Extending the Application of CARAT to Planning and Analysis

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Introduction

The Chemical Accident Risk Assessment Thesaurus (CARAT) is a database of entries that represent laws, regulations, guidance documents and definitions of terms related to the risk assessment of accidental releases of chemicals from fixed installations. The database also contains entries on the application of risk assessment using specific examples of potential chemical releases. These entries do not simply reproduce the original documents but convert the documents into 'operational language', thereby reducing or eliminating confusion that often arises with the interpretation of specific wording or translation from one language to another. The data is based on a common set of operational terms that have been selected as appropriate translations of the intended meaning derived from the source document. The CARAT contains information entered by various international and national agencies, chemical companies, and individuals regarding risk assessment processes related to chemical releases. The entire system is accessible via the Internet at http://www1.oecd.org/ehs/carat/v3.0/htm/default.htm

The CARAT is a useful resource for developing requirements for risk assessment of chemical accidents and comparing results to existing guidance. But to stop there would fail to utilize the full potential of the system. The structure of the CARAT provides a comprehensive checklist that can be used to identify those items that need to be addressed in a risk assessment prior to performing the risk assessment. In addition, the hierarchy and format allow the database to be used to analyze accidents, thereby documenting the risk assessment aspects for future use and comparison to other entries. The present mandate of the committee does not specifically include these applications.

Background

Following a workshop on Risk Assessment held in Paris in July, 1995, the Working Group on Chemical Accidents of Organization for Economic Cooperation and Development (OECD) recognized the potential for problems associated with misinterpretation of risk assessment terms. The Working Group established a task team with a mandate to establish a tool that would address this concern. The result of this work is the Chemical Accident Risk Assessment Thesaurus (CARAT).

The Thesaurus:
- makes more transparent the various approaches used in different countries to assess the risk of an accidental release of chemicals from fixed installations;
- promotes understanding of, and communication about, chemical accident risk assessment processes including the commonalties and differences among the various approaches; and
- facilitates communication concerning chemical accident risk assessment between, and within, countries, helping to overcome the problems introduced because of different cultures and language.

The CARAT does not attempt to harmonize or establish standard terminology or to make judgement on the value of various risk assessment methodologies. Instead, the CARAT captures only what risk assessment professionals understand to be the state of understanding of particular laws, regulations, or procedures currently in effect or in use. It can be viewed as a "translation engine" which captures the intended meaning of a risk assessment item and "translates" it into objective or operational language.

Structure and Hierarchy of the Entries

There are four classes of information that can be entered into the System:
1. Definitions of words and phrases associated with risk assessment;
2. Laws and regulations concerning risk assessment of hazardous facilities;
3. Guidelines, policies or codes related to risk assessment; and
4. Specific risk assessment studies that have been conducted on particular cases.

Persons making an entry into the database interpret the meaning they attach to their entry by responding to a series of questions that lead the person through the System hierarchy and, at each level, probes successively deeper using more specific expressions to convey the meaning. There are five levels in the hierarchy:

1. *Generic elements*, a set of related, operationally defined process steps;
2. *Sub-elements*, one of the operationally defined process steps contained in a Generic Element;
3. *Terms*, the concept which is the subject of the process defined in the Sub-element;
4. *Categories*, a set of examples used to give specific operational meaning to a Term; and
5. *Descriptors*, single examples illustrative of specific operational situations in the Category.

At its highest level, the CARAT hierarchy consists of four broad *generic elements* representing the commonly accepted stages in the process of assessing the risks associated with hazardous installations. They can be loosely described as
- hazard identification;
- hazard release and exposure scenarios;
- source and subject interaction; and
- expression of the risk.

In addition, there are two other elements that may be utilized to capture aspects that are generally considered outside the risk assessment process, *per se*. A Pre-assessment element captures features that are judged to precede risk assessment processes, such as a statement of the scope of the entry; and a Post-assessment element that describes features that generally follow the risk assessment process itself, such as, risk management or risk communication. The Pre- and Post-assessment elements are free-form text facilities, lacking the hierarchical structure of the four generic elements.

The four Generic Elements are presented in Figure 1. Because the risk assessment process is presented in operational language, i.e., uses no 'terms of art,' the language of the Generic Elements tends to be wordy, and uses words that lack immediate connection to any specific risk assessment.

Figure 1- The Four Generic Elements of CARAT

Generic Element I: Identification of sources with the potential to cause undesired outcomes to subjects of concern that is the focus of the estimation of likelihood.

Generic Element II: Identification of possible sequences of events leading to loss of containment of the potential to cause undesired outcomes to a subject of concern resulting in its entry into a domain of the ecosystem. Estimation of possible distributions of both the released potential and the subjects of concern over time periods within compartments delimited by specified boundaries or end-points.

