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WAIT (PART II) – RESULTS OF APPLICATION IN REAL ACCIDENTS

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ABSTRACT

This paper is the continuation of a previous one, in which a new technique was proposed for the investigation and analysis of occupational accidents. The first paper (Part I) described WAIT (Work Accidents Investigation Technique) in some detail and provided a practical example of its application.

This second paper (Part II) reports empirical work carried out for *testing* the performance of WAIT, in terms of its applicability and coverage. It starts with a brief summary of the technique's investigation process, followed by a description of how the method was tested in real conditions through its application, *in situ*, to the investigation of 56 accidents that occurred in 16 industrial firms of various sizes and from a diversity of industrial sectors. Some aggregated statistical results are presented and discussed. It provides evidence that WAIT was able of capturing the applicable problem-areas and covering relatively well a wide range of situations (from simple to complex accidents). The use of some new harmonised variables, being introduced by the Eurostat for the production of European statistics, is also addressed. Certain problems associated with one of these variables are identified and commented upon.

A forthcoming paper (Part III) will address more specific studies, providing a preliminary insight on the techniques' validity and reliability.

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INTRODUCTION

The WAIT technique, proposed earlier in Part I (Jacinto and Aspinwall, 2003), is an accident investigation tool, which follows, in the main, Reason's (1997) model of accident causation. The method comprises nine steps grouped into two main stages. The first is a simplified investigation process that covers legal reporting requirements and focuses on the analysis of immediate causes and circumstances, i.e., on the more 'observable' elements of the occurrence. There are 4 Steps in this ***basic investigation*** stage, as follows:

1- Collect information (a standard questionnaire is provided to assist in this step)

2- Identify all active failures (and their consequences or potential consequences)

3- Establish the applicable influencing factors (at the level of the local workplace)

4- Compare the findings with relevant risk assessment(s) – and amend them if necessary

The second stage is an ***in-depth analysis***, or a full investigation, in which other possible weaknesses and conditions within the organisation are identified and analysed. This second stage goes beyond current legal duties; it is intended to provide organisations with a structured tool for identifying opportunities to improve their safety practices and policies, regardless of whether or not they have a formal safety management system. It comprises further 5 Steps, which are:

5- Analyse individual and job factors

6- Analyse organisational and management conditions

7- Link findings to the local H&S management system - if one does not exist, WAIT proposes the use/adoption of OHSAS 18001 (1999) as a model

8- Make recommendations and prioritise them

9- Search for positive influencing factors (i.e., other kinds of *accidental factors* - unplanned/unexpected events - which, by 'mere chance' had a positive impact and could provide insights for new preventive measures)

The method was designed to be used, as a *practical toolkit*, by common industry safety professionals, who need to report and investigate accidents at work as part of their ordinary duties.

This second paper describes empirical work carried out for *testing* the performance of WAIT. Within this research work, *testing* is "to examine someone or something especially by trial" (Chambers, 1996; p.1458), or "a procedure in which the performance of a product is measured under various conditions" (Parker (*ed*), 1997; p.509). The key words in this case are *by trial*, and *various conditions*. This experimental work was, actually, about testing the general performance of this new "product": both the technique itself and the user's manual as its tangible physical support. This was achieved by means of trials, while investigating 56 real accidents *in situ*, in 16 organisations of various sizes and activity sectors.

GENERAL PERFORMANCE OF WAIT – TESTING PROCEDURE

As explained, the technique was tested through a series of trials, as a means of examining, in the main, its applicability and coverage in real-life situations. It is important to highlight that the aim was not to study accident causation, for which a much larger sample would have been necessary. Due to time restrictions, the number of cases analysed was not statistically representative of an entire accident population. Besides, it was felt to be more prudent to assess the method's adequacy and validity first, before using it in more comprehensive studies.

The testing stage was carried out in the UK, in two phases, over a period of approximately 13 months. It started with a pilot run in 5 SMEs, in which 17 accidents were investigated. Following this, a number of refinements were introduced and the WAIT user's manual was amended accordingly. It was then re-tested in a second run, covering another 11 organisations of different sizes and from a diversity of industrial sectors. The refinements introduced did not affect the findings of the pilot run, because the WAIT process remained the same – only the codes of two categories of factors were modified to improve their consistency (i.e., facilitate a common understanding). As a result, a few of the 17 cases analysed in the pilot study were re-coded so that they could be used in conjunction with those investigated in the second phase.

In both trials the general procedure was the same. The pre-conditions were that all cases had to be (re)investigated *in situ*, using the WAIT process (without restrictions) and that they should be relatively recent accidents to ensure that the people involved would still remember the occurrence (no earlier than 2000). Since the use of the technique without restrictions was important, the choice of which cases to study was left to the firms: most of them opted for starting with RIDDOR-reported[1] accidents (or dangerous occurrences) before moving to low-injury cases. This variety, ranging from over-simple to quite complex cases, suited the purpose of the trial testing.

All but 3 organisations chose to remain anonymous. The exceptions were DuPont Nylon (Gloucester), Land Rover (Solihull), and the Engineering Directorate of QinetiQ (Boscomb Down). The first two not only provided cases for testing WAIT, but they also took part in two specific validation studies.

RESULTS AND DISCUSSION OF THE TESTING STAGE

In total, WAIT was used to investigate 56 accidents across 16 organisations. Of these, 3 were not occupational accidents; there were no people injured (only damage occurred to property), but they demonstrated the flexibility of the method. Table 1 shows the types of organisation covered, whereas the typology of the cases investigated is summarised in Table 2.

