ABSTRACT

The paper presents the development of a modern computer environment for the preparation and execution of the deterministic neutron-gamma computer codes in a user friendly way, adopted for today standards and users. At present, the system integrates the codes for the nuclear cross-section preparation (TRANSX-2.15), the code PARTISN for 1-, 2-, and 3-dimensional neutron and gamma transport calculations and the SUSD3D code for the nuclear data sensitivity and uncertainty analysis. User-friendly plotting codes are also available for the 3-dimensional visualisation of neutron fluxes, spectra and sensitivity profiles. The system will be available through the OECD/NEA Data Bank.

1 INTRODUCTION

Several high quality deterministic neutron transport codes are available from the OECD/NEA Data Bank, such as ANISN [1], DORT-TORT [2], DANTSYS [3], PARTISN [4] etc. The developments of many of these codes dates back to the 60-ies and 70-ies and use the computational standards of these times. Nowadays these tools are less and less used, on one side due to the progress achieved in the Monte Carlo codes, and on the other due to the archaic input formats used by these old transport codes. However, the deterministic codes are still attractive for the use in many possible applications, be it for the sensitivity and uncertainty analyses, deep penetration problems and validation of Monte Carlo calculations. The motivation for this work was to facilitate the use of deterministic transport codes within a modern environment and thus bring these tools to the nowadays users.

2 COMPUTER CODE SYSTEM DESCRIPTION

With the objective to allow an easier utilisation of the deterministic codes an user – computer interface was developed based on the Xbase++ (R) Compiler 1.90.331 and Alaska 32-Bit Linker [5], for the pre- and post-processing of the input and output data. The computer code environment encompasses the complete self-consistent set of deterministic codes with the following utility functions:

- nuclear cross-section preparation
- transport of neutral particles for criticality and shielding calculations
nuclear data sensitivity and uncertainty calculations

The system contains some older as well as few more recent computer codes (TRANSX
[6], PARTISN [4], SUSD3D [8]) traditionally difficult to use. All these codes are available
from the OECD/NEA Data Bank and RSICC. Objective of this work was to make the input
and output handling for these codes as user friendly as possible, passing information among
the codes internally.

2.1 TRANSX-2.15 [6]

TRANSX is a computer code that reads nuclear data from a library in MATXS format
and produces transport tables compatible with many discrete-ordinates ($S_N$) and diffusion
codes. MATXS format libraries are prepared using the NJOY-99 [7] code (or more recent
versions). Tables can be produced for neutron, photon, charged-particle, or coupled transport.
Options include adjoint tables, mixtures, homogeneous or heterogeneous self-shielding, group
collapse, homogenization, thermal upscatter, prompt or steady-state fission, transport
corrections, elastic removal corrections, and flexible response function edits.

TRANSX reads through the materials in a MATXS library and accumulates the cross
sections into a transport table using the user’s mix instructions. At the same time, response
function edit cross sections are accumulated using the user’s edit instructions. They can thus
be any linear combination of the cross sections available in the library. When the table is
complete, it is written out in the desired format. Output options include DTF-style card
images, FIDO, ISOTXS, and the binary group-ordered GOXS format.

TRANSX is written in FORTRAN-77 and runs under DOS, LINUX and UNIX
operating systems.

2.2 PARTISN [4]

PARTISN (PARallel, TIme-Dependent SN) is a relatively recent $S_N$ transport code for
shielding and criticality calculations and the evolutionary successor to CCC-547/DANTSYS.
The code is a modular computer program package designed to solve the time-independent or
dependent multigroup discrete ordinates form of the Boltzmann transport equation in several
different geometries. The modular construction of the package separates the input processing,
the transport equation solving, and the post processing (or edit) functions into distinct code
modules: the Input Module, the Solver Module, and the Edit Module, respectively. PARTISN
is the evolutionary successor to the DANTSYSTM code system package. The Input and Edit
Modules in PARTISN are very similar to those in DANTSYS. However, unlike DANTSYS,
the Solver Module in PARTISN contains one, two, and three-dimensional solvers in a single
module. In addition to the diamond-differencing method, the Solver Module also has
Adaptive Weighted Diamond-Differencing, Linear Discontinuous, and Exponential
Discontinuous spatial differencing methods. The spatial mesh may consist of either a standard
orthogonal mesh or a block adaptive orthogonal mesh. The Solver Module may be run in
parallel for two and three dimensional problems. One can run 1-D problems in parallel using
Energy Domain Decomposition.

