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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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INTERNATIONAL CONFERENCE ON INDUSTRIAL RISK MANAGEMENT AND CLEAN TECHNOLOGIES

VIENNA - AUSTRIA

13 - 17 NOVEMBER 1988

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INTERNATIONAL ASSOCIATION FOR CLEAN TECHNOLOGY

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PAPERS

INTERNATIONAL CONFERENCE ON INDUSTRIAL RISK MANAGEMENT AND CLEAN TECHNOLOGIES

Organised by the International Association for Clean Technology (IACT) and the United Nations Industrial Development Organisation (UNIDO) and other international and national organisations.

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SCHEME FOR AN INFORMATION-SYSTEM FOR THE USAGE AND TRANSPORT OF HAZARDOUS SUBSTANCES

SUMMARY

Taking into account the interdependence of economics and ecology we are trying to view the problem of hazardous substances in its entirety by looking at it in an explicit and implicit way.

First of all there are problems concerning legal responsibility. Additionally there are innumerable legal acts which are quite complex and difficult to comprehend. A rather limited number of sources of information and communication makes the interpretation and association of data realy difficult.

On grounds of economical and economic reasons we have been developing a scheme that provides greater safety precautions for the usage and transport of hazardous substances. Further it offers a more effective way of collecting and storing the potential of risks we are facing.

The scheme for an information-system for hazardous substances focuses on three points:

a) the documentation of legal acts
b) the data base of hazardous substances
c) the digital map of hazardous substances.

The decisions underlying the scheme are aimed at preventing an event, which assumed, might change the current situation, it might be a spectacular accident somewhere in Austria, which is being caused by the transport or usage of hazardous substances.

DI D. Sueng e.h.

PROPOSALS FOR AN INFORMATION-SYSTEM FOR HAZARDOUS SUBSTANCES

1. Introduction

In 1887, a hundred years ago, Hermann Hollerit invented calculating and scrting machines for punch cards to rationalize the census procedures.

In 1988 we are operating the Fifth Generation, calculators, which have been designed for the use in the field of artificial intelligence. They communicate in various languages and store specialized knowledge.

Between the two extremes of historical development we can place the data processing. But where, in the field of hazardous substances, are data processors in use and how far have they been developed?

Dipl.-Ing. Hermann Drax stated in a paper on EDP FOR HAZARDOUS SUBSTANCES, which was published 10 years ago, that

"The time has come to introduce EDP-technology in the field of hazardous substances, since it has been used and proved worthwhile in all the areas of economy."

Indeed, it's time, it's even high time for the introduction of EDP in the field of hazardous substances.

The developments made in both technologies electronic data processing and data recording -have opened up new ways. Both technologies combined lead via data processor to the information processor.

Data processing has been carried out by specialists in isolation. It is only effective when plenty of the same data is processed at the same time. In contrast to data processing information processing will be carried out by a specialist at his working place and through it, communication between the computer and the specialist or some other users will be possible. Access to data which can be selected when needed will become the norm.

According to the development we would like to adapt or improve the services for hazardous substances with respect to

- safety
- efficiency
- realisation
- combination of data
- content of information
- supply of computers
- keeping a current record (constant updating).

Other alternatives are to leave things as they are, to be laissez-faire and not to interfere, or to be optimistic hoping there will not be any spectacular accident of hazardous substances in Austria in the near future.

A further alternative would be to continue persuing the development of the DP without ever implementing or installing it.

Assuming that we are determined to improve and modernize the present services for hazardous substances we will have to install an information system.

2. Initial stage

Dealing with the problem area hazardous substances we are concerned with the legislative-legal as well as the interdependent-technological aspects.

Presenting the problem in its entirety we are trying to describe the current situation, the status quo, in order to discuss the problem explicitely and implicitely.

The initial situation is marked by the dispute about competence, the numerous and complex regulations, the redundant work done by more than one authority, the rather restricted ways of linking and interpreting the data available and the limited amount of information and communication of different authorities.

The substantial body of regulations and legal orders concerning hazardous substances comprises a complex and vast number of single orders and regulations which can be found scattered in regulations of various authorities. Moreover, these regulations have to be changed according to the latest developments in science and technology, thus they are amended in rather short intervals.

The vast and complex area of regulations raises critical questions:

* Will more regulations provide larger safety?
* How, that means, how effectively can the vast amount of regulations be enforced?
* How clear and comprehensible, are the present regulations, especially when they have to be amended quite frequently?
* How useful and economic is DP in legislation?

These problems can be met by bridging the existing gap between the norms, accessible to specialists only, and the knowledge users have.

In addition to the regulations concerning hazardous substances there is a considerable number of reference books and instructions about hazardous substances, which contain specific data with comments and information about emergency and precautions.

This vast number of reference books and instructions is generally kept in the central office for emergency or news services. Access is only possible via radio network. Apart from the fact, that a book how accomplished and complex it may be, can never be up to date, an enquiry to the central office will in general take quite a long time of seeking. This traditional, almost classic use of reference books in connection with the multitude of substances and the frequent supplements and modifications gave rise to the development of a new equipment, which should give the user the opportunity to inform himself about hazardous substances, in a simple, clear and practical, but most of all modern and timesaving way.

The hazardous substances are in various respects not only complex but dynamic matters. Especially the latter fact in connection with precautions and emergencies requires thorough knowledge of the potential dangers of the quantity of dangerous storages and the transport of hazardous substances. Since nowadays the quantities of substances stored and transported depend on the technological industrial development and the national and international economy we have to take into account and register the changes rather frequently.

The documentation concerning potential dangers of substances stored and transported will be carried through graphically, on so-called maps for hazardous substances.

Maps for hazardous substances ought to indicate:

* the actual situation of traffic ways
* the percentage of single traffic carriers
* the potential dangers on routes of transport and within the districts.

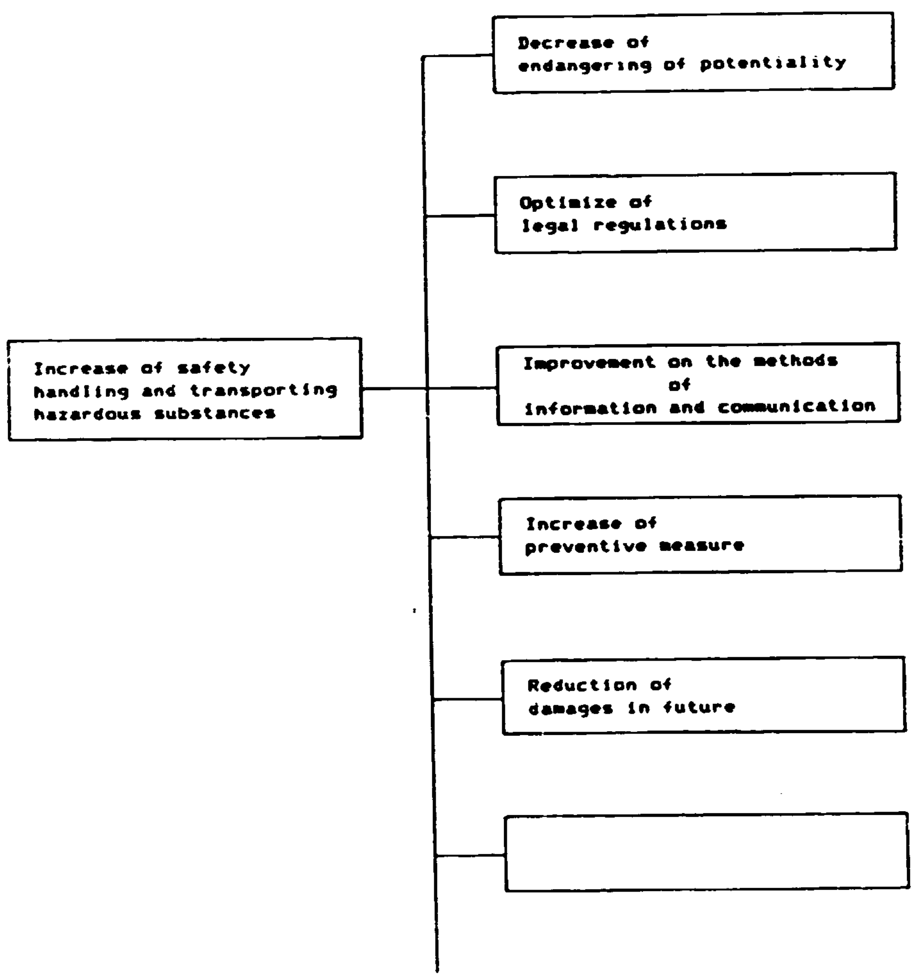
Moreover, we will be informed about the effects concerning infra-structure of the emergency forces, the creation of traffic schemes, the effects on the environment and desirable alternatives.

Further factors such as accidents, volume of traffic, geological and hydrological conditions, wild life parks, wild life-conservations and institutions such as road-data-banks, informationsystems and systems concerning hazardous substances demonstrate the problems of interdependencies of authorities, the redundant work of one or more bodies dealing with the same subject, the difficulties of combining data and the little knowledge about hazardous substances.

3. Requirements

The installation of an information-system for hazardous substances in Austria is intended to contribute to a reduction of risks connected with hazardous substances. Moreover, it is intended to rationalize the administration for hazardous substances and to make current data accessible to everybody who is concerned with this subject matter. In addition, it offers new ways of communication and further use of stored data.

Aims to reduce the dangers are illustrated in picture 1.



picture 1

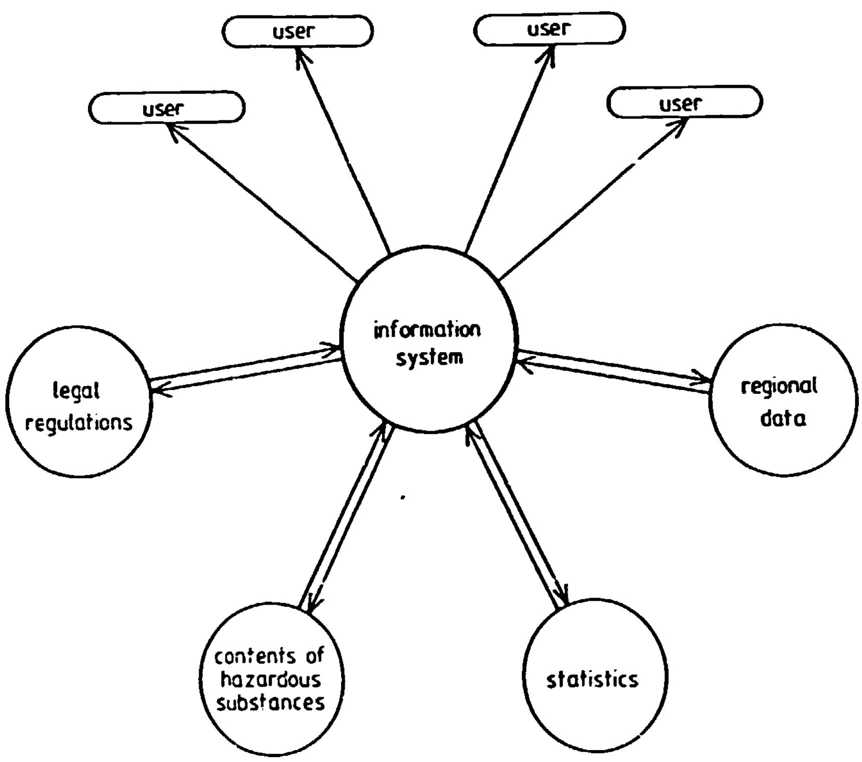
4. Proposal

Planning a data bank system in its complexity is not easy, and it is very difficult to implement such a system. The following ideas might seem utopical or partly old fashioned. Assuming we have achieved these effects we got what we intended. Nowadays nowhere else past and future are so close together as in information processing.
Proposals of this kind need realistic fantasy to be up to date. They have to be flexible to allow changes when something unexpected happens.

