INTERTRAN2 - A Computer Code for Calculating the Risk from Transportation of Radioactive Materials.

Ann-Margret Ericsson and Clifford Järnry,
AMC Konsult AB, Sweden

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In this paper a description of IAEA Coordinated Research Program (CRP) dealing with the updating of the computer code INTERTRAN is given. The paper includes a summary of the work performed by several member states within the CRP as well as gives a description of the final product that will be presented to the IAEA. As Sweden has been a part of the CRP this paper naturally focuses on the contributions made by Sweden. It is expected that a lot of the very extensive work provided to the CRP by participating member states will be presented in other papers at the PATRAM symposium.

The first version of the internationally developed computer code INTERTRAN was released by the IAEA in 1983. The code was a result of a cooperative effort from countries participating in the coordinated research program (CRP) on "Risk Assessment Techniques Related to the Safe Transport of Radioactive Materials" 1979-1981.

The INTERTRAN model released in 1983 was provided to member states of the IAEA to use for risk calculations on transportation of radioactive materials.

In 1987 a meeting was held in Stockholm, Sweden, to discuss experience gained from using the INTERTRAN code for risk estimates. The users present in Stockholm had been using the code for different purposes, some had been using the code to perform a complete risk assessment on the radioactive materials transportation in their countries while others had used the model to study a specific transport.

It was found, however, that experiences gained during the years could be used to update the code. It was also found that the original goal of developing a tool for making world-wide risk assessment had changed to developing a tool available to all IAEA Member States for use in studies of specific transportation problems.

The group that met in Stockholm was able to formulate a philosophy that all participants at the meeting could agree upon. The philosophy was stated as follows:

The INTERTRAN computer code should:

- be a tool on a national basis to provide absolute or relative numbers to be used either for comparison of the risk from different shipment options or show the consequences of a certain shipment when asking for transportation permits

- be a tool for national risk assessments

- be a tool for making specific shipment studies
- be a tool that is international in the sense that it is tested and confirmed as adequate internationally
- treat both nuclear material, industrial materials and radiopharmaceuticals
- be user friendly
- be well documented, with clear description of how input data are prepared, how they can be changed etc..

Upon recommendation of its main advisory group, SAGSTRAM, the IAEA decided to organize a Coordinated Research Program to update the INTERTRAN computer code according to the experiences gained from the use of the first version. It was also recognized that the only way to get an internationally accepted code is that the code comes out of a collective effort of member states to make sure that as many needs as possible are satisfied.

The first Research Coordination Meeting of the INTERTRAN2 coordinated research program was held in Albuquerque, NM, USA, in October 1989. This meeting determined the goals and time schedule for the revision of the INTERTRAN.

Since that time eleven Member States of the IAEA have been participating in the CRP. These countries are Canada, Egypt, Finland, France, Germany, India, Japan, Peoples Republic of China, Sweden, UK and the USA. Two additional meetings have been held within the group, in Vienna July 1990 and in Paris September 1991.

The member states of the CRP all agreed that the end product to be presented to the IAEA should be a computer code based on the US computer code RADTRAN4 (Neuhauser and Kanipe, 1992). Sandia National Laboratories agreed to make RADTRAN4 available for use within the group. Sandia also volunteered to make a version modified in accordance with the recommendations from the group.

The code INTERTRAN2 should be runable on a PC (at least a 286 suitable for Windows). Modifications for use on a PC are made by AMC Consultants in Sweden.

In addition to the code for assessing the risk from transporting radioactive materials, an atmospheric dispersion model should be submitted. The atmospheric dispersion model chosen is submitted by France, Commissariat á l'Energie Atomique (CEA) (Pages et Rancillac, 1992).

Furthermore, experiences reported by member states indicated that many users encountered problems when trying to run the code. For the PC version it was therefore agreed that a preprocessor should be developed to facilitate the input data generating. The Swedish Nuclear Power Inspectorate offered, through AMC Konsult AB, to develop the preprocessor (the preprocessor will be presented in more detail later in this paper).

In addition to the different codes, proper documentation on each of the parts will be provided. Technical documentation as well as a user's guide giving a step by step instruction for using the preprocessor and running the code will be provided.

