health and Safety Laboratory (HSL) would like to thank the three organisations that gave their assistance with this project and allowed them to observe and interview their staff. In particular, thanks are extended to all the individuals who agreed to be interviewed, observed or took part in focused group discussions.

# CONTENTS

<b>1</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	Background .....	1
1.2	Aims and Objectives .....	1
1.3	Scope .....	1
<b>2</b>	<b>METHODOLOGY.....</b>	<b>2</b>
2.1	Design .....	2
2.2	Participants.....	2
2.3	Materials .....	2
2.4	Procedure .....	3
2.5	Analysis .....	3
<b>3</b>	<b>FINDINGS.....</b>	<b>5</b>
3.1	The System .....	7
3.2	The Organisation .....	11
3.3	The Supervisor .....	15
3.4	The Team .....	17
<b>4</b>	<b>SUMMARY:THEMATIC ANALYSIS OF CONTRIBUTORS.....</b>	<b>21</b>
<b>5</b>	<b>CONCLUSIONS.....</b>	<b>31</b>
5.1	The System .....	31
5.2	The Organisation .....	32
5.3	The Supervisor .....	33
5.4	The Team .....	33
<b>6</b>	<b>APPENDICES.....</b>	<b>34</b>
6.1	APPENDIX 1: Supervisor Interview Schedule .....	34
6.2	APPENDIX 2: Focus Group Schedule .....	36
6.3	APPENDIX 3: Copy of Letter sent to Participants.....	37
<b>7</b>	<b>BIBLIOGRAHY.....</b>	<b>38</b>

## EXECUTIVE SUMMARY

Third party damage to underground services of all types continues to be a source of danger and financial loss to workers, members of the public, utility companies and contractors. When the underground service is a Major Accident Hazard Pipeline (MAHP) such as a high-pressure gas main or a petrochemical pipeline then the consequences of a rupture can be devastating to people and the environment.

The aim of this project was to conduct a pilot study to explore the Human Factors (HF) issues surrounding damage to underground services related to third party pipeline infringements. The specific objectives of this pilot study were to conduct site visits at three different utility organisations in order to gather data from a variety of sources on the performance influencing factors (PIFs) that can potentially lead to third party pipeline infringement.

A combination of observation, semi-structured interviews and focused group discussions were used to collect data. Three work crews of pipe fitters participated in focus groups. Additionally, interviews were conducted with two Operations Managers, two corporate Health and Safety Managers, one Construction Manager, one depot Health and Safety Manager and three Supervisors to gain a variety of perspectives on the causes of damage to underground services.

Three researchers conducted a thematic analysis of the main contributing factors. These factors were discussed and verified at a workshop with Industry and HSE representatives. The thematic analysis revealed four broad areas each with a number of factors influencing or contributing to infringement. These areas were: the System, the Organisation, the Supervisor and the Team.

Although these four areas interact with each other, the role of the Supervisor and the interaction between the Supervisor and the Team were found to be critical for managing safety when working above or near underground services.

Detailed findings are presented in the conclusions section of this report.

# **1 INTRODUCTION**

## **1.1 BACKGROUND**

Third party damage to underground services of all types continues to be a source of danger and financial loss to workers, members of the public, utility companies and contractors. When the underground service is a Major Accident Hazard Pipeline (MAHP) such as a high-pressure gas main or a petrochemical pipeline then the consequences of a rupture can be devastating to people and the environment. According to current estimates, utility companies dig approximately four million holes every year. This excludes excavations made by construction projects.

The Health and Safety Executive's (HSE) Hazardous Installations Directorate (HID) commissioned researchers at the Health and Safety Laboratory (HSL) to explore the Human Factors (HF) issues that potentially underlie third party pipeline infringement. This report details the findings of a pilot scoping study conducted to gain initial insight into the HF issues surrounding damage to underground services by third parties.

## **1.2 AIMS AND OBJECTIVES**

The aim of the project was to conduct a pilot study to explore the Human Factors issues surrounding third party damage to underground services. The specific objectives of this pilot study were to conduct site visits at three different utility organisations in order to gather data from a variety of sources on the performance influencing factors (PIFs) that can potentially lead to third party pipeline infringement.

The findings of this initial pilot study will inform a larger study of HF issues related to pipeline infringement. The results of the larger study will be used to develop HF guidance information for duty holders that will reduce the likelihood of third party damage to underground services of all types.

## **1.3 SCOPE**

The scope of the research focused on the Human Factors issues relating to Supervisors and Teams working near or above MAHPs.

## **2 METHODOLOGY**

### **2.1 DESIGN**

HSL researchers used qualitative methods to facilitate exploration of the Human Factors (HF) issues and generate sufficient detail to gain insight and understanding. A combination of observation, semi-structured interviews and focused group discussions were used. Interviews and discussions were tape recorded (where possible), transcribed and thematically analysed. Researchers conducted an initial site visit to familiarise themselves with the work tasks and context, to gain a better understanding of the work involved, and to help devise appropriate question sets. This is discussed in more detail in the Procedure (Section 2.4).

### **2.2 PARTICIPANTS**

Three separate organisations gave their assistance with this project and allowed researchers to observe and interview their staff. The HID Pipelines team from HSE recruited these organisations. Two of these organisations managed gas pipe replacement, and the other was responsible for the installation of duct for telephone cables. Researchers held focused group discussions with work crews from each of the three cooperating organisations. All these crews were involved in excavation work and all had experience of causing damage to underground services. Two crews comprised four members and the other had two members. The level of experience of each crew member varied. All crews consisted of a mixture of experienced and less experienced staff. Length of service in the industry ranged from 3 days to 20 years. Most crew members usually worked together in the same team.

In addition, researchers conducted semi-structured interviews with work crew supervisors, operations managers, corporate Health and Safety advisors, depot Health and Safety managers and construction managers (Table 1). These participants all had direct personal experience of managing excavation work. All of the participants were men of working age (18 - 65 years).

### **2.3 MATERIALS**

Schedules were developed for the semi-structured interviews and the focused group discussions (Appendices 1 and 2). These were based on the information gained during the initial familiarisation visit. Topics covered included:

- Training;
- Level of experience in the industry;
- Experience of infringements;
- Views on the causes of infringement and the reason some teams have lower 'strike rates' than others.

The schedules were amended slightly after each visit, in order to reflect the researchers increasing understanding of the practical situations. Schedule amendments included shortening the schedule and framing the questions differently. An observation chart was also developed. However, this was not fully utilised because researchers found the most efficient way to perform the observation was to invite staff from the organisation to describe and explain what they were doing. This was also a useful source of exploration of the HF issues, as it generated more details by providing prompts and contextual cues. Crew members were able to show

researchers the information provided to conduct the work e.g. ‘job packs’, and discuss some of the strengths and weaknesses of the material.

## **2.4 PROCEDURE**

An initial site visit was conducted to allow researchers to familiarise themselves with the work, its context and any other relevant organisational issues. This involved discussions with a variety of personnel including supervisors, Health and Safety managers (regional and national), an Operations Manager and crew members. In addition, researchers attended a worksite in a residential area undergoing gas pipe replacement. The work was described and explained, and workers demonstrated the use some of the tools used on the job including the ‘Cat and Genny’, a cable detection device.

Following the familiarisation visit researchers developed interview and focus group schedules plus observation charts. Three further site visits took place as follows:

**Site 1:** Researchers observed a crew of four inserting duct for telephone cable underneath a footpath in an industrial estate with a moderate volume of traffic. A focus group was conducted at the road side with the crew. Interviews were conducted off-site, at the depot, with two supervisors and a national Health and Safety manager. The national Health and Safety manager was interviewed separately. He was present for all aspects of this site visit. Tape recordings were not obtained because of the level of noise from road traffic. Notes were taken of all interviews and discussions.

**Site 2:** A crew of two were observed undertaking excavation for gas mains pipe replacement in the highway of a suburban, residential area with a heavy volume of traffic. The construction manager attended and explained the work and the ‘job packs’. He discussed some of the difficulties encountered in the work. A focus group was conducted at the depot with the crew. Researchers also interviewed the construction manager and the operations manager together. Interviews and the focus group were tape-recorded and notes were taken.

**Site 3:** Researchers observed a crew of four finishing a job that involved replacement of large diameter gas mains pipe in the highway of a city residential area, with a high volume of traffic. The crew participated in a focus group discussion in a cafe next to the work site. Interviews were conducted individually at the depot with the crew’s supervisor, the Operations manager and the national Health and Safety manager. Tape recordings were obtained of the focus group, the supervisor interview and part of the construction manager interview. Notes were taken of all interviews and discussions.

