Automatic Verification and Validation of Fire Models

Kristopher Overholt

Fire and Evacuation Modeling Technical Conference 2014

September 8, 2014

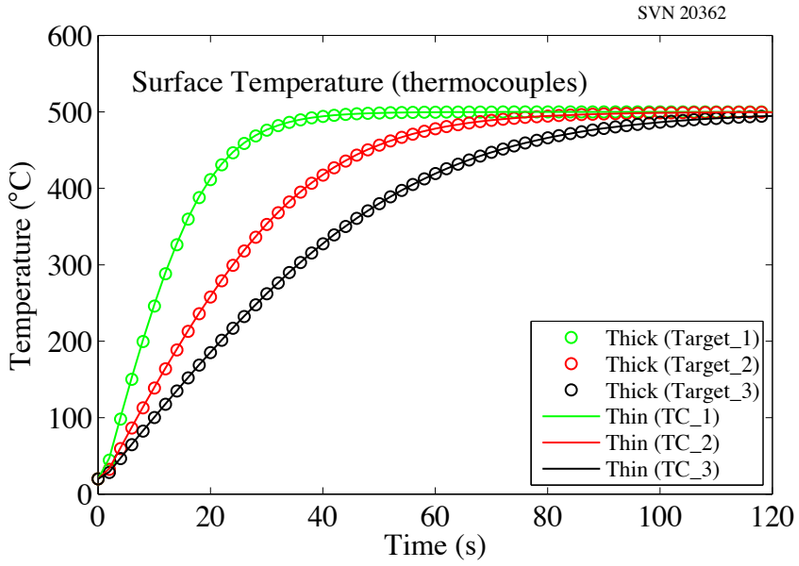
National Institute of Standards and Technology
U.S. Department of Commerce

Outline

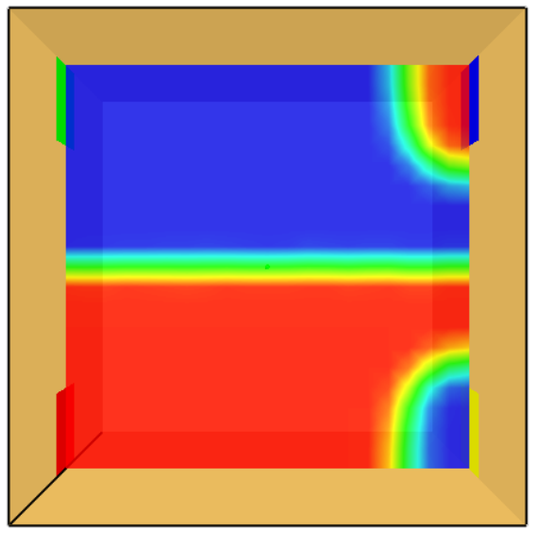
1) The verification process
2) The validation process
3) Resources for users
4) How users can contribute

Why automate the verification process?