Table 1: Organisations Testing WAIT

Number of organisations by size and activity sector						
Code for size* / **Sector *** / **No employees**	**1** (1-9) micro	**2** (10-49) small	**3** (50-249) medium	**4** (250-499) large	**5** 500+ very large	**sub-total**
15- manuf. of food products and beverages					1	*1*
17- manufacture of textiles					1	*1*
24- manufacture of chemical products	1					*1*
26- manuf. of non-metallic mineral products				1		*1*
28- manufacture of fabricated metal products, except machinery and equipment		4	2			*6*
29- manuf. of machinery and equipment			1			*1*
34- manufacture of motor vehicles, trailers and semi-trailers					1	*1*
35- manufacture of other transport equip.			1		1	*2*
45- construction			1			*1*
no code - design, testing and manufacture of aircraft engineering systems					1	*1*
sub-totals & Total	*1*	*4*	*5*	*1*	*5*	**16**

(*) European harmonised classification (Eurostat, 1999)

Table 2: Typology of Cases

Type of Occurence	**TOTAL No.**	**Reported to RIDDOR**
Accidents (Personal Injury)	53	22 (41.5%)
Loss of Property (Material Damage only)	3	2
TOTAL Cases	56	24

[1] RIDDOR stands for Reporting of Injuries, Diseases and Dangerous Occurrences Regulations; in the UK this is the official system for notifying the authorities.

For illustrating the use of WAIT, two examples of application were presented elsewhere in detail (see Jacinto and Aspinwall, 2003 – Part I). One of them, in particular, provides a typical example of those investigated: it was neither over-simple nor complex. In addition, it was a case in which "positive influencing factors" were identified, thus illustrating this particularity of the WAIT technique.

AN OVERVIEW OF ALL THE CASES

Of the total analysed, a few cases were quite complex and involved a variety of failures (4 cases) while others were over-simple (5 cases). The latter provided evidence that not all accidents offer a good opportunity for learning, showing the advantage of having a two-stage process, and that in certain cases a basic investigation would be sufficient, saving time and resources. The very complex cases, in contrast, demonstrated the comprehensiveness of the WAIT technique, and how a structured and systematic approach helps in disclosing a variety of latent weaknesses in the working system. In between these two extremes, all other cases were quite typical accidents at work, and they covered a wide spectrum of situations and injuries.

The people directly involved in the 53 *occupational accidents* investigated (60 in total) were from both sexes and their ages ranged from 19 to 64 years old. Of these, the vast majority (~72%) were Production Workers, while Supervisors (or Area-Managers) and External Contractors accounted for 7% each. Administrative employees, maintenance technicians, warehouse personnel, and drivers were also part of this population, but they were a minority (ranging from 2 to 5% for each category). The consequences, measured through "days lost", varied from no days lost (only minor injuries) to more than 6 months.

The remainder of this paper presents some aggregated statistical results, aimed at not only demonstrating the outputs obtained, but also the method's coverage and applicability concerning various aspects, i.e., what types of information it provides. Not all the results are discussed, only the most relevant, particularly those associated with novel aspects. For practical reasons, the discussion runs in parallel with the presentation of results.

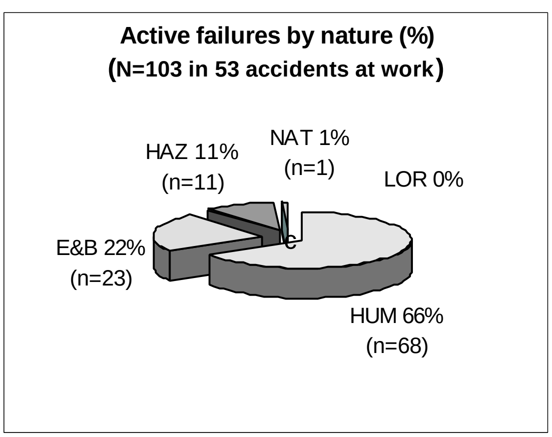
Aggregated results of particular aspects and/or variables

The beginning of the WAIT process identifies the accident sequence of events. This information can be coded through the use of a series of *variables*, some of which are presented here. These variables are discrete and the permissible statistics are, therefore, frequency and mode. For analysing this type of data the authors opted for relative frequencies, as they are generally more meaningful than absolute frequencies.

Accidental events (active failures and contact)

Only *accidents at work* (53 cases) were included in these statistics; the remaining 3 were not part of the same population, and Fig.1 shows the distribution of active failures by their "nature". The figure shows that a total of 103 active failures were found in these 53 accidents.

Figure 1 - Distribution of active failures



Even though the sample was small, these results seem to be consistent with those reported in the literature for other types of accidents. Of particular interest is the 66% frequency rate obtained for failures of human nature (HUM). Hollnagel (1998), for instance, stated that human erroneous actions generally contribute to accident causation in the range of 60-90%, with an extreme value of around 51% in the nuclear-power industry (where "defences-in-depth" are in place), and in excess of 90% in car accidents. In industrial accidents, this ratio is believed to be around 70-80% (Kosmowski and Kwiesielewicz, 2000), whereas in maritime accidents it has been reported as ~60% (Antão, 2000).