Generic Element III: Identification and description of how the specified undesired outcome is related to the intensity, time, and mode of contact of a specified potential to cause the undesired outcome to the subject(s) of concern.

Generic Element IV: Consists of two parts: Part A: Identification of the methods for estimating and expressing the likelihood of a specified effect and describing the quality of such estimates. Part B: Identification of the basis for comparing derived estimates of likelihood to specified guidelines and describing the dependence of these estimates on explicitly specified alternative assumptions.

Generic elements have varying numbers of *sub-elements*. Sub-elements are procedural in nature and represent operations, methodologies, actions, or process steps that encompass a phase of the generic element in the risk assessment process. Each sub-element has an associated *term* that is the subject of the action defined by the sub-element. In grammatical terminology, terms are noun phrases, lacking any notion of 'action,' and sub-elements are verb phrases, containing the notion of 'action on a subject.' Figure 2 illustrates *sub-elements* and *terms* for Generic Element I.

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Figure 2. - Sub-elements and Terms Corresponding to Element I

  Element I
    Sub-element I i: Identification of sources with the potential to cause undesired outcomes
    to subjects of concern
        Term I i: Sources with the potential to cause undesired outcomes

    Sub-element I ii: Identification subjects of concern
        Term I ii: Subjects of concern

    Sub-element I iii: Identification undesired outcomes to subjects of concern
        Term I iii: Undesired outcomes to subjects of concern
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Each term is divided into *categories* of specific sets of *descriptor* examples that are the operational representation of the intended meaning. Descriptors allow the person entering an item to describe the risk assessment operation with ultimate specificity. Figure 3 shows the Categories associated with Sub-element I, Term 2.

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Figure 3 - Categories Corresponding to Element I, Sub-element I, Term 2: Subjects of concern
        Categories:
            People
            Ecosystems/environment
            Cultural assets
            Property and physical systems
            Facilities
            Other subjects of concern
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In Figure 4, one can trace a specific path through the hierarchical structure. Element I deals with the operation of "identifying sources of the potential to cause undesired outcomes to subjects of concern". This is decomposed into three Sub-elements (operations), one of which is "Identification of subjects of concern". The Term for this Sub-element is "Subjects of concern". Associated with this Term are Categories of descriptors such as 'people', 'property', 'ecosystems' etc. Each category contains specific Descriptors. For example, the Category 'people' contains Descriptors such as 'residents,' 'workers,' 'pregnant women,' etc. The system also contains provisions for entering additional descriptors in a Category, or indeed new Categories if the suggested ones do not directly capture the intended meaning in a given situation.

Generic Nature of the Entry Process

The data entry process provides the opportunity to add levels of detail or to provide general descriptions of the specific reference being entered. In addition, the client is permitted to add other descriptors. The client may type in wording that better describes the meaning under that category. The system adds the new item to the existing list. As many additional descriptors as are required for the entry may be entered, thereby increasing the scope of the database.

Query Capability

The greatest value to the user is probably the public access to the information contained in the CARAT by means of the query module. The query module can search the CARAT for its entries and present the results on-screen for immediate examination or send the results of the search to a local printer. A "Comparison" facility allows the user to make a side-by-side comparison of the CARAT entries of laws, regulations, Specific Risk Assessments, Risk Assessment Guidance, or definitions, in any combination. The comparison can be made at the element, term, category, or descriptor levels. The final query can perform searches by identifying entries that contain either certain combinations of hierarchical details (Hierarchy searches), or certain combinations of descriptor details (Descriptor searches). Both types can be conducted in Boolean 'and/or' mode, and the Descriptor searches can specify items that are to be excluded from the search.

Application of the CARAT System

Most comparisons using CARAT will focus on comparing various laws and regulations, definitions or specific risk assessments. But the system is much more powerful, especially to corporate users. Companies can put specific standards, guidelines, risk assessments, or other risk-related applications into the system and use the comparison feature to determine where the specific input may be at variance with the legal system in the country. For a company like NOVA with facilities in several countries, a comparison of the risk assessment standard to the laws and regulations in the various countries can verify that the standard meets the requirements of all or some of the countries. This type of comparison provides guidance regarding areas where changes should be meet to assure compliance.

The system source code can also be obtained from the OECD and installed on a company's local server. Using this facility the company can enter specific standards and codes of practice and compare work from the various sites to assure that the requirements have been met. The system could also be used as repository for specific risk assessments. These could be accessed by employees within the company and used as guidance for other risk assessments. It would also provide an archive facility for those wishing to update risk assessments on a regular basis.

Users of the database can compare entries to determine areas of conformity and areas of difference. This is especially important when existing programs or processes are be used to meet legal requirements in

different countries or jurisdictions. The system can also be used to assure that specific risk assessments meet the requirements outlined in specific legislation or guidance.