## **2.5 ANALYSIS**

All tape recordings were transcribed and anonymised. Using the processes of thematic analysis three researchers systematically identified themes using the notes and transcriptions. To reduce investigator bias within the data analysis, each investigator independently coded and analysed the transcriptions. This was deemed to add rigour and transparency to the outcome. Thematic analysis revealed four broad areas each with a number of factors influencing or contributing to infringement. These areas were:

1. The System.
2. The Organisation.

3. The Supervisor.
4. The Team.

A summary of individuals interviewed is found in Table 1.

<b>Table 1. Interviews conducted</b>			
	<b>Company 1</b>	<b>Company 2</b>	<b>Company 3</b>
<b>Operations Manager</b>	<b>X</b>	<b>X*</b>	
<b>Corporate Health and Safety Advisor</b>	<b>X</b>		<b>X</b>
<b>Construction Manager</b>		<b>X*</b>	
<b>Depot Health and Safety Managers</b>	<b>X*</b>		
<b>Supervisors</b>	<b>X*</b>		<b>X</b>
<b>Team/Crew</b>	<b>X*</b>	<b>X*</b>	<b>X</b>

X\* = Accompanied by transcripts.

The factors that were identified as contributing to third party pipeline infringements were discussed and verified at a workshop with Industry and HSE representatives in December 2006.

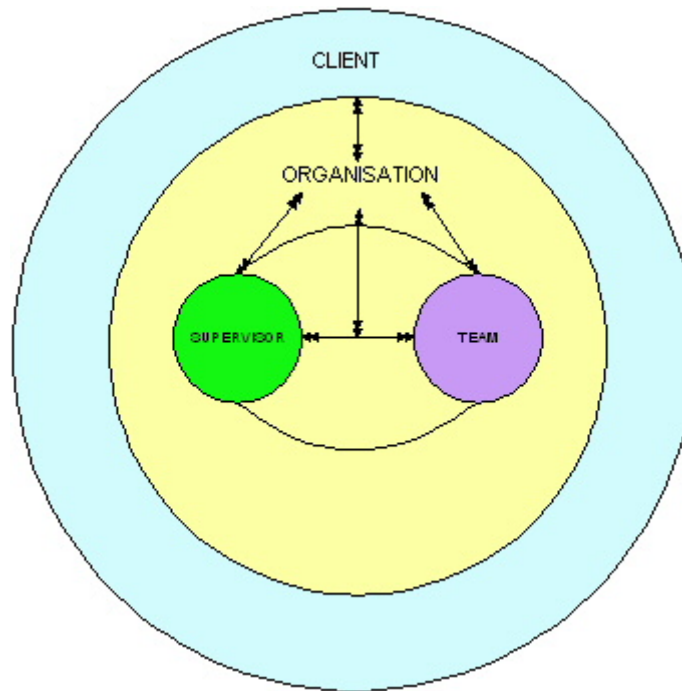
### 3 FINDINGS

The site visits generated data on the causes of damage to underground services by third parties. Thematic analysis revealed four broad areas each with a number of factors influencing or contributing to third party damage. A table of these results can be found in Section 4.

These areas were:

1. The System.
2. The Organisation.
3. The Supervisor.
4. The Team.

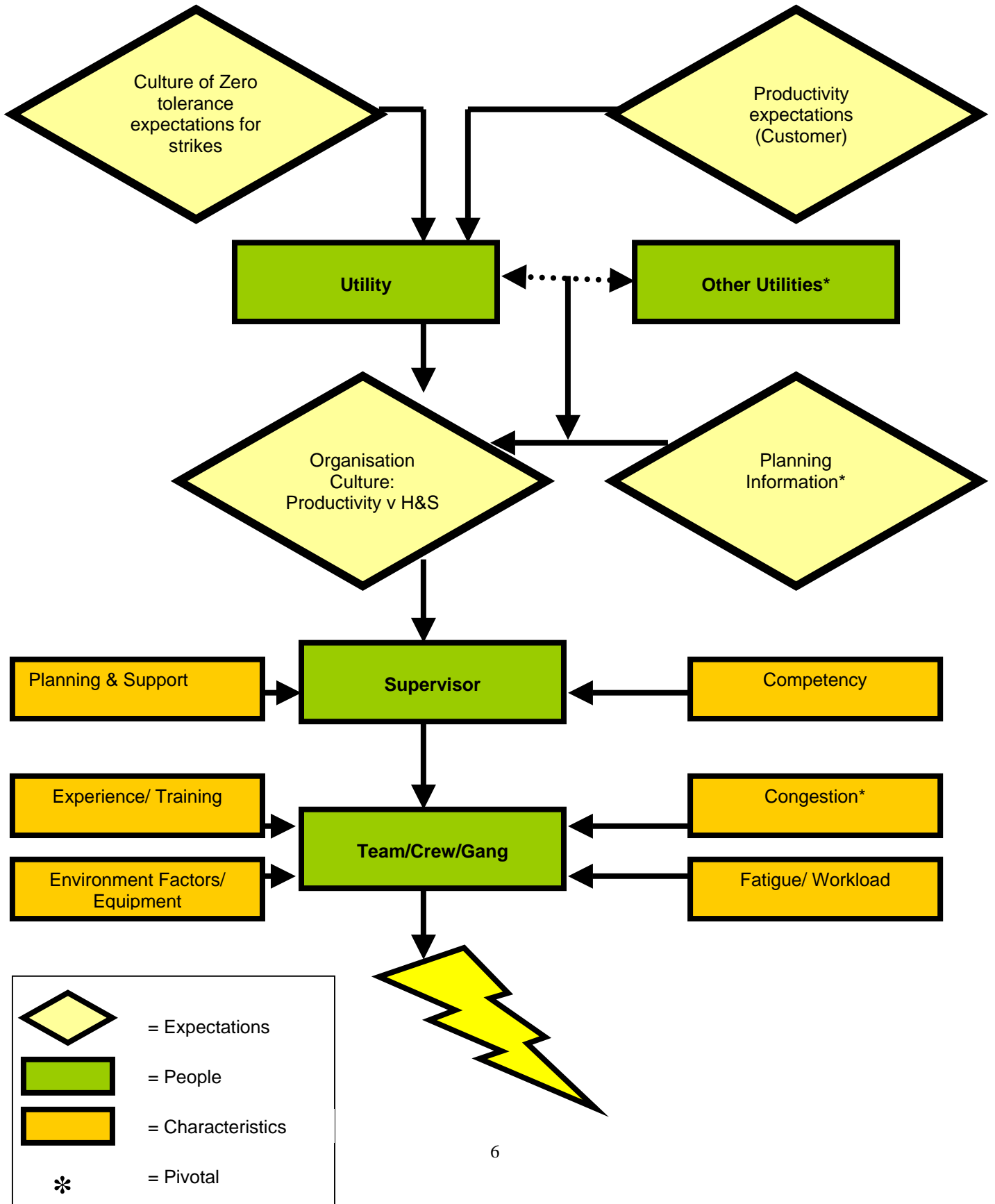
Figure 1 below depicts the interaction of The System (represented in the diagram as The Client), The Organisation, The Supervisor and The Team.



**Figure 1. Interaction of three levels of investigation**

The following section will consider the different factors pertaining to each of these areas in turn. The summary of main influences between the factors is demonstrated in Figure 2.

**Figure 2. Summary of Main Influences of Potential Causes of Third Party Cable/Pipeline Infringement**



### 3.1 THE SYSTEM

There follows a list of the main themes identified that related to the system. Each of these is discussed in more detail in the subsequent text.

- Current Code of Practice for Underground Positioning of Pipes not widely observed
- Accountability
- Perceived Pressure from Customers to meet Production Targets
- ‘In house’ versus external planning
- Zero tolerance pressure (HSE and external customer)
- Lack of cooperation between utilities
- Perceived pressure due to time limits of work permits
- Lack of provision of current and appropriate information for the worksite
- Drawing or map quality within the ‘job packs’

The recommendations and implications for managing these factors are presented in bold type.

#### 3.1.1 **Current Code of Practice for Underground Positioning of Pipes not widely observed**

The layout of underground services varies from site to site. There is no single system of underground pipeline arrangement. Although the National Joint Utility Group (NJUG) produced a code of practice specifying the position and depth of pipes of different kinds, this has not been universally observed. There is no consistency in the position of pipelines and cables, and work crews have no information on the depth of utilities. It is felt that the code of practice has not helped to reduce the number of damages. It is only of potential use in virgin footpaths and does not help with replacements in existing footpaths.