The ranking and general distribution pictured in Fig.1 was almost the same when the results were broken down into two separate sets: the ten SMEs on one side, with 31 accidents, and the six large organisations on the other, with 22 accidents. Regardless of these (much) smaller sub-samples, not only was the order exactly the same, but also the percentage variations were less than 2%, with HUM failures in the range of 65-67%. Whether or not these convergent results are significant needs to be examined in the future using a statistically representative sample, but it seems reasonable to expect a rough value of ~70% (60-80) for human active failures in the case of occupational accidents.

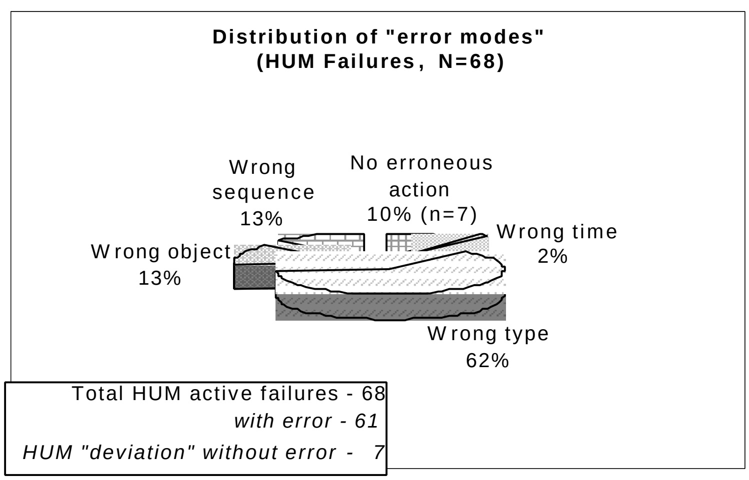
The second contribution comes from faulty equipment and buildings (E&B ~22%), which is also consistent with technical failures found in other accidents (Hollnagel, 1998; Antão, 2000). In third place were hazardous agents (HAZ ~11%), whereas natural elements (NAT) contributed in only one of the cases analysed. Living organisms (LOR) were not found at all, but this was not surprising since this trial testing only covered accidents occurring in industrial settings. LOR agents and their failures are probably more commonplace for instance, in farming/agricultural accidents.

Other details concerning HUM active failures

Before moving into some of the harmonised European variables, two others, directly associated with the codification of HUM failures, will be discussed here. Active failures of human nature are coded by means of three variables: "error modes" and "violations" in all instances plus "deviation" if the failure was the last one, immediately before the "contact".

Fig.2 shows the distribution of error modes. It can be seen that "wrong type" (62%) was the most frequent within the 68 HUM active failures registered.

Figure 2 – Distribution of "error modes"



Such a high incidence seems logical, since in this classification scheme, which was adopted from Hollnagel (1998), the error mode of "wrong type" is the broadest as it includes several physical dimensions (e.g.: force, distance, speed and direction). The text-box in the figure draws attention to a particularity: there were 7 active failures involving humans (thus HUM) for which there was not a corresponding "error mode". There are two reasons for this apparent discrepancy in the statistics, both associated with the use of the European variable "deviation". They are:

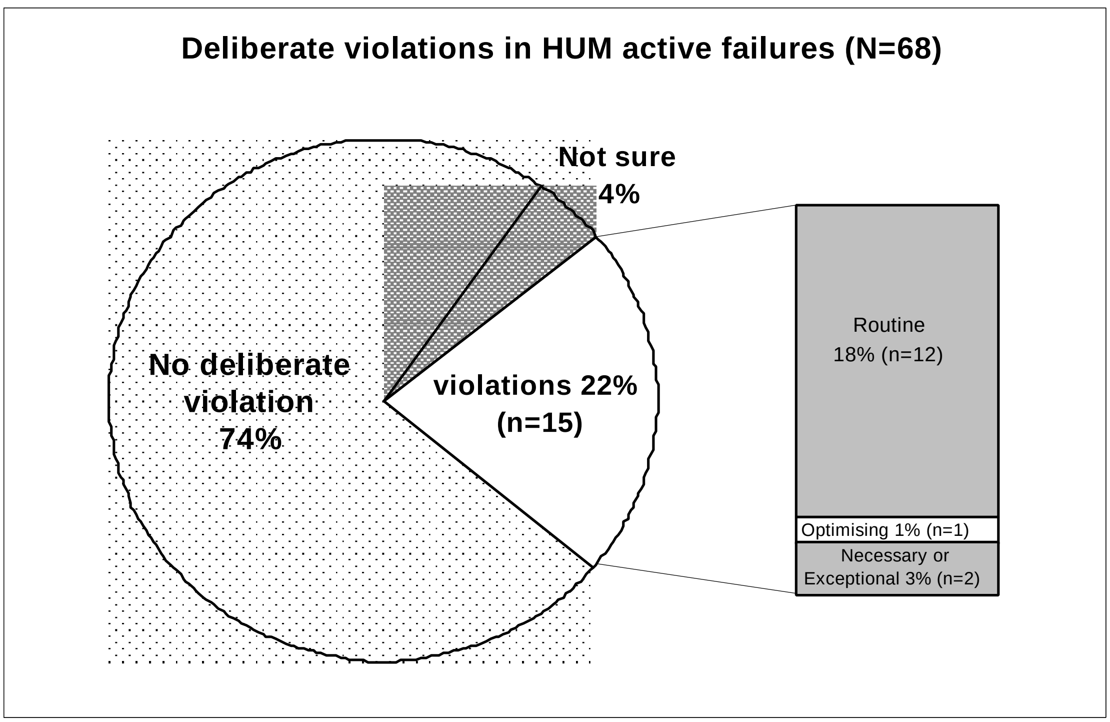
a)- the last event was a human "deviation" (e.g.: fall of a person) but the person did nothing wrong and could not have avoided it; there was no error mode. Usually this last deviation was a direct consequence of a previous event caused by another agent.

b)- the last event was a human "deviation" (e.g.: caught by something, or lost control of something) but the erroneous action of the person was actually performed in a previous event, and the *error mode* was already accounted for. It seemed more correct not to register it again.

