ANS MATHEMATICS AND COMPUTATION SOFTWARE STANDARDS

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Abstract

The Mathematics and Computations Division of the American Nuclear Society sponsors the ANS-10 Standards Subcommittee. This subcommittee, which is part of the ANS Standards Committee, currently maintains three ANSI/ANS software standards. These standards are: Portability of Scientific and Engineering Software, ANS-10.2; Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry, ANS-10.4; and Accommodating User Needs in Scientific and Engineering Computer Software Development, ANS-10.5. A fourth Standard, Documentation of Computer Software, ANS-10.3, is available as a historical Standard.

Keywords: Standards, Software, Portability, Verification & Validation, User Needs

1. Introduction

As part of its national activities, the American Nuclear Society maintains a Standards Committee. This committee coordinates all aspects of standards activities within ANS and makes recommendations to the Society on matters concerning standards. The standards developed by the Standards Committee meet the full acceptance requirements of the American National Standards Institute (ANSI).

The work of the Standards Committee is managed by four consensus committees. A consensus committee is a balanced body that conducts the consensus ballot on proposed standards. Of the four, the N17 committee is of most interest to the members of the Mathematics and Computation (M&C) and Reactor Physics Divisions. This committee is charged with oversight of standards activities in the areas of research reactors, reactor physics, radiation shielding and computational methods.

As part of the Standards activities directed by N17, the M&C Division sponsors the Standards Subcommittee, ANS-10. This subcommittee was formed because of the desire of the M&C Division to encourage and promote the interchange of digital computer programs within the nuclear industry. The Standards that have been developed by ANS-10 are based on the

experience of people performing scientific and engineering calculations in the nuclear industry. In general, these standards can be applied to software running on the full range of computer systems from of supercomputers to microcomputers.

The ANS-10 subcommittee currently maintains three standards. Each one deals with an area of interest to the members of the M&C Division. This paper will summarize the principal features of each standard.

2. Portability of Scientific and Engineering Software, ANS-10.2 [1]

ANS-10.2 provides a set of recommendations and requirements for the developer to help ensure that the software is readily portable. These recommendations and requirements are divided into a number of different areas.

2.1. Program Organization

This section addresses program structure and flow. The standard recommends a top down design with a top to bottom flow in the program. The program should start with input processing and checking, proceed to computations and data processing and conclude with final edits. The program should be structured as a number of subprograms, each with a well-defined function. This permits algorithms to be changed without disrupting large portions of the program.

2.2. Programming Language

The standard recommends the use of an ANSI or ISO standard language such as Fortran or C++. The use of language extensions or assembly language is discouraged except where required for special applications. When language extensions or assembly language is used, the standard requires the use be fully documented so the functionality can be reproduced if the program is ported.

2.3. Data Handling

Data handling is also discussed in the standard. Because of the volume of data used in many nuclear industry codes, it is often necessary to use adjustable arrays, special file access methods or binary data libraries for efficiency. The use of these can significantly reduce the portability of a program if they are not a standard part of the programming language being used. If used, the standard requires these features to be fully documented and recommends that their use be localized. Utility programs are required to convert binary data libraries to and from a portable format.

2.4. Program Features

Features that make a program easier to convert, install and use correctly are described. These features may be used in the following areas: initialization and input processing, computation and data processing, error detection and diagnostics, and output and termination processing.

2.5. Source Statements and Variables

ANS-10.2 provides specific recommendations for documenting the source code. These recommendations cover variable names, specification statements, and source documentation. Source documentation includes both the internal source code comments and external "README" files.

2.6 Hardware and Software Dependencies

The use of features which are specific to a computer system are discouraged. Where they are used, they must be documented and localized. If a software package external to the program is used, the interface to that package must be fully documented.

3. Guidelines For The Verification And Validation Of Scientific And Engineering Computer Programs For The Nuclear Industry, ANS-10.4 [2]

The ANS-10.4 Standard deals with quality assurance aspects of nuclear industry software. The current version of this Standard, described in detail below, is undergoing extensive maintenance. The new draft, tentatively titled Criteria for Quality Assurance of Scientific and Engineering Computer Programs for the Nuclear Industry,

ANS-10.4 provides a set of guidelines and checklists for developing and implementing a verification and validation (V & V) program specific to the nuclear industry. The standard presents an overview of the V & V process and provides detailed V & V information for the following software life cycle phases: software definition, design, coding, integration and testing, installation, and operation and maintenance. The standard also provides information on the V & V of existing programs.

In the context of this standard, verification is the process of evaluating the products of a software development phase to provide assurance that they meet the requirements defined for them by the previous phase. Validation is the process of testing a computer program and evaluating the results to ensure compliance with the specified requirements.

