



## Department of Energy

Washington, DC 20585

June 11, 2010

Dr. John S. Nasstrom  
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Dear Dr. Nasstrom:

In your letter dated April 16, 2010, you summarized the work done by the Lawrence Livermore National Laboratory (LLNL) to meet the Department of Energy's (DOE) recommendations from the 2007, *Software Evaluation of HotSpot*, and *DOE, Safety Software Toolbox Recommendation*, for inclusion of V2.07 in the DOE Safety Software Central Registry. Based on this work, you further requested that HotSpot be included in the DOE Central Registry.

The DOE team that reviewed the LLNL work has prepared the enclosed report, *Evaluation of HotSpot Software and Recommendation for Inclusion in the Central Registry*, documenting the team's review of the actions taken by LLNL. The team's conclusion is that LLNL has adequately addressed the critical and additional recommendations identified in the 2007 evaluation report, and the updated HotSpot V2.07.1, having met the DOE safety software quality assurance requirements, can be listed as a Toolbox code in the DOE Safety Software Central Registry.

The Office of Health, Safety and Security concurs with the review team's conclusion and has designated HotSpot V2.07.1 as a Toolbox code for inclusion in the Central Registry. Please note that the citation of HotSpot in the Central Registry will be accomplished by the end of June 2010.

Your commitment to this effort is appreciated as it will not only aid in DOE's continuing effort to improve software quality, but will also benefit the entire DOE community by providing access to a qualified software tool. Questions may be directed to me at (202) 586-5680 or Subir Sen at [subir.sen@hq.doe.gov](mailto:subir.sen@hq.doe.gov) or (301) 903-6571.

Sincerely,

Andrew C. Lawrence  
Director

Office of Nuclear Safety, Quality Assurance  
and Environment  
Office of Health, Safety and Security

Enclosure



Printed with soy ink on recycled paper

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# **Evaluation of HotSpot Software and Recommendation for Inclusion in the Central Registry**



**U.S. Department of Energy  
Office of Health, Safety and Security  
1000 Independence Avenue, S.W.  
Washington, DC 20585-2040**

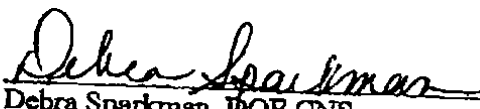
**May 2010**

HotSpot Review Team Concurrence

  
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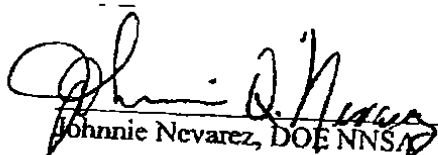
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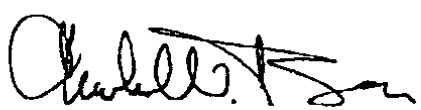
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## EXECUTIVE SUMMARY

At the request of the Department of Energy's (DOE) Subcommittee on Consequence Assessments and Protective Action, HotSpot Health Physics (HotSpot) V2.07 software was evaluated for inclusion as a Toolbox code in the DOE Safety Software Central Registry. HotSpot, developed by the Lawrence Livermore National Laboratory (LLNL), provides emergency response personnel and emergency planners with a fast, field-portable set of software tools for evaluating incidents involving radioactive material. The software may also be used for safety analysis of DOE facilities that handle nuclear material.

HotSpot was initially evaluated in 2007 to determine if it met the DOE safety software quality assurance (SSQA) requirements specified in DOE O 414.1C, *Quality Assurance*, and further explained in DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance*. The resulting gap analysis report, *Software Evaluation of HotSpot and DOE Safety Software Toolbox Recommendations, March 2007*, made five critical recommendations that were to be addressed before HotSpot could be considered for inclusion in the DOE Safety Software Central Registry. Also, 17 additional recommendations were identified that should be considered as future improvements of the software.

Subsequently, in March 2009 LLNL submitted a letter to the Office of Health, Safety and Security (HSS) outlining the actions taken to address the five critical recommendations as well as actions taken or planned to address the 17 additional recommendations. These actions included adding new capabilities to the software as well as creating and improving the supporting documentation. HSS convened a review team with expertise in the HotSpot code and DOE SSQA evaluation process as well as involvement with the previous evaluation of the code. The team reviewed the documentation submitted by LLNL, participated in meetings with the HotSpot code developer, and generated several recommendations to improve LLNL's response for addressing the critical and additional recommendations. As a result LLNL made significant changes to the major documentation supporting the software which the team reviewed and accepted. In April 2010, LLNL submitted a letter together with the revised documentation to inform HSS of the completion of their effort to include HotSpot in the Central Registry.