By coding these particular situations as '00' (= *not applicable or no error mode*), it was felt that the statistical results were more accurate, and the appropriate code for registering the variable "deviation" was still preserved.

Finally, a consideration of the type of "violations", as detailed in Fig.3, will complement the discussion about human actions in active failures. As can be seen, the majority (~74%) of the 68 human failures in the accidents analysed were not violations, or at least, not deliberate ones, i.e., even when there was a violation of a safety rule, the person concerned was not aware of it. This may indicate that, in general, people tend to adhere to safe working methods.

Figure 3 - Distribution of violations in human active failures



Deliberate (conscious) violations occurred in 15 cases (22%), most of them being "routine" (18%). In this instance, the interviewed person reported the reasons as: "it was faster", or "easier" and "everyone around does it". According to Reason (1997) routine violations are very frequent and they typically involve corner-cutting, which can be promoted, among other factors, by clumsy procedures. The accidents analysed in this study proved this to be the case.

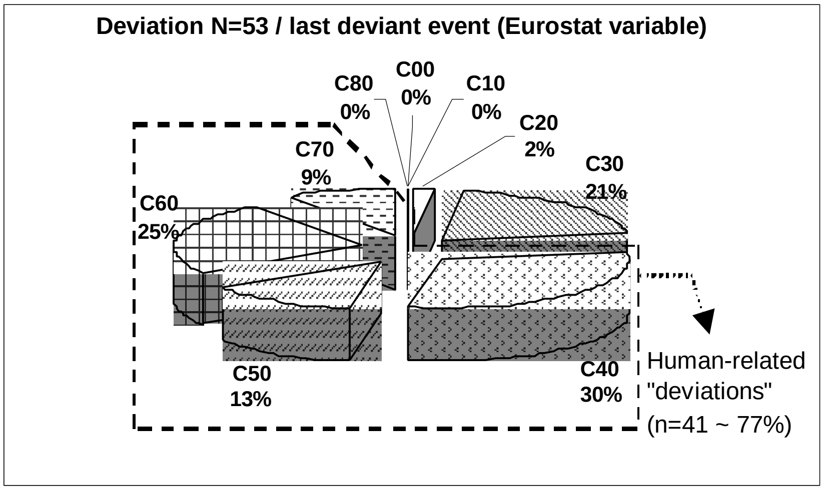
Eurostat new variables "Deviation" and "Contact – Mode of injury"

As mentioned earlier, several harmonised European variables were incorporated into WAIT. However, not all of them are of special interest in this study. Of the new variables being introduced by the Eurostat only two will be discussed; they are "deviation" and "contact – mode of injury".

“Deviation”

By definition, “deviation” is the last deviant event immediately preceding the “contact” - i.e., the last abnormal event leading to the accident itself (Eurostat, 1999, 2000). If adopted by all the EU member states, it will be included in the official *notification forms*, and this will be the only active failure registered for compiling harmonised EU statistics. Its classification scheme covers failures of all types/nature, and Fig.4 shows the distribution in the 53 accidents analysed.

Figure 4 - Distribution and coding of “deviation”



Class code	Deviation - heading of class (Eurostat, 2000)
00	no information
10	due to electrical problems, explosion, fire
20	by overflow, overturn, leak, flow, vaporisation, emission
30	breakage, bursting, splitting, slipping, fall, collapse of material agent
40	loss of control of: machine, means of transport, ..., hand-held tool, object, animal
50	slip, stumbling, fall of persons
60	body movement - without physical stress
70	body movement under or with physical stress
80	shock, fright, violence, attack, threat, presence
99	other deviations not listed above in this classification

It is immediately apparent that, with the exception of three classes, the others were fairly well represented. It was only by chance that the hazards/risks listed in C10 and C80 were not present in the 53 cases investigated. The most frequent was C40, followed by C60 and C30. The higher occurrence of C40 and C60, both associated with human deviations, corroborate the higher percentage found in HUM active failures. On the other hand, C30 (21%) is closely associated with E&B failures, and C20 (2%) is commonly associated with HAZ (hazardous agents) failures. The profile obtained, therefore, not only shows that the cases analysed covered a variety of different “deviations”, but also that the results were consistent with the totals obtained at an earlier stage (see Fig.1). There were no major differences in this profile when data was treated separately for SMEs and large organisations.

Unfortunately the results obtained through the variable “deviation” only show part of the picture. In practice, *all active failures* are deviations from the norm, although those that are not the “last” need to be registered under different headings (“error modes” for humans, and “failure modes” for all other cases). Statistics solely based on “deviations” are consistent with the total, and show the same ranking (or order), but they do not “mirror” the total, and *the frequencies are different*. The additional note in Fig.4 serves to highlight this limitation: if one analyses these 53 cases only taking the variable “deviation” into account, the percentage attributed to human actions would be ~77%, far higher than the 66% obtained when *all active failures* are considered. This limitation is not surprising, since this particular variable was designed to register the *last deviant event* only.