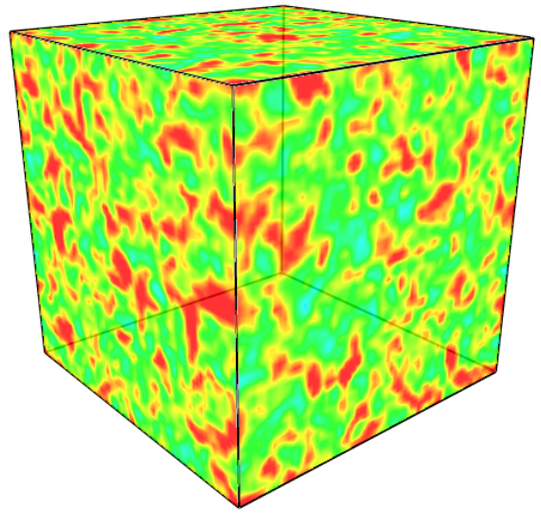
FDS Verification Cases



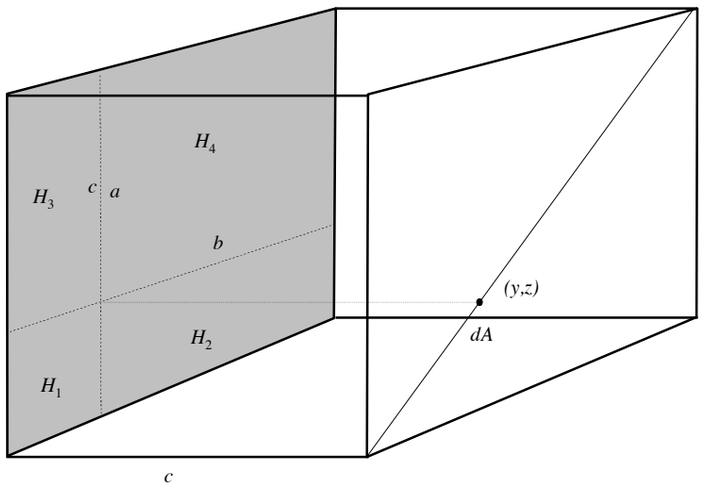
Heat Transfer



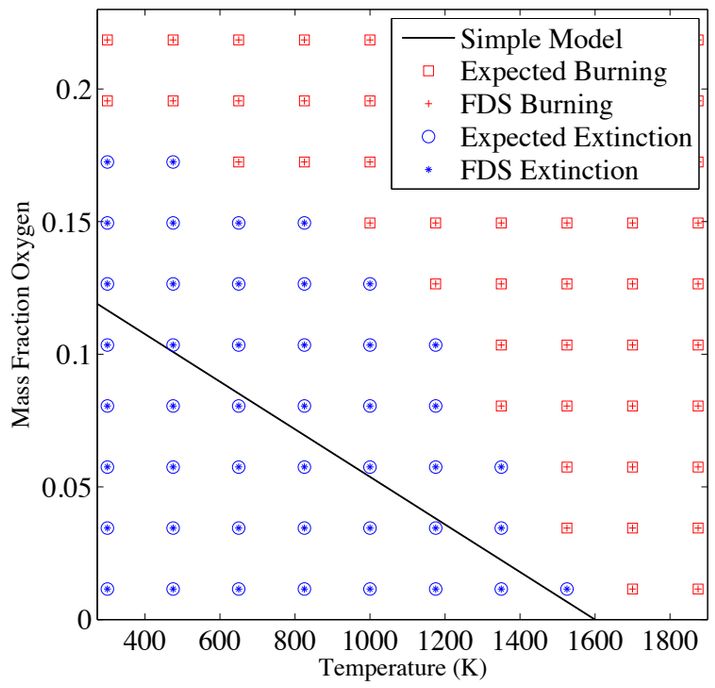
HVAC



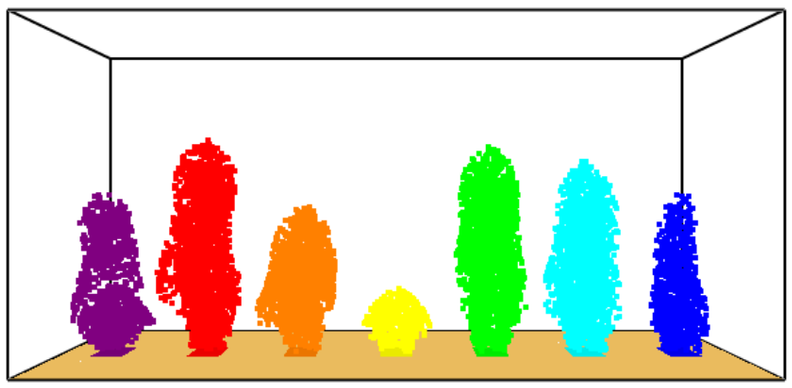
Turbulence



Radiation

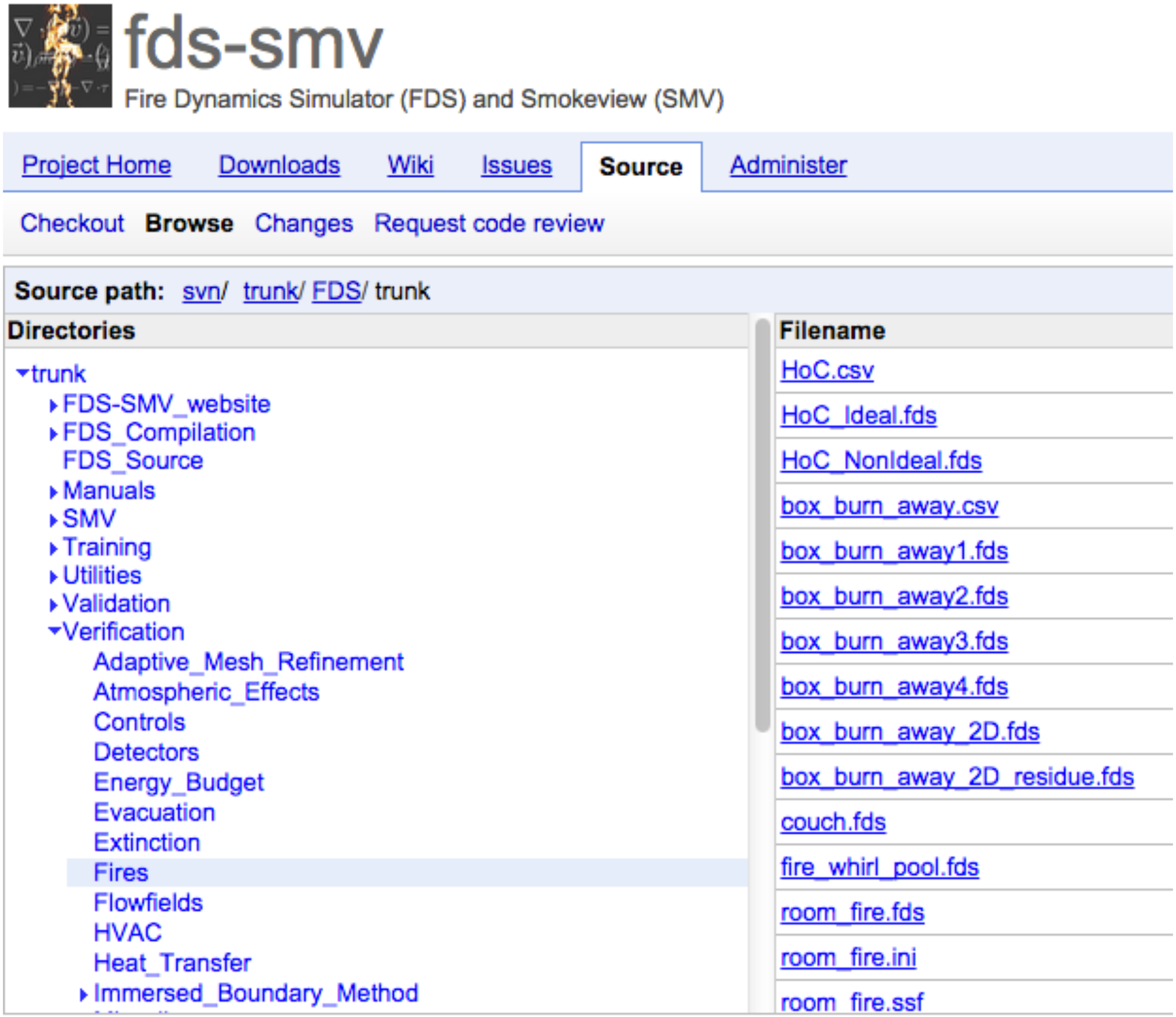


Combustion

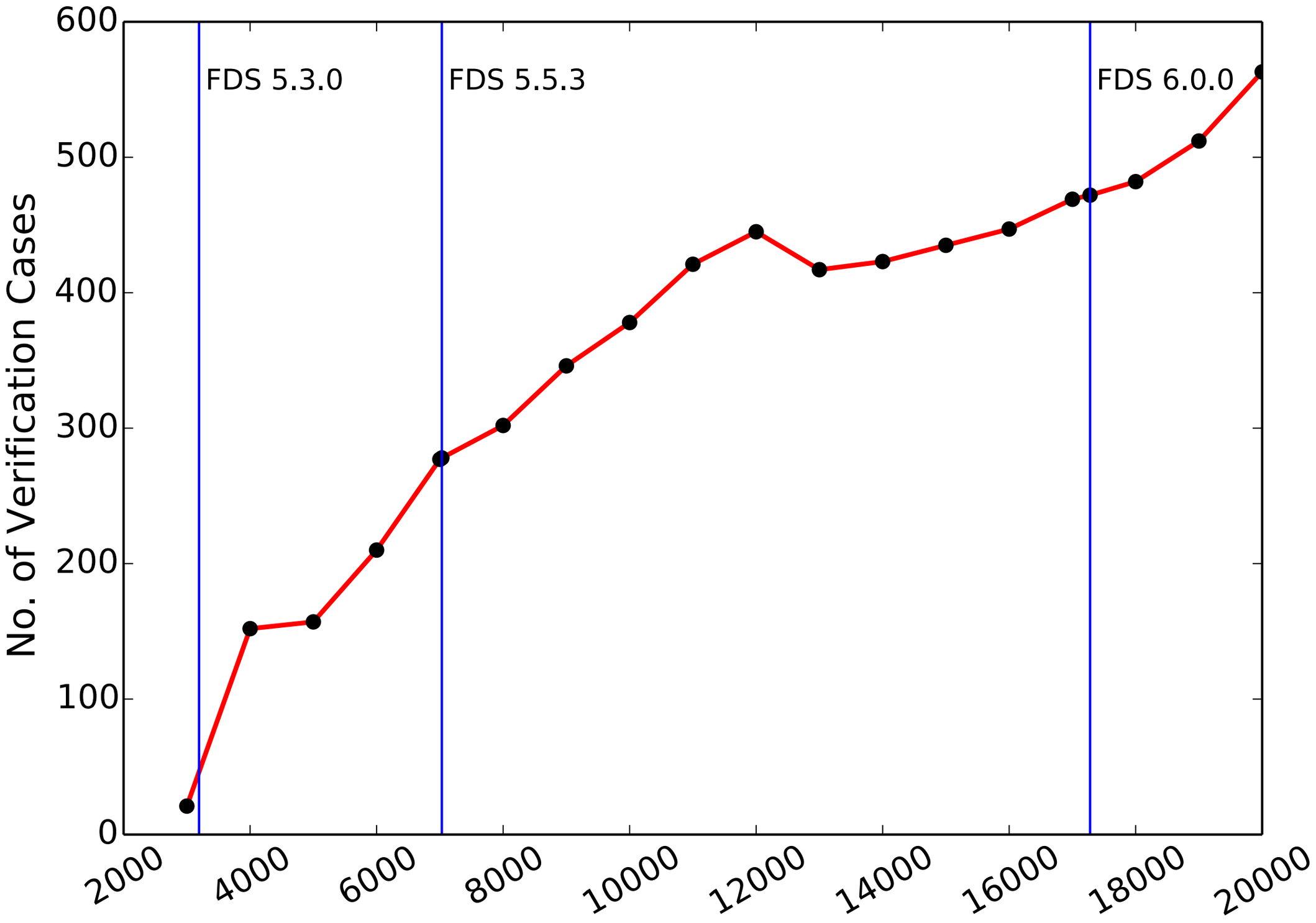


Controls

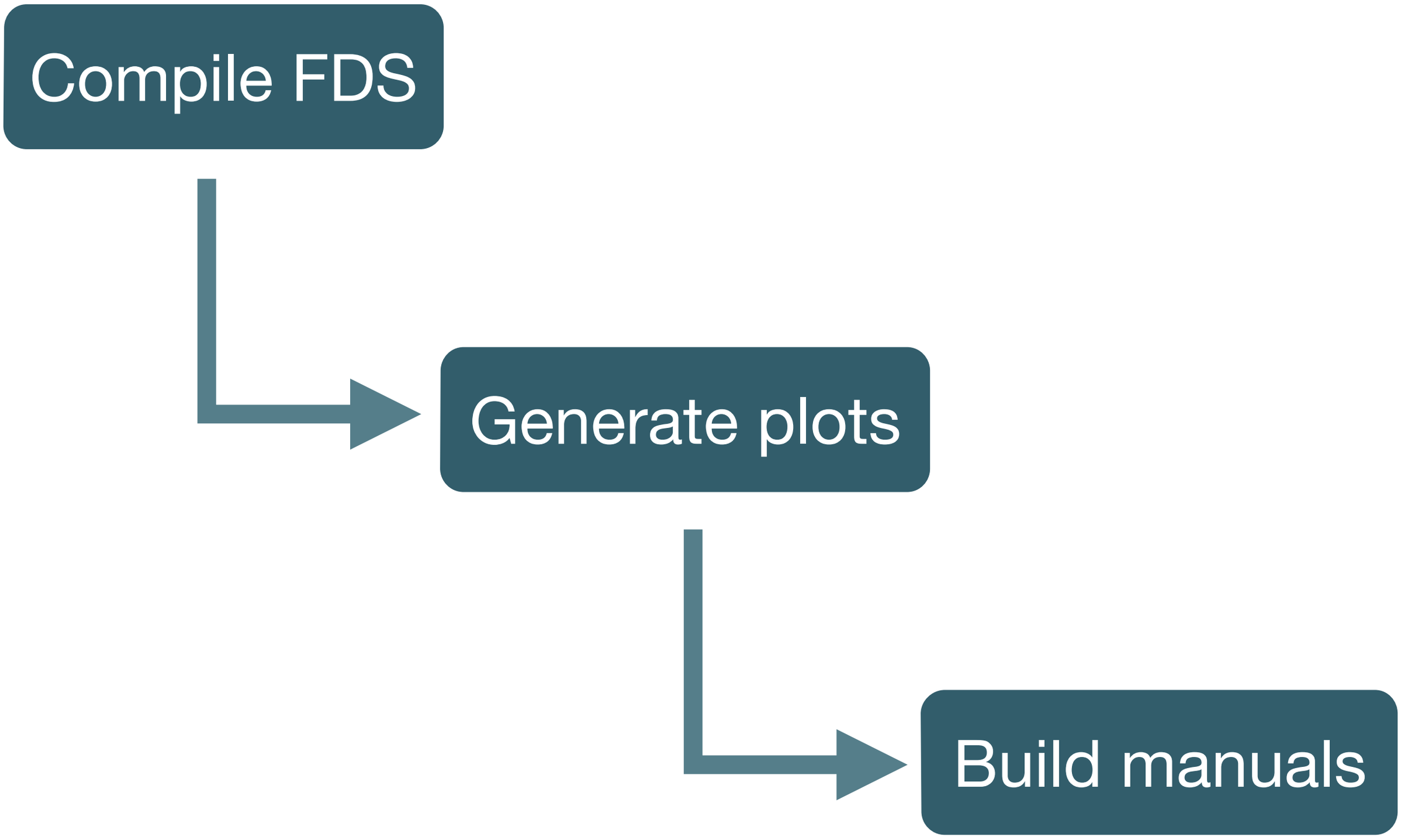
Working in the FDS-SMV repository



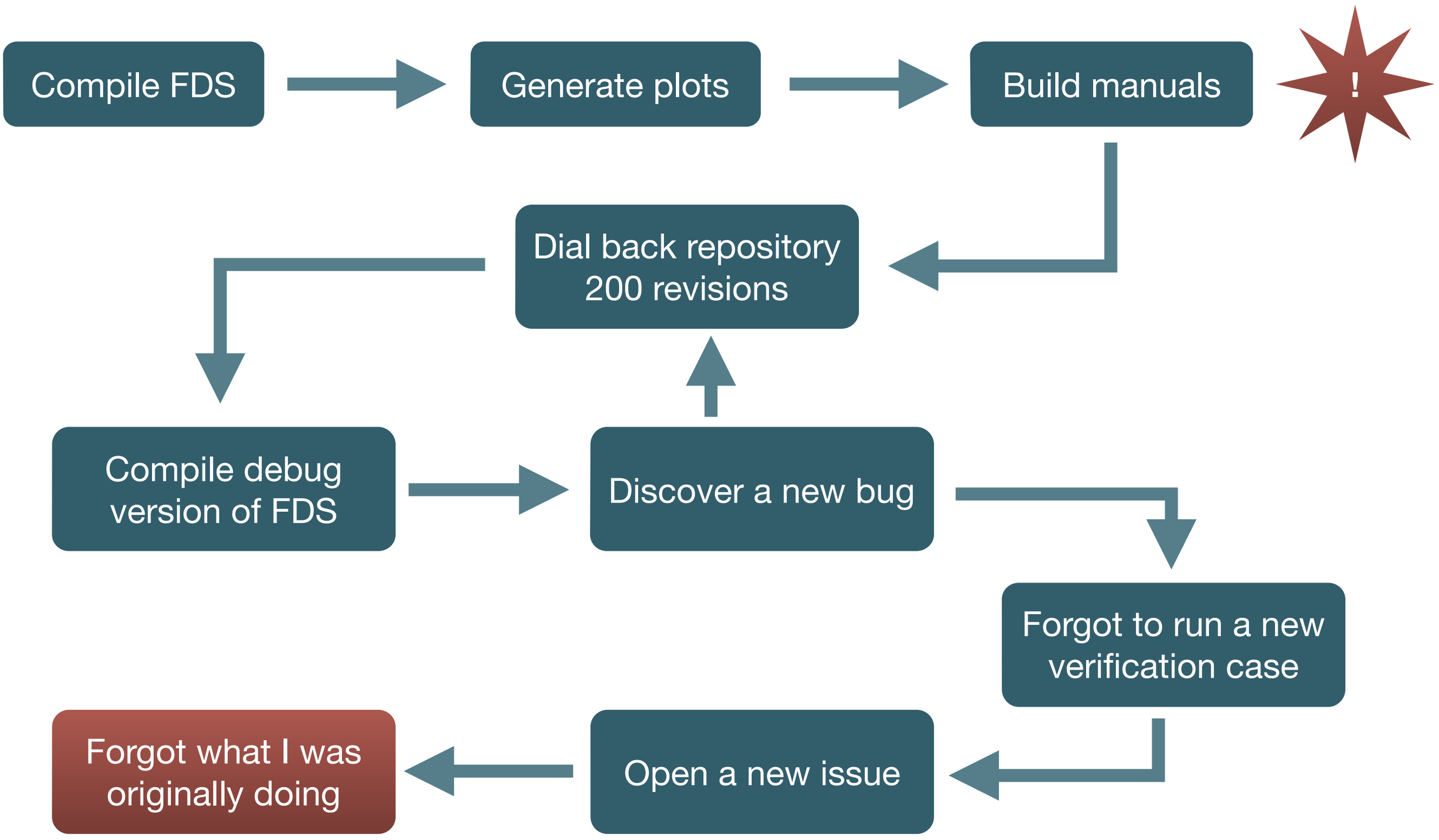
FDS Verification Cases



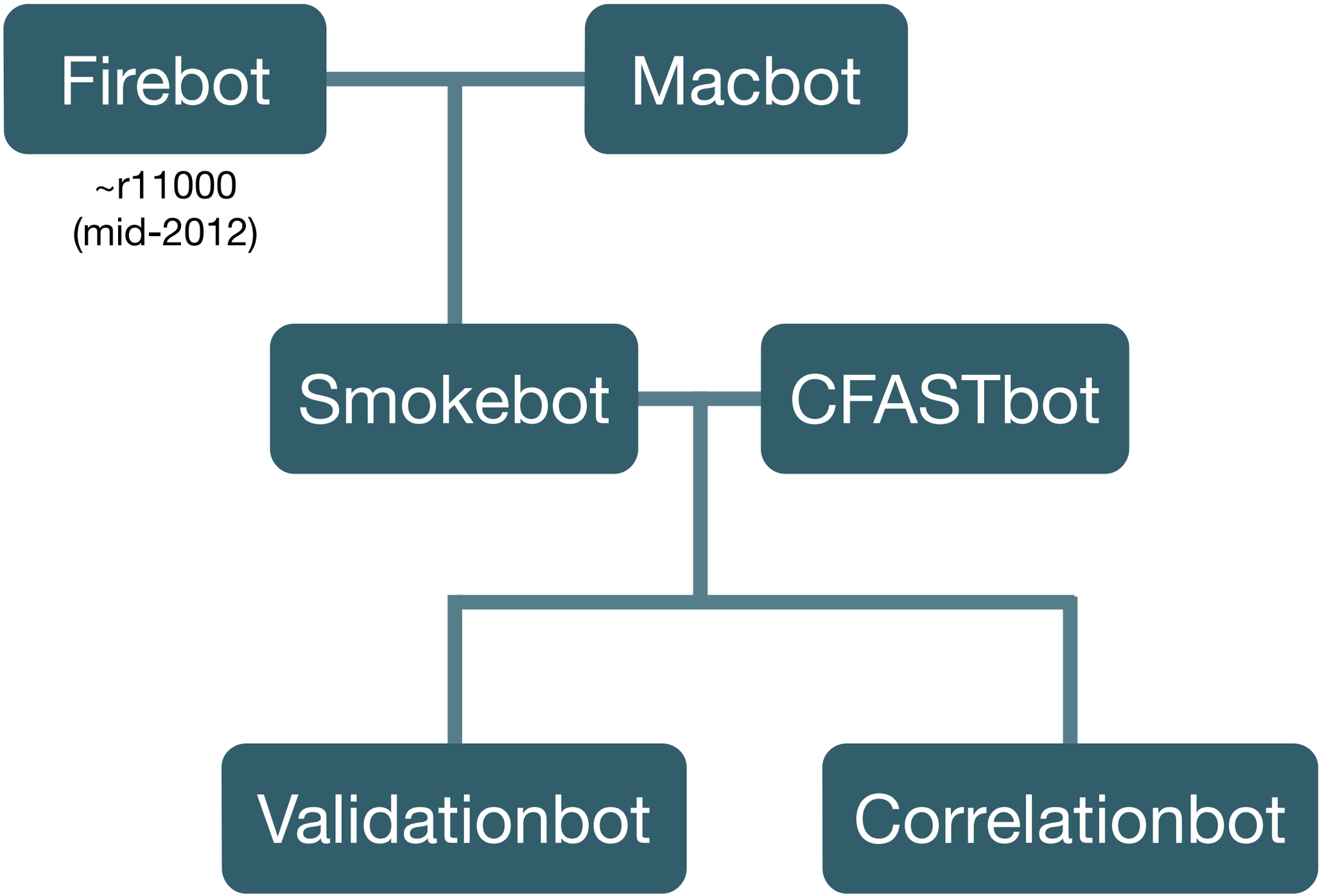
A typical (ideal) workflow