A brief description of the V & V requirements defined by the standard for each phase of the software life cycle is presented below.

3.1. Software Definition Phase

ANS 10.4 divides the V & V activities during the software definition phase in to four parts:

3.1.1. Preparation of the V & V plan. The document will include a description the V & V plan including scope and objectives, the approach to be used, a schedule of V & V activities and milestones, the V & V project organization, and a description of the V & V project management.

3.1.2. Verification of the software requirements specification. Verification of the requirements is to ensure that the requirements are complete, correct, consistent and clear. Furthermore, it will ensure that the requirements are both feasible and testable. The standard provides a checklist to help in verifying the requirements specification.

3.1.3. Development of the preliminary test plans. The plan will include a description of the overall plan, approach to be followed, acceptance criteria for each requirement, test case specifications and test procedures.

3.1.4. Verification of the preliminary test plan. The test plan is verified is to ensure that the plan is consistent with the scope and objectives stated in the plan, and that the tests are adequate and sufficient to demonstrate the program meets the requirements specification. The standard provides a checklist to help in verifying the test plan.

3.2. Design Phase

The V & V activities during the design phase are also divided into four parts:

3.2.1. Verification of the design. Design verification ensures that all program requirements are implemented in the design and that all parts of the design are traceable to the requirements. It also ensures the design is correct, feasible, consistent and clearly presented. A checklist is provided in the standard to help in verifying the design.

3.2.2. Verification of the preliminary program documentation. This verification is performed to ensure that program input descriptions are sufficient to permit test planning and are consistent with the verified requirements and design specifications. The standard provides a checklist to aid the user in this activity.

3.2.3. Updating of the test plan. The test plan is updated to include information resulting from the design process. This should include a detailed description of each test case, draft test procedures, experimental data or analytical results used to evaluate program results and any additional test problems needed based on the software design.

3.2.4. Verification of the updated test plan. The updated test plan is verified to ensure that the tests being considered will be adequate and sufficient to show the program conforms to the requirements specification and is consistent with the design specifications and preliminary program documentation. The standard provides a checklist to aid the user.

3.3. Coding Phase

The V & V activities during the coding phase are:

3.3.1. Verification of the source code. The source code is verified to ensure the code is a clear, understandable and logically correct representation of the design specification. It will also ensure that all aspects of the program design have been implemented in the code. The standard provides a checklist for use in source code verification.

3.3.2. Verification of the updated program documentation. This verification will ensure that the updated program documentation is clear, internally consistent and agrees with the requirements, design and coded program. A checklist is provided.

3.3.3. Completion of the test plan and test data base. During the coding phase the test plan is completed and the test cases are completed.

3.3.4. Verification of the test plan and test data base. Verification of the test plan is conducted to ensure that the test cases are sufficient to show the program conforms with the requirements and that the test cases are in accordance with the test plan. The standard provides a checklist to help the user.

3.4. Implementation and Testing Phase

The V & V activities during the integration and testing phase are:

3.4.1. Verification of program integration. Verification ensures that all components (library routines, object modules, external data libraries...) are brought together to produce a correctly integrated program. A checklist for program integration is provided.

3.4.2. Execution of the test plan (Validation). Each test case is run in accordance with the test procedures in the test plan, and the results are compared with their expected values in the requirements specification. A test report is produced as a part of this process. The standard provides guidance in the contents of the test report. A checklist is provided to help in determining if the results of the testing demonstrate compliance with the requirements.

3.4.3. Verification of the test results. The test report and test outputs are evaluated to ensure that the test was conducted in accordance with the test plan and that the test report is an accurate description of the results obtained. A checklist is provided in the standard.

3.5. Installation Phase

V & V activities during the installation phase are:

3.5.1. Verification of the installation package is to ensure that all elements needed to install the program and reproduce the expected test results are available. A checklist for performing this activity is provided in the standard.

3.5.2. Verification of the final program documentation. During the installation phase, the program documentation is revised and enhanced to provide a complete description of the computer program. Verification is to ensure that the documentation is complete and is a clear and correct description of the completed computer program. A checklist is provided to help in this activity.

3.5.3. Preparation of the final V & V report. This report summarizes the V & V activities carried out, describes the overall results and presents conclusions and recommendations

concerning acceptance and use of the program. The standard provides a list of topics which should be included in this report.

3.6. Operating and Maintenance Phase

V & V activities during the operating and maintenance phase may be required because of:

3.6.1. Modification in the operating environment. The standard provides guidance on the types of environment changes which can affect program performance and the additional V & V activities which may be necessary because of those changes.

3.6.2. Program modification. The amount and type of additional V & V activities required depends on the reason the program was modified (i.e. code improvements, error correction). The standard provides help in determining the additional V & V requirements.