The review team's evaluation of LLNL's action is presented in this report. The team's conclusion is that LLNL has adequately addressed the critical and additional recommendations identified in the gap analysis report and recommends that the updated HotSpot V2.07.1 be listed as a Toolbox code in the DOE Safety Software Central Registry.

## 1.0 Introduction

The Department of Energy (DOE) maintains a collection of "Toolbox" codes in the Safety Software Central Registry that had been evaluated against the DOE Safety Software Quality Assurance (SSQA) requirements. At the request of DOE's Subcommittee on Consequence Assessments and Protective Action (SCAPA), HotSpot Health Physics (HotSpot) V 2.07 was considered for inclusion as a Toolbox code in the DOE Safety Software Central Registry (Reference 1).

HotSpot was developed by LLNL to provide emergency response personnel and emergency planners with a fast, field-portable set of software tools for evaluating incidents involving radioactive material. The software may also be used for safety analysis of DOE facilities that handle nuclear material. HotSpot provides a fast and usually conservative means for estimating the radiation effects associated with the short-term (less than 24 hours) atmospheric release of radioactive materials.

### 1.1. Background

In March 2007, HSS completed an evaluation of HotSpot Health Physics V2.07 for inclusion in the DOE Safety Software Central Registry (Reference 2). The evaluation report (a gap analysis) identified the strengths and weaknesses of HotSpot when compared to the SSQA requirements and criteria in DOE O 414.1C, *Quality Assurance*, and DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance*. The evaluation of HotSpot identified five critical recommendations that were to be addressed before HotSpot could be added to the DOE Safety Software Central Registry. The evaluation team also identified 17 additional recommendations that should be considered as future improvements for HotSpot and its software processes.

### 1.2. Current Activities

In March 2009, LLNL submitted a response to HSS outlining the actions taken to address the five critical recommendations (Reference 3) for HotSpot V2.07. In April 2009, HSS assembled a review team to conduct the necessary evaluation of the supporting documentation submitted by LLNL on the actions taken to address the five critical recommendations (Reference 4). The team reviewed the LLNL submittal and supporting documentation. Written comments were provided and discussed in meetings and conference calls with LLNL staff responsible for the development and maintenance of the HotSpot code. Changes made to HotSpot V2.07 as a result of the DOE review team evaluation have been incorporated by LLNL as HotSpot V2.07.1. In April 2010, LLNL submitted a summary of the actions taken to meet the critical and additional recommendations along with supporting documentation (Reference 5).

### 1.3. Review Team

The DOE review team included the following members with expertise in the HotSpot code, DOE SSQA evaluation process and involvement with the previous evaluation of the code.

- Subir Sen, DOE, HSS, Team Lead
- Debra Sparkman, DOE, Office of Chief of Nuclear Safety
- Johnnie Nevarez, DOE, National Nuclear Security Administration
- Cliff Glantz, Pacific Northwest National Laboratory
- Carl Mazzola, Shaw Environmental
- Wayne Davis, URS Safety Management Solutions
- Charles Thayer, MAS Consultants

## 2.0 Review Results

### 2.1. Critical Recommendations

Five critical recommendations were identified in the earlier evaluation (Reference 2) that must be implemented by LLNL prior to HotSpot V2.07.1 being considered for inclusion in the DOE Safety Software Central Registry.

#### 2.1.1. Critical Recommendation 1

*Prompt development and implementation of a formal configuration management plan that documents the process to be followed in providing configuration management for the HotSpot program. This included documentation for the version control system, software storage, software back-up and disaster planning. Critical to the configuration management implementation is a baseline labeling system that addresses major and minor releases and the establishment of a formal change control process that identifies proposed enhancements and potential.*

##### 2.1.1.1. LLNL Action

LLNL addressed this critical recommendation by writing a software configuration management plan (SCMP), and by developing the LLNL processes, activities, tools, organization, roles and responsibilities described in that plan. Comments and recommendations received from the review team were incorporated during two revisions of this document. The current plan is contained in the LLNL report, *HotSpot Software Configuration Management Plan* (Reference 6).