A typical (real-world) workflow



The Firebot Family Tree



Principles of continuous integration

- ✓ 1. Maintain a code repository
- ✓ 2. Automate the build
- ✓ 3. Make the build self-testing
- ✓ 4. Everyone commits to the baseline every day
- ✓ 5. Keep the build fast
- ✓ 6. Test in a clone of the production environment
- ✓ 7. Make it easy to get the latest deliverables
- ✓ 8. Everyone can see the results of the latest build

Firebot Stages

Build Stage	Description
Stage 1	Obtain latest source code
Stages 2a-2b	Compile FDS (debug)
Stage 3	Run verification cases (debug)
Stages 4a-4b	Compile FDS (release)
Stage 5	Run verification cases (release)
Stages 6a-6e	Smokeview operations
Stages 7a-7c	Generate plots and statistics
Stage 8	Build manuals

[Firebot@blaze] Build success! Revision 20042 passed all build tests. Firebot x

firebot

Host OS: Linux
Host Name: blaze
Start Time: Wed Jul 30 21:56:01 EDT 2014
Stop Time: Thu Jul 31 03:58:36 EDT 2014

Nightly Manuals (private): http://blaze.nist.gov/firebot
Nightly Manuals (public): https://drive.google.com/folderview?id=0B_wB1pJL2bFQaDJaOFNnUDR4LXM#list
---