**Companies should acknowledge within their risk management systems that the NJUG code of practice is not widely observed. Further research at an industry wide level should be aimed at addressing reasons for this perceived low level of compliance. Before suggestions of accountability can be raised it would be important to examine why the code is not followed. The motivation for deviating should be explored, e.g. are the procedures (within the code) wrong or out-of-date; is there a quicker or easier way to complete the task, or does following the full code take too long? Involving the end-users should ensure more usable guidelines.<sup>1</sup>**

#### 3.1.2 **Accountability**

Companies that have breached the NJUG code of practice have not been held to account for their actions. For example, a recurrent theme throughout the interviews was the problems caused by street light cables. These often lie superficially in the ground, and excess cable has been left in the ground in loops. This makes it more difficult to predict the position of cable since it does not lie in a straight line. Electric cable fitters have left the cable in the ground to save the time involved in cutting and joining cables to ensure an exact fit. This practice has not been challenged. This was illustrated by the following comment:

---

<sup>1</sup> *The implications of the findings for risk management practices are presented in bold typeface.*

*“There is a code of practice...electric companies, there is a recommended depth that they should lay at ...but there is no sort of feedback for enforcement to make them do that.”<sup>2</sup>*

**As a long-term recommendation for improving accountability an industry-wide initiative that enforces standards regarding pipe laying would be beneficial. Additionally, increased enforcement of apparent ‘less compliant’ companies may help regulate the code.**

**In the short-term, a reminder of the code could be issued to help increase awareness. Companies should be reminded that by following the code they will also be complying with the law.**

### **3.1.3 Perceived Pressure from Customers to meet Production Targets**

Customer organisations exert pressure on the service provider organisation to meet targets. This time pressure can be transmitted down to the workforce who can be under pressure to get work done quickly. Rushing work for a number of reasons including this one was cited as one of the causes of damage to underground services. A typical response when asked about the causes of damage to underground services was:

*“It’s about money – rushing.”*

People working in a variety of different roles and different organisations across the sample of participants acknowledged these production pressures.

**Production targets negotiated between the organisation and client, should be realistic and attainable, whilst including sufficient contingency, and so prevent the relative prioritisation of productivity over health and safety performance.**

### **3.1.4 ‘In house’ versus external planning**

Desktop planning was cited as a contributing factor to damage to underground services, whereby engineers who did not actually attend the site planned jobs. A number of interviewees reported that important information is gathered on site, which dictates how the work should be done, such as observations of street furniture. Therefore, it was pointed out that jobs should be planned after attending the site to assess any factors that may influence the way the work is done.

**To manage the risk of third party pipeline infringements companies need to consider the benefit of on-site planning as opposed to desk-based planning. It is a recommendation that site visits are made part of the procedure for planning jobs in order to accurately assess the hazards that may impact upon safety performance.**

### **3.1.5 Zero tolerance pressure (HSE and external customer)**

The way the pressure to reduce the strike rate feeds down from the customer or client was illustrated by the following remark:

---

<sup>2</sup> *Italics represent direct quotes from interviewees.*

*“I think they are under a bit of pressure too probably from \*\* [name of organisation] or whatever they are called nowadays, to lower cable strikes and things like that. I think it is just an embarrassment for them.”*

**It is a recommendation for the organisation to address the external demands from HSE and the client to reduce strike rates in a managed and proactive manner. This is to circumvent the potential for organisations to deal with the issue in an ad-hoc and reactive manner at the level of the individual’s performance, and to ensure manageable workloads and time frames for the worker.**

### **3.1.6 Lack of cooperation between Utilities**

The problems arising from a lack of communication and cooperation between the different utility services was a recurrent theme throughout the interviews. Although most utility companies would supply other companies with copies of plans or maps this was often the only collaboration to take place. Some people interviewed stated that the only other contact they had with other utility companies was after damage had occurred. They stated that it would be preferable to speak with other utilities before the event. There were some notable exceptions to this. A few examples were given of companies who had tried to address this by providing a ‘dial before you dig’ service, or even personnel from utility companies attending worksites before the job started to ‘mark up’ the location of services.

**Formal communication between utilities should be an essential part of pipelines management. However, the existence of formal communication systems does not inevitably ensure that the right information is communicated to the right people at the right time. The potential for poor information should be acknowledged within an organisation’s risk management system. Commitment for increased inter company communication must come from the companies themselves. The common benefits of communication, such as collective protection and customer retention, should be emphasised.**

### **3.1.7 Perceived pressure due to time limits of work permits**

Another potential source of time pressure was the time limit in which local councils place on the company to complete the pipelines work. Companies apply to the Local Authority (LA) for permission to undertake the work. The LA issues a notice allowing the company to complete the work and states a time limit. If this is exceeded the LA fines the company. If there are delays for any reason and the work will not be completed to target, the company must apply to the LA for an extension. Work crews were aware of this time pressure as was illustrated by the following statement:

*“You have just got to try and get it done during the opening notice from the council.”*

**The time constraints set by LAs to complete work has the potential to lead to productivity being prioritised over health and safety performance. This potential should be acknowledged in an organisation’s risk management system, planning process and formal communications between the LA and the company.**

### **3.1.8 Lack of provision of current and appropriate information for the worksite**

The information received for planning the job from other utility companies was perceived to be misleading at times. This was thought to be because databases had not been updated with any new work completed. As a consequence, work crews stated that they were obliged to undertake work using plans with incomplete information. For example, it was explained that some plans have no markings to indicate recent housing developments.

**The inaccuracy of local information provided by utilities for planning and conducting the work is a potential performance influencing factor that should be addressed in a company's risk management system.**

### **3.1.9 Drawing/ map quality within the job packs**

The interviewees stated that the quality of the drawings or maps supplied by utility companies (detailing the position of pipelines) was inconsistent and often poor and misleading. They explained that maps lacked detail and often gave limited information about the location of services. They were also perceived to be unclear and were often not in colour. The scale of the maps varied from one plan to another. Interviewees stated that they can find it difficult to tell if a line was an electric cable or a footpath on some maps. The problems with the maps were supported by these comments:

*"...some of them could do with being more detailed. ...all you can see is a load of squiggles."*

*"Cable drawings vary. In Nottingham they're good. But in London they're not so good. ...The quality of the drawings may influence workers' perceptions of management's approach to safety – they see a bad drawing and think management are not concerned with Health and Safety."*

A coloured map was frequently suggested as a solution to some of the problems leading to damage to underground services. Organisations were taking steps to address the quality of the maps, as the following quote suggests:

*" I think when we first started we had a few problems with the electric drawings where they were only black and white.... Whereas now they are getting more detailed and they come in colour which is helpful."*

**The provision of poor information regarding the location of services has the potential to influence safety performance. Companies should adopt a consistent approach to the design of maps, including: colour coding, sufficient resolution of detail, and harmonising standards for both commercial and residential areas.**

## 3.2 THE ORGANISATION

A number of themes emerged relating to the organisational level. These are listed below and then described in more detail in the ensuing text, along with the implications for an organisation's risk management processes.

- Potential to prioritise productivity in relation to H&S
- Zero or minimal strike rate expectations
- Potential to over emphasise performance at individual level
- Policy of working in reduced lighting conditions
- Policy on fatigue management
- Provision of information
- Auditing
- Performance related penalties
- Pay schemes

### 3.2.1 Potential to prioritise productivity in relation to H&S

Some interviewees perceived that there was a potential to prioritise productivity in relation to health and safety, which they felt could influence their performance. The interviewees thought that there was a strong incentive to work at a fast rate because crews are paid for the work they complete. Therefore, it was acknowledged that there is greater remuneration for crews who lay a greater number of pipes

*“If you get the work done they're happy with you.”*

However, many of the interviewees felt that time pressure was not a significant factor affecting damage to underground services, as illustrated by the following remarks:

*“I don't get the impression that they are working at unnecessarily dangerous speed.”*

*“You can only go at a certain speed anyway. Depends on the ground.”*

**There is the need to reconcile the competing demands of health and safety and productivity. There is a potential for financial incentives to prioritise productivity over health and safety performance. Ideally, the system of remuneration should incentivise both productivity and health and safety performance. Rewards should be based on the presence of fundamentally safe behaviour rather than the absence of an unsafe outcome. Similarly, visible management commitment to health and safety practices over and above production needs to be communicated throughout the organisation.**

### 3.2.2 Zero or minimal strike rate expectations

Opinions, amongst the interviewees, were divided on whether or not it was realistic to aim for a strike rate of zero. Some of the participants believed it was possible to achieve a zero strike rate. Whereas others felt it was an unrealistic target since some damage was inevitable and unavoidable. These contrasting views are evident in the following quotes.

