April 30, 2003

MEMORANDUM TO: Suzanne C. Black, Director
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

FROM: Farouk Eltawila, Director ***Original signed by F. Eltawila***
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

SUBJECT: RELEASE OF THE BETA-VERSION OF THE TRAC/RELAP ADVANCED COMPUTATIONAL ENGINE (TRACE, formerly TRAC-M) THERMAL-HYDRAULIC SYSTEM ANALYSIS CODE

Over the last several years, RES has actively pursued a program of code consolidation and modernization for its reactor safety thermal-hydraulic analysis codes. The culmination of this program will be the initial public release of the TRACE (formerly called TRAC-M) code at the end of calendar year 2003. Important milestones leading up to this public release are the release of the "alpha" version to internal USNRC users (January 2003) and the release of the "beta" version to CAMP members, and other domestic issues. This memo documents the release of the beta-version of TRACE.

TRACE is a two-phase, two-fluid thermal-hydraulic reactor systems analysis code. The TRACE acronym stands for TRAC/RELAP Advanced Computational Engine, reflecting its ability to run both RELAP5 and TRAC legacy input models. It includes a three-dimensional kinetics module called PARCS for performing advanced analysis of coupled core thermal-hydraulic/kinetics problems and has recently been linked to CONTAIN providing the capability to perform integrated reactor analysis at levels of efficiency and accuracy not possible until now. Recent and planned improvements to the code will also give TRACE the ability to model advanced reactor types such as ESBWR and ACR700.

Until recently, the primary objectives of the TRACE development program have been to consolidate the modeling capabilities of four legacy codes (RELAP5, TRAC-B, TRAC-P, and Ramona) into one code that implements a modernized code architecture. Furthermore, to conserve the investment in input models and ease the transition for users, TRACE needed to be capable of accepting input models constructed for RELAP5, TRAC-B and TRAC-P. Both of these goals have largely been achieved. While some development work does still remain in the area of RELAP5 consolidation, this phase of development should be coming to a close in the coming months. It should be stated that the recent rapid addition of advanced BWR fuel modeling capabilities for ESBWR is a direct result of the code infrastructure and modernization improvements made over the past 5 years.

We believe that as TRACE further matures, and it will be the "tool of choice" for a significant portion of the safety analysis performed both in RES and NRR. In fact, RES is now using TRACE to perform confirmatory analysis for AP1000, address various other safety issues and plans to use it in future ESBWR and ACR700-related applications.

Attachment: CD

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TRACE Beta Release

The beta-version of TRACE corresponds to the developmental version designated as 4.000 and is included on the attached CD-ROM. The code has also been uploaded to NRR's multi-node DEC Alpha (nrr2.nrc.gov) machine and compiled there as a courtesy. An itemized list of new features (since the last official release) is shown below:

1. Improved 1-D and 3-D level tracking model
2. RELAP5 input conversion - includes hydro & control system mapping logic, limited heat structure conversion
3. Improved fine mesh re-zoning algorithm
4. Advanced BWR CHAN component including GE-12 and Atrium-10 fuel bundle models
5. New radiation model including both cross-string and ray-tracing view factor algorithms
6. ESBWR-specific kinetics capability
7. Coupled with the CONTAIN analysis code using the ECI
8. Platform independent dump files (TPR functionality)
9. Improved run-time behavior and code robustness
10. Advanced Transmutation of Waste (ATW) functionality
    a. Fluid power component
    b. Trace species tracking
    c. Enhanced Equation of State model - support for numerous working fluids - H2O, D2O, Na, PbBi, He, N2, R5H2O, and air
11. Enhanced modeling flexibility
    a. Single-volume separator component
    b. Improved off-take model
    c. Enhanced Single Junction component
    d. Spherical Heat Structure model
    e. Additional Heat Structure boundary conditions
    f. Three new valve types - Check Valve, Inertial Valve, and Motor Valve
    g. Generalized Radiation Enclosure component
    h. ANS94 decay heat standard and non-separable feedback types
    i. RELAP5 General Table capability - enhanced input for material properties
    j. BREAK is now an "active" component
    k. Dead-ended components (no longer need a break or fill as a component terminator)
    l. Two new pump types
    m. New homologous pump curves for Bingham and Westinghouse pump types
12. Enhanced control system
    a. Generic signal variable capability
    b. New control block and signal variable types (improves compatibility with RELAP5 and TRAC-G)
    c. Automatic sorting of control blocks, signal variables and trips
    d. Improved modularity and readability
13. Co-located heat structures (heat structure and fluid nodes are synchronized)
14. Scaled residuals for testing the convergence of the semi-implicit mass and energy equations solution
15. Improved choked flow model - mitigated downstream dependence in model
16. Enhanced TRAC-B input processor to facilitate conversion of ESBWR input models
17. Command line arguments
18. Increased adherence to the F95 standard

19. True free format source code with pretty print capability
20. Ability to run multiple input decks in the same directory

In January, with the release of the alpha version, it was reported that three development activities remained to be completed before the initial public release of TRACE:

- Complete the addition of logic to enable the mapping of control systems from RELAP5 input models.

- Development of an interim reflood model as the performance of the legacy TRAC-P model has been judged deficient.

- Implementation of a modularized interfacial friction package that also includes the models from the TRAC-B code for interfacial friction in rod bundles and subcooled boiling.

The control system mapping has been completed, although the code still lacks the ability to properly map all 180+ RELAP5 minor edit variables. Given RES limited code development resources and NRR's request for significant code development related to ESBWR and ACR700 modeling. We plan to add capabilities for these variables on an "as-needed" basis. The code logic has been designed & structured to facilitate this transition with relative ease.

The second and third items have been partially completed. The code now features a much improved fine mesh re-zoning algorithm. This should dramatically improve predicted reflood results. Model development for the interim reflood model has been completed and testing is now underway to assess its adequacy against FLECHT test data. It is scheduled for inclusion into the code in the coming months, once testing is completed and the last few bugs shaken out.

With respect to the modularization of the interfacial friction package, the 1D models, along with the TRAC-B interfacial drag models for rod bundles and subcooled boiling have been updated although they are still undergoing testing. Improvements to the 3D VESSEL logic still remain to be completed.