The specific items in this Critical Recommendation are addressed as follows:



- Version control system: Section 3 of the SCMP describes the version control system used for HotSpot. The details are included in Appendix C of the SCMP, which describes the tools and procedures for software version control.
- Software storage, software back-up and disaster planning: Section 5.2 of the SCMP describes software storage and backup for disaster planning.
- Baseline labeling system that addresses major and minor releases: Section 3.1 of the SCMP describes the baseline labeling system and major/minor releases. The details are included in Appendix C of the SCMP. Additional information on the details of release packaging, acceptance and deployment are described in Appendix A of the SCMP.
- Formal change control process: Sections 2.1, 2.2 and 2.4 of the SCMP describe the organization, roles and responsibilities for change control. Sections 3.2, 3.3 and 3.4 of the SCMP provide information on HotSpot software configuration control, status accounting, evaluation and reviews. The details of the processes, responsibilities, tools and procedures for change control are presented in Appendix A of the SCMP.

#### 2.1.1.2. Review Team Evaluation

The team evaluated the SCMP which LLNL developed using IEEE STD 828-2005, *IEEE Standard for Software Configuration Management Plans*, as guidance. The review first determined how well the HotSpot SCMP met the general requirements of IEEE STD 828-2005; and secondly how well the SCMP performed against a graded application of the IEEE STD 828-2005. The graded approach was appropriate as HotSpot, designated as level B software in accordance with DOE G 414.1-4, Section 2, *Safety Software Types and Grading*, was not considered to be "critical software" as defined in IEEE Std 828-2005. Critical software is defined in the IEEE Standard as software whose failure would impact safety or cause large financial or social losses. The key elements considered in the review were based in part on:

- DOE G 414.1-4, Paragraph 5.2.3, *Software Configuration Management*, which identified four areas of software configuration management (SCM) that should be addressed when performing configuration management: (1) configuration identification, (2) configuration control, (3) configuration status accounting, and (4) configuration audits and reviews; and
- The elements of Critical Recommendation 1, which required the development of a formal configuration management plan to include the following SCM activities: (1) version control system, (2) software storage, (3) software back-up and disaster planning, (4) baseline labeling system that addressed major and minor releases, and (5) formal change control process that identified proposed enhancements and potential defects.

The team's review generated several comments related primarily to the level of detail for many of the elements of the SCMP. LLNL addressed the comments by revising the SCMP which followed the provisions of the IEEE Std 828-2005, Clause 3. The cited Clause 3 also included the four elements of SCM as

described in DOE G 414.1-4, Paragraph 5.2.3. The revised SCMP contained enhanced provisions related to the purpose, scope, organizational structure, configuration items, and change control process. The key elements of Critical Recommendation 1 were incorporated in Appendices A, B, and C along with additional references in the main section of the SCMP.

The revised HotSpot SCMP adequately addresses the issues identified in Critical Recommendation 1.

### **2.1.2. Critical Recommendation 2**

*Plan, implement, and document the verification and validation test processes. The test processes should include both developer-level testing (component, integration, and system) as well as the acceptance testing already performed through the quality control method.*

#### **2.1.2.1. LLNL Action**

LLNL has addressed this Critical Recommendation by writing a software test plan and by developing LLNL processes, activities, tools, organization, roles and responsibilities described in this plan. This document describes both developer-level and acceptance testing. Comments and recommendations received from the review team were incorporated during the revision to this document. The current plan is contained in the LLNL report, *HotSpot Software Test Plan*, (Reference 7).

#### **2.1.2.2. Review Team Evaluation**

The team evaluated the *HotSpot Software Test Plan*, LLNL-TR-411352, Rev. 0 and Rev. 1, inspected test results at the LLNL site, and conducted interviews with the National Atmospheric Release Advisory Center (NARAC) personnel in charge of the program, software development, and end user interface for HotSpot.

The test plan was modified to address developer testing at the component and system levels. With HotSpot in the maintenance software life cycle phase, integration testing was not applicable. Test results were reviewed to ensure that system level testing addressed off-normal scenarios, regression testing, and testing of the 95<sup>th</sup> percentile meteorological capability.

The test plan and test execution for HotSpot V2.07.1 satisfactorily address the issues identified in Critical Recommendation 2.