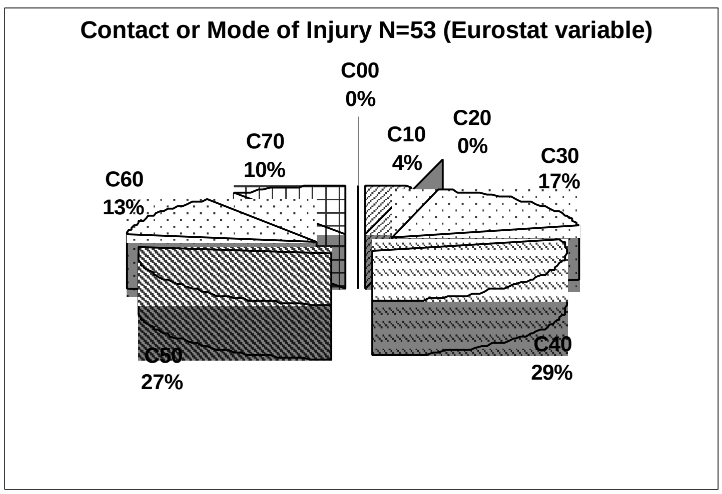
This discrepancy suggests that results obtained by official statistics will not accurately represent the whole state of affairs - and may lead to misinterpretation if care is not exercised. Naturally this problem can be suppressed through statistical inference/estimation, by adjusting the data, as is currently done, for instance, to deal with under-reporting (Dupré, 2000). In order to adjust data, however, a supplementary method is needed for collecting the missing information on all other failures (prior to "deviation"), and this is a particular area where WAIT, or a similar method, could be advantageous and useful.

This was the only European variable that posed some difficulty (in three of the cases), because the level of detail of the accident description can influence its coding. Despite this, it was felt that the initial difficulty tends to disappear with experience. Another important contribution for reducing potential distortions, is that "deviation" must be considered alongside "contact", i.e., they have to "match" (Eurostat, 2000), which facilitates the process, because "contact" is quite straightforward to use.

"Contact – Mode of injury"

This new European variable registers the accident itself, following the classical principle of energy transference. It is very similar to the current "kind of accident" and will replace it if the new system is adopted at European level. The main difference is that "contact – mode of injury" has a more detailed classification scheme and was designed to be used in conjunction with "deviation". The results from this trial are depicted in Fig.5.

Figure 5 - Distribution and coding of "contact"



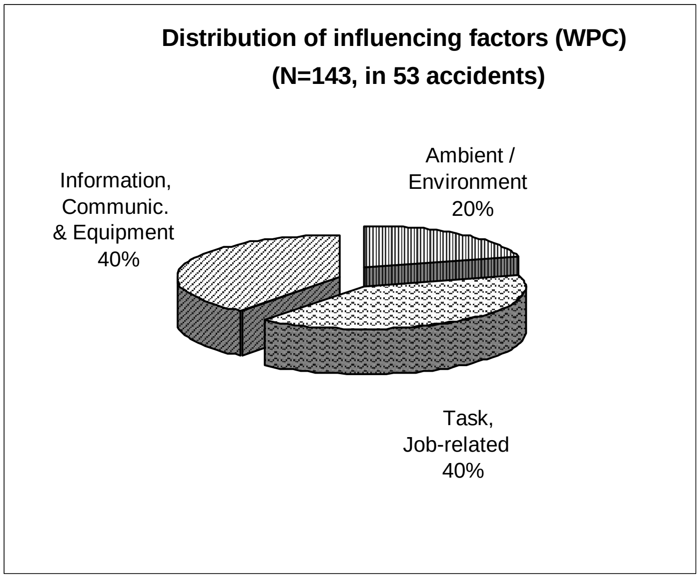
Class code	Contact or Mode of injury - heading of class (Eurostat, 2000)
00	no information
10	contact with electrical voltage, temperature, hazardous substances
20	drowned, buried, enveloped
30	impact with/against a stationary object (the victim is in motion)
40	struck by object in motion, collision with
50	contact with sharp, pointed, rough, coarse material agent
60	trapped, crushed, etc.
70	physical or mental stress
80	bite, kick, etc.
99	other contacts - modes of injury not listed in this classification

It can be seen that the accidents analysed were again fairly well distributed across all classes, with the exception of C20, showing that this testing of WAIT covered almost all kinds of accidents. To a certain extent, this variable is associated with the hazards/risks present (i.e., with the type of activity or sector), rather than the size of the organisation. The trials covered 10 different sectors of activity (see Table 1), but a breakdown of the data into each of them is not feasible, since the number of accidents in each sector was rather small and would render the analysis meaningless.

Influencing factors (WPC)

Once the active failures, the contact and the resulting consequences have been registered, WAIT prompts investigators to identify their influencing factors. There are two main categories of factors for this step: WPC (workplace conditions) and NAI (natural phenomena). Natural/atmospheric elements were relevant in only 3 of the cases although a few more accidents did occur outdoors. In contrast, WPC factors were identified in practically all the cases, the results being summarised in Fig.6.