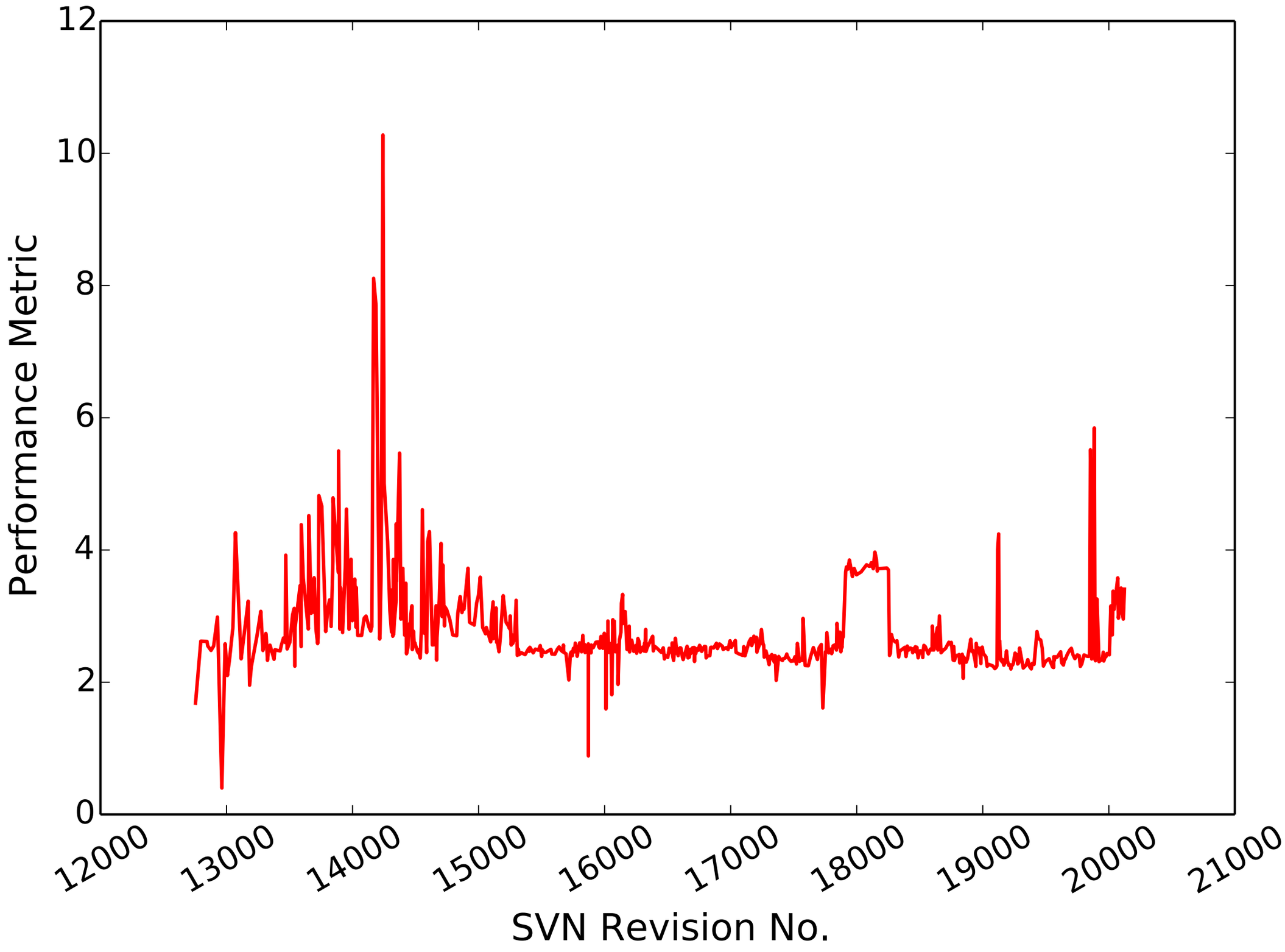
[Firebot@blaze] Build failure and warnings for Revision 20097.

Firebot x

firebot

Errors from Stage 2a - Compile and inspect FDS debug:
../makefile:484: warning: overriding commands for target `mpi_intel_linux_64ib'
../makefile:171: warning: ignoring old commands for target `mpi_intel_linux_64ib'
rm -f *.o *.mod *.obj
Building intel_linux_64_inspect
../makefile:484: warning: overriding commands for target `mpi_intel_linux_64ib'
../makefile:171: warning: ignoring old commands for target `mpi_intel_linux_64ib'
ifort -c -g -O0 ../../FDS_Source/prec.f90
ifort -c -g -O0 ../../FDS_Source/mpis.f90
ifort -c -g -O0 ../../FDS_Source/cons.f90
ifort -c -g -O0 ../../FDS_Source/devc.f90
ifort -c -g -O0 -openmp ../../FDS_Source/type.f90
ifort -c -g -O0 -openmp ../../FDS_Source/pois.f90
ifort -c -g -O0 -openmp ../../FDS_Source/mesh.f90
ifort -c -g -O0 -openmp ../../FDS_Source/func.f90
ifort -c -g -O0 ../../FDS_Source/data.f90
ifort -c -g -O0 ../../FDS_Source/smvv.f90
ifort -c -g -O0 ../../FDS_Source/irad.f90
ifort -c -g -O0 ../../FDS_Source/ieva.f90
ifort -c -g -O0 ../../FDS_Source/scrc.f90
ifort -c -g -O0 ../../FDS_Source/gsmv.f90
ifort -c -g -O0 ../../FDS_Source/ctrl.f90
ifort -c -g -O0 -openmp ../../FDS_Source/turb.f90
ifort -c -g -O0 ../../FDS_Source/hvac.f90
ifort -c -g -O0 ../../FDS_Source/fire.f90

FDS Performance Statistics



Why automate the validation process?

In 2007, the U.S. Nuclear Regulatory Commission (NRC), together with the Electric Power Research Institute (EPRI) and the National Institute of Standards and Technology (NIST), conducted a research project to verify and validate five fire models used for nuclear power plant (NPP) applications.

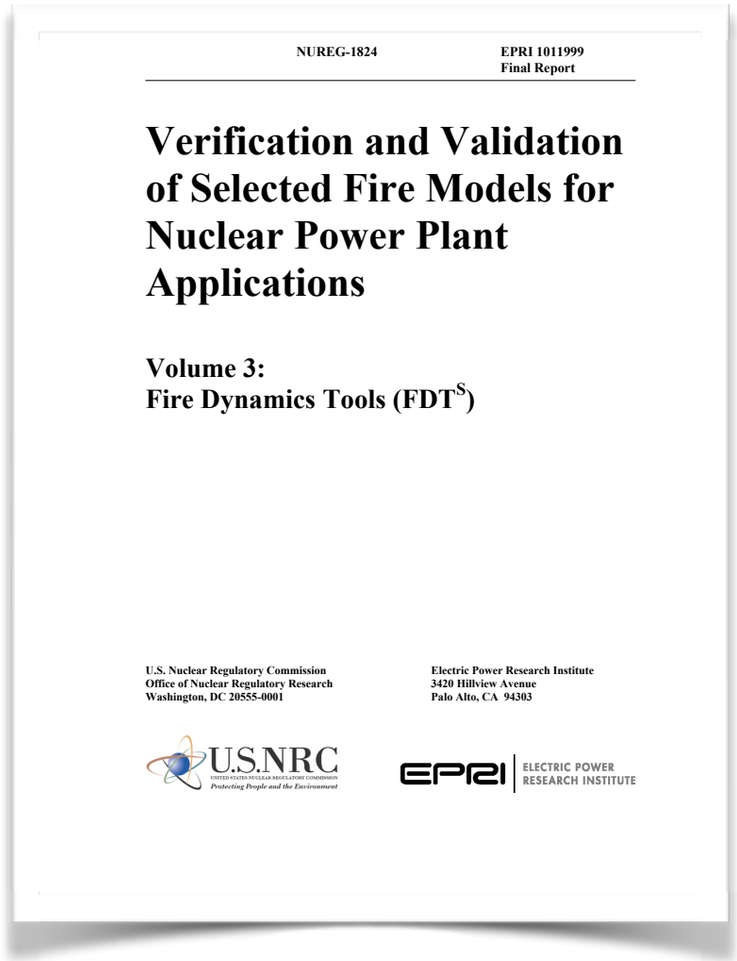
U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

EPRI
ELECTRIC POWER
RESEARCH INSTITUTE

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

The results of this effort were documented in a seven-volume report, NRC NUREG-1824, Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications.