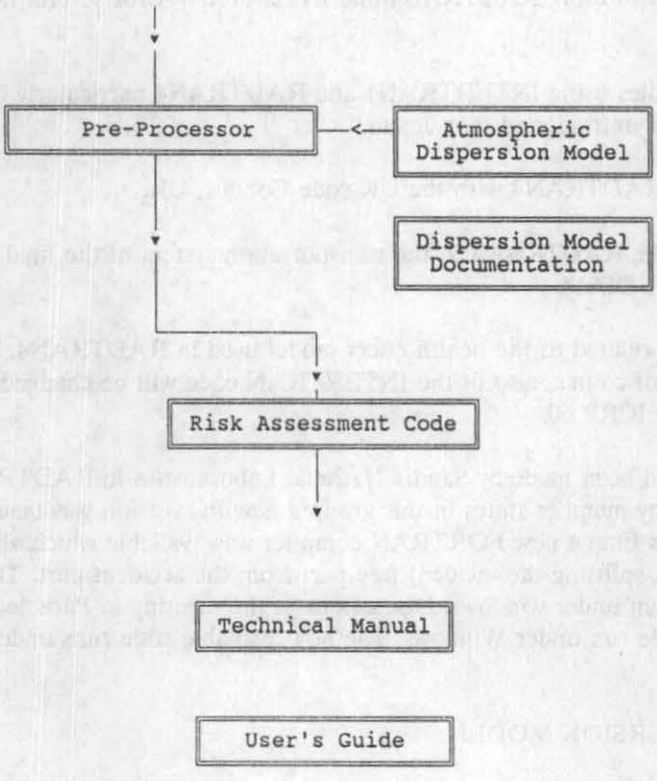

Figure 1. Content of end product.

In December 1989 the first PC version of RADTRAN4 was produced and distributed to members of the CRP by AMC Konsult AB. The size of the code made it necessary to split the original code in two parts to be run separately, one part containing the incident free case and one part dealing with the accident case.

COMPARISON STUDIES MADE BY MEMBER STATES

Several of the participating member states have contributed to the project by making comparison studies using the old INTERTRAN1, RADTRAN versions on main frame computers and the PC version of RADTRAN.

Examples of comparison studies made by member states are;

- Shipments of radioisotopes and nuclear fuel cycle related materials, India.
- Comparison studies of transportation of uraniumhexafluoride using INTERTRAN1 and RADTRAN4, Peoples Republic of China.
- The use of INTERTRAN/RADTRAN in the safety analysis for the transport of radioactive materials to the planned repository KONRAD in Germany, Germany (earlier FRG).
- Transportation of spent fuel, Canada.
- Transportation of spent fuel, Finland.

- Comparison studies using RADTRAN4 and INTERTRAN1 for several radioactive materials, Egypt.

- Comparison studies using INTERTRAN1 and RADTRAN4 particularly for the analysis of road transportation of unirradiated fuel, Japan.

- Comparison of RADTRAN4 with the UK code Condor, UK.

- Application of the RADTRAN4 to the transportation system of the final repository Morsleben, Germany (earlier DDR).

A lot of comments were related to the health effect model used in RADTRAN4. This part of the RADTRAN4 code, and of course, also of the INTERTRAN code will be changed in the near future in accordance with the new ICRP 60.

After several changes had been made by Sandia National Laboratories in RADTRAN4 some resulting from experience gained by member states in this group a new PC version was made based on the version RADTRAN 4.10. At this time a new FORTRAN compiler was available which allowed the code to be run in one piece without splitting the incident free part from the accident part. This could only be done though if the code was run under windows. Discussions at the meeting in Paris led to accepting requirement that the code run under Windows. The now available code runs under windows 3.0.

ATMOSPHERIC DISPERSION MODEL

Previously, dilution factors were given as default values within the INTERTRAN code not taking into account release height and removal processes. The reason for having a separate atmospheric dispersion model is to provide the INTERTRAN user a separate tool for calculation of atmospheric dispersion factors. The atmospheric dispersion model, TRANSAT, provided by the Commissariat á l'Energie Atomique in France, takes into account supplementary parameters such as release height and removal from cloud by wet deposition.