Figure 6 - Distribution of workplace factors (WPC)



The chart shows a good spread between all three main groups, suggesting that these groups, and their classification schemes, are well balanced and sufficient to cover all situations. The least frequent was category A (~20%), which comprises, in the main, problems associated with the physical working environment. Although not statistically representative, this seems to be a logical result; with few exceptions, the first concern of any management is, typically, ensuring an organised and tidy workplace, which not only enhances safety and quality, but also (and sometimes more importantly) productivity. Preoccupations with a physically organised workplace are common to enterprises of all sizes, and the breakdown of data, in this case, showed the same profile for both SMEs and large firms: group A was always the smallest (19-22%), with the other two being more or less of similar magnitude.

In the particular case of group B (task, job-related factors), the code '99' (= *others*) needed to be used very frequently, suggesting that its coding structure was not comprehensive enough to capture the problems. In fact, of the 20 occurrences recorded as '99', 16 were problems associated with the configuration, or the morphology of an object (e.g.: large, extremely small, heavy, awkward shape, sharp edges, etc). These are normally intrinsic properties of the objects, but such characteristics could facilitate the occurrence of active failures (e.g.: losing control of a tool, or object). Frequently the problem cannot be eliminated, but it could - and should - be taken into account during a risk assessment. These results suggest that another code should be added to group B to yield adequate frequency of *identifiable* data. This improvement was incorporated into WAIT. In contrast, a few codes were not used in this study, but the authors and the people involved believe that they are likely to be relevant in other situations (e.g.: temperature extremes, high level of noise or vibration, or instrumentation problems, for instance).

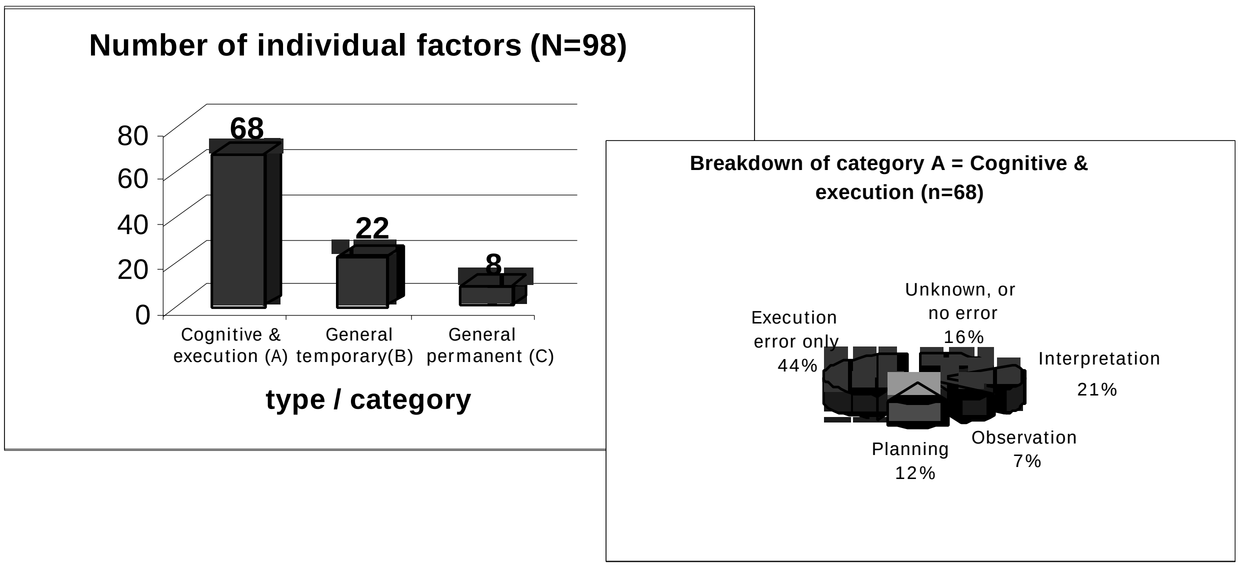
The discussion of the results has followed the same order as the WAIT process and the "*review of risk assessment*", which is the next step, would normally follow. However, this attribute of WAIT was assessed in a different way, and will be discussed in another paper (Part III), together with the preliminary validation studies.

Individual factors (IND)

As mentioned, the classification schemes for analysing/recording human erroneous actions were adopted, in the main, from Hollnagel (1998). The evident advantage of such an approach is that it allows a clear distinction between error modes (observable actions) and the individual factors behind them (usually inferred). Fig.7 shows the distribution of all the individual factors identified in the 53 accidents analysed.

Class A (cognitive functions and execution errors) had 68 occurrences, which equalled the number of (HUM) active failures identified, showing that they were all analysed again at this second stage (the in-depth analysis). Of these, 44% did not involve thinking and were classified as execution errors only; of those involving cognitive functions, "interpretation" failures (e.g.: incorrect diagnosis) seemed to be the most frequent (21%) in this study.

Figure 7 – Individual factors identified (with breakdown distribution of category A)



An apparent discrepancy in the percentages obtained previously for "error modes" was the higher value for code '00' on this occasion (n=11, 16%). This is because, in addition to the 7 failures classified as "no error" (explained earlier), there were another 4 cases classified as "unknown". This was due to not having the possibility of using the WAIT questionnaire for interviewing the individuals concerned, and not having enough information to make a credible judgement. It is worthwhile mentioning here that this was a step where the *standard questionnaire* provided in WAIT proved to be extremely useful.