A scheme concerned with hazardous substances which is to meet the requirements has to work fast and must be easy to operate. It must take into consideration the multitude of printed data which have to be recorded, the combination with existing data to keep the data up to date and the communicative competence. A device which has these functions is a data bank or information system.

There are many ways of organising and installing an information system. Hazardous substances cause a variety of problems which are met by various authorities spread over the whole country.

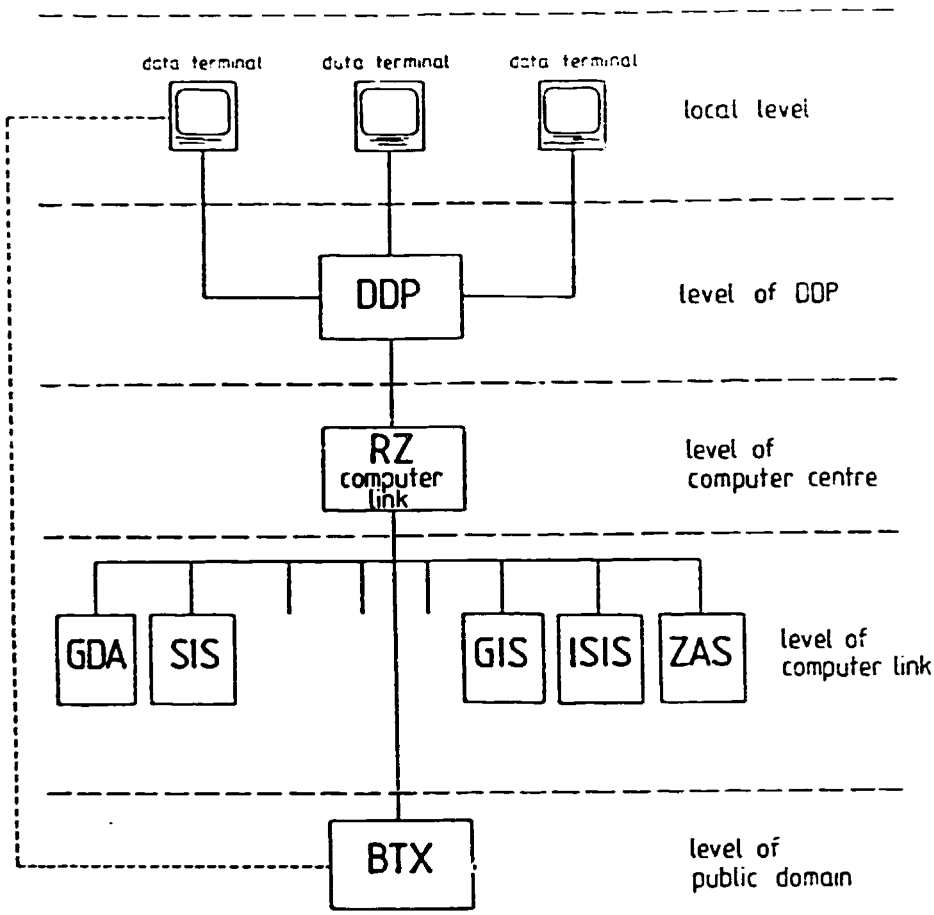
Picture 2 illustrates the target:



picture 2

The proposal for an information system takes into consideration the present or future uses of EDP such as:
'data bank of landed property, data file for borderlines of administrative districts, road information system, statistical information system, data bank for hazardous substances, geographical information systems a.s.o. The planned system will link the present uses and increase their number by integrating new sectors such as textprocessing and graphic data processing.

The scheme provides five levels which form the data and communication network (picture 3). In-built standardized interfaces ensure the existence in the future.



DDP ... Distributed Data Processing	BTX ... Viewdata
RZ ... Computer Centre	GIS ... Geographical Information System
GDA ... Data Bank for Hazardous Substances	ISIS ... Integrated Statistical Information System
SIS ... Road Information System	ZAS ... Central Displacement System

picture 3

The scheme provides basic structures which meet the different requirements or demands. Thus communicative competence is achieved in the administration and in the personal area.

5. Uses

From a series of uses we want to discuss how the system can be applied to the following areas:

* documentation of legal regulations
* data bank for hazardous substances
* digital map for hazardous substances.

Documentation of legal regulations

The regulations and instructions concerning hazardous substances are, as mentioned above - extremely complex and numerous. They are subjected to permanent changes in order to be up to date with the latest developments in science and technology. They fill the yearly files of regulations and legal orders waiting to be implemented as quickly as possible in everyday routine work.

Knowing the legal regulations and keeping to them will help to reduce the existing risks when dealing with hazardous substances. Moreover, the latest in data effects decisions to a great extent.

The intensions of the legislator should be clearly perceptible so that laymen, non-lawyers and non-experts, can understand them. Frequent amendments and combinations of regulations prove the opposite.

Apart from publishing the regulations, the texts which are needed for the setting copies can be stored in an electronic legible data carrier or data terminal, which not only avoids redundancy of texts but also takes advantage of the uses of textprocessing and especially the information system.

The textprocessing which is a constituent of the scheme has the following advantages:

* standardized EDP-structures
* multiple use of EDP-resources
* excellent possibility of development and economy.

The documentation of hazardous substances provides texts efficiently, amendments and regulations are accessible faster and more efficient, at the same time users have access to current regulations by means of viewdata.
Moreover, a well defined code is the key to a textlibrary where current and historical regulations can be retrieved very quickly. Alternatives of linking the system with other sectors should be considered.

Data bank for hazardous substances

We have already discussed the multitude of hazardous substances and the reference books and instructions for emergency and first aid.

The electronic data processor would be an alternative which could improve the situation. A central information system, spread over the whole country, which is always ready to give information when needed, would be essential. Since the Austrian research centre in Seibersdorf started the project "Hazardous substances, data bank Austria" the problem has no longer been a current one.

The advantages of such a system are the following ones:

* digital and graphic data can be stored in great quantities in computer centres. They are very productive and flexible, and they have interfaces for telecommunication
* high quality of data
* high degree of relevance
* large choice of code to retrieve data
* the level of data can be regulated with the help of indicators
* change of data needs only to be made once to be effective immediately
* direct access in various presentations.

Apart from those I've discussed, there are some other advantages the information system offers:

* multiple use of EDP-resources
* the change of regulations which causes that a new substance will be added to a group of hazardous substances can be made visible by linking the relevant EDP-resources of the stored data.
* references of relevant legal instructions can be stored. The instructions themselves can be retrieved in combination with the documentation of regulations.

To be able to use all the advantages, the data need processing to be stored and recorded. There are various ways, thus we are assuming that there is no device to record the data electronically. Economy and usage are relevant for the choice of one of the possibilities mentioned below:

* recording and storing of all available data in instructions without any editorial revision
* Editorial revision of the instructions before data are recorded and stored
* New ways of recording the data based on existing material and the know how of a team of specialists.

No matter which of the alternatives you choose some advantages of the information system will still exist. The problem how to transfer data to the place of emergency has been improved but not solved. The access at the scene of the accident will be possible via radio. But even here data carrier for hazardous substances, at least for "hazardous substances-vehicles" could replace reference books for emergencies or first aid brochures.

The use of a data bank for hazardous substances rationalizes the administration considerably, at the same time it is easy to operate and it offers some comfort to the users which can only be provided when their interests are all integrated in the information system.

Digital map for hazardous substances

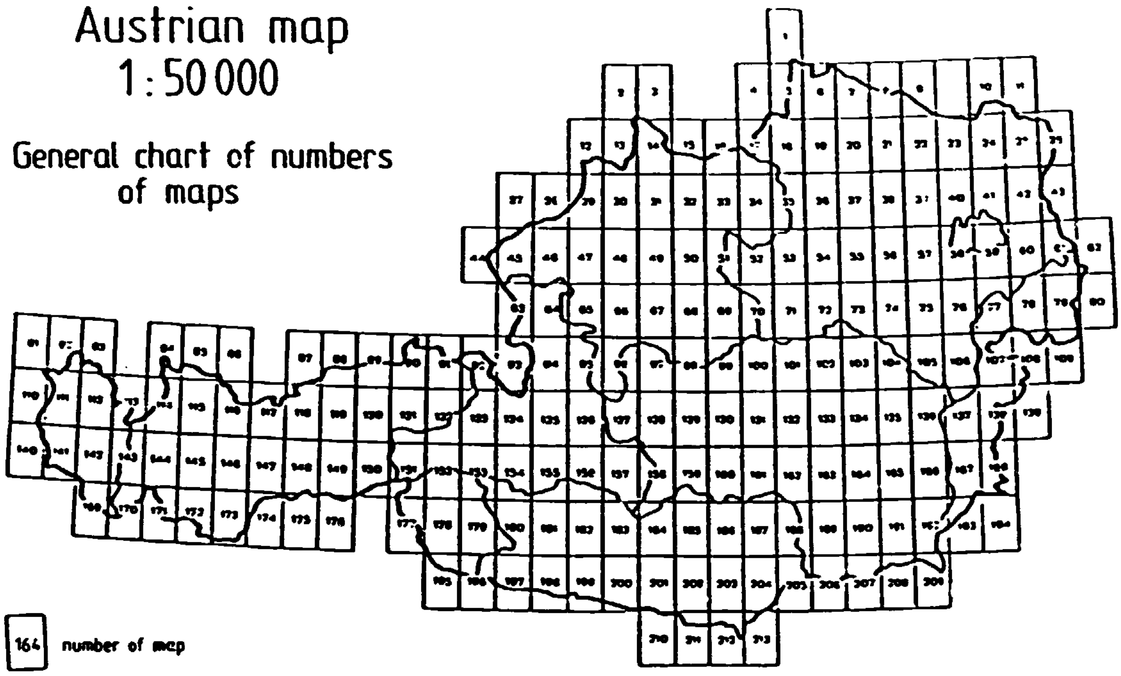
A digital map for hazardous substances contains a lot of regional data. The regional data are mainly based on cartographic data of high relevance.

The traditional maps for hazardous substances are standardized maps which are adapted and continued periodically. The required effort is considerable, expecially if the maps have to be kept up to date.

Computerization will be essential in this field as well.

The proposal being discussed is based on relevant data and it makes possible the realisation of a digital map for hazardous substances.

The data is provided by the "Verwaltungsgrenzdatei" (data file for borderlines of administrative districts) of the "Bundesamt für Eich- und Vermessungswesen", which has been established throughout Austria according to a contract with the "österreichisches Statistisches Zentralamt" (Austrian Centre for Statistics). The borderlines of the smallest administrative districts (Katastralgemeinden) presented on the current general maps were digitalized. Like these map projections the borderline polygones are marked on the Gauß-Krüger Projection and that in the 3-grad projection strip on the concerned map (picture 4). The data is processed by an interactive graphic data processor system.



picture 4

Depending on the demand this central data file can be used for other areas of interests and for evaluations of data in a graphic or non-graphic way.

A selective programme exists for evaluations via parameter (number of the Austrian map, rectangular coordinate system) or via hierarchical stages. The output can be either a draft or a precise drawing or a magnetic tape.

