# Data Collection Systems

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## 1. An Overview of Data Collection Systems

The function of this document is to provide an overall framework within which to describe the important aspects of data collection systems. The emphasis on data collection in this document will be on methods for identifying the causes of errors that have led to accidents or significant near misses. This information is used to prevent the reoccurrence of previous accidents, and to identify the underlying causes that may give rise to new types of accidents in the future. Data collection thus has a proactive accident prevention function, even though it is retrospective in the sense that it is usually carried out 'after the event' (an actual accident or near miss).

However, in most industries such proactive error management strategies will not be in existence. Therefore, the setting up of a comprehensive and effective data collection system will often be the first stage of an error management program. The advantages of this are two-fold. First, both company and regulatory requirements mean that some form of data collection system, even if it only fulfills the most basic of statutory requirements, will probably already be in existence. This means that it is possible to build upon this to develop a more comprehensive system designed to address the underlying causes of incidents. The second advantage of setting up a data collection system as the first stage of an error management program is that it provides insights into where the major problems lie, and hence allows subsequent proactive interventions to be targeted at the areas where the most rapid benefits will be obtained.

Figure 1 provides an overview of the structure of a data collection system. As with all aspects of human error management, the attitudes and beliefs held by the company and management to safety in general, and human factors in particular, will be critical in developing a successful data collection system. Management will influence the effectiveness of data collection systems in three ways. First, they control the resources required to set up and maintain the system. Second, management will be responsible for determining the culture that exists in the plant. If management encourages a culture which emphasizes blame and punishment for errors, then it is unlikely that a data collection system which is intended to address the underlying causes of incidents will ever be successful. Third, the attitudes of management will determine the 'model' of error causation that drives the data collection effort. Thus, the traditional view of human error which emphasizes individual rather than system causes of error will lead to the use of data collection and analysis methods which focus on these factors.

The model of human error held by management and the plant culture constitutes the environment in which the data collection system operates. Within this environment, all data collection systems need to address the topics listed in Figure 1.

