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HotSpot Software Test Plan

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Revision History

Document Version	Revision Date	Revision Description
0.0	March 18, 2009	Initial version

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1 Introduction

Purpose of the plan

This Software Test Plan (STP) describes the procedures used to verify and validate that the HotSpot Health Physics Codes meet the requirements of its user base, which includes:

- Users of the PC version of HotSpot conducting consequence assessment, hazard assessment and safety analysis calculations
- Users of the NARAC Web and iClient software tools, which allow users to run HotSpot for consequence assessment modeling

This plan is intended to meet Critical Recommendation 2 from the Software Evaluation of Hotspot and DOE Safety Software Toolbox Recommendation[1] for inclusion of HotSpot in the Department of Energy (DOE) Safety Software Toolbox[2]. These users and sponsors of the HotSpot software and the organizations they represent constitute the intended audience for this document.

HotSpot software is maintained for the Department of Energy Office of Emergency Operations by the National Atmospheric Release Advisory Center (NARAC) at Lawrence Livermore National Laboratory (LLNL). An overview of HotSpot and NARAC are provided below.

Scope of the plan

Overview of the software project

HotSpot

The HotSpot Health Physics codes were created to provide emergency response personnel and emergency planners with a fast, field-portable set of software tools for evaluating incidents involving radioactive material. HotSpot uses a Gaussian plume model to calculate the air concentration and dose from radiological releases to the atmosphere. The software is used for consequence assessment, hazard assessment and safety analysis of facilities handling radiological materials. HotSpot provides a fast and usually conservative means for estimation the radiation effects associated with the short-term (less than a few hours) atmospheric release of radioactive materials (see HotSpot Web page).

NARAC

The National Atmospheric Release Advisory Center (NARAC) provides tools and services that predict and map the spread of hazardous material accidentally or intentionally released into the atmosphere. Located at the Lawrence Livermore National Laboratory, NARAC is a national support and resource center for planning, preparedness, real-time emergency response, and detailed assessments of threats and/or incidents involving a wide variety of hazards, including nuclear,

radiological, chemical, biological or natural emissions. NARAC products provide information on affected areas, potential casualties, health effects, and protective action guides to assist decision makers.[3,4]

NARAC is a distributed system, providing modeling and geographical information tools for deployment to an end user's computer system, as well as real-time access to global meteorological and geographical databases. The core of the system is a suite of models ranging from simple, fast running Gaussian models to advanced three-dimensional model simulation tools run at the national center. These models and their supporting systems must be extensively verified and validated in order to insure that they produce realistic predictions and are reliable in emergency conditions. NARAC's Software Quality Assurance (SQA) procedures are a component of this on-going verification and validation effort. As a consequence, the details of SQA in NARAC are evaluated, adapted and refined with the goal of improving NARAC's overall Quality Assurance within funding and other resource constraints.

The NARAC is complex and can be viewed as consisting of three tiers (see Figure 1):

1. Central System – executes complex atmospheric models and manages large, global collections of meteorological and geographical data.
2. Enterprise System – securely exposes Central System capabilities to customers, provides flexible system product capabilities and runs relatively simple dispersion models such as HotSpot.
3. User tier – provides browser, deployed application and Web service access to NARAC