The data file for the borderlines of administrative districts as presented now, can be the beginning of a national geographical information system that comprises the entire federal state. It was introduced in Austria in 1983 and has been kept up to date since then. As any graphic data bank it does not depend on any scale and can be easily transformed when needed. The requirements for eventual combinations of graphic data of borderline districts and various maps are met.

Thus the "Verwaltungsgrenzdatei" (data file for borderline areas) is an important prerequisite for the realisation of a digital map for hazardous substances.
~~The data file is important for~~ it can be used in the present form for the registration of local storages of hazardous substances.

The registration of the most important traffic carriers, especially their routes, would complete the data file which finally could be used for the electronic recording of graphic data of transported quantities of hazardous substances. For this purpose the routes of the traffic carriers should be made digital from the current maps for Austria on a scale of 1:50 000. The routes should be marked according to the quantities transported.

After all we have tried to show how on the basis of relevant data an alternative can be realised for the introduction and control of a digital map for hazardous substances.

6. Further Possibilities

The information system offers a large number of services. In our previous chapters we have discussed some of them. In connection with the digital map for hazardous substances there are further services. We are going to discuss the most important ones.

The EDP on which the r o a d d a t a b a n k is based concentrates on providing data for road planning and road maintainance which means, that according to the programme data can be principly combined (plan for the volume of traffic on certain routes, average volume of traffic and percentage of lorries) but because of the lack of a standardized reference system, this is not possible. If there were a standardized coordination system or a diagram to which certain characteristics of the actual data bank could be related, the road network could be evaluated and illustrated so that it could be used as the bases for the digital map of hazardous substances.

The alphanumeric data of the official s t a t i s t i c s concerning accidents, volume of traffic, storage and transport of hazardous substances provided by relevant material must be modified, processed and linked to serve as a base for a further graphic processing. An example for a potential evaluation in connection with graphic use are the local quantities of storage and the quantities of hazardous substances carried on the routes of transport.

Nature reserve, national parks, wild life-conservations, water reservations and water consideration areas are laid down in regulations. This includes a cartographic diagram showing the borderline, which again could serve as a base for relevant data, concerning the borderline of a district displayed on a screen.

The digital map for hazardous substances and the use discussed above can be considered as the outcome of a special use of the data file of administrative borderline districts.

7. Summary

In dealing with hazardous substances world-wide problems have been arising for the industrial countries which in permanent discussions lead to compromises between national safety and economic necessities.

The problem has been treated from its entirety which has lead to a definition of its position. Thus the problem and the demands for an information system for hazardous substances have become quite obvious.

Taking into account the economical side and exploiting the present resources based on EDP we are trying to introduce a scheme that provides mainly an increase in safety when dealing and transporting hazardous substances. But in addition the recording and retrieving of potentials for hazardous substances are more effective. Moreover, the administration of hazardous substances will be rationalized.

Major achievements of the system are the documentation of legal regulations and instructions, the data bank for hazardous substances and the digital map for hazardous substances.

The ideas underlying the concept arise from the wish to avoid the incident which assumedly will change the present situation immediately, that is a spectacular accident of hazardous substances in Austria.

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Téléphone : 45 78 33 33
Télex : 204 997 F
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INDUSTRY AND ENVIRONMENT OFFICE
DEPARTEMENT INDUSTRIE ET ENVIRONNEMENT

TOUR MIRABEAU
39-43, quai André Citroën - 75739 PARIS CEDEX 15

AWARENESS AND PREPAREDNESS FOR EMERGENCIES AT LOCAL LEVEL: A PROCESS FOR HANDLING TECHNOLOGICAL ACCIDENTS

J. Aloisi de Larderel
Director, Industry and Environment Office
United Nations Environment Programme

"Development and environmental preservation are compatible and essential... But development will fail unless it is built on firm ecological foundations", Dr M.K. Tolba, Executive Director, UNEP.

In late 1986, following various industrial accidents that occurred in both highly industrialized and industrializing countries, resulting in adverse impacts on the environment, the United Nations Environment Programme (UNEP) suggested a series of measures to help governments, particularly in developing countries, minimize the occurrence and harmful effects of chemical accidents and emergencies. In particular, even if it is believed that all industrial accidents are preventable, one must be realistic enough to prepare response plans in the event that such accidents occur. Such preparation should lead to a better understanding of local hazards, and thus to preventive actions.

In this context, the UNEP Industry and Environment Office (IEO) has developed, in co-operation with industry, a Handbook on Awareness and Preparedness for Emergencies at Local Level (APELL), designed to assist decision-makers and technical personnel in improving community awareness of hazardous installations, and in preparing response plans should unexpected events at these installations endanger life, property or the environment.

APELL has two main goals:

- Create and/or increase community awareness of possible hazards within the community.
- Based on this awareness, develop a co-operative plan to respond to any emergencies that these hazards might present.

The APELL Process advocates a co-operative approach to technological accidents. APELL has also been prepared by UNEP/IEO in a co-operative way, with the Chemical Manufacturers' Association (CMA) and the Conseil Européen des Fédérations de l'Industrie Chimique (CEFIC). It has involved other international organizations (and in particular the CEC, OECD, WHO, UNIDO) and non-governmental associations.

I. THE APELL PROCESS

I.1 Why APELL?

Recent events raise the issue of safety and emergency preparedness for all people in all nations of the world.

Everybody still has in mind the dioxin-containing release in Seveso in 1976, the propane explosion in Mexico City in 1984, the release of methylisocyanate at Bhopal in 1984, the fire and discharge of contaminated waters in the Rhine in 1986 from a warehouse in Basel.

It is now universally acknowledged that every disaster, whatever the cause, has an environmental impact.

Whilst most industrial accidents can be contained within the boundaries of the industrial plant, there are those cases where impacts extend beyond its boundaries to affect the plant neighbourhood and have adverse short- or long-term consequences affecting life, life-support systems, property, or the social fabric. The extent of loss caused by such accidents depends to a large extent on the actions of the first responders to an emergency, within the industrial facility and the local community around it.

Clearly, adequate response to such situations calls for well-co-ordinated actions of individuals and institutions from the local community. This can only be achieved if there is awareness in the community of the possible hazards and of the need for mutual preparedness to cope with their consequences.

The APELL Handbook describes a process for such a co-operative action to improve community awareness and emergency preparedness.

I.2 What is APELL?

APELL involves two basic aspects:

- To create, and/or increase community awareness of the possible hazards involved in the manufacture, handling and use of hazardous materials, and of the steps taken by authorities and industry to protect the community from them.

- To develop, on the basis of this information, and in co-operation with the local communities, emergency response plans involving the entire community, should an emergency endangering its safety arise.

Thus APELL consists of two parts:

- Provision of information to the community which will be called "Community Awareness".

- Formulation of a plan to protect the public, which will be called "Emergency Response".

APELL addresses all emergencies related to any industrial or commercial operation with potential for fire, explosion, spills or releases of hazardous materials. How to determine which industrial and commercial operations should be concerned by the APELL Process is in principle the result of a risk assessment. In most cases however simple judgement and common sense may identify the facilities which may present a potential for a major accident. Also the criteria (lists of substances and threshold levels) set up in international or national regulations or recommendations may provide guidance.

APELL is flexible. It is clear that the various countries differ in culture, value systems, community infrastructure, response capabilities and resources, and in legal and regulatory requirements. Their industries present different potential dangers and risks. However, we believe all these differing situations have one common need: the ability to cope with an industrial accident affecting the local community. The APELL Handbook provides the basic concepts for the development of local action plans, which can be adapted to the local conditions.

Since the containment of health and environmental impacts depends upon the speed and scope of the initial local response, the emphasis is thus directed at local level participation. The Handbook recognizes, however, the fundamental roles of national governments, ministries, and the chief executive officers of industries to support and assist these efforts at the local level.

Finally, this Handbook is neither a unique model for the co-ordination of the efforts of all participants in the APELL Process, nor is it a detailed manual of the actions and requirements for initiating and implementing the APELL Process successfully. It is more a policy document that sets out the objectives and overall organizational framework for APELL. The objectives remain unchanged yet the mechanics of the operation will change from place to place, and must be adapted to specific local conditions and requirements.

I.3 What are the objectives of APELL?

APELL's overall goals are: to prevent loss of life or damage to health and social well-being, avoid property damage, and ensure environmental safety in the local community. Its specific objectives are:

- Provide information to the concerned members of the community on the hazards involved in industrial operations in its neighbourhood, and the measures taken to reduce these risks.
- Review, update, or establish emergency response plans in the local area.
- Increase local industry involvement in community awareness and emergency response planning.
- Integrate industry emergency plans with local emergency response plans for the community to handle all types of emergencies.
- Involve members of the local community in the development, testing and implementation of the overall emergency response plan.

I.4 Who are the APELL partners? What are their responsibilities?

At the local level there are three very important partners who must be involved if APELL is to succeed:

- Local authorities: these may include province, district, city or town officials, either elected or appointed, who are responsible for safety, public health and environmental protection in their area.
- Industry: industrial plant managers from either state-owned or private companies are responsible for safety and accident prevention in their operations. They prepare specific emergency preparedness measures within the plant and establish review of the industrial plant's operation. But their responsibilities do not stop at the fence. As leaders of industrial growth and development, they are in the best position to interact with local authorities and leaders, to provide awareness on how the industrial facility operates, and on how it could affect its environment and to help prepare appropriate community response plans in the event of an emergency. The involvement and active participation of the work force is also important.

- Local community and interest groups, such as environmental, health, lay care, media, and religious organizations, and leaders in the educational and business sectors that represent the concerns and views of their constituents in the community.

At the national level, governments have an important role to provide the co-operative climate and support under which local participants can achieve better preparedness. Through leadership and endorsement, national authorities should foster participation of everyone at the local level. Industry associations should also get involved.

There are other partners: the APELL Process is designed so as to harmonize with other initiatives and efforts in reducing risk and hazards as well as their consequences.

II. STARTING THE APELL PROCESS

II.1 How will APELL work?