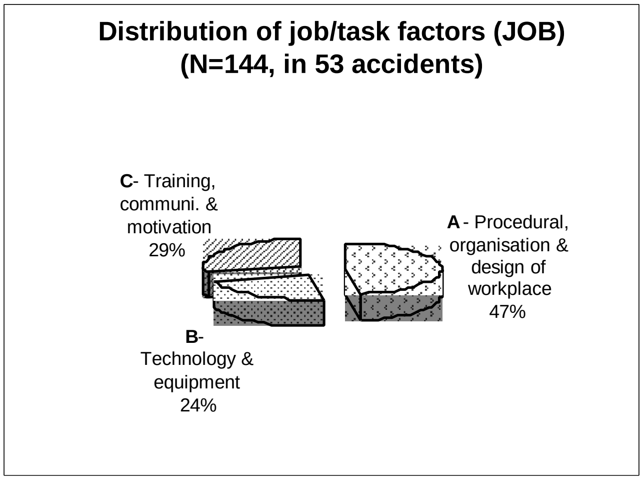
These results illustrate how the classification schemes adopted (for error modes and individual factors) allow the collection of data, and their frequencies, for use in predictive studies, i.e., for risk assessment studies. At company level, however, it seems that users find them more useful in providing ideas for corrective and/or preventive actions.

Job/task and technological factors (JOB)

The previous analysis of "*identification of influencing factors*" searched for "observable" factors within the workplace (WPC factors), rather than "possible" inferred reasons, as is done at this stage of the in-depth analysis; this separation is a fundamental principle in WAIT. The distribution of JOB factors, in Fig.8, shows a good spread between all three groups.

In the accidents studied the most frequent was group A (~47 %), mainly due to the fact that problems with "procedures/instructions" and "supervision" were quite common in all the organisations. The total number found (N=144) is similar to the total in WPC (N=143), but there is not a direct relationship. In some of the accidents, particularly the very simple ones, JOB factors were not registered, as they were not relevant for the cases under analysis. This means that other cases had several JOB factors linked to a particular WPC problem.

Figure 8- Distribution of JOB factors

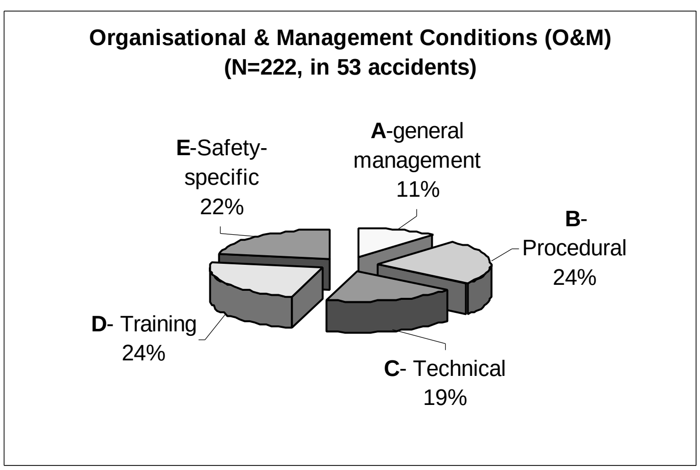


A closer look at each of the three groups revealed that, in contrast with WPC factors, those listed in the JOB classification scheme are not only sufficient, but they also seem to be adequate for covering all situations. Practically all the codes were used, and code '99' was only registered once. When the data was broken down into SMEs *versus* large firms, the resultant distributions followed a similar pattern. In spite of the similarity, this time there were more visible differences in the percentages for JOB factors, whereas for WPC factors the differences were negligible. This may not be statistically significant, but one feels that some differentiation becomes apparent the higher one progresses the hierarchy of factors. This feeling was re-enforced with the analysis of organisational and management conditions (O&M).

Organisational and management conditions (O&M)

These are the latent conditions, which are grouped into the five main clusters suggested by Reason (1997). The classification scheme lists general aspects likely to exist in any organisation, regardless of how formal its management and specific H&S systems are. Fig.9 shows the distribution of results.

Figure 9 - Distribution of O&M conditions

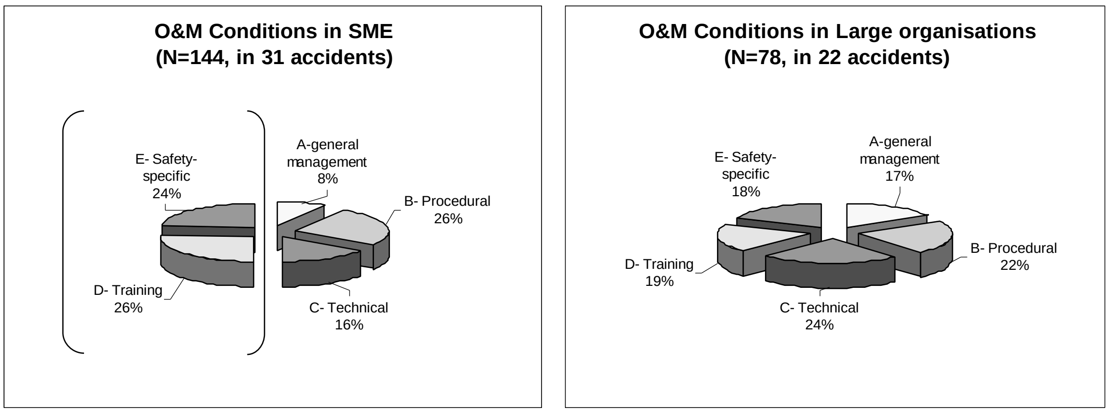


Once again, the weaknesses found were fairly well distributed across the five groups, suggesting that the clusters proposed by Reason are well balanced. Group A, which embraces top-management functions, was the smallest, but this seems logical since improvement opportunities are more likely to focus, initially, on ordinary day-to-day aspects such as procedures, training or technical resources.