*“With damages, there is no excuse when it is planned work.”*

*“I don’t believe we’ll ever get a zero on it.”*

The following quote shows how the participant perceives that some damage is inevitable. In this example they attributed the damage to the congestion in the pavements:

*“...we try and avoid it wherever we can but sometimes it does happen because of the congestion in the place we are working. If we are working down a field and we know exactly where the crossings are, I would not expect any damage whatsoever. I would be most annoyed if anything got damaged. ... We are not in that reality. We are in the centre of **\*\*[city]**. Where we have got to provide pedestrian access round us. So therefore we have got to minimise the size of hole that we need to dig in order to, because the council won’t want us to close off the middle of **\*\* Road [main road] in **\*\* [city centre]**. They will want us to maintain pedestrian access, it is a legal requirement.”***

**If the expectation of zero strikes can be perceived as an unrealistic goal by the workforce, that fails to acknowledge the reality of their actual work context and related practices, this could be indicative of a divergence of perceived norms regarding acceptable levels of performance between the workforce and the management. Organisations should minimise the potential for this divergence by ensuring that the norms and standards for safety related behaviour are not idealised and set in a top down fashion, but also incorporate the local and contextual knowledge of the workforce.**

### **3.2.3 Potential to over emphasise performance at individual level**

There was some suggestion that managers in some organisations had a stronger tendency to blame the work force rather than the environmental factors that influence individual behaviour for strikes. Although the findings of this study revealed a variety of causes for damage to underground services - both environmental and human - there was some evidence that the individual was more often held responsible.

*“At the end of the day, it’s [mistakes are] down to the individual.”*

It was reported that some organisations had ‘league tables’ of individual’s strike rates on view for all crews to view. There were also reports that these ‘name and shame’ approaches had been dropped because they were unpopular with crews.

Crew members interviewed during this study all reported that they considered themselves to have a high level of commitment do their work well. They told researchers that they were keen not to cause damage to underground services both in the interests of their own safety, and from a desire not to inconvenience the public.

*“So, nobody likes to knock on a door and say ‘oh your electric is off. Sorry about that’. You do take quite a lot of care. ...It is not very nice is it if they have a couple of hundred pounds worth of food in the fridge/freezer.” (Participant: team member)<sup>3</sup>.*

*“...he said [the supervisor]’ you couldn’t really help it but you still shouldn’t have damaged it. It is understandable, you couldn’t really avoid doing that but you still shouldn’t have done it’. I know I shouldn’t have done it, we didn’t do it on purpose.” (Participant: team member).*

---

<sup>3</sup> The terms ‘Crew member’ and ‘Team member’ are used interchangeably throughout the report.

Managers also acknowledged crews commitment to working to the best of their ability, as the following quote suggests:

*“They take pride in their work. They want to do it safely and to the best of their ability. ...They like to get respect. We’ve got a hell of a lot of lads like that – they’re good lads.”*

**There is a potential for companies to focus at the level of the individual worker, as opposed to the organisational factors that determine an individual’s behaviour. It is important to stimulate a culture of support, within the company, that balances praise for jobs well done with constructive intervention when strikes occur. Managers need to recognise that a variety of factors can contribute to strikes and that the good management of this has an impact on the morale and motivation of the individual and team.**

### **3.2.4 Policy of working in reduced lighting conditions**

Working in the dark was cited as a cause of strikes in some instances. Accounts varied between companies. Workers from one organisation said they try not to do any excavations in the dark, and work mainly between 8 am and 4 pm. However, a crew from another company said there were circumstances when they had to work during the hours of darkness. For example, when they were trying to reconnect customers to their power supply in the evening. Crew members reported that the torches and lighting sets supplied for working in the dark were inadequate. Torches were too small and lighting sets were too bulky to be carried at all times in the van. This necessitated another trip to the depot in order to acquire lighting. One Operations Manager stated the company had a policy requiring crews to start work no later than 9 am on the day of a ‘big push’ (new pipe insertion) in order to allow sufficient time for reconnection before dark.

**Extraneous events can lead to work being conducted during reduced lighting conditions. This Performance Influencing Factor (PIF) should be recognised within a company’s risk management system, and the risk mitigated through contingency planning, resource allocation and provision of appropriate equipment.**

### **3.2.5 Policy on fatigue management**

Some crews and supervisors reported working long hours without adequate rest breaks between shifts. For some this was an exceptional occurrence, however, other crews stated they could feel pressurised by managers to ‘get the job done’ and therefore felt obliged to return to work early next morning even after an unusually late finish.

**Working long hours and fatigue will impact negatively on safety performance. The risks of these Performance Influencing Factors (PIFs) should be removed or controlled by organising and planning working arrangements to ensure an appropriate workload, adequate rest breaks, and scheduling demanding tasks for when workers are most alert. This means avoiding safety-critical work at night or in the early hours. Supervisors play a key-role in recognising problems associated with fatigue. Workers should be made aware of the potential impact of fatigue via training/information.**

### **3.2.6 Provision of information**

The perceived quality of ‘job packs’ containing the information necessary to conduct the job varied from one organisation to another. Many crews and supervisors commended them for

their level of detail and the relevance of their content. However, the poor quality of some of the maps made planning difficult in some instances. One crew said they were able to request further information from their supervisor in some instances, but this could delay the work. Another organisation did not keep 'back-up' copies of the plans. This caused delays if a plan was lost because a further application had to be made to the utility company for another copy of the plan. (See 3.1.9).

**The provision of poor information has the potential to influence safety performance. Companies should adopt a consistent approach to the design of maps, including: colour coding and sufficient resolution of detail. Additionally, copies of the project plan should be kept in a safe place and efficiently distributed to the teams as needed.**

### **3.2.7 Auditing**

A number of auditing systems were described. One operations manager reported the main purpose of their audits was to check equipment and site safety rather than observing workers actually using equipment. Therefore, competency at using cable detecting equipment such as the 'Cat and Genny' was not routinely assessed. Competency at using the 'Cat and Genny' was cited as one of the reasons some crews have lower strike rates than others. One work crew reported that frequent changes to the forms used in 'job packs' was inefficient because they had to spend time familiarising themselves with different paperwork on a regular basis.

*"They keep changing certain things which is quite hard to keep up to speed and the way they do the risk assessment and everything."*

**To manage the risk of third party pipeline infringements companies need to consider the scope, suitability and sufficiency of their auditing tools. The auditing process should be visibly consistent for all aspects throughout the organisation as a whole. Worker involvement throughout the audit process would highlight the importance of auditing 'how' things are done so that the process is not perceived as a mechanistic 'tick box' exercise.**

### **3.2.8 Performance related penalties**

One supervisor reported that contracted workers were charged for damages they cause whereas the direct work force were not (unless they exceeded a certain number of strikes in one month). He felt that strike rates might go down if the direct work force were also charged for damages they caused.

**There is a potential for penalization relating to strikes to induce perverse motivations where the workforce fails to report strikes in order to avoid the financial penalties. This approach assumes the reason for the strike is due to individual and team performance, and fails to account for the wider organisational factors that also mediate individual performance. Poorly planned safety incentive and reward programmes may be counter-productive. Rewards should be based on the presence of fundamentally safe behaviour rather than on the absence of an unsafe outcome.**

### 3.2.9 Pay schemes

An important issue raised by participants was the balancing of productivity with health and safety. As regards pay schemes, all workers said were paid for the amount of pipe they fitted. Therefore the more work that was done the more they were paid. Any delays for whatever reason would impact on their pay. (See 3.2.1).

**There is the need to reconcile the competing demands of health and safety and productivity. There is a potential for financial incentives to prioritise productivity over health and safety performance. Ideally, the system of remuneration should incentivise both productivity and health and safety performance.**

### 3.3 THE SUPERVISOR

The main themes related to the supervisor are listed below. Each theme is then explained in more detail along with the implications for organisational management.

- Technical competency of Supervisor
- Supervisor Support Skills
- Investigation procedure
- Job demands of Supervisor's role
- Risk Perception

#### 3.3.1 Technical competency of Supervisor

A number of work crews suggested it was important that supervisors had direct experience of conducting excavation work before becoming a supervisor. They expressed the view that those who have not done the job do not know enough about the risks associated with the work. Inexperience was cited as a reason for supervisors making impractical or even dangerous suggestions, which could lead to strikes, such as putting crews under pressure to rush a job.