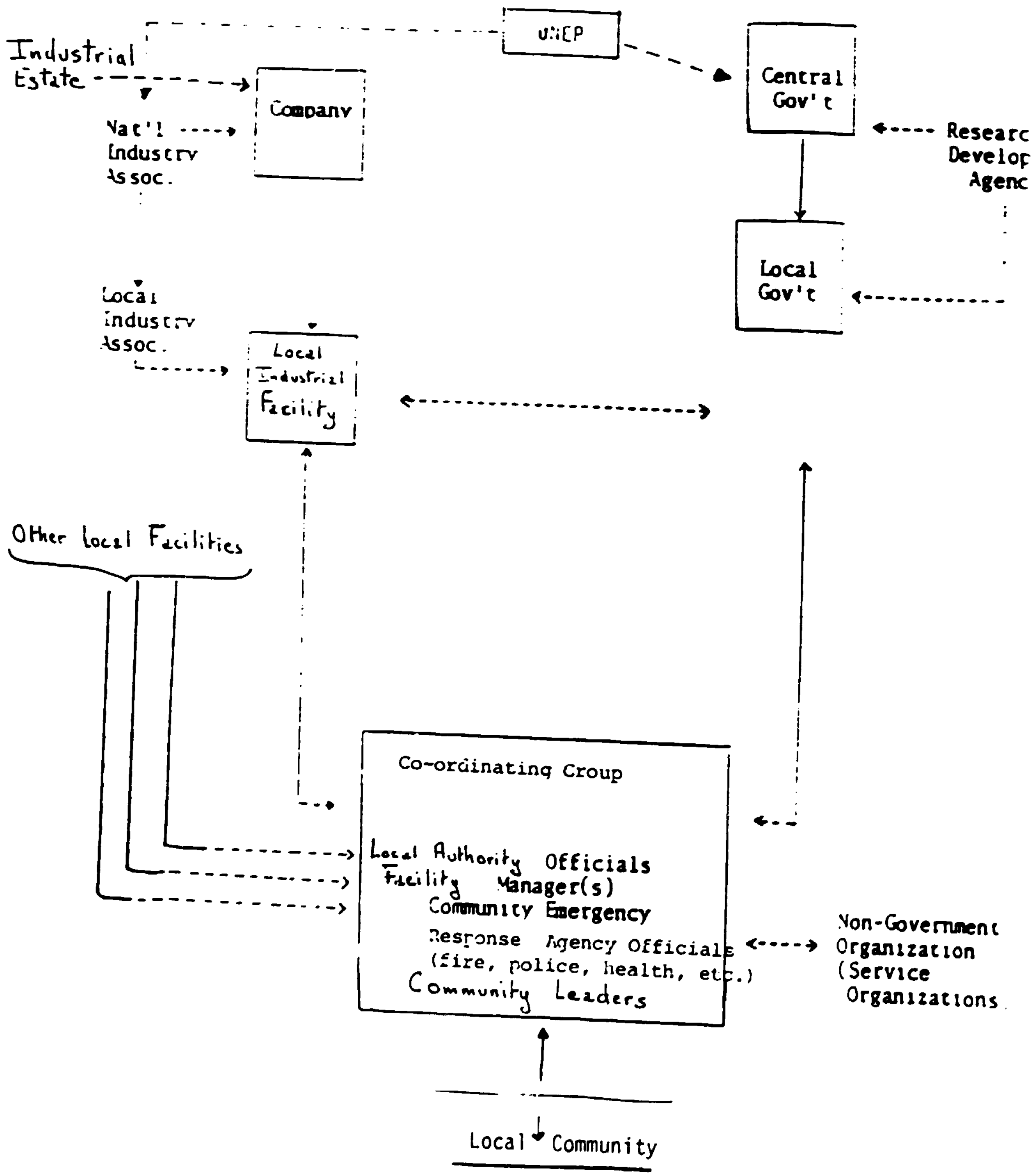
All industrial facilities have a responsibility to establish and implement a "facility emergency response plan". A key foundation for such a plan is a safety review of facility operations. This safety review, which is central to a company safety plan, examines in detail those items that affect safe operation of the facility. One part of this in-depth review by the facility management is the preparation of an emergency response plan. It is worth noting that several components of the emergency response plan involve notification and communication, with both authorities and citizens of the local area surrounding the industrial facility.

In addition to the existence of facility emergency plans, there may also be national government emergency plans or programmes in place. The APELL Process is designed to build, using all emergency plans that may already exist as a basis, a co-ordinated single plan that will operate effectively at the local level where first response efforts are so critical. While national organizations and plans exist for emergency response, there is always the need for an effective support structure at the local level.

In order for local authorities and local leaders to play their most effective roles with respect to awareness and preparedness for emergencies, there must be close and direct interaction with representatives of those industrial facilities to which the local area plays host. Indeed, local authorities and leaders and industrial representatives need to find the means to build a bridge between local government responsibilities and industry responsibilities.

The APELL Process recognizes this need for a bridge. Figure 1 contains a diagram showing schematically how industry representatives and local authorities/leaders can interact to form a partnership which will

FIGURE 1



APELL INFORMATION AND ORGANIZATION FLOW CHART

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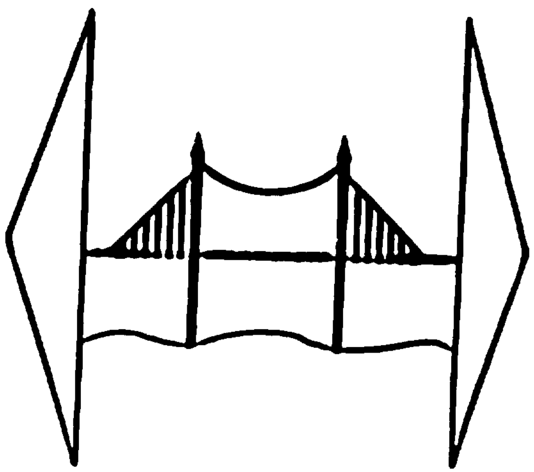
FIGURE 2

RESPONSIBILITY BRIDGE

INDUSTRY RESPONSIBILITIES

1. Assure safe work practices
2. Assure personal safety of employees and visitors.
3. Establish safety programs.
4. Protect lives and property on-site.
5. Coordinate all plant personnel during an emergency.
6. Develop plans and procedures to respond to emergencies.
7. Provide security, safety equipment, training, and information on chemical hazards.

COORDINATING GROUP BRIDGING ACTIONS



- Open lines of communications
- Information sharing
- Coordinate emergency plans and procedures.
- Interact with other emergency response agencies.
- Joint education and training
- Common problem solving group.
- Mutual aid assistance

LOCAL GOVERNMENT RESPONSIBILITY

1. Provide a safe community.
2. Assure the safety and well-being of all residents and transients within community.
3. Establish public safety programs.
4. Protect lives, as well as private & public property.
5. Coordinate community emergency response forces during an emergency.
6. Develop plans and procedures to respond to emergencies.
7. Conduct training, drills, and exercises with other response agencies within the community, area, or state.
8. Maintain communication channels with national governments.

provide the needed bridge, or "Co-ordinating Group" to ensure close and direct interaction between industry and the local community. Figure 2 indicates how the bridge can operate in implementation of the APELL Process.

The Co-ordinating Group is clearly the mainspring of the APELL Process. Members of the Co-ordinating Group must be able to command the respect of their various constituencies, e.g. industry, local group, etc., and be willing to act co-operatively in the interest of local well-being, safety and property. The Leader(s) of the Co-ordinating Group ideally should be able to ensure motivation and co-operation of all segments of local society regardless of cultural, educational, economic and other dissimilarities among these segments. This attribute of the Leader(s) of the Co-ordinating Group needs to be kept firmly in mind when selecting individuals to act in the role of Leader(s).

In sum, the Co-ordinating Group's role arises since industry is primarily responsible for protective actions "inside the fence" while local government is responsible for the safety of the general public. The role of the Co-ordinating Group is to provide the bridge between industry and local government with the co-operation of community leaders (see Figure 2) and develop a unified and co-ordinated approach to emergency response planning and communication with the community. It should be clear that the Co-ordinating Group has not itself a direct operational role during an emergency, but is preparing the various parties involved to be ready and know their tasks should an accident occur.

II.2 How to form the Co-ordinating Group?

The key organizational step to make the APELL Process work is the formation of a Co-ordinating Group representing the various constituencies that have or should have a voice in the establishment of an emergency response plan. The group should include members from local authorities, local community leaders and industry. It is important to bear in mind that all affected parties have a legitimate interest in the choices among planning alternatives. Strong efforts should therefore be made to ensure that all groups with an interest in the planning process are included.

In particular, plant managers of industrial facilities in the local area need to be active participants in the Co-ordinating Group. In turn, local authorities and community leaders need to know that these plant managers are acting with the blessing and authority of the highest officers of their respective organizations, in order to ensure the success of the APELL Process.

The APELL Process may be initiated by any member of the three involved groups: local authorities, local community leaders, or industry managers.

III. BUILDING COMMUNITY AWARENESS

III.1 The need for the local community to know about hazardous installations

Citizens in local communities have expressed corcern that potentially hazardous materials which could affect their health and environmental safety may be produced or used in their community. These citizens want to know if these materials are presert; their concern is often termed the "Right-to-Know".

In addition they need to be informed about potential hazards of hazardous installations in order to understand why an emergency plan has been established, how it works and what actions they are expected to take in case of an emergency.

Such principles are embodied in many regulations or recommendations such as the Guidelines for World Industry set forth by the International Chamber of Commerce.

III.2 What and how to communicate?

There is really nothing mysterious about a community awareness programme. A fenced-in industrial plant can look threatening to the public. But much of the mystery disappears when people know what the plant uses and manufactures, that it has a good safety plan and safety record, and that an effective emergency plan exists.

No one can prescribe the activities necessary for a local awareness programme that will fit every industrial facility or complex at every location. However, industry managers, local authorities or community leaders should consider the following points:

- define the local community concerned
- inventory existing local community contacts
- contact other industrial facilities to co-ordinate community activities
- plan an initial meeting of the Co-ordinating Group
- develop fact sheets or kits on each industrial operation
- develop fact sheets on community preparedness
- assign responsibility for communications tasks
- look for communication opportunities
- select methods of communications appropriate for local circumstances
- get outside help
- inform employees and personnel.

III.3 The do's and don'ts of information! ?

In preparing and building this community awareness, the following considerations should be borne in mind:

- all parties active in the APELL Process have a duty to keep the public informed as to the progress. Moreover all parties have a responsibility to insure that the public does not receive conflicting or confusing messages;

- developing relationships with the media is not a magical process, but rather one that requires time and effort on the part of plant managers, local authorities, community leaders and the Co-ordinating Group as a whole;

- media relation efforts, like local area co-operation programmes cannot be started after trouble has arisen.

Some of these considerations may seem obvious... but recent events show that they are not that obvious!...

IV. ACHIEVING PREPAREDNESS FOR EMERGENCIES

IV.1 Issues to be addressed

Among the first steps in the planning process are the gathering of information and assessment of the current situation. Therefore one of the first tasks facing the Co-ordinating Group is the collection of basic data. This can be done through personal contacts by Co-ordinating Group members or by surveys sent to local industry and government offices to:

1. identify local agencies making up the community's potential local awareness and response preparedness network

2. identify the hazards that may produce an emergency situation

3. establish the current status of community planning and co-ordination for hazardous materials emergency preparedness and assuring that potential overlaps in planning are avoided

4. identify the specific community points of contact and their responsibilities in an emergency

5. list the kinds of equipment and materials which are available at the local level to respond to emergencies

6. identify organizational structure for handling emergencies

7. check if the community has specialized emergency response teams to respond to hazardous materials releases

8. define the community emergency transportation network

9. establish the community procedures for protecting citizens during emergencies

10. set up a mechanism that enables responders to exchange information or ideas during an emergency with other entities.

The above issues cover only some of the major considerations or issues that should be resolved within or by the Co-ordinating Group. More details will be found in the APELL Handbook.