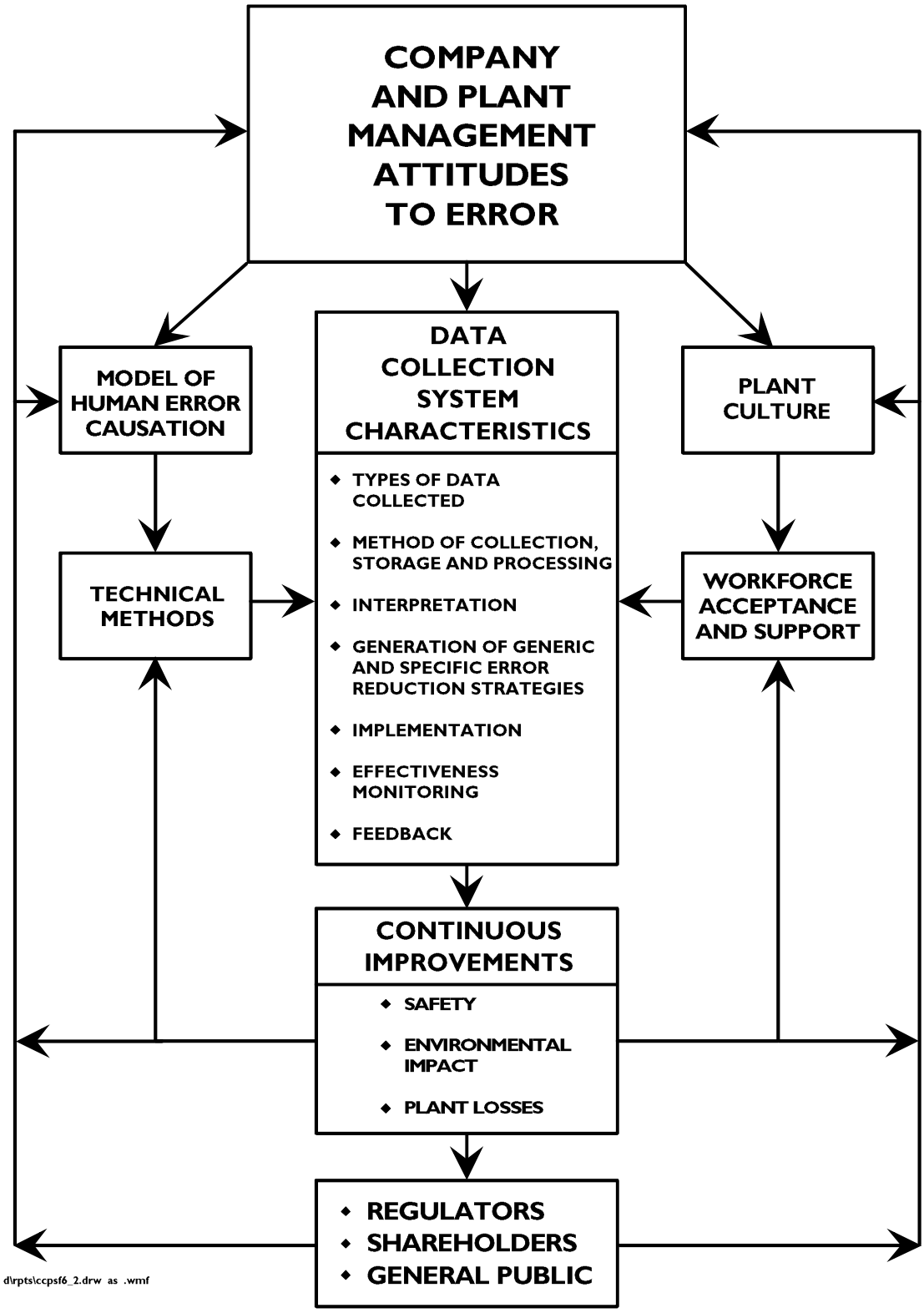


**Figure 1: Overall Structure of Data Collection System**

Figure 1 emphasizes the fact that the outputs from data collection systems, particularly those that address safety and environmental issues, are of critical importance to an organization in that they are used as major indications of the acceptability of a company's operating practices by regulators, shareholders and the general public. This criticality has both advantages and disadvantages. From the positive perspective, there is considerable pressure on a company to ensure that its policies produce low accident rates. On the negative side, there is equally strong pressure to produce data collection systems that present the operating record of a company in the best possible light. Unfortunately, these considerations can often work against the development of reporting systems that are designed to get at underlying causes of accidents.

Figure 1 also indicates that the output from data collection systems is a vital aspect of the Continuous Process Improvement cycle advocated in Total Quality Management. Feedback on the underlying causes of problems is necessary to ensure continuing support for error and accident reduction programs by senior management. Feedback also leads to changes in the model of error causation held by senior management and to changes in plant culture which can further enhance the effectiveness of data collection systems by gaining ownership and commitment from the workforce.

# 2 Model of Accident Causation Held by the Organization

The type of data collected on human error and the ways in which these data are used for accident prevention will vary depending upon the model of error and accident causation held by the management of an organization. A number of alternative viewpoints or models of human error will now be briefly reviewed and their implications for the treatment of human error will be discussed.

## 2.1 The Traditional Safety Engineering (TSE) view

The traditional safety engineering view is the most commonly held of these models in most industries. This view assumes that human error is primarily controllable by the individual, in that people can choose to behave safely or otherwise. Unsafe behavior is assumed to be due to carelessness, negligence and to the deliberate breaking of operating rules and procedures designed to protect the individual and the system from known risks.

The responsibility of management from the TSE perspective is to provide a safe system of work to minimize the exposure of the individual and the process system to these risks. This is achieved by technical approaches such as barriers and interlocks, and through the provision of personal protective equipment. Management also has the responsibility to inform workers of these risks and to ensure that safe methods of work are adopted by providing appropriate training. Given that management carries out these functions adequately, the main strategy for maximizing safety from this perspective is to motivate the workforce so that they do not commit deliberate unsafe acts.

## 2.2 Implications of the TSE view for data collection

The implications of this approach for the data collection philosophy will be as follows:

### *Causal analysis*

There will be comparatively little interest in the underlying causes of errors leading to accidents. This is because the TSE view assigns virtually all errors to unsafe acts that are preventable by the individual workers concerned. There is little therefore little incentive to delve into other causes.

### *Prevention strategies*

Emphasis for prevention will be on changing individual behavior by symbolic or tangible rewards based on statistical evidence from the data collection system. 'Hard' performance indicators such as lost time incidents will therefore be preferred to 'softer' data such as near-miss reports. Accident prevention will also emphasize motivational campaigns designed to enhance the awareness of hazards and adherence to rules.

### *Changes in data collection strategies*

The TSE model of causation in terms of accidents primarily being due to individually, controllable unsafe acts is unlikely to be modified over time. This is because very little evidence on the background and conditions which led up to an accident will be collected. This means that the data collection strategy is likely to remain static since the data collected will, by definition, not contradict the underlying assumptions.

## 2.3 The System-Induced Error Approach

The System-Induced Error Approach comprises the following elements:

### *Error Tendencies and Error-Inducing Conditions*

Human errors occur as a result of a combination of inherent human error tendencies, and error-inducing conditions. Errors then combine with unforgiving situations (lack of recovery and the presence of hazards) to produce an accident.