3.7. Prior Existing Programs

This section of the standard documents the V & V activities for a program which was developed without a formal V & V program. These activities are divided into seven different areas:

3.7.1. Preparation of the V & V review plan which documents the requirements for the V & V activities and the scope and objectives of the review.

3.7.2. Determination of program requirements. The standard provides a list of topics to be considered in determining program requirements.

3.7.3. Review of program design. The standard provides guidance on verifying design specifications or reconstructing a summary design specification if a design specification does not exist.

3.7.4. Review of source code, program integration and documentation. These items are verified, if required by the V & V review plan, as described above.

3.7.5. Review of program testing. The standard provides a list of topics to be considered to determine if test coverage is adequate.

3.7.6. Review of the test results - Validation. The test results should be reviewed to determine that all the requirements have been tested. Guidance is provided for conducting this review.

3.7.7. The V & V review report. This report documents the results of the V & V review and should include the following sections: V & V review plan, program requirements summary and review, review of test coverage, and evaluation of test results (validation).

4. Accommodating User Needs in Scientific and Engineering Computer Software Development, ANS-10.5 [3]

ANS-10.5 provides the software developer guidance in accommodating the needs of the user when software is being developed. This information is divided into the following areas: program specification, program design considerations, and program application.

4.1 Program Specification

Program specification is the phase of software development when assumptions, approximations and decisions are made which determine the program's applications and limitations. Some of the items which are addressed are: models and algorithms used, computer architecture, program design and cost (development, operation and modification). These items impose constraints on the program which should be documented and communicated to the user. Having the user involved with these decisions can save considerable effort later on during program development.

4.2 Program Considerations

Program design considerations include programming language, program organization, and input and output facilities. The standard includes requirements and recommendations on program organization, control capabilities, input processing, computation and data processing, output processing, computational environment, modification provisions and interactive programs.

4.3 Program Application

Program application deals primarily with the operation and maintenance phase of program development. During software development, the developer will identify a great deal of information important to the end user. This information will include areas such as applicability, computational costs, execution experience, and software quality. This information plays an important role in the correct use of the software.

5. Guidelines For The Documentation of Computer Software, ANS-10.3 [4]

ANS-10.3 is an historical standard and not under active maintenance. It provides a guide to the developer for writing a set of comprehensive software documentation. This documentation is divided into four different parts: the software abstract, application information (or user's manual), problem or function definition, and implementation information.

5.1 Program Abstract

The software abstract is designed to provide the potential user with a concise summary of the program capabilities, computer operating environment requirements, and other reference information.

5.2 User's Manual

Application information for the User's Manual is oriented towards the software user. It should provide the user with:

- A synopsis of the problem being solved and the methods used,
- A description of program options, code restrictions, and error messages,
- A description of external data files used or produced,
- A description of the input data and allowable ranges,
- The operating system commands required to run the software,
- A description of the software output, and
- Sample problems including the input data and the results generated.

5.3 Functional Definition

The problem or functional definition provides information on the models and algorithms used in the software. This documentation should include:

- A description of the physical theory being solved,
- The source of the models and mathematical formulations used, and
- any known limitations or assumptions,
- A description of the algorithms and numerical techniques used,
- Information on the source, contents, and use of data libraries, and
- A description of how the software was validated.

5.4 Implementation Information

The information in this section is for the person responsible for implementing the software, modifying it, or porting it to a different computer environment. The documentation should include:

- Information on the programming language(s) used,
- Diagrams showing program structure, logic and data flow,
- Documentation of known system dependencies,
- Details of the main program and all subprograms,
- A complete description of the data files used or generated by the software,
- Implementation requirements including both hardware (memory, disk space...) and software (graphics packages, database software...), and
- Information on interfaces to other software modules if the software is part of a larger system.

While not part of the standard, ANS-10.3 describes two additional documents. These are the Software Package and Transmittal Material, and the Installation Environment Report. These documents should be produced whenever software is sent from one organization to another, or when the software is installed on a specific computer system.

6. References

1) ANSI/ANS-10.2-2000: American National Standard Portability of Scientific and Engineering Software. American Nuclear Society, La Grange Park, Illinois, 2000.

2) ANSI/ANS-10.4-1987;R1998: American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry. American Nuclear Society, La Grange Park, Illinois.

3) ANSI/ANS-10.5-2006: American National Standard Accommodating User Needs in Scientific and Engineering Computer Software Development. American Nuclear Society, La Grange Park, Illinois.

4) ANSI/ANS-10.3-1991: American National Standard Guidelines for the Documentation of Computer Software. American Nuclear Society, La Grange Park, Illinois.