IV.2 A ten-step approach to the APELL Process for planning for emergency preparedness

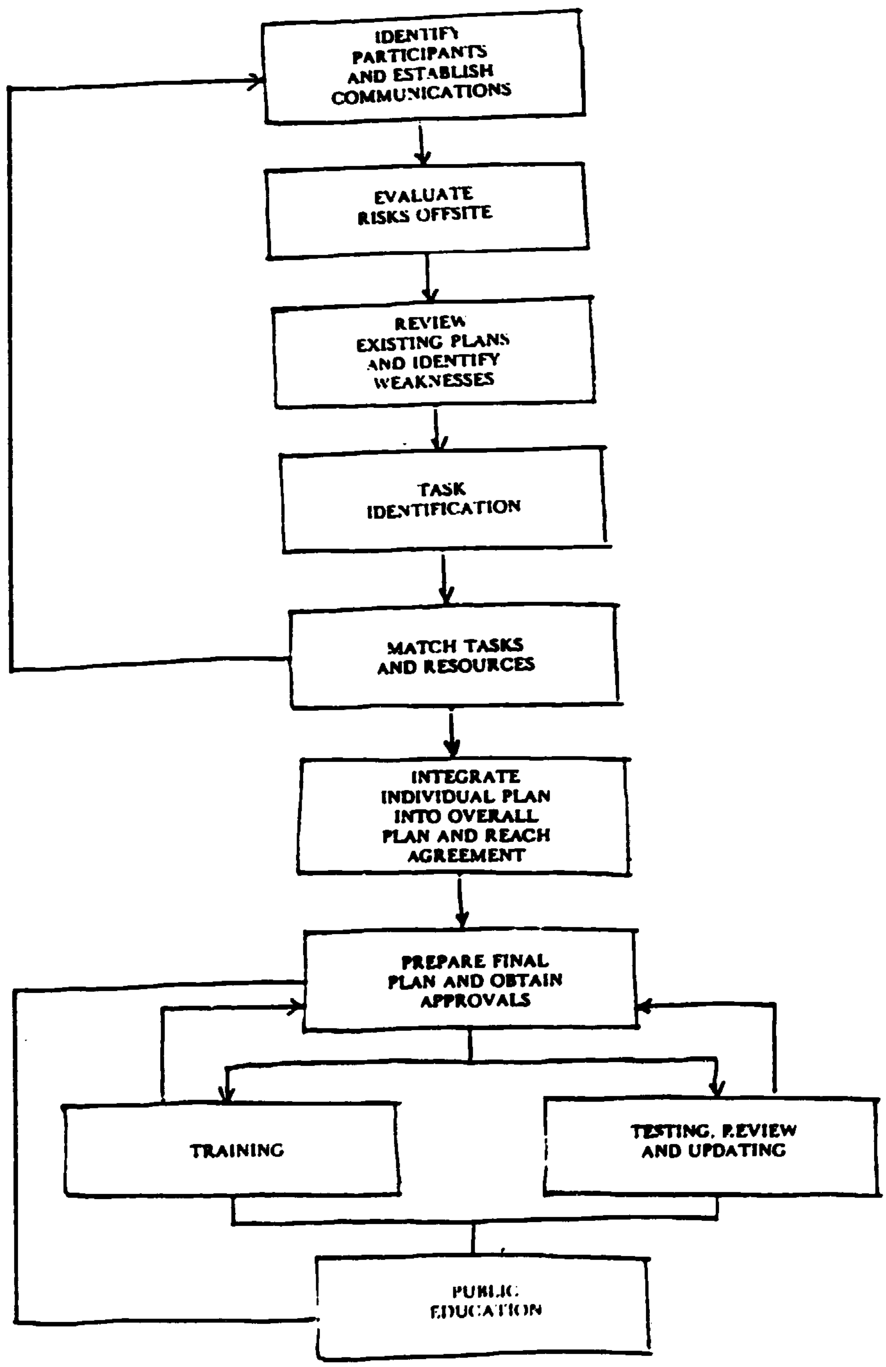
Based on experience, a ten-step approach to implement the APELL Process can be set forth which leads to a useful and effective integrated community emergency response plan. Significant effort will be required to complete each step. Listed below are the ten steps which are also presented in a flow chart (see Figure 3).

- identify the emergency response participants and establish their roles, resources and concerns
- evaluate the risks and hazards that may result in emergency situations in the community
- have participants review their own emergency plan for adequacy relative to a co-ordinated response
- identify the required response tasks not covered by existing plans
- match these tasks to the resources available from the identified participants
- make the changes necessary to improve existing plans, integrate them into an overall community plan and gain agreement
- commit the integrated community plan to writing and obtain approvals from local governments
- educate participating groups about the integrated plan and ensure that all emergency responders are trained
- establish procedures for periodic testing, review and updating of the plan
- educate the general community about the integrated plan.

The APELL Handbook describes the content of each step and provides a checklist useful for completing it.

Figure 3

COMMUNITY EMERGENCY PLAN IMPLEMENTATION FLOW CHART



CONCLUSION

In preparing the APELL Handbook, UNEP/IEO wishes to provide a tool which will enable national and local authorities, together with industry, to be better prepared to prevent and respond to industrial accidents. Of course, we know that this is just an element, a starting point, and that other tools will need to be developed. The APELL Process will be presented in a meeting hosted by the French Government. It will be illustrated by case studies describing current applications of the process. Future development and complements will also be discussed.

In particular we hope that we will be able to start a network to exchange information and experiences throughout the world on the subject. UNEP looks forward to this international co-operation.

ANNEX 1

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP) PRESENTATION

Created in 1972 with headquarters in Nairobi, Kenya, UNEP is not a big bureaucracy. It functions as a catalyst. It co-ordinates United Nations activities in the field of the environment and ensures the co-operation and participation of government and the international scientific and professional communities. UNEP activities include:

- A programme of global environment quality monitoring:
  - GEMS - Global Environment Monitoring System
  - INFOTERRA - International Environmental Information System
  - IRPTC - International Register of Potentially Toxic Chemicals
- An environmental management action plan: regional seas, inland waters, desertification, energy, terrestrial ecosystems, etc.
- Support measures: education and training, public information, environmental law.

UNEP has an overall annual budget (operating costs and project funding) of approximately $ 35 million of which $ 1.2 million is allocated to the Industry and Environment Office. Voluntary contributions are received from 75 countries. UNEP is staffed by approximately 180 professionals including 7 assigned to the IEO. Five Regional Offices represent UNEP around the world. UNEP's Executive Director is Dr. Mostafa K. Tolba.

The Industry and Environment Office (IEO) was established by UNEP in 1975 to bring industry and government together for environmentally sound industrial development. Its office is located in Paris.

The goals of the IEO are to:

- encourage the incorporation of environmental criteria in industrial development plans;
- facilitate the implementation of procedures and principles for the protection of the environment;
- promote the use of safe and "clean" technologies;
- stimulate the exchange of information and experience throughout the world.

To achieve these goals, the IEO provides access to practical information and develops co-operative on-site action and exchange backed by regular follow-up and assessment.

Some Examples of Recent UNEP/IEO Activities:

Technical publications (1986-1988): fields covered have been the aluminium and iron and steel industries, drilling mud, industrial risk management, diesel vehicles, petroleum refineries and terminals and non-ferrous metals. Technical guides on metal finishing, storage of chemicals, tanneries are being prepared.

Main themes of the "Industry and Environment" review in 1987-1988: Environmental management in the petrochemical industry and downstream activities, environmental management of small- and medium-scale industries, the working environment, emerging technologies, hazardous waste management, technological accidents, and environmental self-auditing.

Promoting awareness: symposia on the use of "clean" technologies in developing countries held in Karlsruhe and Dakar; conferences for industry managers in Kenya, India and the Philippines.

Training: seminars on the environmental management of aluminium smelters (Dubai, 1986) and of iron and steel production plants (Tokyo, 1987); workshops on hazardous waste management (Asia and Latin America, 1988).

Diagnostic studies: six Japanese experts carried out diagnostic studies of three iron and steel works and two aluminium smelting plants in the People's Republic of China and of one Indian chemical factory; two French experts undertook missions to Venezuela and Algeria to assist in the implementation of an industrial waste management policy.

For more information contact :

UNEP Industry and Environment Office
Tour Mirabeau
39-43, quai André-Citroën
75739 Paris Cedex 15
France

tel: 33-1-45.78.33.33

telex: 204997F

telefax: 45 78 32 34 (Coframines/Unep)

ANNEX 2

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Computer-Based Information and Decision Support Systems for the Management of Hazardous Substances and Industrial Risk

Kurt Fedra
Advanced Computer Applications (ACA)
International Institute for
Applied Systems Analysis (IIASA)
A-2361 Laxenburg, Austria

ABSTRACT

Hazardous substances and industrial risk management are typical examples of a problem domain that combines a large number of complex technical and scientific facts with subjective values, arbitrary judgement, perceptions, and qualitative policy objectives. To support the complex tasks of comprehensive risk management, the objective of this project is to develop and implement an integrated set of software tools, building on existing models and computer-assisted procedures. Using concepts of *artificial intelligence* (AI) coupled with more traditional methods of *applied systems analysis* and *operations research*, these tools are designed to provide easy and direct access to scientific evidence, and allow the efficient use of formal methods of analysis and information management by *non-technical* users as well.

THE PROBLEM ADDRESSED

Risk from the production and use of hazardous substances is ubiquitous. In addition to hazardous wastes, there is a large number of commercial products that are also hazardous. Their production, transportation, and use – before they enter any waste stream – is clearly also of concern. Industrial production processes that involve hazardous raw materials, feedstocks, or interim products, which may reach the environment after an accident, causing direct health risks to man, are a major component of overall industrial activities.

Further, the transportation of hazardous substances such as chlorine poses considerable risks to public health and the environment. The analysis of alternative policies for transportation, storage, and the location of production and consumption facilities should be based on a detailed scientific assessment of numerous alternatives, involving technological, environmental, socio-economic and political elements in a comprehensive and directly usable form of risk analysis.

The problems of managing hazardous substances then, are neither well defined nor reducible to a small set of relatively simple subproblems. They always involve complex trade-offs under uncertainty, feedback structures and synergistic effects, non-linear and potentially catastrophic systems behavior – in short, the full repertoire of a real-world mess. The classical methods of operations research and control engineering, that require a complete and quantitative definition of the problem from the outset, are certainly insufficient.

While only the combination of a larger set of methods and approaches holds promise of effectively tackling such problems, the subjective and discretionary human element must also be given due weight. This calls for the direct and interactive involvement of users, allowing them to exert discretion and judgement wherever formal methods are insufficient.

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PROJECT BACKGROUND AND OBJECTIVES

The background information required for strategic planning and policy making is characterized by a broad range of disciplines and is subject to a variable degree of resolution and uncertainty. The management and decision-making process therefore requires a strong element of human expertise and judgement in addition to the more formal, scientifically-based, analytical techniques. Methods of applied systems analysis and risk assessment, implemented using modern information processing technology, can now support such a comprehensive, interdisciplinary approach to the management of industrial risk. This approach can provide a powerful interactive tool for planners, regulators and policy makers, because it makes access to a large number of relevant databases, problem simulation modules, and decision support tools easy.

The R & D carried out by ACA (Fedra, 1985, 1986a,b; Fedra and Otway, 1986) concentrates on integrated systems of software tools to make the scientific basis for planning and management directly available to planners, policy and decision makers.

The objective of the project is to design and develop an integrated set of software tools, building on existing models and computer-assisted procedures. This set of tools is intended for non-technical users and should provide them with easy access to methods of analysis and information management which have previously been restricted to a small group of experts. To facilitate access to complex computer models by the non-expert user it is necessary to build much of the accumulated knowledge of the subject areas into the user interface. The interface therefore incorporates elements of knowledge-based expert systems which assist the user to select, set up, run and interpret the specialized software relevant to his needs.

By providing a coherent user interface, the interactions between different models, their databases and auxiliary software become more transparent to the user and a more experimental, educational style of computer use can be obtained. Extensive use of high-resolution graphics and menu-driven operations aids this transparency and makes the system user friendly. This greatly facilitates the assessment of alternative policies and strategies for the management of industrial risk.

A DECISION SUPPORT APPROACH

The approach to decision support proposed here is based on *information management* and *model-based decision support*. It envisions experts as its users, as well as decision and policy makers, and in fact, the computer is seen as a mediator and translator between expert and decision maker, between science and policy. The computer is thus not only a vehicle for analysis, but even more importantly, a vehicle for communication, learning, and experimentation.

