A SYSTEMS APPROACH TO THE CONTROL OF CHEMICAL DISASTERS*

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ABSTRACT

A systems approach is suggested for interlinking the three main components of a chemical accident: the event, the target and the effects. Such an approach helps in identifying information gaps vitally needed for establishing cause-effect relationship, for assessing risks from continuing or long-term effects and for developing preventive measures for reducing injury from chemical accidents. Feasible classification modes of accidents such as during production, processing, distribution, transport and disposal can be conveniently incorporated. Contingency and rehabilitation plans can be put in proper perspective so that the support infrastructure needed can be established and updated. Areas of research to be pursued on priority basis to get feed back on methods for assessing risks can be delineated along with programmes for the development of the required technical manpower.

INTRODUCTION

THE immediate provocation for attempting the exercise embodied in this article came from the author's involvement during the last ten months in organizing the activities of the Scientific Commission for Continuing Studies on the Effects of Bhopal Gas Leakage on Life Systems set up by the Government of India[1] in August 1985. One of the eleven responsibilities assigned to the Commission is—"... taking such other measures and actions as may be considered necessary to achieve the objectives of establishing scientific basis and which should be of value in minimizing short and long term effects of the toxic and related materials in future to living systems".

During this period several questions had to be asked on the uncertainties that plague vital aspects of Bhopal like chemical disasters concerning cause-effect relationship. Furthermore, the steps initiated to overcome the consequences have to be reduced to some basic principles of logistics leading, hopefully, to the development of a sustainable model for prevention and control of chemical disasters.

This author also participated in a Task Force Meeting on Risk and Policy Analysis Under Conditions of Uncertainty convened in Vienna in November, 1985, by the International Institute for Applied Systems Analysis. While presenting his concern with the prevalent indifference to problems already surfacing consequent to the cultural transplant of technologies from industrialized countries into developing ones, the author highlighted the possibility of catastrophic system failure and hence the need for enunciation and institutionalization of policies for anticipating and preventing adverse effects of technological development[2]. The use of systems approach to establish cause-effect relationship and the means for prevention and control of chemical disasters is articulated in this paper.

RISK ASSESSMENT OF TOXIC MATERIALS

A model to characterize the process for managing risks was presented by Lave in 1982 particularly in relation to chemicals[3]. In August, 1985, Camougis reviewed the systems approach to risk assessment of toxic materials[4]. He mentioned: (i) the possibility of taking "a comprehensive overview" optimizing the system rather than its components, and (ii) the emergence of a conceptual approach to problem-solving, as advantages inherent to systems analysis. These have been extensively used in the past to study the environmental impact of major engineering projects but have not been deployed by scientists concerned, with the overall problems of chemical safety and in particular the control of major chemical disasters. Camougis has outlined how the systems approach can be used to integrate the different steps involved in risk assessment, hazard determination, assessment of risk to human health, assessment of risk to environment, financial risks and the process of decision taking by regulatory agencies.

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DIMENSIONS OF CHEMICAL DISASTERS

The decade 1974–84 witnessed a number of major industrial accidents involving hazardous chemicals: the Flixborough explosion in 1974, the Beek disaster in The Netherlands consequent on the release of propylene, the Seveso disaster, the Mississauga explosion in Canada due to collision of train loads of chlorine and propane, the Houston incident involving the accidental spill of anhydrous ammonia, the Sommerville–Massachussetts incident involving the spill of phosphorus trichloride and, the worst in the history of chemical technology, the Bhopal disaster. Obviously, each one of these accidents had its own characteristic scenario with the tragic element manifesting itself in varying magnitudes and many dimensions. Nevertheless, they all unfailingly fit into the definitions of disaster used either by WHO or the NATO Committee on the Challenges of Modern Society. According to WHO, disaster is a situation which implies unforeseen, serious and immediate threats to public health. According to NATO-CCMS, a disaster is an act of nature or an act of man which is or threatens to be of sufficient severity and magnitude to warrant emergency assistance[5].

CONCEPTUAL FRAMEWORK TO DEAL WITH CHEMICAL DISASTERS

Almost all the disasters mentioned above are comprised of the following three sequential steps:

ACCIDENT → IMPACT ON TARGETS → EFFECTS

Against this highly simplified conceptual linear flow of events that characterize any major chemical disaster, it becomes relatively easy to look at the components as distinct entities and then unravel their interlinks. If prevention and control is recognized as the main goal in any worthwhile national policy on chemical safety, the relative significance of analyzing in greater depth, each one of the three steps and their sequence in chemical disasters becomes self-evident.