Lack of planning skills on the part of the supervisor was also highlighted as a perceived contributing factor to strikes. One crew described a situation where deliveries arrived late because the supervisor had not ensured they were ordered in time:

*“That is another thing that could make men rush. We were waiting the other day for some pipe to come in. It was supposed to come in the morning – it didn't come till 5 o'clock and at the end of the day when we are rushing to fuse pipes together to get home on a night – that's when accidents occur....It should have been there the week before though. All piping, all fittings that we need, he [the supervisor] should know well in advance, or even ask us what we're going to need. ...his management skills are wrong.”*

**The following competencies/ experience are important for success in a Supervisory role: On-the-Job Experience, Good Planning Skills, and Good Support and Leadership skills (including a positive and supportive communication style). Organisational selection processes for Supervisors need to acknowledge these competencies and experiences.**

#### 3.3.2 Supervisor Support Skills

One crew expressed the wish for better support from their supervisor. They described a number of situations where he could have helped them and did not, for example:

*“You might ring him up, we will be working late, and ask him for something, and he’ll say ‘I am not bringing it out, I will get stuck in traffic. I will be late’. I thought, ‘we are late. We are stuck up here’. Whereas a lot of managers would say, ‘yes, I will get it out to you straight away’.”*

It was felt the specific supervisor did not praise the team for work well done and performed post strike investigations in a way that the crew members felt was inappropriate.

*“..it is annoying when you do damage something and your gaffer [Supervisor] comes out with a piece of paper saying: ‘how could you have done that different?’ ...They patronise you.”*

**It is important to have a relationship of mutual support and trust between the supervisor and team as this facilitates overcoming problematic issues. In part this relationship is developed and sustained through the communication skills of the supervisor. The need for supervisors to be skilled when dealing with workers should be acknowledged at an organisational level.**

### **3.3.3 Investigation procedure**

As illustrated above in section 3.3.2, team morale can be undermined if post strike investigations are dealt with mechanistically without reference to the context. One team said the usual procedure after a strike was for the supervisor to take the person responsible into his car or back to the depot, and spend about 30 minutes questioning him. Often the crew had to wait for the supervisor to arrive and could not continue with the job. This delayed the work further, and the crew would be losing income while work was halted. All members of the crew agreed that they considered the post strike investigation could have been conducted in a more effective manner.

*“When you do damage a cable or any utility, when you have that sit down talk after, it makes you feel like a bairn [child].”*

**The investigation procedure is an important element to understanding the reasons why third party strikes occur. However, they should be conducted in such a way that does not focus on issues of safety performance at the level of the individual worker at the expense of the wider organisational level. The aspect of the investigation as a learning opportunity should also be highlighted, as opposed to the rationale for the investigation being to assign culpability.**

### **3.3.4 Job demands of supervisor’s role**

Most supervisors reported visiting each worksite daily. One reported that this was desirable but not always possible because of the pressure of other work demands. He worked long hours (10-11 hours per day). Teams were supervised remotely for the majority of the time. It was acknowledged that it would be preferable to spend more time with the work crews actually observing their work practices. However, supervisors had other responsibilities such as planning future work. As discussed earlier, some crews felt they did not get the practical support they needed from their supervisor.

**The role of the Supervisor is central, and the experience and knowledge of the Supervisor needs to be incorporated into the decision-making at the various stages of the job, especially the planning stage. There is a need to acknowledge the work demands placed on supervisors and make sure they are reasonable such that health and safety does not receive lower prioritisation relative to other issues.**

### **3.3.5 Risk perception**

Evidence from some interviews suggested that crews were sometimes cognisant to take more care not to hit electric cables than other types of service, because of the immediate danger to their own safety. One supervisor expressed the need to raise awareness of the far-reaching consequences of water and gas strikes as well.

*“I think everybody is focused on the electric but there is more being focused on other cables from different utilities now – trying to get them to be equally important.”*

**It may be necessary for companies to raise the general awareness regarding the far reaching consequences to individual workers, customers and the company of third party strikes to water and gas pipelines.**

## **3.4 THE TEAM**

The main themes regarding the team are listed below, followed by more detailed explanations and the implications for organisational management.

- Experience and Training
- Working Conditions and Equipment
- Concentration and Fatigue

### **3.4.1 Experience and Training**

There was a view that experienced staff were less likely to damage underground services because they take more care and time, and are more able to fully assess the risks of the job, by using both the maps, equipment and the environmental clues. Participants in a variety of job roles, including crew members, supervisors and operations managers, expressed this view.

*“You have got to have a lot of experience to be able to sort of guess where things are.”*

*“I think it is a case of the more experience you have out on site, the more they seem to be, there is a different generation, they seem to take more time, they seem to be a lot more aware of what damage things can do. Whereas the younger ones have not got that, it takes years of experience for them to get to the same kind of standard.”*

Experience was also recognised as an important contributor to hazard recognition. Examples were given of instances where strikes had occurred because crews had made assumptions about the position of cables – expecting them to lie in straight lines or follow the same pattern as other cables.

*“...somebody gets in their mind set: right, there are four holes, they are all okay and then the fifth one...expecting the unexpected.”*

*“You have got to be alert. The best thing to do, you couldn’t just send somebody off the street, you need to come with someone like us, where they know what they are doing. You just give them a bit of training.”*

This highlights the importance of ‘on the job’ training with an experienced crew member who can explain and show how the work is done. It was also acknowledged that learning to use the equipment correctly is a matter of practice. Although crew members receive off-site training in the use of equipment such as the ‘Cat and Genny’, it is only by doing the job that they come to be proficient in its use.

Crews interviewed also conveyed a commitment to reporting all damages, as reflected in the following remark:

*“You can’t not report it because when we went on that electric one [training] with cable, he showed us a section of pipe that had the outer coating on it damaged - not actually inside the sleeve or the metal part – but the water had seeped into it and caused it to expand and bust. Water had got into it and that caused more problems to fix.”*

Finally, it was reported that team members vary in their level of competence to use equipment such as the ‘Cat and Genny’. One Operations manager acknowledged that some staff were able to use it in all three modes correctly and efficiently, whereas others did not use it in the manner in which they have been trained. Introducing new, more sophisticated equipment with these employees would not have been practical.

*“Some people are not as proficient with a Cat as others. The cable locator is a more sophisticated piece of equipment. Some would be able to learn to use this. However, some people can’t use the Cat properly, so would be unlikely to learn to use the cable locator correctly. But even with the best of teams, they still hit cables.”*

**Sufficient training and competence assessment regarding equipment, contextual cues and work practices in general should be a requirement for every company, so that each team member has an adequate level of competency on site. Additionally, more experienced personnel’s knowledge of contextual cues should be formalised to pass on to less experienced members of the team. Appropriate planning and resource allocation should ensure that levels of competent staff are sufficient for the type and lifecycle of each job.**

### **3.4.2 Working conditions & Equipment**

There are a number of difficulties encountered by crews due to their working environment. Footpaths are often congested with a variety of cables and pipes. As discussed already, these are not arranged in a predictable pattern because some companies have disregarded codes of practice. Consequently, it can be difficult to avoid causing damage. Economic factors can influence the decision or need for excavation. Footpaths are often used for pipe insertion because it is cheaper than using the highway. One participant stated it cost £30 per metre to lay duct in the footpath compared with £100 per metre to lay duct in the highway.

Other conditions, which make the work more challenging, include:

- Bad weather;
- Working in failing light or darkness;
- Working in areas with heavy traffic or a high flow of pedestrians;
- Overhead cables.

For example, heavy rain affects visibility because holes fill up with water. Working in residential areas was also cited as more difficult sometimes because less detail of services exists on plans. Time of day, week or year could also impact on the working environment. For example, one company cited shortages of staff during holiday periods as a possible contributor to strike rates. Other companies did not support this however, they stated that crews often took holidays at the same time so were unlikely to be working with people they did not know. Time of day was also thought important, as crews were potentially more likely to rush their work towards the end of the day when it might be going dark and their need to finish.

**It is necessary for an organisation's risk management system and procedures to address how the environment in which the work is conducted can act as a Performance Influencing Factor that increases the risk of third party strikes. The risk management system should contain a number of contingency procedures to mitigate potential influencing factors such as working in: bad weather; failing light; heavy traffic; or a high flow of pedestrians.**

### **3.4.3 Concentration and Fatigue**

Throughout the interviews it was acknowledged that some factors undermine concentration levels, such as rushing to complete the job, rushing at the end of the day and other distractions. One crew described their experiences of a strike which resulted from them being given incorrect information by another contractor. They were told that a house near the worksite had no gas supply. In response to this some of the crew started to dig a new hole to investigate the cause of this. Whilst digging they damaged an electric cable. This occurred towards the end of the day. It later transpired that the information about the interrupted gas supply to the house was false (which also implies the need for a system that allows the verification of the veracity of information provided to ensure that the resulting action is appropriate).