### **2.1.3. Critical Recommendation 3**

*Establish, implement and document a problem reporting, evaluation and notification process consistent with the guidance in DOE G 414.1-4 for level B custom software.*

#### 2.1.3.1. LLNL Action

LLNL has addressed this recommendation by writing a SCMP, and by developing LLNL processes, activities, tools, organization, roles and responsibilities described in that plan. Problem reporting, evaluation and notifications processes are described in Section 2.1.3, and in Appendices A and B. Appendix A describes the LLNL problem evaluation, prioritization and resolution tools and processes. Appendix B describes the user registration, problem reporting and notification process for users outside LLNL. As part of this process, the HotSpot web site now provides a problem reporting form.

#### 2.1.3.2. Review Team Evaluation

The HotSpot problem reporting changes made by LLNL have resulted in three new web links that help external users remain current regarding HotSpot status:

- HotSpot users can register to be notified via e-mail about new HotSpot releases, any problems discovered in HotSpot, and updates on progress towards future releases and new capabilities;
- The HotSpot web site includes a *problem reports* link that provides current information on known problems and the status of current work on HotSpot; and
- A problem reporting link is also available to allow users to provide contact information, a description of a problem, and the platform being used. An e-mail message is automatically sent to the NARAC/HotSpot customer support team for evaluation.

The LLNL problem reporting and corrective action are managed by the HotSpot Software Task Management System. This system handles requirements tracking, configuration management processes, and trouble reporting. The Software Task Management System can generate a variety of reports to assist in prioritizing tasks, packaging the collection of selected changes into a release, and determining the testing status of a release and its readiness for deployment to external users.

In summary, the team finds that the problem reporting, evaluation and notification process outlined in the SCMP (Reference 6) is consistent with the guidance in DOE G 414.1-4 for level B custom software.

#### 2.1.4. Critical Recommendation 4

*Promptly complete and issue the HotSpot User Manual and online help modules for V2.07.1 with awareness that these resources are the primary sources for user training.*

#### **2.1.4.1. LLNL Action**

LLNL has addressed this recommendation in the new version of the HotSpot software with the updated on-line help and the new *HotSpot Health Physics Codes User's Guide* (Reference 8). The on-line help has been included in HotSpot V2.07.1, which is available for download from the HotSpot web site: <https://narac.llnl.gov/HotSpot/HotSpot.html>.

#### **2.1.4.2. Review Team Evaluation**

Before HotSpot V2.07, online help was available to guide users, but a separate user's guide was not available. LLNL addressed this recommendation by writing the user's guide for HotSpot V2.07.1, (Reference 8) and by updating the online help for the HotSpot software. The user's guide includes documentation of the new 95<sup>th</sup> percentile dose module that has been added to the HotSpot code to address the Critical Recommendation 5. Comments from the review team were used to revise the user guide.

The HotSpot V2.07.1 user's guide satisfactorily addresses the issues identified in Critical Recommendation 4.

#### **2.1.5. Critical Recommendation 5**

*Implement a method to read meteorological input data files to satisfy the 95<sup>th</sup>-percentile dose requirement of DOE-STD-3009-94 Change Notice 3, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis, Appendix A, subsection A.3., Dose Estimation/Atmospheric Dispersion.*

##### **2.1.5.1. LLNL Action**

LLNL has addressed this recommendation by adding the Percentile Dose Module in HotSpot V2.07.1, and it is described in Section 5 of Reference 8. The validation of this module is discussed in Section 4.3.2.5 of Reference 7.

##### **2.1.5.2. Review Team Evaluation**

The team worked with the HotSpot code developer to select the meteorological data file format that would best meet the requirements of DOE-STD-3009-94 Change Notice 3, Appendix A. Actual meteorological data from the Savannah River National Laboratory (SRNL) Atmospheric Technologies Group was used for testing. Using the SRNL data file, a comparison was performed between HotSpot V2.07.01 and MACCS2 V1.13.1 (current Central Registry Toolbox code). The results of the HotSpot / MACCS2 comparison using similar assumptions for dispersion methodologies (coefficients) showed good agreement (Reference 9).

HotSpot V2.07.1 effectively implements a method to read meteorological data files in a manner that fully satisfies the 95<sup>th</sup> percentile dose requirement of DOE-

STD-3009-94, *Change Notice 3* Appendix A, subsection A.3.3 *Dose Estimation/ Atmospheric Dispersion* and addresses Critical Recommendation 5.