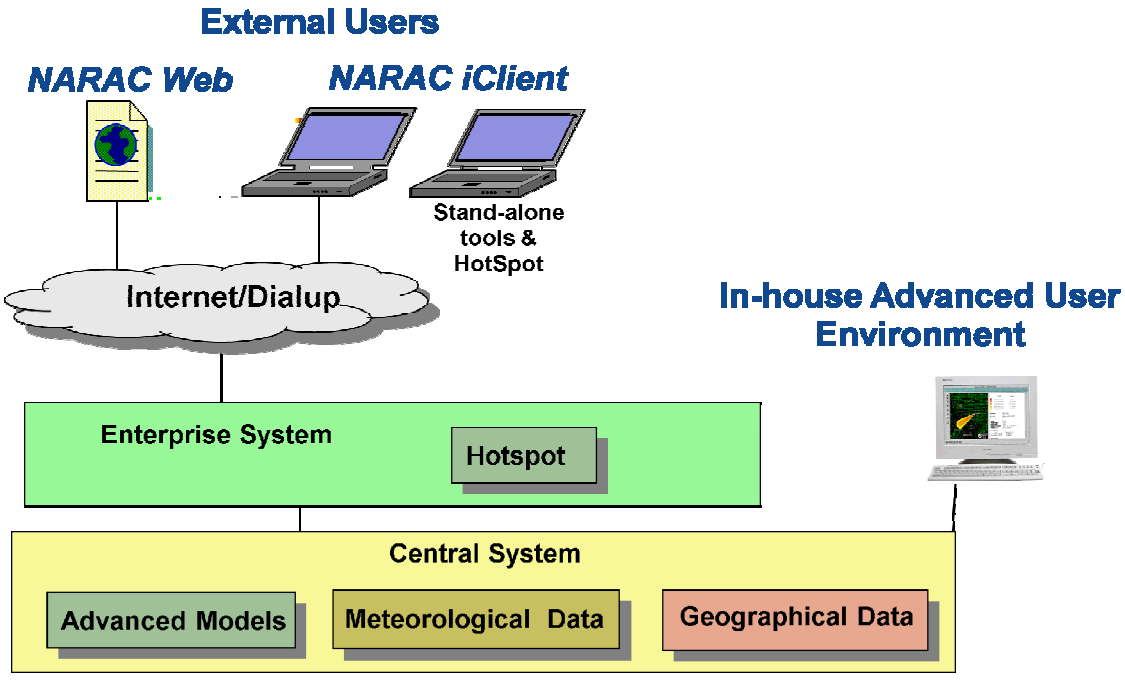


Figure 1. NARAC System

NARAC tools and services are supported by four teams that interact regularly to ensure that the center's capabilities meet current operational requirements and that models and system software are continuously updated to meet new requirements:

1. *Program Management*. Program Leaders provide oversight of the work to ensure quality and alignment with sponsor work authorization and budgets. Team Leaders work with Program Leaders to provide supervision of Operations, System Development and Model Development.
2. *Operations Team*. Scientists and technicians test and apply software tools, define operational requirements for software, and provide scientific guidance, support and training to external users.
3. *Model Development Team*. Physical scientists maintain and improve current atmospheric transport and fate models, develop new models, and acquire and study external models for potential integration into the NARAC System.
4. *System Development Team*. Software developers and information technologists who integrate internal and external models and data with the necessary system software, control mechanisms, network support and hardware to meet the requirements of sponsors, external customers and Operations.

HotSpot testing

The core of the HotSpot testing approach is a built-in test suite that exercises all key aspects of the code and fills in a checklist indicating success or failure for each test. This core is supplemented with additional testing by NARAC personnel:

- New scientific capabilities and changes to the science included in the code are reviewed and tested by a NARAC model developer.
- HotSpot capabilities used in the Enterprise System are reviewed and tested by an Enterprise System developer.
- General testing of HotSpot is also completed by NARAC Operations staff as part of the preparation for a new release. Operations also uses HotSpot for some response and assessment activities, which provides an on-going test of HotSpot in differing situations.

Given the integration of HotSpot procedures with those of NARAC, this STP will make reference to selected NARAC SQA procedures, tools, and activities (for a concise overview of SQA in NARAC with reference to HotSpot see Walker, et al., 2008) [5].

2 Test Items

All components of the HotSpot system are included in this plan. However, particular focus is on those components that are required for use of HotSpot as nuclear safety software.

3 Features Tested

All features of the HotSpot system are included in this plan. However, particular focus is made on those capabilities that are required for the use of HotSpot as nuclear safety software.

4 Approach

Unit testing

Unit testing is the responsibility of the developer. All current and past work has been done by the single developer/scientist. In the future, other NARAC software developers will make changes to Hotspot, with the oversight of the primary developer, and so will take on some of the unit testing responsibility.

Integration testing: Stand-alone HotSpot

Integration testing of HotSpot as a stand-alone system is provided by the built-in test suite. This test suite also serves as verification of the correct installation of the HotSpot software by users who download the code – a capability which is of demonstrated value to the user base.

Integration testing: HotSpot as a NARAC Tool

HotSpot is integrated with the NARAC Enterprise System and made available to NARAC customers via the NARAC Web and iClient. The integration testing of HotSpot with the Enterprise System is the responsibility of the Enterprise System developer who handles the HotSpot integration effort. Much of this testing focuses on the interface between HotSpot and the Enterprise System, but some regression testing of HotSpot as a model is also a part of Enterprise System testing procedures.