*“One of the fitters, one of their guys who said...I was working with him ...and he just came up to me and said 23 had no gas. So that is why I told them and they had gone digging and looking for it.”*

Fatigue was another factor affecting work teams on some occasions. This was discussed in section 3.2.5.

**There are implications for safety from reduced performance due to insufficient alertness or vigilance. There has been considerable focus on alertness and vigilance in safety critical occupational environments. Companies should incorporate the existing practices and knowledge from these sectors into their risk management systems, especially job design principles for safety critical tasks requiring high levels of concentration and attention.**

An outline of principles for job design for safety critical tasks requiring high levels of concentration and attention is presented below:

- Operators should be able to maintain sufficient attention to monitor incoming information, detect changes to the immediate process or environment and react appropriately.
- They should not be bored and should be capable of remaining fully alert at all times. Low levels of activity for prolonged periods may be fatiguing and can prevent immediate notice of, or attention to, the work context. It can also increase the time required to solve problems.

- Distractions should be controlled to allow incidents or problems to be identified and dealt with effectively.
- Work demands (workload) should allow sufficient spare capacity for the operator to cope with degraded situations. High levels of activity can lead to a narrowing of attention and restrict the number of possible problem solutions identified. It can also restrict working memory and decrease the efficiency of learning or recalling of information from memory.
- Sufficient time should be provided for safety critical tasks. Time pressures (including the perception of these) can prevent careful reasoning and can curtail information collection.
- Sufficient training, experience and supervision should be provided to ensure that operators can manage the work effectively including infrequently experienced situations.
- Working patterns should be designed to manage the risks from fatigue.
- The working environment should be designed to support the operator's well being. High levels of noise, vibration, extremes of temperature can have an effect on alertness and ability to concentrate.
- Equipment that impacts on an operator's role should be reliable.

The following section summarises the thematic analysis of contributors to third party pipeline strikes or infringements. Attention is given to the possible reasons such infringements do, or do not occur, and possible solutions.

#### 4 SUMMARY OF FINDINGS: STRIKES/PIPELINES INFRINGEMENT: THEMATIC ANALYSIS OF CONTRIBUTORS

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
Individual	Straight line assumption	Undermines ability to anticipate loops or residential services at right angles		Inclusion in training.
	Performance Incentives	Paid by amount of pipe/cable in ground. Incentive for rushing. Safety incentives can encourage rushing.	For better performing teams - strike league tables & pride in record.	Clear directives on the emphasis of safety relative to productivity. Praise safe performance.
	Customers		Gangs don't want to inconvenience public	
	Concentration	Undermined when rushing to complete job, time of day, week, cold	Remaining alert	Clear directives on the emphasis of safety relative to productivity. Concentration training (identifying hot spots, critical moments, pacing concentration, carbohydrate intake, stress reduction etc).
	Experience	Lack of experience	Learn potential strike cues, street furniture, when to adopt hand digging, change in soil,	Training
	External circumstances	Distraction		Raise awareness of how distracters affect concentration

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	Training	Inadequate - e.g. not enough practice in how to use equipment	High 'fidelity' training. Readily transferable to work context.	Training on how
	Fatigue	Concentration.		Flexible working patterns policy.
Work Environment Conditions	Weather	Wet conditions - visibility & hole filling	More care when wet	Flexibility for job taking longer when wet.
	Time of day/week/year	Working in dark. Rushing because end of day/week. Understaffing, e.g. in summer when on leave.	Policy - not to commence work after 9.30am on day of 'push' Taking time because of conditions.	Develop and enforce 'working in dark' and 'fatigue' policy. Allow 'sleep catch up'. Staffing contingency.
	Underground hazards	Haphazard and unpredictable laying of pipes/cables, particularly cable & street lights. Too close to surface (cable television). Electric cable loops. Lack of cable protection. Congestion	Using 'cues' such as street furniture & change in soil.  Experience -e.g. knowing to undermine concrete casing.	Labelling jobs. Universally consistent & enforceable standards in: <ul style="list-style-type: none"> <li>• Protection applied.</li> <li>• Direction</li> <li>• Depth</li> <li>• Rules - e.g when cable is in concrete ring the agent.</li> <li>• Excess cable.</li> </ul>

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	Over-ground hazards	Pedestrians Traffic	Clear procedures on hazards.	
	Residential versus public	Less detail on residential services		
	Footpath versus road	Cheaper to dig footpath where there is more congestion.		
Equipment/ Resources	Job Packs	Comprehensiveness/ presentation varied between sites.	Comprehensive information (risk assessments, drawings, method statements). Provide all the information necessary to do the job. Handed over from supervisor to gang leader at start of job.	Adopt consistent high standard in robust folder.
	Drawings/Maps	Often lack detail, inaccurate, be black & white, be indecipherable, and inconsistent layout/protocol between & within utilities. Delays in having to request further detailed drawing.	More widespread adoption of colour e.g. within electric drawings. Advised to treat as a guide only.  Using 'cues' such as street furniture & change in soil.	Universally consistent standards. Improve accuracy. Improved detail.  Wider area Greater use of colour prints, e.g. different colours for high, medium & intermediate gas pressures.

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	CAT & Genny	Not use full capability (e.g. all signal types or CAT & Genny together) Signal interference in congested areas.	Training. Thorough use of CAT & Genny	Repeated training. Spot check. Supervisor observation of correct usage. More widespread usage of depth equipment.
Supervisor	Supervisor technical competency	Inexperienced supervisor. Lack of planning skills. Can put team under pressure to engage in more hazardous activities/ rush a job.	Understands job because they've done it themselves. Inspires respect. Up to speed. Advanced planning (e.g. book bagging off in advance). Training quality.	
	Supervisor attitude to safety	Convey (by instruction/behaviour) productivity is more important than safety.	Provides training in using CAT & Genny, equipment appropriately. States safety most important.	Clear, consistent and repeated management directive that safety is paramount.
	Supervisor communication skills	Where inadequate, reinforces blame culture during investigation procedures.	Constructive learning approach	Supervisor selection. Supervisor training in constructive feedback.

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	Investigation procedure	May reinforce blame culture and undermine worker cooperation/morale if not conducted constructively	Human factors training.	Supervisor competency Supervisor training in constructive feedback Incorporate communication skills in selection criteria for supervisors.
	Supervisor accessibility	Supervisor workload can undermine time available at any one site.		Increase supervision time of gangs on site. Reduce duplicated effort by supervisor (e.g. repeated admin.)
Managers/ Organisation	Productivity/time pressure	Bonus schemes. Productivity targets. Piece meal payment.	Acknowledged at all levels as a pressure. Equipment (e.g. lighting)/ welfare facilities provision.	Need to reconcile health and safety and productivity conflict.
	Zero/minimal strike rate expectations.	Could drive a 'blame culture' (see below).	Comprehensive & repeated safety training/behavioural safety training.	
	Residual blame culture	Indirect influence through damaging morale and worker involvement.	More widespread recognition of problems with 'systems' rather than individuals and concerted efforts to overcome historical blame cultures.	Develop culture that balances praising success with highlighting shortcomings.

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	Risk perception	Bias to electric rather than gas & water strikes due to immediacy & severity of consequences. Bias potentially reinforced by management practices.	Awareness of consequences.	Raise awareness of far reaching consequences of water & gas strikes to self, customers and company.
Internal Policy/ Procedures	Policy of working in dark	Working in dark		Universally developed/applied & clearly communicated to teams. Portable lights carried in vans
	Policy on fatigue management	Fatigue		Universally developed/applied & clearly communicated to teams
	Planning	Inadequately informed due to inaccuracy of drawings		
	Auditing	'Keep changing forms'	Rigorous job hand over procedure	Audit 'how' not just 'what'
	Direct versus contracted workforce?	Possibility of more strikes for contracted labour?		

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	Pay schemes	Pay based on volume of work <i>may</i> contribute		
External agencies' influence <sup>4</sup> E.g. Highways Agency, HSE, other utility companies, Local Authorities	Unworkable code of practice	Unsuitable in non-virgin ground. Inconsistently observed across utilities (not applied by cable/electric)		Increased regulation/enforcement of apparent 'less compliant' utilities, e.g. cable & lamp post fitters  Review the code of conduct produced by the National Joint Utility Group.