## **2.2. Additional Recommendations**

In addition to the five critical recommendations, 17 additional recommendations were identified in the earlier evaluation (Reference 2).

### **2.2.1 Additional Recommendations 1 through 17**

*The evaluation team identified 17 additional recommendations that should be considered as future improvements for HotSpot and its software processes.*

### **2.2.2 LLNL Action**

Appendix A describes the additional recommendations as well as LLNL's response regarding actions to address these recommendations.

### **2.2.3 Review Team Evaluation**

The team evaluated and accepted the LLNL disposition of the 17 additional recommendations. Some of the recommendations have been implemented while others will become part of the HotSpot continuous improvement process.

## **3.0 Conclusions and Recommended Actions**

The team's conclusion is that LLNL has adequately addressed the five critical and 17 additional recommendations identified in the earlier evaluation (Reference 2) and recommends that HotSpot V2.07.1 be listed as a Toolbox code in the DOE Safety Software Central Registry.

## **4.0 References**

1. Patrice Bubar memorandum to Distribution – Evaluation of HotSpot for Inclusion in DOE's Safety Software Central Registry, August 8, 2006
2. Software Evaluation of HotSpot and DOE Safety Software Toolbox Recommendation, DOE/HS-0003, March 2007
3. John Nasstrom letter to Andrew Lawrence – Critical Recommendation Status, March 31, 2009
4. Andrew Lawrence letter to John Nasstrom – Review Team, April 30, 2009
5. John Nasstrom letter to Andrew Lawrence – Summary of LLNL Work to Meet Critical HotSpot Recommendations, April 16, 2010

6. *HotSpot Software Configuration Management Plan (2010)*, H. Walker and S. Homann, Lawrence Livermore National Laboratory, Livermore, CA, 94550, Report LLNL-TR-411343, Rev. 2
7. *HotSpot Software Test Plan*, H. Walker and S. Homann, Lawrence Livermore National Laboratory, Livermore, CA, 94550, Report LLNL-TR-411352, Rev. 1, March 10, 2010
8. *HotSpot Health Physics Codes User's Guide*, S. Homann, Lawrence Livermore National Laboratory, Livermore, CA, 94550, Report LLNL-TM-411345 Rev. 1, March 8, 2010.
9. *David C. Thoman, Kevin M. Brotherton, Wayne Davis, Benchmarking Upgraded HotSpot Dose Calculations Against MACCS2 Results*, Washington Safety Management Solutions LLC, EFCOG Safety Analysis Working Group, May 2009

## Appendix A: *Status of Additional Recommendations*

**R1-1:** *Document a comprehensive and complete Software Quality Assurance Plan (SQAP), which contains provisions for software project management, software configuration management and other appropriate elements for HotSpot, following the guidance outlined in DOE G 414.1-4.*

Many elements of a SQAP are included in the *HotSpot Software Configuration Management Plan* and the *HotSpot Software Test Plan*, and in the processes, activities, tools, organization, roles and responsibilities described in these plans. In particular, the material in *HotSpot Software Configuration Management Plan* Section 2.1 and Appendix A describes the organizational structure used for the HotSpot project and how the project was managed, as well as software configuration management. In addition, LLNL and DOE maintain additional project management documentation with an annual statement of work reviewed and approved by DOE/NNSA headquarters, and monthly progress reports sent to DOE/NNSA Headquarters program managers. As part of the ongoing work to maintain the HotSpot software and the plans in the future, LLNL will write an overarching document that will reference the substantial amount of material that is already written in the HotSpot plans.

**R1-2:** *For each software release, develop a simple integrated schedule with appropriate milestones and other measurable performance criteria to ensure the planned release schedule is met.*

This recommendation is addressed in the *HotSpot Software Configuration Management Plan*. In particular, the tools described in Appendix A allow software modifications and releases to be scheduled for HotSpot. LLNL is working on making modifications to these tools to generate release schedules automatically to schedule and monitor progress on a software release more efficiently in the future.