All the factors listed within groups A and C occurred, although none was particularly more frequent. In contrast, the remaining three groups had at least one factor that was far more frequent within the group. For example in group B, "working procedures" and "supervision" were quite frequent problems in all the firms covered by this trial. In the case of SMEs, however, the problem was more often "non-existent/lack of", whereas in large organisations it was more likely to be "inadequate procedure". In the case of group D, the more frequent were "identification of training requirements" and "measurement of training effectiveness". Finally, and not surprisingly, the most frequent problem within group E was "risk assessment", which covers both "non-existent" and "not sufficient / not adequate".

The breakdown of data for SMEs and large firms is presented in Fig.10 and, as mentioned before, it appears that different causal patterns might be found when one progresses further up the hierarchy of the analysis.

Figure 10- Breakdown of O&M conditions for SMEs and large organisations



A noticeable difference is, for instance, that in SMEs the sum of groups D and E accounted for ~50% of all weaknesses found, whereas in large organisations it was only 37%. Another difference is the magnitude of group A in large organisations, 17% against only 8% in SMEs. In this particular trial, this was associated with a higher incidence, in large firms, of the following issues: "management of change", "management of contractors", and "communication practices". Such areas of concern may provide a logical explanation for the difference; SMEs are less likely to have re-engineering processes, they depend less on external contractors, and usually have better and more flexible communication. Nevertheless this is early days and only a study using a representative sample could show whether or not this was a mere coincidence or a real difference in causal patterns between organisations of different sizes.

In general, however, the overall results obtained in this trial appear to be logical and consistent. The complex cases in this sample demonstrated the comprehensiveness of the WAIT process, and the classification schemes used, proved to have the ability of capturing the problem-areas and covering the range of simple to complex accidents relatively well.

The steps immediately following in the WAIT technique are "*linking findings to the H&S management system*" and "*making recommendations*". These do not have any associated classification scheme, and their usefulness and adequacy was, therefore, assessed by a different method, based on the users' judgement. These characteristics of WAIT will be addressed in another forthcoming paper.

Positive influencing factors

The search for "*positive influencing factors*" is the last step in WAIT and one that gathered many sympathisers, not just among its users. This is an approach that is worthy of further exploration. At this stage there is little to discuss, since there is nothing against which to compare the findings of this work. The idea is relatively new and, as far as the authors understand, WAIT is the first method integrating this type of search – at least in an explicit and systematic manner.

Perhaps the most relevant issue for this brief discussion is that they exist, they were found in 10 of the cases and, on several occasions they have provided interesting insights for the improvement of either risk assessment or preventive measures. In short, they can contribute to the improvement of safety in the workplace. In addition, this step adds a *positive philosophy* to the investigation task, and the people involved seemed to appreciate it as a means of reducing friction and increasing goodwill. In practice, this search is carried out alongside all the others - and so does not require additional time.

CONCLUSIONS

This paper has discussed the results of empirical work aimed at testing the general performance of WAIT (Work Accidents Investigation Technique), a new practical tool for use in the investigation and analysis of occupational accidents. It has presented the aggregated statistical analysis of 53 occupational accidents investigated *in situ*. The aim was, in the main, to test the technique's performance in terms of applicability and coverage. The results obtained demonstrated that the proposed method is systematic and comprehensive, and also that it provides good coverage in many different types of accidents, in a variety of industrial sectors and across organisations of different sizes.

Although the number of cases covered by this trial was not statistically representative of the entire accident population, the aggregated results appear to be logical and consistent with what is known from the literature in the case of other types of accidents. The variety of real accidents analysed, ranging from very simple ones to rather complex cases, demonstrated that not all accidents offer the same opportunity for learning (and improving safety) and showed the benefits of having a two-stage investigation process to allow the use of time and resources more efficiently.

The variety of cases also demonstrated that the new harmonised European variables provide good coverage. In the particular case of the variable "deviation", however, certain problems were identified: its codification is not always straightforward, and may sometimes be influenced by the level of detail of the accident description. A second limitation is that this variable does not accurately "mirror" the statistical distribution of *all* deviations in the sequence of events leading to the accident (i.e., all the other active failures). This is an area where the use of WAIT, or another similar method, can prove to be advantageous, since it covers (and provides coding schemes) for all failures in the sequence.

The classification schemes proposed in WAIT seem to be well balanced between comprehensiveness and consistency. On the one hand they are sufficiently detailed to cover a wide range of causation/contributing factors, from the individual and the local workplace to the organisation. On the other hand, they are not excessively refined and yield adequate frequency of data. The statistical results presented in this paper are illustrative of what data can be systematically collected for use in future (and representative) studies of accident causation.

"Positive influencing factors" were found in 10 of the cases and they sometimes provided interesting leads for improving the quality of risk assessments and/or defining preventive measures. This trial provided evidence that this approach is worthwhile including, systematically, in accident investigation.

Overall this piece of research has demonstrated that structured and systematic approaches to the investigation of occupational accidents are valuable, and that learning from accumulated accident data is feasible and beneficial. As concluding remarks it can be said that these initial results are promising and there are grounds for being relatively optimistic. However, this is early days and more cases need to be analysed to confirm these findings. As has already been mentioned, the validation of the technique will be discussed in a third and final paper (Part III) of this series.

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