The three basic functions of such decision support systems are:

to *supply factual information*, based on existing data, statistics, and scientific evidence, or to educate and inform the user;

to assist in *designing alternatives* and to assess the likely consequences of such new plans or policy options, i.e., to generate and analyze a set of possible solutions, often referred to as *scenario analysis*, and

to help in a systematic *multi-criteria evaluation and comparison* of the alternatives generated and studied, i.e., to structure and assist the actual decision process.

The framework foresees the selection of criteria for assessment by the user, and the assessment of scenarios or alternative plans in terms of these criteria. Value judgements are made by the user – he must make the decisions; the computer supports this task.

Hybrid Systems: Embedded AI Technology

The application- and problem-oriented rather than methodology-oriented system is designed as a *hybrid system*, where elements of AI technology are combined with the more classical techniques of information processing and approaches of operations research and systems analysis. Traditional numerical data processing is supplemented by symbolic elements, rules, and heuristics in the various forms of knowledge representation.

The basic approach employed is *rapid prototyping* together with and around well established operations research techniques. The ACA group designs and develops an *integrated set of software tools*, building on existing models and computer-assisted procedures.

AI techniques are embedded in the overall system at various levels:

- the object-oriented overall design and problem representation employs several concepts of expert systems for systems integration;
- the user interface includes various elements of expert systems technology, e.g., natural language parsing, rule-based input checking and error correction;
- throughout the system, context-dependent help and explain functions are implemented;
- selected system components are based on symbolic simulation techniques, inference procedures and rule-based heuristic procedures.

There are numerous systems components where the addition of a quite small amount of "knowledge" in the above sense, e.g., to an existing simulation model, may considerably extend its power and usefulness and at the same time make it much easier to use. Expert systems are not necessarily purely knowledge driven, relying on huge knowledge bases of thousands of rules. Applications containing only small knowledge bases of at best a few dozen to a hundred rules can dramatically extend the scope of standard computer applications in terms of application domains as well as in terms of an enlarged non-technical user community.

Model Integration and the User Interface

From a user perspective, the system must be able to assist in its own use, i.e., explain what it can do, how it can be done, and where a result comes from. The basic conceptual elements of this menu-driven system are the following:

- *the interactive user interface* that handles the dialog between the user(s) and the machine; this is largely menu-driven, that is, at any point the user is offered several possible options which he can select from a menu provided by the system (Figure 1);
- *a task scheduler or control program*, that interprets the user request – and, in fact, helps to formulate and structure it – and coordinates the necessary tasks (program executions) to be performed; this program contains the "knowledge" about the individual component software modules and their interdependencies;

  the control program can translate a user request, for example, into:

- a data/knowledge base query;
- a request for scenario analysis:

the latter will be transferred to

- ***a problem generator***, that assists in defining scenarios for simulation and/or optimization; its main task is to elicit a consistent and complete set of specifications from the user, by iteratively resorting to the database and/or knowledge base to build up the *information context or frame* of the scenario. A scenario is defined by a delimitation in space and time, a set of (possibly recursively linked) processes, a set of control variables, and a set of criteria to describe results. It is represented by
- ***a set of process-oriented models***, that can be used in either simulation or optimization modes. The results of creating a scenario and either simulating or optimizing it are passed back to the problem generator level through an
- ***evaluation and comparison module***, that attempts to evaluate a scenario according to the list of criteria specified, and assists in organizing the results from several scenarios. For this comparison and the presentation of results, the system uses a
- ***graphical display and report generator***, which allows selection from a variety of display styles and formats, and in particular enables the results of the scenario analysis to be viewed in graphical form. Finally, the system employs a
- ***system's administration module***, which is largely responsible for housekeeping and learning: it attempts to incorporate information gained during a particular session into the permanent data/knowledge bases and thus allows the system to "learn" and improve its information background from one session to the next.

It is important to notice that most of these elements are linked recursively. For example, a scenario analysis will usually imply several data/knowledge base queries to provide the frame and necessary default parameters transparently. Within each functional level, several iterations are possible, and at any decision breakpoint that the system cannot resolve from its current goal structure, the user can specify alternative branches to be followed.

The system must, however, on request "explain" where a result comes from and how it was derived, e.g., from a database, inferred by a rule-based production system, or as the result of a model application.

AI technology is embedded in this integrated software system at various levels, in several modules. They range from heterarchical, frame-based databases to rule-based pre-processors and input generators for classical numerical simulation models, rule-based heuristic feasibility and consistency checking of interactive input, to symbolic simulation and intelligent parsers for language-oriented input. The emphasis, clearly, is on a broad set of problem- and knowledge-representation techniques, integrated into one coherent framework.

While most operational examples of expert systems work in a relatively small and well-defined problem domain (computer systems configurations, interpretation of chromatographic experiments, diagnosis of a small set of illnesses, etc.; for a recent review see Weigkricht and Winkelbauer, forthcoming) our system spans the very large and not-so-well defined composite problem area of strategic risk management.

The model for our object-centered system's design is therefore based on the composite concept of a **team of experts**, coordinated by

- a **systems analyst**, who orchestrates the tasks of the
- individual **domain experts**.

Primary interaction is through the systems analyst, represented by the menu-driven and largely symbolic user interface. The user interface translates the user's request and specifications into tasks the system can perform, calls upon the domain experts (models and databases), and communicates their results to the user.

SYMBOLIC REPRESENTATION AND COMPUTER GRAPHICS

To almost everybody but the developer, a model is what one sees of it. And here a picture is certainly worth a thousand words, or numbers, for that matter. It needs little persuasion to convince most people that a color-coded overlay of say, the path of a cloud of toxic or radioactive material over the map of Europe is more immediately understandable than a table with numbers. This, however, is only the most obvious part of the user interface.

The user interface, from a more technical point of view is characterized by its bandwidth, i.e., the amount of information that can pass between man and machine per unit of time. Clearly, serial interfaces such as speech or typing and reading are very slow and cumbersome. Graphical representations, on the other hand, are less precise; they convey patterns or gestalt, but the individual element, the pixel, cannot be decoded as a unit.

It is quite obvious that any efficient system will need all forms of encoding: numbers, text, and pictorial or symbolic formats, and, in fact, even sound. In addition to the visible (or audible) parts of the user interface, it also needs some logic structure, or some intelligence. A very promising approach is the object-oriented model of a team of experts, as mentioned above, providing consultation to the user.

While command-driven interfaces can be very effective for the experienced user, menu-driven systems offer the advantage of self-teaching and error-proof features. To return to the model of the expert team, the team initiates the dialog, and guides the user through the set of possible actions that could be taken to describe the problem and the search for feasible solutions. It will also assist the user to ask meaningful and sufficiently formulated questions only, it will provide background information on request, and it will explain its reasoning and suggestions.

To make such a complex system easy to use, it has to be self-explanatory. Part of this can be achieved with a well-structured system of menus, and additional explain functions at each of the system's functional levels.

Responsiveness and speed are another key element: whenever the user does something, there must be an immediate response acknowledging the user's entry, offering further options or instructions, or indicating the system's state resulting from the user's action: The user should not be left in any doubt about his last input.

As a related issue, the control logic must be straightforward and obvious. Consistency in the logical structure of menu options, as well as in the pictorial layout of the interface, are important in order to minimize a novice's frustration as well as to maximize the efficiency of an experienced user.

UNCERTAINTY, ROBUSTNESS, AND QUALITATIVE REPRESENTATION

Every model will always include a considerable element of uncertainty. Some variation in the assumptions will result in somewhat different answers (Gupta et al., 1985; Goodman and Nguyen, 1985) However, we must offer the assurance that any result the system might communicate to the user is valid over a reasonable range of conditions, or in other words, that solutions are robust.

The graphical techniques of communication make it easy to incorporate uncertainty in the interface: scaling of symbols or color coding allow only a relatively low resolution. The basic qualitative aspects of results however, can be communicated very effectively by symbolic formats, and they should certainly be the more reliable aspect of any solution. Detailed numerical information certainly requires numerical formats – and interpretation, at least in the form of some qualification as to its precision.

Graphical representation can also imply the use of a more coarse yardstick, which, in most cases, is also the more appropriate and honest yardstick to use. But the use of symbolic and declarative, rather than numerical and procedural representations, also allows human experience and knowledge, both very important factors, to be tapped for inclusion in computer-based systems.

APPLICATION EXAMPLES

Under contract to the Commission of the European Communities' Joint Research Centre (JRC), Ispra, ACA is working on a project, *Decision-oriented Software for the Management of Hazardous Substances and Industrial Risk.* The primary intended application of the decision support system is for regulatory purposes e.g., within the framework of the EEC post-Seveso Directive or similar legislation. Based on a demonstration prototype developed in 1985 and installed at the JRC in early 1986, the system has now been extended toward a full-scale pilot system by the inclusion of several additional modules, new linkages between the modules, and a number of improvements as a result of first tests at the JRC. An assessment of the potential benefits of this modern approach was started with the development of a Demonstration Prototype System, called the IRIMS (Ispra Risk Management Support) system.

In a related project sponsored by the Dutch Ministry for Housing, Physical Planning, and the Environment (VROM), an *interactive, graphics-based intelligent interface* to a large *fault-tree analysis and consequence modeling* system is being developed, which addresses problems of production, transportation and use of chlorine in the Netherlands. In parallel, this serves as a test case for the concept and approach of the IRIMS system.

These two R & D projects implement several examples of the decision support approach described above.

Several databases, numerous simulation and optimization models, and specific decision support tools are integrated in an interactive and graphics-based user environment. At the current stage of development these systems include:

Databases:

Structures, test implementations, and integration with either interactive browsing programs, graphical display options, or operational simulation models have been completed for the following databases:

- **Geographic data**: the basic background map of the demonstration prototype is a contour map of Europe; the contents of various databases used in one or several of the simulation models can be viewed as interactively constructed map "overlays". They include:
  - political boundaries;
  - major settlements (>100,000 inhabitants; the actual settlements database is more than twice as large, including more than 1000 entries, which are used in the transportation network database);
  - European highway and national roads network (the complete European highway network as well as selected national roads, connecting the above settlements and numerous auxiliary towns; this database also provides direct input to the transportation risk/cost analysis module);
  - major industrial plant locations (concentrating on phenol and chlorine as major feedstocks or products);
  - chemical storage facilities (concentrating on phenol and chlorine);
  - major water bodies (rivers, lakes).

- **Hazardous chemicals database**: the chemical substances database includes a subset of the EC's ECDIN database (Figure 2). Its structure and contents are specifically geared toward the data requirements of the simulation models used. The preparation of a useful operational subset requires considerable input from the end user, in particular for compiling and processing the physical properties of selected substances, according to the substance description questionnaire developed. Detailed descriptions for a few individual substances as well as the allocation of substances to a few substance classes (organized largely by chemical taxonomy), defined together with the end user, have been included in the database (Fedra et al., 1987).

  Our approach foresees the use of a basic list of about 700 *substances* (or individual substances, i.e., entities that do not have any subcategories), constructed as a superset of EC and US Environmental Protection Agency (USEPA) lists of hazardous substances. In parallel we have constructed a set of *substance classes* which must have at least one element in them. Every *substance* has a list of properties or attributes; it also has at least one *parent substance class* in which it is a member. Every member of a group inherits all the properties of this group. In a similar structure, all the groups are members of various other parent groups (but only the immediate upper level is specified at each level), where finally all subgroups belong to the top group *hazardous substances.*

  While attributes of individual substances are, by and large, numbers (e.g., a flash point or an LD_{50}), the corresponding attribute at a class level will be a range (flash point: 18-30°C) or a symbolic, linguistic label (e.g., toxicity: very high).