**R2-1:** *Document and implement a risk management process for HotSpot. This includes performing a risk analysis and identifying any risk mitigation controls.*

This recommendation is addressed to a significant degree in the *HotSpot Software Configuration Management Plan* and the *HotSpot Software Test Plan*. In particular, *HotSpot Software Configuration Management Plan*, Sections 2 and 3, and Appendix A, cover management practices, evaluations, controls and reviews that reduce risk. Oversight and review by the End User Software Development Team Leader, the SQA Coordinator, the HotSpot Project Leader and the NARAC Program Manager helped control risk. The training of a second HotSpot developer and the addition of a supervising Software Development Team Leader reduced the risk associated with having only one trained developer, which was mentioned in the earlier HotSpot evaluation. The addition of independent testing, as described in the *HotSpot Test Plan*, has significantly reduced risk. Up-to-date documentation in the *HotSpot User's Guide*, which includes information on the basic requirements and assumptions for HotSpot, reduces the risk

associated with undocumented software requirements, which was mentioned in the HotSpot Software Evaluation. In general, risk is minimized by virtue of HotSpot V2.07 being a well developed, widely used and tested computer code that uses proven methods, development tools, and operating system.

**R3-2:** *Incorporate technical plans, documentation, testing results, and other important project documentation in the configuration management system. Operating system and commercial software used in HotSpot should also be archived along with the HotSpot source code, executables, and key documentation.*

This recommendation is addressed in the *HotSpot Software Configuration Management Plan* and the *HotSpot Test Plan*. In particular, the material in *HotSpot Software Configuration Management Plan* Section 3.1 covers the configuration items maintained in the HotSpot configuration management system, including software and documentation. While the operating system and commercial Help package (i.e., RoboHelp) are not in the configuration management system, they are backed-up and archived according to the procedures described in Section 5.1 of this document. Because HotSpot has not shown sensitivity to the operating system or development environment over an extended period, it does not appear necessary at this time to place the operating system or development tools, which are readily available from the vendors and backed-up and archived at LLNL, into the configuration management system.

**R3-3:** *The HotSpot program should remain cognizant to the potential need for employing configuration management software. As the HotSpot program evolves and as other atmospheric scientists, health physicists, and computer programmers begin to play an active role in code maintenance, testing, and development, the need to employ formal configuration management software will develop.*

This recommendation is addressed in the *HotSpot Software Configuration Management Plan*, where the configuration management software tools used for HotSpot are described.

**R4-1:** *Develop and maintain technical and quality requirements for acquired software in the project's quality assurance files.*

This recommendation is addressed by the *HotSpot Software Configuration Management Plan*. In particular, the material in Section 3.6 covers the procurement issues associated with HotSpot.

**R5-1:** *From previous versions of HotSpot, identify and document any critical software requirements used in the development of HotSpot.*

This recommendation is addressed in the *HotSpot Health Physics Codes User's Guide* and plans. The HotSpot User's Guide provides detailed descriptions of the equations and assumptions used, which define the core requirements. This document includes the



history of HotSpot, which provides information on how the requirements have evolved with time. In addition, the robust built-in test suite described in both the User's Guide and in the *HotSpot Software Test Plan* provides presentations of core requirements along with model results showing that these requirements are met. The HotSpot Task Management System, described in the *HotSpot Software Configuration Management Plan*, is used to enter and track requirements for HotSpot.

**R5-2:** *Develop and document software requirements and traceability to those requirements for HotSpot. Requirements documented should include: functional, performance, security, user access control, interface and safety, and installation and design constraints.*

This recommendation is addressed in the *HotSpot Software Configuration Management Plan*. In particular, the material in Section 2.1 and Appendix A covers starting with HotSpot V2.07.1, how requirements, improvements and corrections are tracked from submission through acceptance testing and into the released version of HotSpot. In addition, the *HotSpot Software Test Plan* provides details on how issues are tested in HotSpot to confirm that the new requirements are being met and how the regression testing insures that previous requirements continue to be met. HotSpot Task Management System, which is documented in the *HotSpot Software Configuration Management Plan*, describes how requirements for HotSpot are continually entered and tracked.

**R6-1:** *Consolidate requirements from software development folder(s) into a more global requirements document.*

Basic HotSpot design Data Flow Diagrams are included in the HotSpot configuration management system. During the normal course of HotSpot maintenance work at LLNL, requirements and design information from paper documents will continue to be captured and placed under configuration management.