The TRANSAT model uses a Gaussian plume model with standard deviations calculated according to the Pasquill type scheme of weather conditions. The input parameters are release height and isodose areas. If isodose areas are not submitted default values conforming with the values in RADTRAN are used.

The atmospheric dispersion model provides tables containing dilution factors for all six Pasquill categories for a chosen number of areas and a chosen release height. Several runs can be made by TRANSAT and all results are stored in files. These files can be loaded into databases in the preprocessor. Different Pasquill category tables can be selected from the preprocessor when making an input data block. Weighted averages of dilution factors (when probabilities of different Pasquill categories are used) are calculated within the preprocessor.

PREPROCESSOR

After the first PC version of RADTRAN4 was released to members of the CRP for test runs, it was apparent that preparing the input data block was not an easy task for everybody. Therefore it was agreed to develop a preprocessor to facilitate the input data preparation.

For the inexperienced user the preprocessor will work as a tool to help the user prepare the input data blocks for the code. This is done through an interactive procedure supported by on-line help functions containing explanations and descriptions as well as tables of default data etc..

For the experienced user the preprocessor will facilitate the compilation of the input data for example when performing parameter studies. This is done by using data bases which gives the user a possibility that in an easy way combine groups of data like packages, routes, Pasquill categories, economical data etc..

In addition, the preprocessor will prevent errors in the input data block by an advanced QC function checking the data and warning the user when impossible combinations or data not allowed are introduced.