Includes experimental data from 26 individual tests.

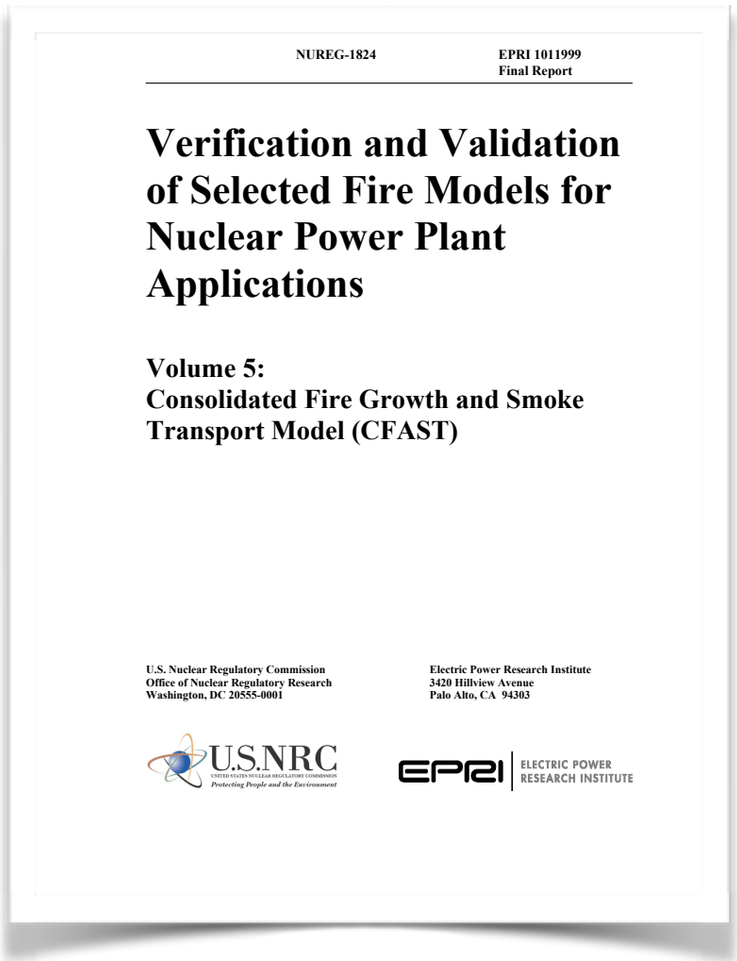

NUREG-1824 EPRI 1011999 Final Report

Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications

Volume 3:
Fire Dynamics Tools (FDT^S)

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94303

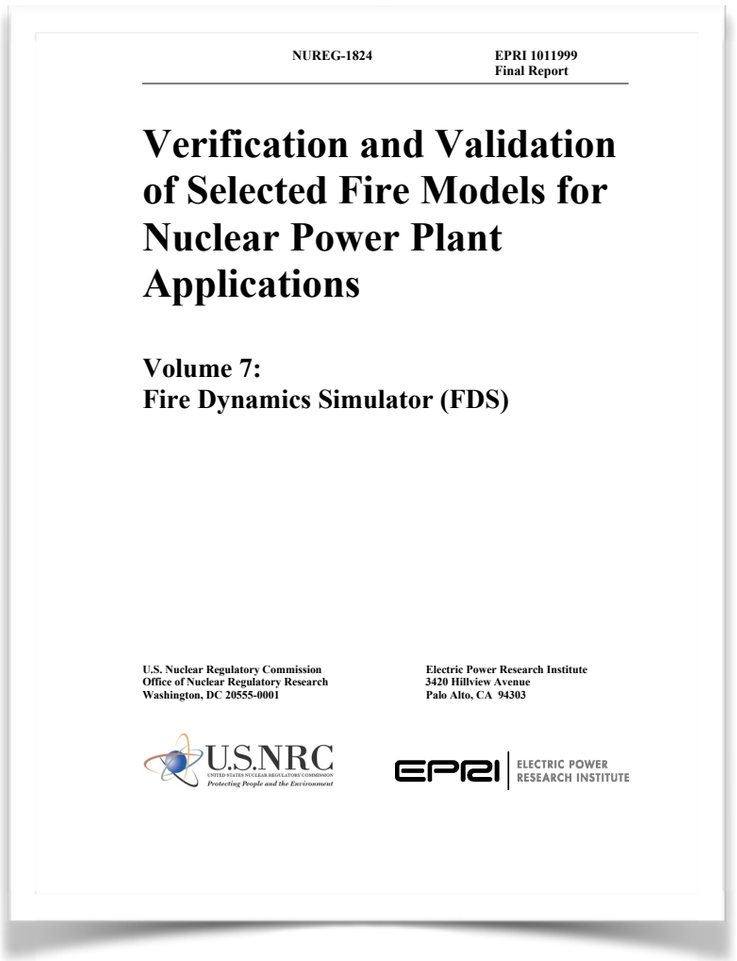

NUREG-1824 EPRI 1011999 Final Report

Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications

Volume 5:
Consolidated Fire Growth and Smoke Transport Model (CFAST)