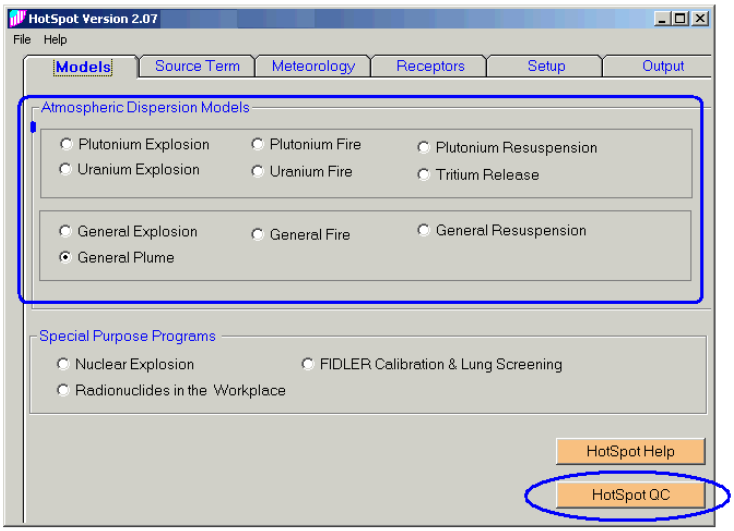
System testing

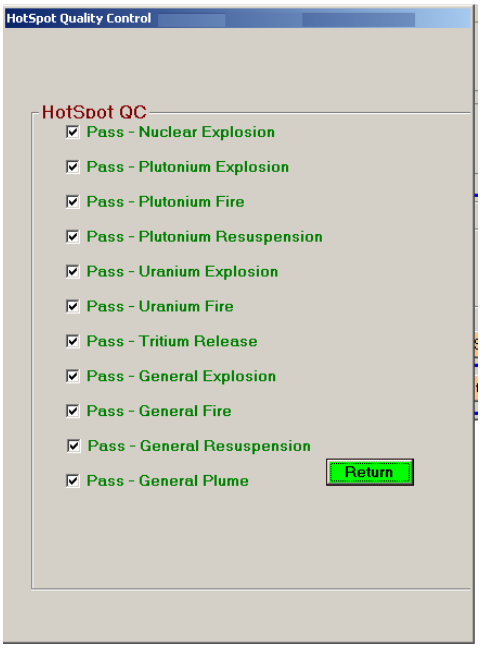
Built-in Test Suite

The HotSpot Health Physics Codes have been designed with a test feature that verifies that all of the atmospheric dispersion modules are functioning properly. To access this capability, the user clicks the "HotSpot QC" bar located at the lower right of the main HotSpot screen (Figure 2, left panel). The test is routinely performed during software development cycles to ensure correct behavior. This test also confirms that HotSpot has been installed correctly on a user's computer system.

The HotSpot scenario library contains test cases for a suite of scenarios (see Figure 2, right panel), which are described in detail in the HotSpot User's Guide[6].

Each of these test cases is loaded from the library inclusive of all setup parameters, the model is run, and dose, integrated air concentration, and deposition values are calculated and compared (at several downwind distances) with the expected values. To pass the test, all calculated values must be identical with the expected values to three significant figures. A checkmark and message indicating that all models pass should appear in green. If one of the dispersion modules does not pass the test, a red "Failed" will be displayed adjacent to the applicable module. The HotSpot User's Guide recommends contacting NARAC if the test fails.





Functional testing

Functional testing of HotSpot is focused on validating the numerical output of the model and is largely handled by the built-in test suite. Additional reviews and testing by one or more NARAC model developers are included in the HotSpot testing process. This has the following benefits:

- Independent evaluation of the science and the numerical implementation increases confidence in the correctness of both.
- Consistency between the HotSpot model with other NARAC codes is maintained as much as possible
- NARAC staff continue to expand their HotSpot expertise broadening the personnel base capable of supporting and maintaining this code.

Regression testing

The built-in test suite meets much of the requirement for regression testing. Both the Enterprise System test procedures and the Operations testing of HotSpot include regression tests that supplement the built-in testing and further decrease the probability that software errors will be included in a release package.

5 Pass/Fail Criteria

The built-in HotSpot test suite requires matching of results that have been defined by the primary scientist/developer on the basis of the scientific literature, independent analytical calculations and related procedures. This suite reports in the form of a checklist.

Collaboration between the primary developer and NARAC model developers provides a review of these procedures. Many of the Enterprise System tests are focused on mechanism, i.e., demonstrating that the interfaces between the Enterprise System and HotSpot are implemented correctly, but test results are compared to earlier runs to validate that the model is running correctly.

6 Test Deliverables

All HotSpot built-in tests are performed prior to each new software release. For NARAC integration, the required Enterprise System checklist includes many HotSpot tests. NARAC Operations tests and approves each Enterprise System release, including the HotSpot component prior to deployment to customers.

7 System Environment

The HotSpot codes have been developed for the Windows (95/98/00/NT/XP/Vista) operating systems. Testing of the independent distribution package requires a Window

system with a supported version of the operating system. The Enterprise System is primarily a Linux-based system that uses a Windows system to support the execution of HotSpot and similar models.

8 Testing Responsibilities

The roles and responsibilities for each phase of testing are described above. In addition to the HotSpot developer, the HotSpot testing process relies on the following NARAC roles:

- Enterprise System Lead – Lead software developer for the Enterprise System
- Operations - Enterprise System Coordinator – Operations team member who coordinates Enterprise System development task identification, prioritization and operational testing
- Model Development Lead – Modeling expert who manages improvements in the NARAC models

Modeling, Enterprise, and Operations Team Leaders provide additional supervision, oversight and quality assurance for the testing process, in collaboration with NARAC Program Management.

9 Staffing and Training Needs

NARAC staff are available for the testing tasks as discussed above. LLNL provides appropriate training of staff members, including in-house training by the primary HotSpot developer.

10 Schedule

Testing schedules are coordinated for each release by the Enterprise System Coordinator on the Operations Team, in consultation with the Enterprise System Team Lead and the Model Development Team Lead. Adequate testing is required prior to any Software release.

References

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5. Walker, H., J.S. Nasstrom, S.G. Homann, 2008: NARAC Software Quality Assurance: Adapting Formalism to Meet Varying Needs, LLNL-CONF-236751.
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