---

<sup>4</sup> Needs further exploration

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	Accountability	'Less compliant' utilities not held to account for poor practice in cable/pipe laying e.g. cables, street lights.		Adoption of industry wide, enforceable consistent minimum standards regarding cable/pipe laying, slack, encasement, depth.  Auditing 'how' not just what.  Utilities 'label' own work.
	Customer (commissioner & public) pressure to perform.	Productivity conflict	Alliance versus Period Contract	Increase alliance contracts
	'In house' versus external planning	Desktop-planning by external commissioning organisation.	On site 'in-house' planning.	Universal on site planning to supplement desk-based planning.
	Zero tolerance pressure (HSE/external customer)	Productivity conflict		

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
	Lack of cooperation between utilities (due to e.g. not having complete records to share, customer retention)	Undermines planning of work/drawing quality	Recent improvements in planning support e.g. 'dial before you dig' & Yorkshire Electricity 'patrol van'.  Line watch/line search (particular to pipeline & NG).	Incentivise & raise awareness of the cooperation incentives, e.g. collective asset/ protection; customer retention. Increase proactive communication/liaison between utilities. Obligatory membership to schemes such as line watch.
	LA/Highway agency time pressure	Fine companies for exceeding deadlines/notice of work.		Realistic time contingency in plans.
	Record/systems updating with new working	Inadequately informed planning		More consistent and rapid updating.
	Drawing quality	Inadequately informed planning		Consistent drawing standards/protocol across agencies. Harmonizing standards for commercial/public and private/residential areas.

Level 1	Level 2	Reasons for strikes/contributing factors	Reasons strikes do not occur	Possible solutions
Government Policy	HSE gas replacement scheme HSG 47 guidance	Elements of HSG47 are not practical to follow.		Review guidance.
Future	Attracting newcomers	Shortfall of interested school leavers/ 'youngster'. Undermining experience available to the industry in the future.		Career promotion. Incentivizing career progression with pay increases etc.

## 5 CONCLUSIONS

This section presents the conclusions to be drawn from the research at the level of the System, the Organisation, the Supervisor, and the Team.

### 5.1 THE SYSTEM

1. Companies should acknowledge within their risk management systems and training that there is no single system of underground pipeline arrangement. There is no consistency in the position and depth of pipelines and cables across sites. Although the National Joint Utility Group (NJUG) produced a code of practice specifying the position and depth of pipes of different kinds, this has not been universally observed.

2. Production targets negotiated between the organisation and client, can introduce risk and perverse incentives at the point of work that encourage the relative prioritisation of productivity over health and safety performance. Initiatives to reduce this risk should emphasise safety performance targets as opposed to merely minimising production targets.

3. To manage the risk of third party pipeline infringements companies need to consider the benefit of on-site planning to complement desk-based planning. It is a recommendation that site visits are made part of the procedure for planning jobs in order to accurately assess the hazards that may impact upon safety performance. There is also a benefit to bringing in contractors at an early stage of the work, as their experience can be used to identify hazards and design out risk from the initial stages of the planning process.

4. Communication between Utilities companies is an essential part of each company's Safety Management System. Clear examples of where this is of benefit are the accuracy of shared plans, and the sharing of information regarding the poor performance of contractors at specific sites.

5. The time constraints set by LAs to complete work has the potential to lead to productivity being prioritised over health and safety performance. This potential should be acknowledged in an organisation's risk management system, planning process and formal communications between the LA and the company. In some circumstances these constraints may make the completion of the work within a safe manner unobtainable.

6. The inaccuracy of services information obtained from Utilities companies for planning and conducting the work by contractor organisations is a potential performance influencing factor that should be addressed in a company's risk management system. These inaccuracies can give rise to false assumptions that when combined with other work pressures can lead to unsafe work.

7. The quality of information provided regarding the location of services has the potential to influence safety performance. It would improve safety performance if companies adopt a consistent approach to the design of maps, including: colour coding, sufficient resolution of detail, and harmonising standards for both commercial and residential areas.

## 5.2 THE ORGANISATION

1. There is the need to reconcile the competing demands of health and safety and productivity. There is a potential for financial incentives to prioritise productivity over health and safety performance. Ideally, the system of remuneration should incentivise both productivity and health and safety performance. Poorly planned safety incentive and reward programmes may be counter-productive. Rewards should be based on the presence of fundamentally safe behaviour rather than the absence of an unsafe outcome. Similarly, visible management commitment to health and safety practices over and above production needs to be communicated throughout the organisation.

2. If the expectation of zero strikes can be perceived as an unrealistic goal by the workforce, that fails to acknowledge the reality of their actual work context and related practices, this could be indicative of a divergence of perceived norms regarding acceptable levels of performance between the workforce and the management. Organisations should minimise the potential for this divergence by ensuring that the norms and standards for safety related behaviour are not idealised and set in a top down fashion, but also incorporate the local and contextual knowledge of the workforce.

3. There is a potential for companies to focus at the level of the individual worker, as opposed to the organisational factors that determine an individual's behaviour. It is important to stimulate a culture of support, within the company, that balances praise for jobs well done with constructive intervention when strikes occur. Managers need to recognise that a variety of factors can contribute to strikes and that the good management of this has an impact on the morale and motivation of the individual and team.

4. The quality of services location information acquired by contractors affects their safety performance. When compiling Services Plans, companies need to adopt a consistent approach to the design of maps, including: colour coding and sufficient resolution of detail. Copies of the Services Plan should be made easily available to all contractors and sub-contractors.

5. Contractors and sub-contractors need to verify that the Services Plans they use accurately show the position of underground services on site. This can be done by digging trial holes, using ground survey techniques (e.g. CAT and Genny), and by contacting the utility company for further advice. All these measures will prevent teams on site from making inaccurate assumptions about the positioning of underground services.

6. It is necessary for an organisation's risk management system and procedures to address how the environment in which the work is conducted can act as a performance influencing factor that increases the risk of third party damage. The risk management system should contain contingency procedures to mitigate influencing factors, such as: working in bad weather; reduced lighting conditions; heavy traffic; or a high flow of pedestrians. These risks can be reduced through effective planning, resource allocation and provision of appropriate equipment.

7. Fatigue caused by working long hours increases the likelihood of accidents happening. This risk can be reduced by managing the work to ensure an appropriate workload, adequate rest breaks, and scheduling safety critical work for when workers are most alert. Typically workers are least alert in the early hours of the morning. Supervisors have a key-role in recognising problems associated with fatigue. Workers should be made aware of the potential impact of fatigue via training/information.

8. Worker involvement with the audit process will highlight the importance of 'how and why' things are done, rather than the audit process being perceived as a 'tick box' exercise.

### **5.3 THE SUPERVISOR**

1. For the working relationship between a Team and their Supervisor to be effective it must be based upon mutual trust. For the Supervisor this means being respected for their authority, fairness and independence. For the Team this means that the Supervisor allows them to work both safely and productively. In part this relationship is developed and sustained through the communication skills of the Supervisor.

2. Organisational selection processes for Supervisors need to acknowledge the following competencies and experiences:

- On-the-Job experience,
- Good planning skills, and
- Good support and leadership skills (including a positive and supportive communication style).

3. Investigations of accidents are important for understanding why pipelines are damaged. Apart from instances of gross negligence or recklessness, investigations should avoid focusing solely on safety performance at the level of the individual worker, at the expense of considering the wider organisational and team factors that may have contributed to the incident. The investigation also represents an opportunity to increase organisational learning about incidents, as opposed to the sole purpose of the investigation being to assign blame.

4. The role of the Supervisor is central to ensuring good safety performance. The experience and knowledge of the Supervisor needs to be incorporated into the decision-making throughout the job, especially the planning stage. Senior managers need to make sure the work demands placed on Supervisors are reasonable so that health and safety issues are not neglected.

### **5.4 THE TEAM**

1. Sufficient training and competence assessment regarding equipment, hazard awareness and work practices should be a requirement for every company, so that each team member has an adequate level of competency on site.

2. More experienced personnel's knowledge and awareness of hazards should be formalised to pass on to less experienced members of the team.

3. Appropriate planning and resource allocation should ensure that levels of competent staff are sufficient for the type and lifecycle of each job.

4. Team members who felt they had the power to stop work (without fear of penalties) in what they considered to be dangerous circumstances, also appeared to take more personal responsibility for managing the risks in their work.

## 6 APPENDICES

### 6.1 APPENDIX 1: SUPERVISOR INTERVIEW SCHEDULE

#### **Introduction**

Thank interviewee for sparing the time to talk to you.

Introduce yourselves, the aim of speaking to them, ask if alright to tape, explain that you will be taking notes but that all information will be anonymous. Tell them approximately how long the interview will take. Put them at ease as best you can.

Ask them to introduce themselves

#### **Interviewee background**

How long have you been working in the industry?

How long have you been with the organisation?

What were your roles before becoming a supervisor?

How long have you been a supervisor?

What is your role, what do you do day to day?

How often do you attend site and how long do you stay?

Have you had any specific training for your role as a supervisor?

What training have you received this year? Over your career?

Have you seen the industry change?