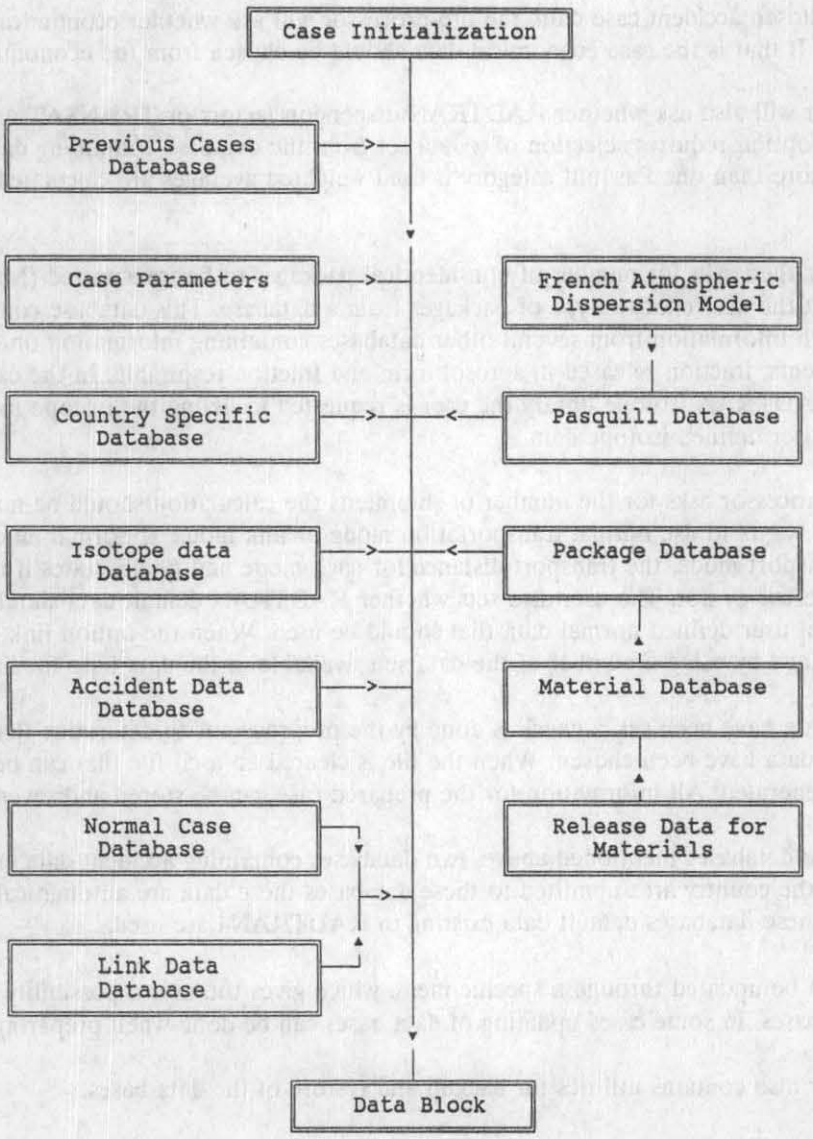

Figure 2. Preprocessor

The preprocessor is constructed around several data bases used to put together the input data block. By stating whether the input data should cover the incident-free and/or accident case and if population dose calculations or health effect calculations should be performed the preprocessor gives the user a possibility to chose a set of data (one record) in each of the relevant data bases. The user can also chose to modify an earlier used case as the preprocessor also contains a specific data base keeping track of earlier cases run.

After setting the main parameters mentioned above the set of system parameters are chosen by the user. This includes the choice of shielding options, flags for different outputs etc..

After that, the preprocessor is asking whether country specific data instead of the default data included in RADTRAN 4 should be used. If the user want country specific data the adequate set of data can be chosen from a pop-up help screen. The country specific data base contains country specific data submitted to the data base by the user. For example population densities, ratio of pedestrian densities, building shielding factors, fraction of rural land under cultivation, cleanup levels etc. are stored in this data base.

If the user has chosen accident case data, the pre-processor will ask whether economical calculations should be made. If that is the case economical data should be chosen from the economical data base.

The preprocessor will also ask whether RADTRAN dispersion factors or TRANSAT data should be used. The TRANSAT option requires selection of a data set from the database containing data calculated by TRANSAT. If more than one Pasquill category is used weighted averages are calculated within the pre-processor.

The preprocessor then asks for number of non-identical packages to be transported (Maximum 12). When the number is set the user chooses type of packages from a database. This database compiles information on a package with information from several other databases containing information on content, fraction released in accidents, fraction released in aerosol form and fraction respirable. In the case an isotope is missing in the RADTRAN isotope library the user is requested to define the isotope in a specific data base containing user defined isotope data.

Finally, the preprocessor asks for the number of shipments the calculation should be made for and whether the user wants to use normal transportation mode or link mode. If normal mode is chosen the user sets the transport mode, the transport distance for each mode and finally states if the transport is made as exclusive use or not. The user also sets whether RADTRAN default data should be used or defines the sets of user defined normal data that should be used. When the option link is used a specific route can be defined by using a number of the data sets available in the data base for links.

After all input data have been set, a check is done by the preprocessor to determine that no not allowed combinations of data have been chosen. When the file is cleared an ascii-file that can be used as input to RADTRAN is generated. All information for the prepared case can be stored and saved in a data base.

In addition to the databases mentioned above, two databases containing accident data exists. If accident data specific for the country are submitted to these databases these data are automatically used. If no data are provided to these databases default data existing in RADTRAN4 are used.

All databases can be updated through a specific menu which gives the user a possibility to, in an easy way, support his databases. In some cases updating of data bases can be done when preparing an input file.

The preprocessor also contains utilities for backup and restore of the data bases.

SPECIAL STUDIES

Studies of specific problems have been carried out by members of the group, for example collection of accident severity categorization data has been made. Canada, through Ms Theo Kempe, Ontario Hydro, has been responsible for the collection and compilation of these data. Even though a wide variety of methods had been used to derive probabilities and the probabilities received are dependent on national/local statistics the framework was regarded as useful in respect that it brings data to a common basis or identifies where different data bases have been used.

It was however, at this time found that there was not enough data in the collection to form a nucleus for recommended data sets.

TIME SCHEDULE

The INTERTRAN2 package will be presented to the Agency in 1994.

A beta version of the code including the preprocessor and the atmospheric dispersion model as well as a draft documentation will be presented to the group at the next meeting which is planned to be held in Cologne, Germany in January 1993.

Some time will be available for comments on the product.

The final code and documentation will be ready for presentation at the final meeting of the group a year later.

References

Neuhauser K.S. and Kanipe F.L. RADTRAN4: Volume 3, Users Guide, 1992.

Pages P. and Rancillac F. TRANSAT, Programmers Guide, 1992.