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94303


NUREG-1824 EPRI 1011999 Final Report

Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications

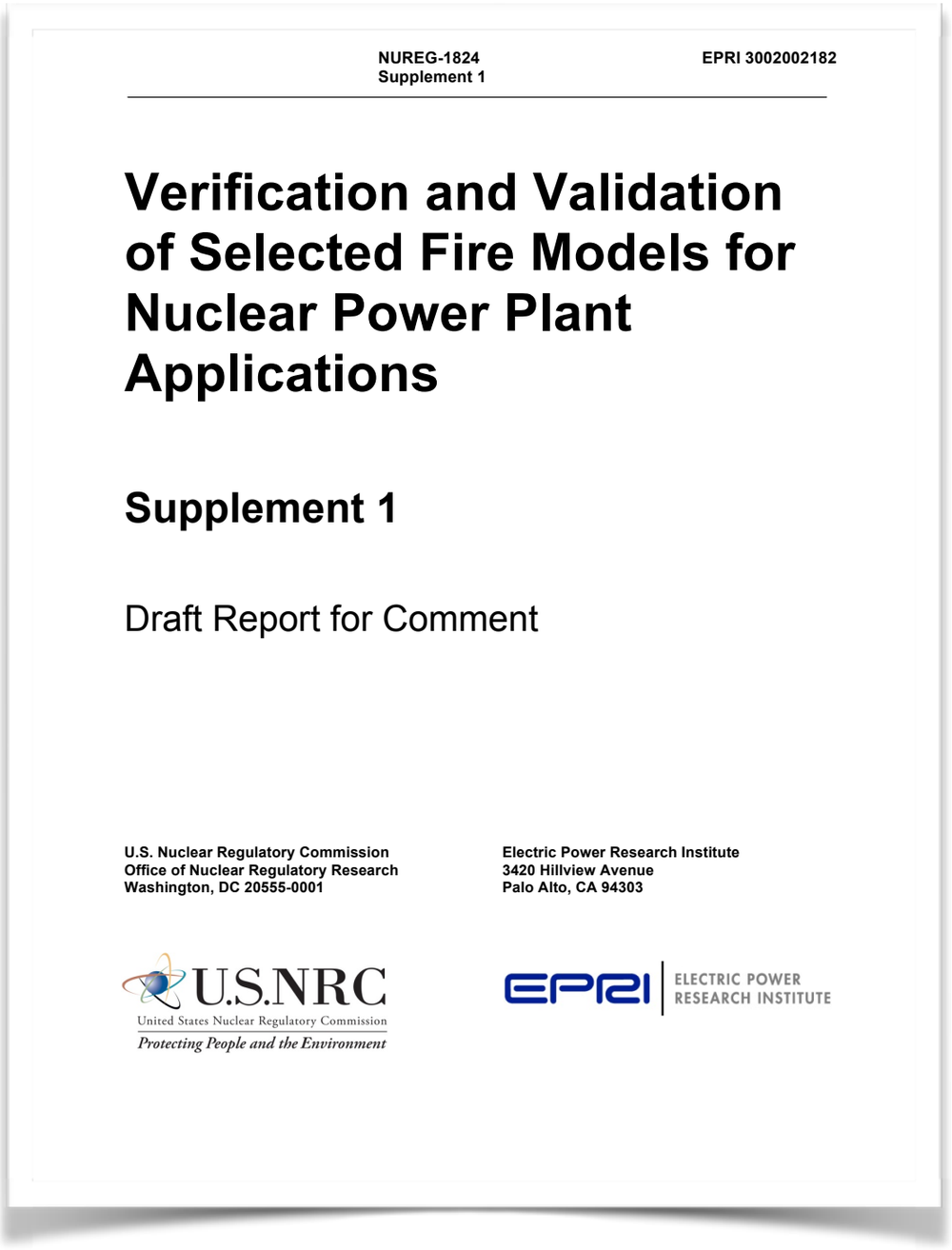
Volume 7:
Fire Dynamics Simulator (FDS)

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94303

In 2014, the verification and validation study was expanded, and the full details of the revised V&V study are summarized in NUREG-1824 Supplement 1 (one volume).

- 860 individual experiments
- 44 experimental data sets
- 5000+ point-to-point comparisons
- Uses the latest versions of the models (FDS 6, CFAST 6)



NUREG-1824
Supplement 1

EPRI 3002002182

Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications

Supplement 1

Draft Report for Comment

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

A Correlation Guide (NIST SP 1169) was created to serve as a verification and validation guide for the empirical correlations to be consistent with the CFAST and FDS V&V guides.

NIST Special Publication 1169

Verification and Validation of Commonly Used Empirical Correlations for Fire Scenarios

Kristopher J. Overholt

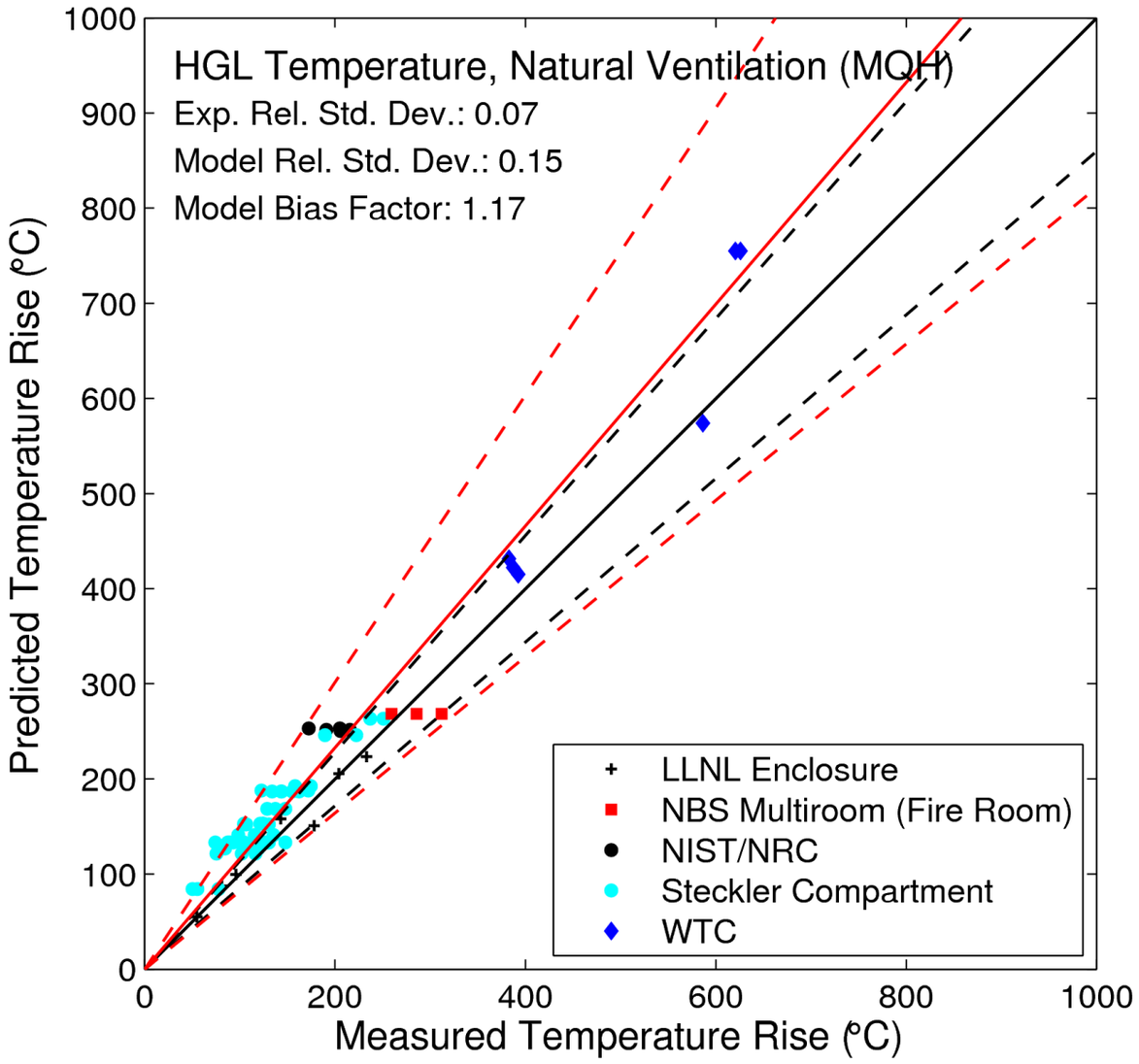
Can maintain empirical correlations in the long term in a centralized location. New empirical correlations and experimental data can be added, and the document can be regenerated in ~15 minutes from the FDS repository.