Most of the existing documentation on chemical accidents deals primarily with mechanistics of the relevant events. The vital information which can give an insight into defects in design, faults in materials of construction or failure of control mechanisms is presumably available within the industry. Enunciation of convincing chemical mechanisms of the disasters has been rendered difficult as there are no means at present to reduce the complexities of 'run away' reactions into simple chemical equations. Yet, the primary event in chemical disaster with the attendant mechanistics is perhaps amenable to recapitulation by simulation experiments.

Moving forward, one can attempt to characterize the consequences of a chemical disaster as shown in figure 1. In this scheme, targets both at the site and outside the site are included and could as well represent a chemical accident which has its impact within the confines of the processing area and outside due to release of toxic materials from the site of accident. The model can also describe accidents during storage or transport of hazardous chemicals.

The steps involved in the management of emergency and post-emergency phases of a chemical disaster are shown in figure 2. A model for a system for prevention and control of chemical disasters is presented in figure 3. The three main components of the proposed system are: i) an authority to give directives based on updated information with a back-up of research, ii) the alert system which notifies the catastrophic event, and iii) the local authority to carry out the emergency and post-emergency action plans.

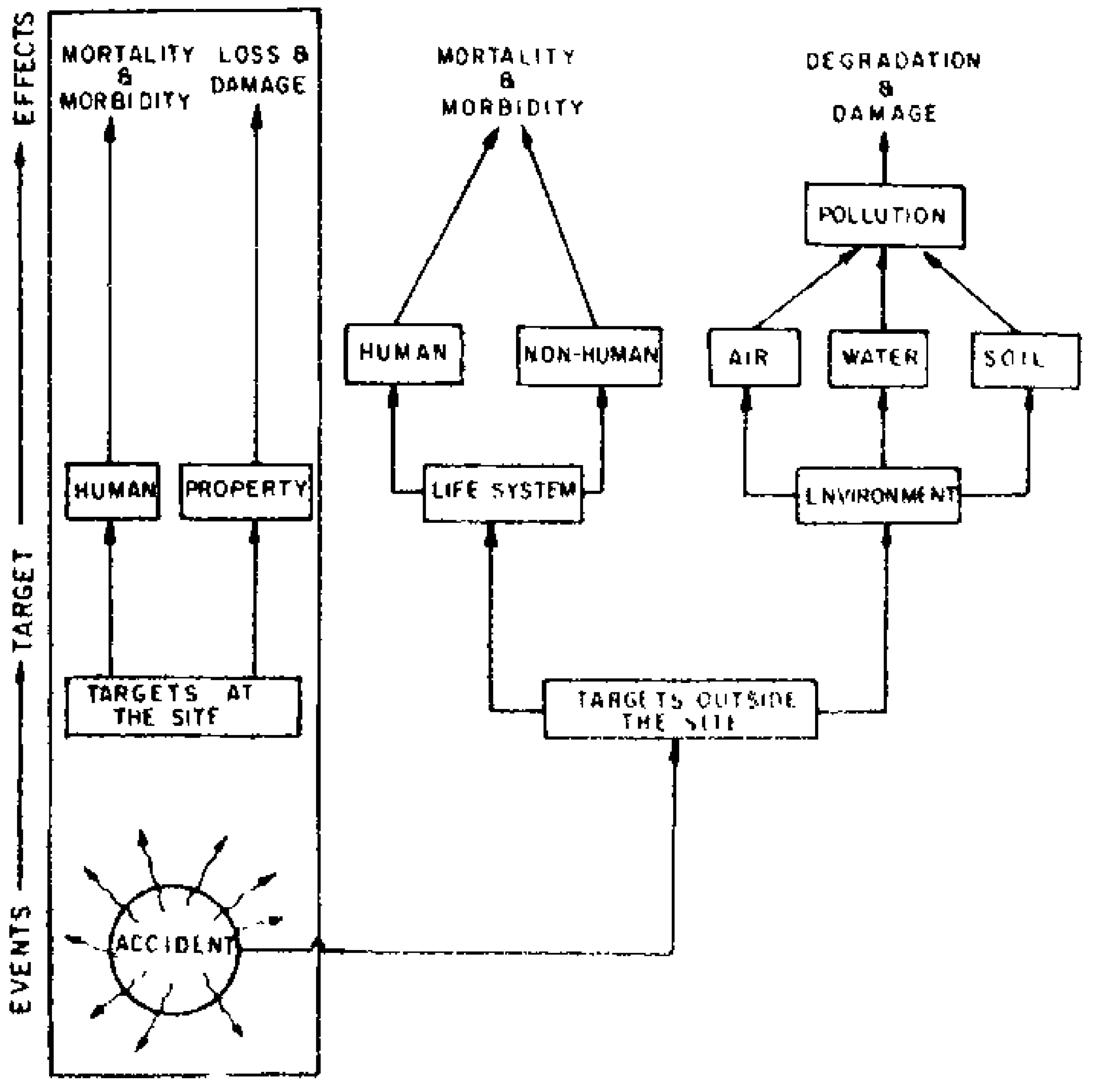

Figure 1. Elements of a major chemical accident.

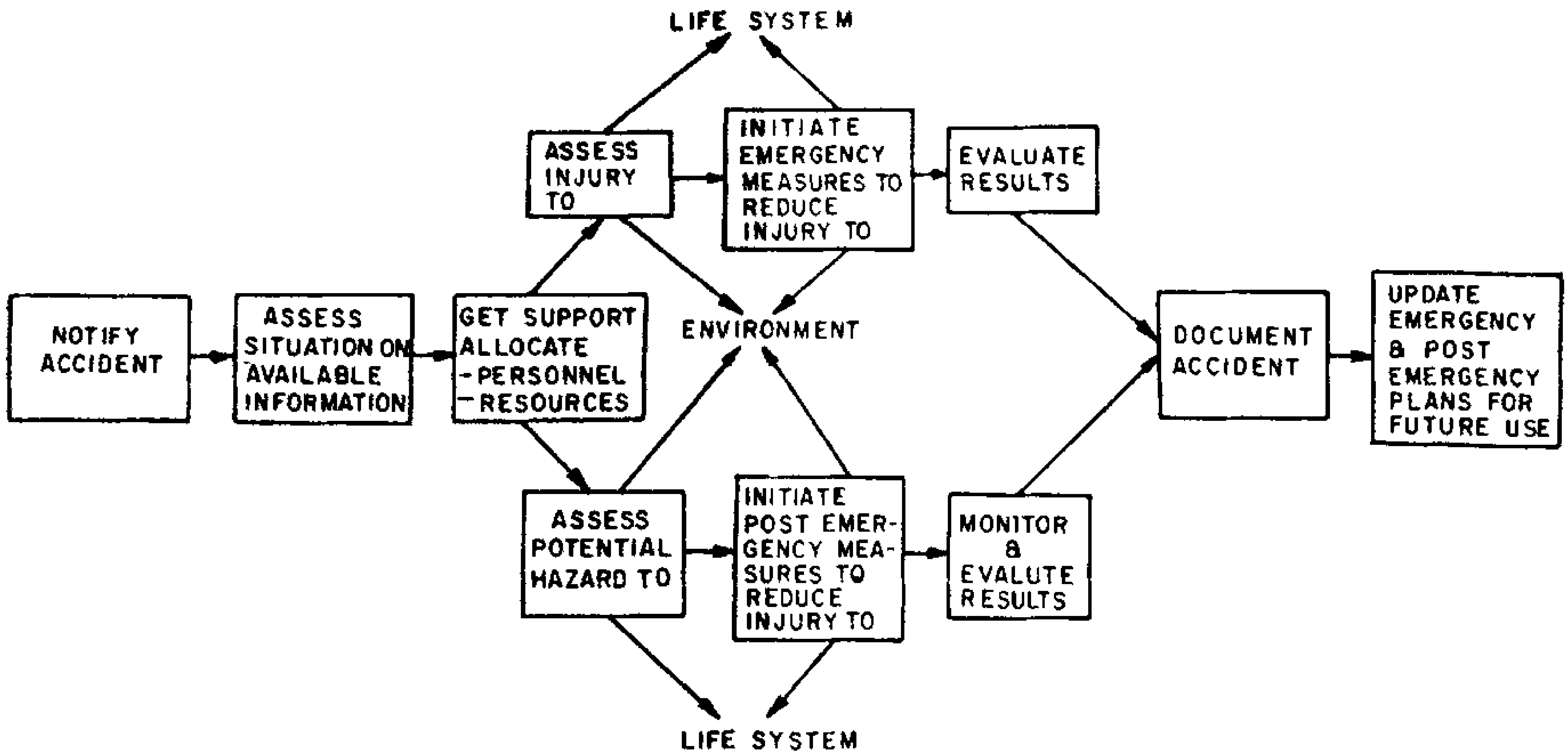

Figure 2. Steps in the emergency and post-emergency management of a chemical accident.