Both the static (fixed source or eigenvalue) and time-dependent forms of the transport
equation are solved in forward or adjoint mode. In addition, PARTISN has a probabilistic
mode for Probability of Initiation (static) and Probability of Survival (dynamic) calculations.
Vacuum, reflective, periodic, white, or inhomogeneous boundary conditions are solved.
General anisotropic scattering and inhomogeneous sources are permitted. PARTISN solves
the transport equation on orthogonal (single level or block-structured AMR) grids in 1-
dimensional (slab, two-angle slab, cylindrical, or spherical), 2-dimensional (X-Y, R-Z, or R-T) and 3-dimensional (X-Y-Z or R-Z-T) geometries.

PARTISN is written in FORTRAN-95 and runs under Linux, DOS Windows, and UNIX operating systems.

2.3 SUSD3D [8]

SUSD3D is a multi-dimensional nuclear cross-section sensitivity and uncertainty code, based on the first-order generalised perturbation theory. The code calculates the sensitivity coefficients and standard deviation in the calculated detector responses or design parameters of interest due to the input cross sections and their uncertainties. Complex one-, two- and three-dimensional transport problems can be studied. Several types of uncertainties can be considered, i.e. those due to:

- (1) neutron/gamma multigroup cross sections,
- (2) energy-dependent response functions,
- (3) secondary angular distribution (SAD) or secondary energy distribution (SED) uncertainties.

Either relative \( \left( \frac{\sigma}{R} \frac{dR}{d\sigma} \right) \) or absolute \( \left( \frac{1}{R} \frac{dR}{d\sigma} \right) \) sensitivities can be calculated, the latter being used for the SEMOVE/GANDR [9] program.

The particle transport calculations are done externally using the existing codes, which guarantees great flexibility and allows the use of the most up-to-date transport codes. At present SUSD3D can use the neutron/gamma flux moment files produced by the DORT, TORT [2], ONEDANT, TWODANT and THREEDANT [3] discrete ordinates codes or the angular flux files from the ANISN [1] and DOT-III codes. Updates for the other codes such as DRAGON and PARTISN are under preparation and validation.

The sensitivity profiles are folded with the cross section covariance matrices to determine the variance in an integral response of interest. Uncertainties due to the fission spectra uncertainties can be calculated either using the classical or the constrained sensitivity method [7, 8], useful particularly in case the fission spectra covariance matrices do not comply exactly with the ENDF-6 Format Manual rules.

SUSD3D runs under DOS Windows, LINUX and UNIX using FORTRAN-95 compiler.
Figure 1: Computer code system
Figure 2: Screen captures of the PARTISN test case 1 and 2 running sequences
3 CONCLUSIONS

A modern computer code interface was developed for the preparation and execution of the deterministic neutron-gamma computer codes in a user friendly way adopted for today standards and users. At present, the system integrates the codes for the nuclear cross-section preparation (TRANSX-2.15), the code PARTISN for 1-, 2-, and 3-dimensional neutron and gamma transport calculations and the SUSD3D code for the nuclear data sensitivity and uncertainty analysis. User-friendly plotting codes are also available for the 3-dimensional visualisation of neutron fluxes, spectra and sensitivity profiles. When validated, the system will be available through the OECD/NEA Data Bank. The beta-version can be on the other hand already obtained directly from the authors for friendly testing.

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REFERENCES