**R6-2:** *Expand developer testing to include non-normal test cases and document the execution of those test cases.*

This recommendation is addressed by the *HotSpot Software Test Plan*, which includes a description of developer testing procedures and non-normal test cases. In particular, the 95<sup>th</sup> percentile dose module validation (see Section 4.3.2.5) includes explicit testing for illegal inputs. In addition, the checklist in Section 4.3.3 checks for correct behavior in the user interface when provided with erroneous input.

**R6-3:** *Document the occurrence of ad-hoc and beta testing by others. Include the relationship of the person(s) performing the ad-hoc tests to the development of HotSpot. It is desired to have this relationship to be independent of the development.*

This recommendation is addressed by the *HotSpot Software Test Plan*, which describes independent testing by non-developers.

**R6-4:** *Enhance the code to highlight input errors and provide more robust notification of input errors.*

There are many checks throughout HotSpot that validate user inputs. This is verified during testing. The 95<sup>th</sup> percentile dose module validation (*HotSpot Software Test Plan* Section 4.3.2.5) includes testing for illegal inputs. In addition, the “GUI Input Fields – Test” checklist in Section 4.3.3 checks for correct behavior in the Graphical User Interface (GUI) when provided with erroneous input. Highlighting of input errors will be added in the normal course of HotSpot maintenance and development work.

**R8-2:** *Generate or update and review the software documents associated the SSQA activities (e.g., software requirements, SQA planning, test cases and procedures) according to the recommendations in the other work activities.*

This recommendation is addressed in the *HotSpot Software Configuration Management Plan* and the *HotSpot Software Test Plan*. These documents will be updated and improved during the normal course of HotSpot software maintenance, including additional requirements tracking.

**R8-3:** *Validate and document the QC test cases that are built into the software with the results from another DOE safety software Central Registry toolbox code or other means appropriate to ensure the results from the test cases are accurate.*

This recommendation is addressed by the *HotSpot Health Physics Codes User's Guide* and the *HotSpot Software Test Plan*, which describes the analytical equations implemented in HotSpot and the tests against the analytical values that were used to verify and validate the model. In addition, the report by, David C. Thoman, Kevin M. Brotherton, Wayne Davis, *Benchmarking Upgraded HotSpot Dose Calculations Against MACCS2 Results*, presented the , EFCOG Safety Analysis Working Group (2009) meeting, describes the comparison of HotSpot against the MACCS2 code. This comparison was ultimately focused on the comparison of the 95<sup>th</sup> percentile dose calculations. However, these calculations summarize many individual HotSpot and MACCS2 calculations and provide verification of HotSpot calculations by another code.

**R10-2:** *Implement a formal training program specifically for DOE users and their application of HotSpot. This training should utilize the existing site-specific training, DOE EFCOG presentations, and other material available. This training should be shared with the HotSpot program manager/developer for adaptation and potential use in the more general HotSpot user community. This requires implementation by DOE.*

The following successful pilot training course was developed and presented by Carl Mazzola and Steve Homann at the DOE EMI SIG Annual Meeting: *HotSpot V2.07*

*Radiological Transport & Dispersion Modeling Workshop and Computer Practicum, San Francisco, CA, May 8, 2009.*

LLNL will continue to work with DOE to propose continuing and expanding the formal training program.

**R10-3:** *Enhance the user training program effectiveness by including several applied problems and solutions to address the full spectrum of HotSpot applications in the appropriate training material.*

In the successful aforementioned piloted training course, numerous applied examples of HotSpot usage were included. LLNL will continue to work with DOE to develop approaches and find opportunities to continue and expand the formal training program and material.

**R10-4:** *Structure the training program to incorporate provisions for continuing education to ensure users are trained on new features.*

LLNL will continue to work with DOE to propose expanding the formal training plan to support continuing education.

## Appendix B: Acronyms

DOE	Department of Energy
EFCOG	Energy Facilities Contractors Group
GUI	Graphic User Interface
HSS	Office of Health, Safety and Security
IEEE	Institute of Electrical and Electronics Engineers
LLNL	Lawrence Livermore National Laboratory
NARAC	National Atmospheric Release Advisory Center
SCAPA	Subcommittee on Consequence Assessments and Protective Action
SCM	Software Configuration Management
SCMP	Software Configuration Management Plan
SQAP	Software Quality Assurance Plan
SRNL	Savannah River National Laboratory
SSQA	Safety Software Quality Assurance