Although the experience in using CARAT in the earlier developmental stages indicated that the data entry process required an intensive effort, participants noted a number of benefits that extended beyond the mere entry of risk assessment approaches into a computer system. Remarkably, participants noted a deepening understanding of their own country's or agency's laws and regulations, and they gained insight into areas of weakness or ambiguity. Through the clarity of operational language, the CARAT is a convenient source of guidance on the risk assessment processes required at individual facilities, and assists, in general, in designing and managing risk assessment programs.

Extension of the CARAT

The system has been in the development and test modes for the last four years. During the past year the system has been available in the public domain. Over this period, it has been noted that the system has broader applicability than simply using it for comparison queries. The system contains an extensive database of risk assessment concepts and terms. As more information is input to the system it will grow due to the addition of new terms, criteria, and tools. This information can be used to advantage by those responsible for completing risk assessments.

Let's consider a risk assessment for a gas plant in Alberta. The company desiring the risk assessment approaches a firm that specializes in risk assessment and requests that they complete the study so the company can determine if anything needs to be changed at the gas plant to make the risk acceptable. The firm has completed risk assessments in the past, but never on a gas plant.

The first step the consultant takes is to access CARAT to review the legislation applicable to the plant. Since the plant is in Alberta, there is nothing specific to provincial requirements; however, the Canadian Environmental Protection Act, sections 199 and 200 provide some guidance, including the need for an emergency response plan. The consultant then checks for specific risk assessment guidance and finds references to Risk Assessment Guidelines for municipalities and Industries, The CCPA Implementation Guide for Acute Risk Assessment, and NOVA Chemicals Responsible Care Standard on Management of Process Risk. These provide additional guidance but are still not specific enough.

The next step is to check for specific risk assessments that may have been entered. There are entries for chlorine and propane, but nothing directly related to a gas plant. At this point the consultant could
- initiate a study by brainstorming using the risk management model outlined in the Risk Assessment Guidelines for Municipalities and Industries;
- try to find someone that had completed such a study; or
- use CARAT as a template to develop the required elements of the risk assessment.

To use the CARAT, the consultant would begin with Element 0 and outline the scope of the project, time frames, location of the facility, and any other relevant information. Element 1 would be used to identify the sources of risk, the subjects of concern that could be affected by the source, and the undesired outcomes that could be expected from an interaction between the sources and the subjects of concern. The exercise would continue through the other elements using the CARAT database as a structure for laying out the study. The existing database should cover at least 90% of the items to be considered. The results of the entry can then be compared against other risk assessment entries to check for obvious holes, and the entry can be modified to correct the deficiencies. The end result is a more comprehensive study that is less likely to miss relevant input.

The second extension to CARAT is to document incidents. Risk assessment studies of hazardous materials are aimed at predicting those events that could happen, the frequency at which they could happen, the distribution of the material taking into account meteorological and topographical conditions, and the outcomes associated with the scenario. In completing these studies numerous assumptions must be made in order to do the modeling. The quality of the assumptions has a significant effect on the quality of the results.

The CARAT was developed to document laws and regulations, risk assessment guidance, specific risk assessments, and definitions. There was never any consideration given to using the system to analyse incidents; however, the database provides all the necessary features to allow this to happen. The input would begin with element one where the specifics of the incident, including such things as date, place, time and background information on the facility, would be entered.

Element 1 would document the source of the hazard, those that were affected by the incident (subjects of concern), and the actual outcomes of the interaction between the sources and the subjects. Element 2 would document the sequence of events leading to the loss of containment, release rates and duration, weather conditions, terrain, distribution limits and concentrations of the material, and distribution of the subjects of concern. Element 3 would document the undesired outcomes along with the methodologies used to determine the outcomes. For example, subjects of concern may be exposed to the IDLH concentration and may have suffered no ill effects. Or the effect of sheltering or protection can be identified to assess their degree of mitigation. Element IV would be used to express the outcomes. These could be contours of injury or fatality, damage circles, contamination levels, or other applicable outcomes, along with the degree of uncertainty or minimum/maximum ranges for the outcomes. Element V would be used to document the emergency response aspects of the incident.

Once the incident is in the database, it can be compared to the applicable risk assessment documents to identify gaps in legislation, regulations, or guidance documents. The comparison could also be used to identify areas that are not adequately addressed in the incident investigation. This information can then be used to improve the quality of future investigations.

The number of entries that will be put into the CARAT will increase at a decreasing rate. As countries enter their laws and regulations, companies and associations enter their guidance documents, and practitioners enter specific risk assessments, the reservoir of available entries will decrease. In addition, the present database has nothing against which to validate these entries. Incidents will continue to occur, and entering these into the database in a risk assessment format will keep the database evergreen and provide a continually increasing resource to validate existing and new laws regulations and risk assessment guidance.

Acknowledgement