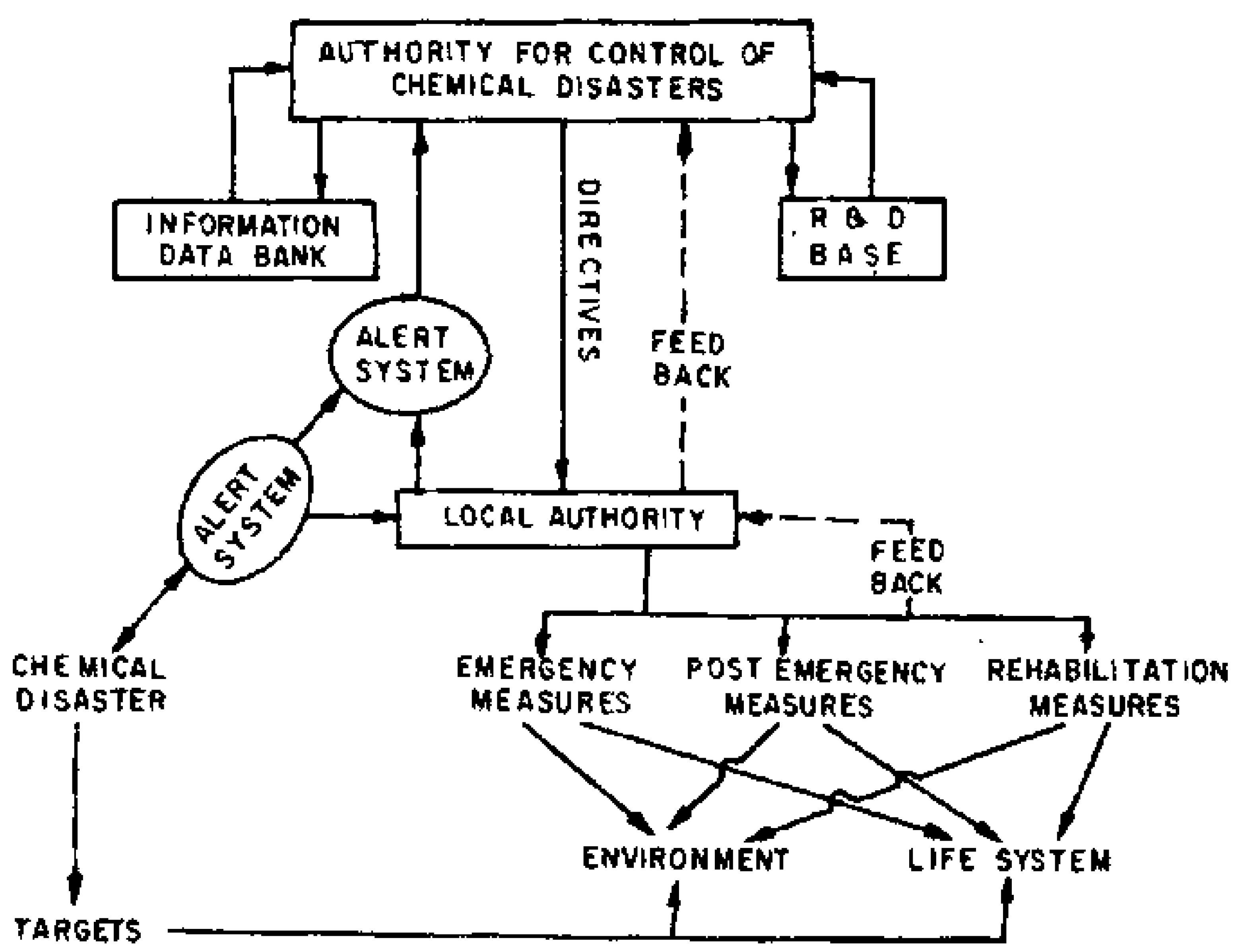

Figure 3. Model for controlling a chemical disaster.

CONCLUSION

A systems approach as suggested above enables one to interlink the three main components of a chemical disaster. Besides locating information gaps, it is useful in identifying needs for further investigations and research to establish cause-effect relationship and to develop effective measures for minimising the injury inflicted on the environment and life system. Planning for emergency and post-emergency action can be done along with the generation of material resources and the development of technical man-power to undertake the diverse tasks involved in the management of chemical disasters keeping in view the interest of public health and the need to protect the environment.

22 July 1986

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