  The structure also takes care of unknowns at various levels within this classification scheme. Whenever a certain property is not known at any level, the value from the immediate parent_class (or the composition of more than one value from more than one immediate parent_class) will be substituted. The structure is also extremely flexible in describing any degree of partial overlap and missing levels in a hierarchical scheme.

An interactive query and display facility for the existing substance and substance classes structure and the subset of individual substances included is implemented and linked to the overall framework. It provides access to individual substance descriptions either from a listing of substances or from substance classes.

- **Industrial waste streams database**: this uses a set of descriptors similar to the RCRA (US Resource Conservation and Recovery Act) database (ICF, 1984). Access to individual waste stream descriptions is either from a list of waste streams, through industrial origin, waste stream names (interpreted by an intelligent parser), or waste stream properties.

  From the individual waste streams, connections are implemented to the above substances database for the constituents of concern, as well as to the industrial sites database for the sources of these waste streams; the latter can be selected by identifying industrial locations from a map of the respective regions.

- **Chemical process technology database**: a chemical processes database, including unit processes, combined process technologies, and unit equipment, has been developed. A test example describing phenol chlorination with plant hardware configuration has been completed. The database is accessible from its own menu-driven interface, providing various access mechanisms including parsed language input, as well as from the hazardous substances database.

  The database, in turn, provides access to the waste streams database and the hazardous substances database. For the example of phenol chlorination, a complete knowledge base to drive the symbolic process simulator is included.

- **Industrial production sites**: a small subset of European producers (mainly related to phenol and/or chlorine production) has been compiled and integrated in a structure similar to the industrial waste streams database.

  Using the list of products and hazardous substances (as defined by the post-Seveso Directive) of a given site as a menu, the corresponding substance descriptions from the hazardous substances database can be displayed.

- **Chemical storage facilities**: chemical storage facilities provides a structure similar to that of the production facilities DB, concentrating, however, on major storage rather than production facilities.

  For the substances in storage, a connection to the hazardous substances database is provided, that allows the appropriate database entries for the respective chemicals to be called.

- **Major industrial accidents**: a simple display program for text files structured according to Appendix VI of the post-Seveso Directive has been developed. A short description of the Seveso accident is included as an example.

  From the accidents database, direct connections to the industrial site database and the hazardous substances database are provided.

- **Regulations and legislation**: along the lines of the above accident reports, the text files accessible through this module cover selected EC directives. As an example, excerpts from the post-Seveso Directive on major-accident hazards of industrial activities and the proposed dangerous substances listing for Directive 76/464/EEC are included.

These text files are also accessible from the hazardous substances database; a list of directives applicable for a specific substance is displayed as part of the information on that chemical. From this list, directives can then be selected for display.

Simulation/Optimization Models

The simulation models of the production system can be configured to describe the comprehensive life-cycle of hazardous substances. The major components of the simulation system are:

- the industrial production sector,
- use and market,
- waste management, including treatment and disposal,
- the cross-cutting transportation sector, and
- man and the environment.

Each of these major components is represented by several individual models, covering a variety of possible approaches and levels of resolution. Each element of the simulation system can be used in isolation, or it is linked with several others as pre- or post-processors into increasingly larger systems of interconnected models. None of the complexities of the system's integration are obvious to the user; the style of the user interface and interactions with the system are always the same at the user end.

Several simulation and/or optimization models have been integrated into the demonstration prototype. They include:

- **PDA (Production Distribution Area)** (Dobrowolski et al., 1982, 1984) is an interactive optimization code (based on DIDASS, one of a family of multi-criteria decision support tools developed at IIASA) and a linear problem solver, for chemical industry structures, configured for the pesticide industry (12 processes, 13 major products) of a hypothetical region.

  The user can select optimization criteria, define allowable ranges or constraints on these criteria, define reference points for the multi-criteria trade-off, and display various levels of model output, including the waste streams generated by the different industrial structure alternatives. These waste streams can then be used to provide input conditions for the environmental impact models.

- **Industrial Process Simulation**: the industrial process simulation module provides a rule-driven dynamic simulation of a production process, implemented in CommonLisp. It is based on a set of production rule packages representing the knowledge on the production processes and the necessary plant equipment driven by an inference engine which performs the forward-chaining of the rules.

  The production process starts as soon as input material is provided to the Operating Units which are connected to the external input streams. These Operating Units perform their Unit Activities depending on the input materials, the operating conditions of the Unit and the constituents of the Unit, and by this produce some output material, which they send (via the linked input/output streams) to other Operating Units, which are activated on receipt of input material. They too perform their Unit Activities and produce output; this activates other Operating Units and so on. After the production and the release of output material an Operating Unit is deactivated until it gets new input material. This sequence of activation and deactivation of Operating Units by materials terminates when there is no more input material for any of the Operating Units, e.g., all external input has been transformed to the desired products, by-products and waste.

During the simulation of the production process the *Operating Hazards* of the Units and the hazards caused by the materials used and produced (e.g. input materials, interim products, end products, waste materials), the *Material Hazards*, are recorded and dynamically updated in the form of Hazard Ratings.

The simulation module features an animated display of the basic steps in the chemical manufacturing technology described in the above technology database, and includes the dynamic display of risk ratings for the individual production steps and process streams (Winkelbauer, 1987).

- **LRAT (Long-Range Atmospheric Transport)**, a Lagrangian trajectory model (Eliassen and Saltbones, 1982) for large instantaneous sources describing e.g., major accidents, using a subset of the EMEP European synoptic wind is implemented on a European scale with completely interactive problem definition, context driven auto-startup feature, and extended (animated) graphical display for the simulation.

  The user can select the location for the accident by simply dragging a cross-hair cursor over the map of Europe. The magnitude of the emission, season, time of the day, and weather pattern can be selected by simply pointing at the appropriate description or icons symbolizing e.g., a repertoire of characteristic weather patterns. The appropriate input parameters are then automatically selected, scaled, or interpolated by the model system.

- **RIVER**, a simple river water quality model for toxic substances, extracted from the generic screening level USEPA model system TOXSCREEN (Hetrick and McDowell-Boyer, 1984) simulates pollutant dispersion in an arbitrary river segment (Figure 3). The model features extensive interactive input modification based on predefined default values as well as animated graphical display.

  The model is connected to the hazardous substances database, so that the parameters for specific substances can be loaded from this database after identifying a substance by one of the database access mechanisms.

- **FEFLOW** (Diersch, 1980), a 2D finite element groundwater contamination model, configured for a set of generic problem situations. Problem descriptions can be modified interactively, by setting pumping rates, activating or deactivating pumps or well galleries, specifying the concentration or mass flux of the pollutant source, and setting material parameters such as decay and adsorption rates. The model generates animated graphical output of flow fields and time-varying concentrations in the observation or pumped wells defined in a given problem.

  A more advanced standalone version has been developed, which combines a fast 1D screening level model with the 2D finite element model, economic evaluation, the dynamic display of spatially distributed pollutant concentrations, and finally geographical background data including LANDSAT satellite maps where appropriate.

- **HASTM (Hazardous Substances Transportation Model)**, a transportation risk/cost analysis (basic software elements developed by the Ludwig Boltzmann Institute, Vienna). The graphics-based interface developed for the model allows interactive definition of a transportation problem (Figure 4). The model is to be used in conjunction with the discrete optimization system described below.

After selecting starting and end points for a specific transport by pointing at these sites on the map, the user can select a specific substance either in terms of a symbolic description based on the hazard diamond code system, or by selecting a substance from the hazardous substances database and defining the amount to be transported. The model will then generate a set of route alternatives, and evaluate them in terms of transportation costs and risk estimates for alternative vehicle types.

Once a set of alternatives has been generated, a discrete multi-criteria decision support tool can be invoked for the comparative evaluation of this set.

- **Multi-criteria Discrete Optimization** (Data post-processor, DIDASS based), which is available as a data post-processor accessible from the main menu level as well as from selected simulation models. The module, based on the reference point approach (Lewandowski and Grauer, 1982; Wierzbicki, 1983) allows interactive problem definition, i.e., selection of relevant decision criteria, the setting of constraints for these criteria, identification of the pareto-optimal set (eliminating dominated alternatives) and provides extended graphical display options.

  These include projections of the decision space for interactively selected pairs of criteria in scattergrams, histograms for individual criteria, and the possibility to cross-reference alternatives in various projections. Finally, the user can define a reference point or a desired target solution, and then find the efficient solution, i.e., the solution closest to this target.

- **Process plant risk analysis (SAFETI)**. The parallel study for VROM develops an interactive and graphics-oriented framework and post-processor for the risk assessment package SAFETI (Technica, 1984) to facilitate the quick generation, display, evaluation and comparison of policy alternatives and individual scenarios.

  The SAFETI package is a computer-based system for risk analysis of process plants. The software package was developed under contract to the *Ministerie van Volkshuisvesting, Ruitmeljike Ordening en Milieubeheer*, in association with the *Dienst Centraal Milieubeheer Rijnmond*, by Technica Inc., Consulting Scientists and Engineers, London.

  SAFETI starts by generating a plant description; next, failure cases are generated and clustered; finally, the failure cases are processed by consequence analysis programs producing: radiation radii for early ignition of flammable gas; dense cloud dispersion profiles and associated flammable mass for late ignition; and toxic effect probabilities as "appropriate" consequence parameters can be combined to produce risk contours and F-N curves. SAFETI is accessible from the IRIMS master menu, and runs under its own interactive, line-oriented menu system.

  The graphical interface to SAFETI's databases and consequence modeling results allows for the display of the raw data such as plant locations, weather data, or population distribution as thematic overlays on a map. Once risk analysis, using SAFETI's original interface, has been performed for a specific process plant, the results are available for graphical display and interpretation. In addition to the F-N curves, risk contours can be displayed as transparent overlays on a map of the Netherlands. This map allows arbitrary zooming to provide the appropriate level of detail and resolution for a given problem.