How has that affected your working practices?

Has it improved your working practices?

Is your organisation supportive? Are you able to get new equipment easily and quickly?

#### **Track record**

What is the experience of the team? Mixed age and experience?

What training have they received?

What is turnover like?

What is the record of your team?

How many men do you supervise?

Do you have the same team every project?

How does this impact on the relationship you have with the gang?

If infringed, what were the reasons for this?

If no infringements, what are the reasons for this?

What difficulties do you experience on site, personnel, public, pipes in the ground.

How much pipe does the team lay, on average, per month?

Do you receive project packs or any information about the site you are visiting?

How is this organised, i.e. separate sheets, a pack etc.

How do you disseminate the information in the project packs?

Are they available on site?

What do you think of the maps? In your opinion how could they be improved?

What lessons have you learned from your experience of pipeline infringement?

How is an infringement reported?

Is this a good method?

Is the person or gang responsible for the infringement asked to comment on why it occurred?

What does your organisation do with the information it receives about pipeline infringement?

Do you feel the organisation places pressure on the gangs? If so, how does this impact on your work?

Do you attend any meetings with other supervisors? How often? What topics are discussed?

Do you attend meetings with senior managers? How often? What topics are discussed?

Revised version – to cater for interviewing other managers

Role, responsibilities, experience, training.

What are the main hazards associated with this work?

How does cable strike compare?

What are the main reasons for strikes?

Why aren't there more strikes?

What are the key learning points?

Do you have a bonus scheme?

Does this influence how the job is done in terms of work pressure?

What kind of audits do you have on site?

Do you use any punitive measures?

What are the factors that reduce the number of strikes?

What would make a difference?

How are the men trained in what might lead to a strike?

How much scope do workers have to influence the work?

The workers we spoke to seem very committed – why is this?

Do the teams that get respect get feedback from you?

What has changed?

## 6.2 APPENDIX 2: FOCUS GROUP SCHEDULE

**Semi-structured: therefore supplement basic questions to explore issue raised by participants.**

- Level of experience
- Nature of the work
- Training received

How do you know what you are expected to do?

What are the main hazards in your work?

What is your experience of damages in the company?

How are damages reported?

What are the main reasons for pipeline infringement?

What could be done to make your job easier?

What would you suggest to reduce the number of strikes?

Why aren't there more strikes?

Do you have a bonus scheme?

Do you get enough support from management?

Is there anything else you can think of that would make it safer?

### **LEARNING POINTS**

- Initial schedules (interview and focus group) were too lengthy – an abbreviated version was produced after the first visit.
- Observation charts were not useful – an explanation of the work, site hazards and job packs by a staff member was more informative.
- As visits progressed questions were framed differently to gain more information. Such as, turning the question around from why are there so many infringements? to why are there so few? This generated useful information on good practice as well as bad.
- Different researchers conducted the interviews/ focus groups at each site, which may have influenced the material gained (differences in approach and gender).
- The participants' letter was generally circulated to participants before the site visit, however in one instance researchers (inadvertently) arrived on site 'unannounced'. Ideally participants should have had more warning than this.

### 6.3 APPENDIX 3: COPY OF LETTER SENT TO PARTICIPANTS

Dear Participant,

The Health and Safety Laboratory have been asked to investigate the reasons that damage is caused to underground services by excavation work, such as that performed by utility companies during repairs. This is of particular concern because damage to a Major Accident Hazard Pipeline (MAHP) can lead to the death or serious injury of large numbers of people.

As part of the project we would like to speak with people involved in this kind of work to explore their views, and observe the work they do. This will involve:

- Researchers observing you at work for approximately 2 hours.
- A 40-minute group discussion with members of the work team, led by our researchers.
- An interview between the team supervisor and one of the research team. The interview will take 20-30 minutes.

The research team consists of 3 researchers based at the Health and Safety Laboratory in Buxton, Derbyshire. We would like to reassure you that all the information you give us would remain anonymous. We may report your views in a report to be given to the Health and Safety Executive but you will not be identified personally. We will not write down your name. We may give some informal feedback to your company, but again this will be anonymous. Your contribution to this project would provide us with valuable insights into the problem.

If you are happy to take part, we would like to thank you for your help with this vital work on controlling major hazards.

Many thanks,

Rachel Cummings, Jenny Lunt and Rachel Lee.

Human Factors Group  
Health and Safety Laboratory  
Harpur Hill  
Buxton  
SK17 9NJ

Tel:	Email:
Rachel Cummings: 01298 218315.	rachel.cummings@hsl.gov.uk
Jenny Lunt: 01298 218373.	jennifer.lunt@hsl.gov.uk
Rachel Lee: 01298 218377.	rachel.lee@hsl.gov.uk

## 7 BIBLIOGRAPHY

### **Bibliography of sources consulted in order to consolidate the interview findings into Human Factors recommendations.**

Daniels, C. & Marlow, P. (2005) Literature Review on the Reporting of Workplace Injury Trends. HSE report: HSL/2005/36.

Energy Institute, London. (2004). Safe Staffing Arrangements – user guide for CRR348/2001 Methodology: Practical application of Entec/HSE process operations staffing assessment methodology and its extension to automated plant and/or equipment.

The Energy Institute. (2006). Improving alertness through effective fatigue management. <http://www2.energyinstpubs.org.uk/tfiles/1164981877/632.pdf>

HSE CRR348 - Assessing the safety of staffing arrangements for process operations in the chemical and allied industries. HSE Contract Research Report 348/2001.

HSE CRR356 - An intervention using a self-help guide to improve the coping behaviour of nightshift workers and its evaluation. (2001). Contract Research Report 356/2001 (CRR 365/2001). [http://www.hse.gov.uk/research/crr\\_pdf/2001/crr01365.pdf](http://www.hse.gov.uk/research/crr_pdf/2001/crr01365.pdf)

HSE OFFSHORE TECHNOLOGY REPORT - OTO 96 003 Effective Shift Handover - A Literature Review.

HSE RR001 - Human factors integration: implementation in the onshore and offshore industries. <http://www.hse.gov.uk/research/rrhtm/rr001.htm>

HSE RR086 - Competence assessment for the hazardous industries. Research Report 086/2003.

HSE RR292 - Different Types of Supervision and the Impact on Safety in the Chemical and Allied Industries. <http://www.hse.gov.uk/research/rrhtm/rr292.htm>

HSE RR446 - HSE's Fatigue Risk Index Tool. (2006). The development of a fatigue/risk index for shiftworkers. Research Report 446/2206 (RR446/2006). <http://www.hse.gov.uk/research/rrpdf/rr446.pdf>

HSE - Human Factors Briefing Note No. 4 – Procedures. <http://www.hse.gov.uk/humanfactors/comah/04procedures.pdf>

HSE - Extract from Inspectors Human Factors Toolkit - Core topic 4: Reliability and usability of procedures. <http://www.hse.gov.uk/humanfactors/comah/core4.pdf>

HSE (1997). Successful Health and Safety Management. HSG65.

HSE (1999). Reducing Error and Influencing Behaviour. HSG48.

HSE (2000). Improving maintenance – a guide to reducing error. HSE Books.

HSE (2002). Developing and maintaining staff competence: Railway Safety Principles and Guidance. Part 3, Section A. HSG197.

- HSE (2006). HSE guidance: Managing shift work – Health & safety guidance. HSG256.
- Hoffmann, D.A., & Morgeson, F.P. (1999). Safety-related behaviour as a social exchange: The role of perceived organizational support and leader-member exchange. *Journal of Applied Psychology*, 84(2), 286-296.
- Lucas, D.A. & Dickinson, C.E. (HMRI, HSE). Safer design through changing expectations. Nice, France, 1-3 March 2006. Conference paper.
- Marlow, P. (2003). Literature review on the value of target setting. *Health and Safety Executive. Health and Safety Laboratory report*. (ERG/03/04).
- Office of Rail Regulation (ORR). Managing fatigue in safety critical work - Guidance.
- Reason, J. (1990). Human Error. Cambridge University Press. New York, USA.
- Reason, J. (1997). *Managing the Risk of Organizational Accidents*. Aldershot, England: Ashgate Publishing Limited.
- Wagenaar, W.A. (1998). People make accidents but organisations cause them. In Feyer, A. & Williamson, A. (Eds.), *Occupational Injury: Risk, Prevention and Intervention* (pp. 121-128). Taylor & Francis: London.
- Weyman, A. (1999). The effects of Job (In)security and Safety Incentive Schemes on Accident Reporting rates and Levels of Risk Taking Behaviour. *Health and Safety Executive. Health and Safety Laboratory report*. (EWPS/98/22).