### *Demand-Resource Mismatch*

The error-inducing conditions consist of two aspects. The first of these is the presence of factors such as poor procedures, inadequate training and time stress, which mean that the worker is unlikely to have the mental or physical resources available to meet the demands arising from the job. This mismatch creates a situation of high error potential. The other aspect of error-inducing conditions is the presence of specific triggering events such as unexpected fluctuations in demand, distractions or other additional pressures.

### *Multiple causation*

Accidents do not arise from a single cause but from a combination of conditions which may be human caused (active or latent failures), characteristics of the environment, or operating states.

### *Role of latent failures*

The final aspect of the system induced error approach is the emphasis on the effects of organizational and managerial policies in creating the preconditions for errors described above. In addition to the direct effects of these policies, management is also responsible for determining the culture in the organization. This may, for example, influence the choices made between profitable but possibly risky ways of working and adherence to stated safety practices.

### *Emphasis on the modification of system factors as a major error reduction strategy*

This emphasis replaces the reliance on rewards and punishment as a means of error control which characterizes the TSE approach.

## 2.4 Implications of the System-Induced Error Approach for data collection

### *Causal emphasis*

There will be strong emphasis on the collection of data on possible causal factors that could have contributed to an accident. The specific data that are collected may be based on an error model. However, this model will usually be modified on the basis of the extent to which it fits the data collected over a period of time. The System Induced Error based approach is therefore dynamic rather than static.

### *Organizational perspective*

Monitoring and detailed accident investigation systems will attempt to address the organizational and work culture factors that influence accident causation. This will encourage the investigation of the global effects of organizational policies in creating the precursors for accidents.

### *Use of near-miss data*

The System-Induced Error Approach emphasizes the value of near-misses as a rich source of information about accident causes. This is based on the concept of accidents as resulting from combinations of conditions such as a poor safety culture, inadequate training and poor procedures, together with a triggering event. Near-miss reporting systems are therefore important to provide early warnings of these conditions before they lead to an accident.

### *Changes in data collection strategies*

Because of the emphasis on modeling accident causation, data collection systems based on the System-Induced Error approach are likely to modify their data collection strategies over time. Thus, as evidence accumulates that the existing causal categories are inadequate to account for the accidents and near misses that are reported, the data collection philosophy will be modified, and a new accident causation model developed. This, in turn, will be modified on the basis of subsequent evidence.

## 3. Cultural Aspects of Data Collection System Design

A company's culture can make or break even a well-designed data collection system. Essential requirements are minimal use of blame, freedom from fear of reprisals, and feedback which indicates that the information being generated is being used to make changes that will be beneficial to everybody. All three factors are vital for the success of a data collection system and all are, to a certain extent, under the control of management. To illustrate the effect of the absence of such factors, here is an extract from the report into the Challenger space shuttle disaster:

> *"Accidental Damage Reporting. While not specifically related to the Challenger accident, a serious problem was identified during interviews of technicians who work on the Orbiter. It had been their understanding at one time that employees would not be disciplined for accidental damage done to the Orbiter, providing the damage was fully reported when it occurred. It was their opinion that this forgiveness policy was no longer being followed by the Shuttle Processing Contractor. They cited examples of employees being punished after acknowledging they had accidentally caused damage. The technicians said that accidental damage is not consistently reported when it occurs, because of lack of confidence in management's forgiveness policy and technicians' consequent fear of losing their jobs. This situation has obvious severe implications if left uncorrected."* (Report of the Presidential Commission on the Space Shuttle Challenger Accident, 1986, page 194).

Such examples illustrate the fundamental need to provide guarantees of anonymity and freedom from sanctions in any data collection system which relies on voluntary reporting. Such guarantees will not be forthcoming in organizations which hold a traditional view of accident causation.

Feedback is a critical aspect of voluntary reporting data collection systems. If personnel are to continue providing information they must see the results of their input, ideally in the form of implemented error control strategies. A method for providing feedback which aims to share any insights gained from a scheme will indicate to all personnel that the system has a useful purpose. One example of an incident reporting scheme with an effective feedback channel is the Institute of Nuclear Power Operation's Human Performance Evaluation Scheme (HPES). Here a newsletter called 'Lifted Leads' is used to publicize anonymous reports of incidents

together with any error control strategies implemented. The newsletter is circulated to all plants participating in the HPES program. In addition, humorous posters have been developed from certain reported incidents and these are also circulated freely.

As well as a non-punitive culture with guarantees of anonymity and feedback there are three other necessary conditions for an effective data collection system. First, it is important that the future users of the system are involved in its design and implementation. Second it is essential that those who use the system should eventually own it. Such owners should be willing to view the information in any database as a neutral commodity for all to use. Finally, it is crucial that effective training is given. This includes training in communication skills and analysis methods for the investigators of incidents, and an awareness training program for all levels of staff who will be involved.