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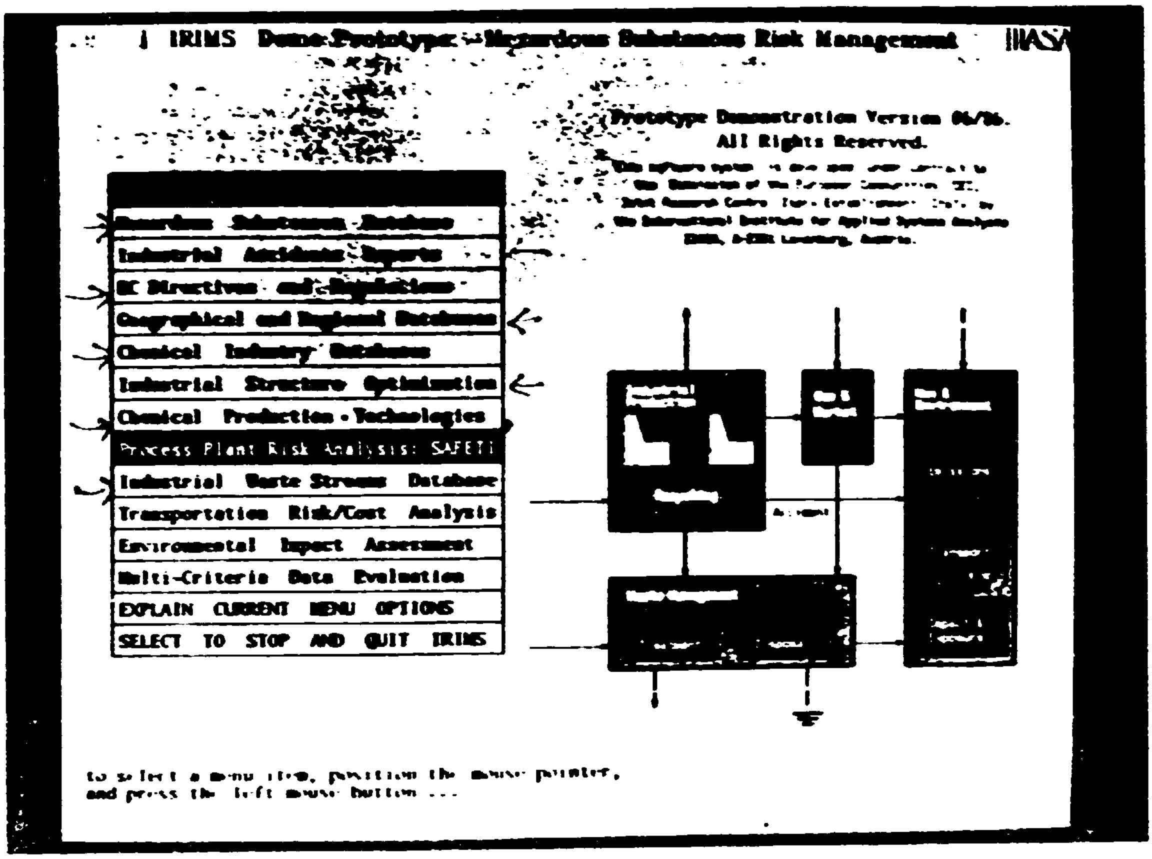

Figure 1 Top level system master menu

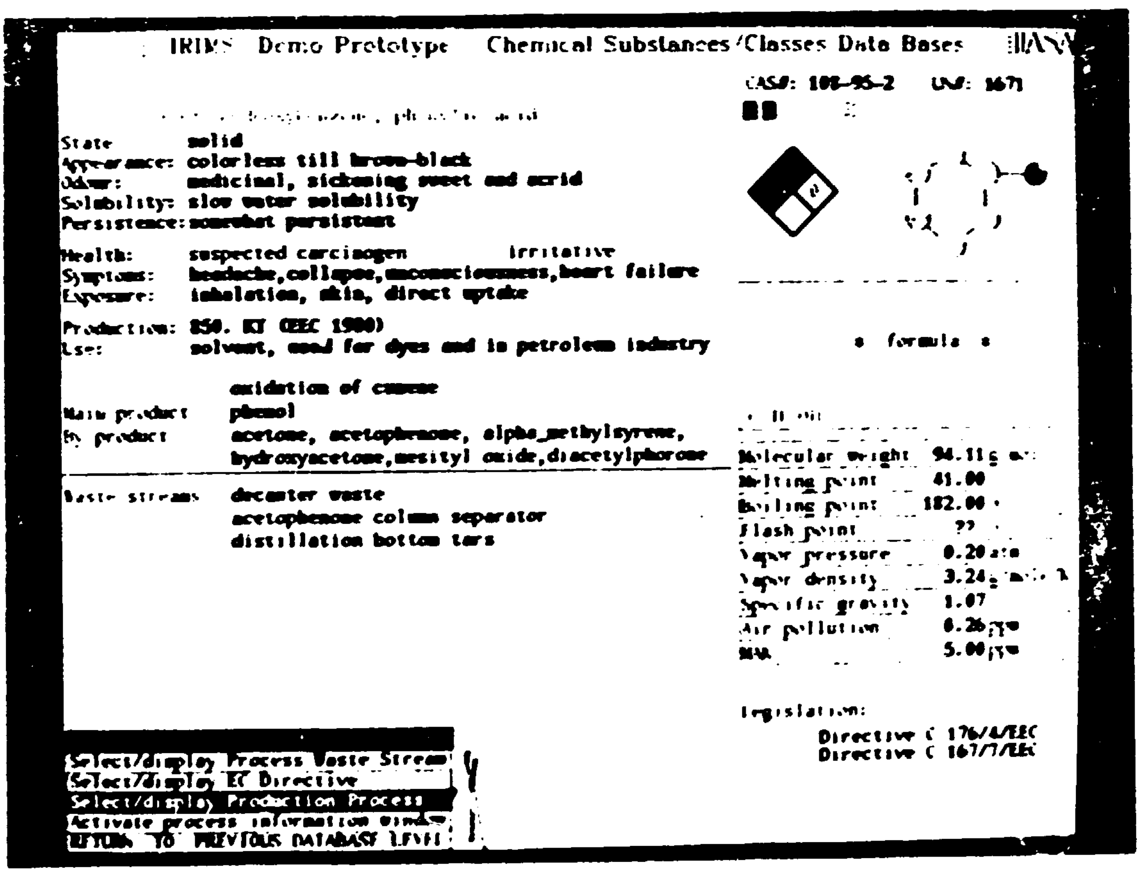

Figure 2 Summary page description for a basic substance

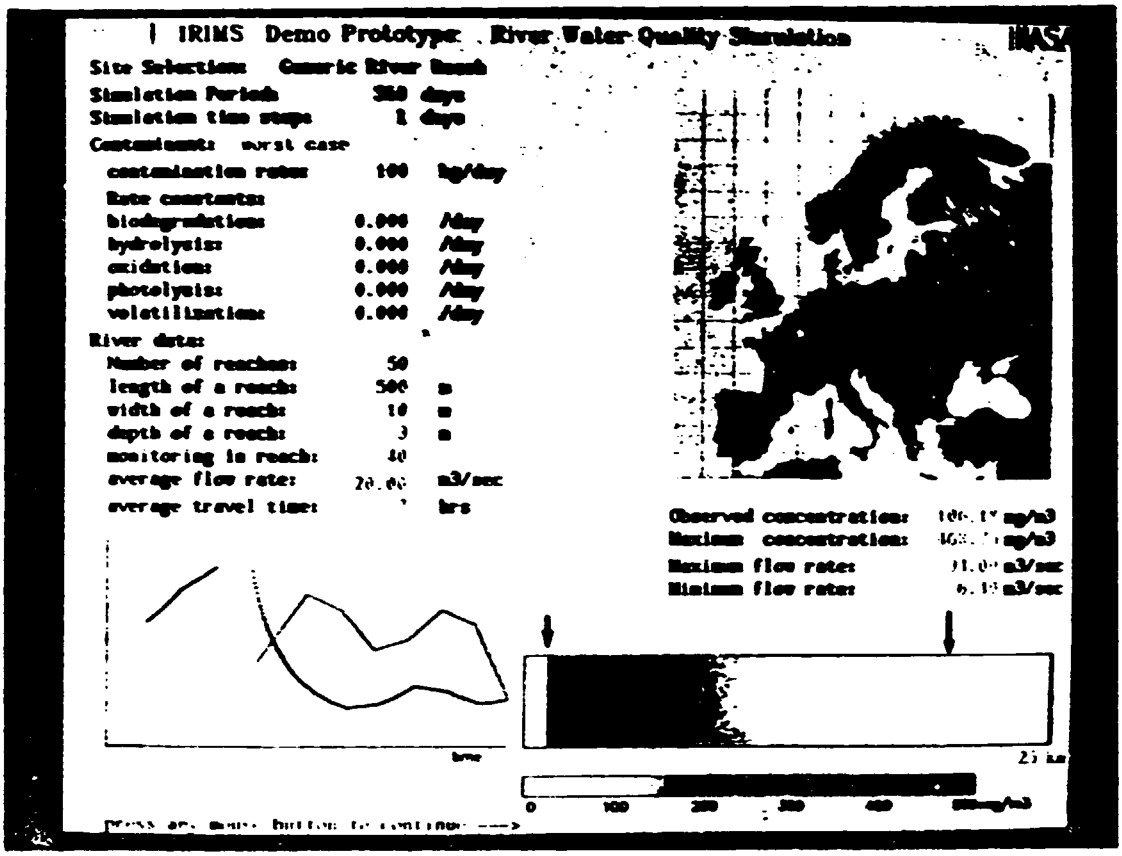

Figure 3 River water quality simulation model

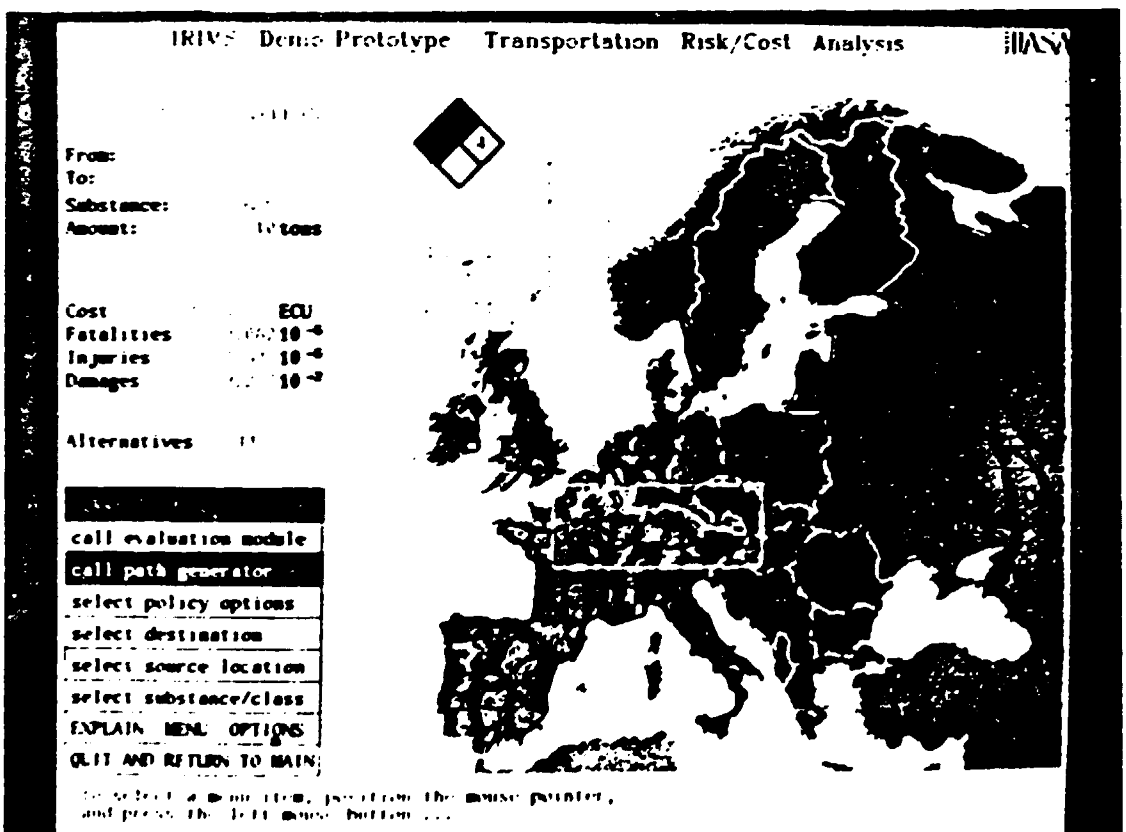

Figure 4 Transportation risk-cost analysis simulation model