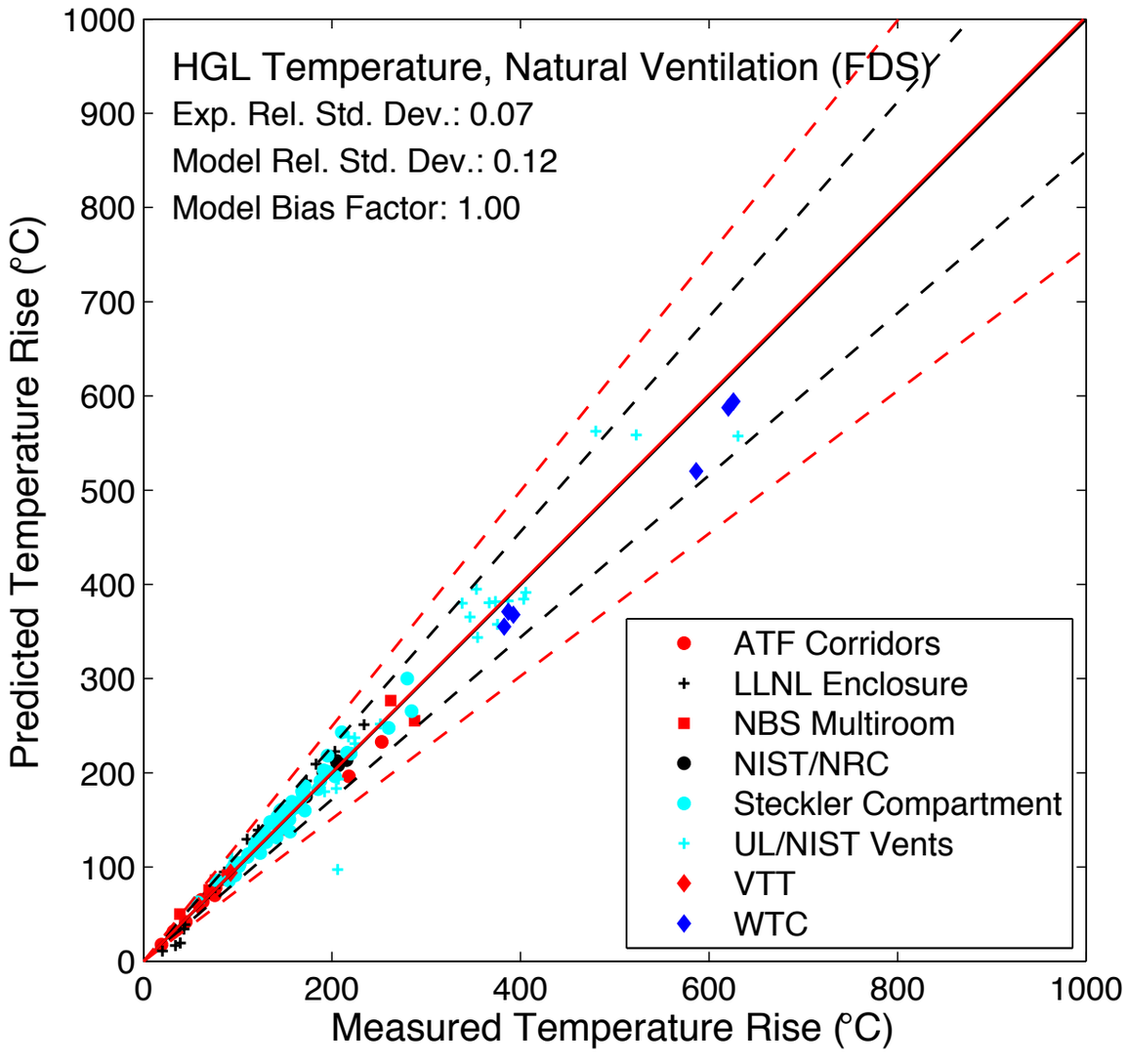
NUREG-1824 Supplement 1 includes the validation results of empirical correlations, zone models, and a CFD model.

14 output quantities were considered, including:

- Hot Gas Layer Temperature
- Ceiling Jet Temperature
- Target Heat Flux
- Target Temperature
- Sprinkler Activation Time
- Smoke Detector Activation Time
- […]

Measured and predicted results are compared via scatter plots and summarized via two metrics: **model bias and uncertainty**.





Summary of NRC NUREG-1824 Supplement 1

Quantities of Interest

Models of Interest

Output Quantity	Empirical Correlations			CFAST		MAGIC		FDS		Exp
	Corr.	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	$\tilde{\sigma}_E$
HGL Temp. Rise, Natural	MQH	1.17	0.15	1.20	0.34	1.13	0.30	1.00	0.12	0.07
HGL Temp. Rise, Forced	FPA	1.29	0.32	1.15	0.20	1.08	0.17	1.21	0.22	0.07
	DB	1.18	0.25							
HGL Temp. Rise, Closed	Beyler	1.04	0.37	0.99	0.08	1.07	0.16	1.20	0.12	0.07
HGL Depth	ASET/YT	-	-	1.12	0.36	1.17	0.31	1.03	0.06	0.05
Ceiling Jet Temp. Rise	Alpert Unconfined	0.86	0.11	1.18	0.33	1.04	0.45	0.98	0.14	0.07
	Alpert Compartment	0.31	0.49							
Plume Temp. Rise	Heskestad	0.84	0.33	1.08	0.20	1.04	0.20	1.20	0.21	0.07
	McCaffrey	0.90	0.31							
Oxygen Concentration	N/A			1.00	0.15	0.93	0.22	1.01	0.11	0.08
Smoke Concentration	N/A			3.16	0.68	3.71	0.66	2.63	0.59	0.19
Pressure Rise	N/A			1.36	0.66	1.32	0.42	0.96	0.27	0.21
Target Temp. Rise	Steel	1.29	0.45	1.58	0.64	1.08	0.38	0.98	0.18	0.07
Target Heat Flux	Point Source	1.44	0.47	0.93	1.16	0.85	0.66	0.98	0.25	0.11
	Solid Flame	1.17	0.44							
Surface Temp. Rise	N/A			1.05	0.28	0.95	0.29	0.99	0.12	0.07
Surface Heat Flux	N/A			0.98	0.34	0.78	0.35	0.92	0.15	0.11
Cable Failure Time	THIEF	0.90	0.11	-	-	-	-	1.10	0.16	0.12
Sprinkler Activation Time	Sprinkler	1.11	0.41	0.80	0.21	0.91	0.20	0.93	0.15	0.06
Smoke Detector Activation Time	Temp. Rise	0.66	0.57	1.12	0.46	1.54	0.36	0.85	0.29	0.34

Validationbot (FDS)

Runs at least 1 FDS validation set nightly

CFASTbot

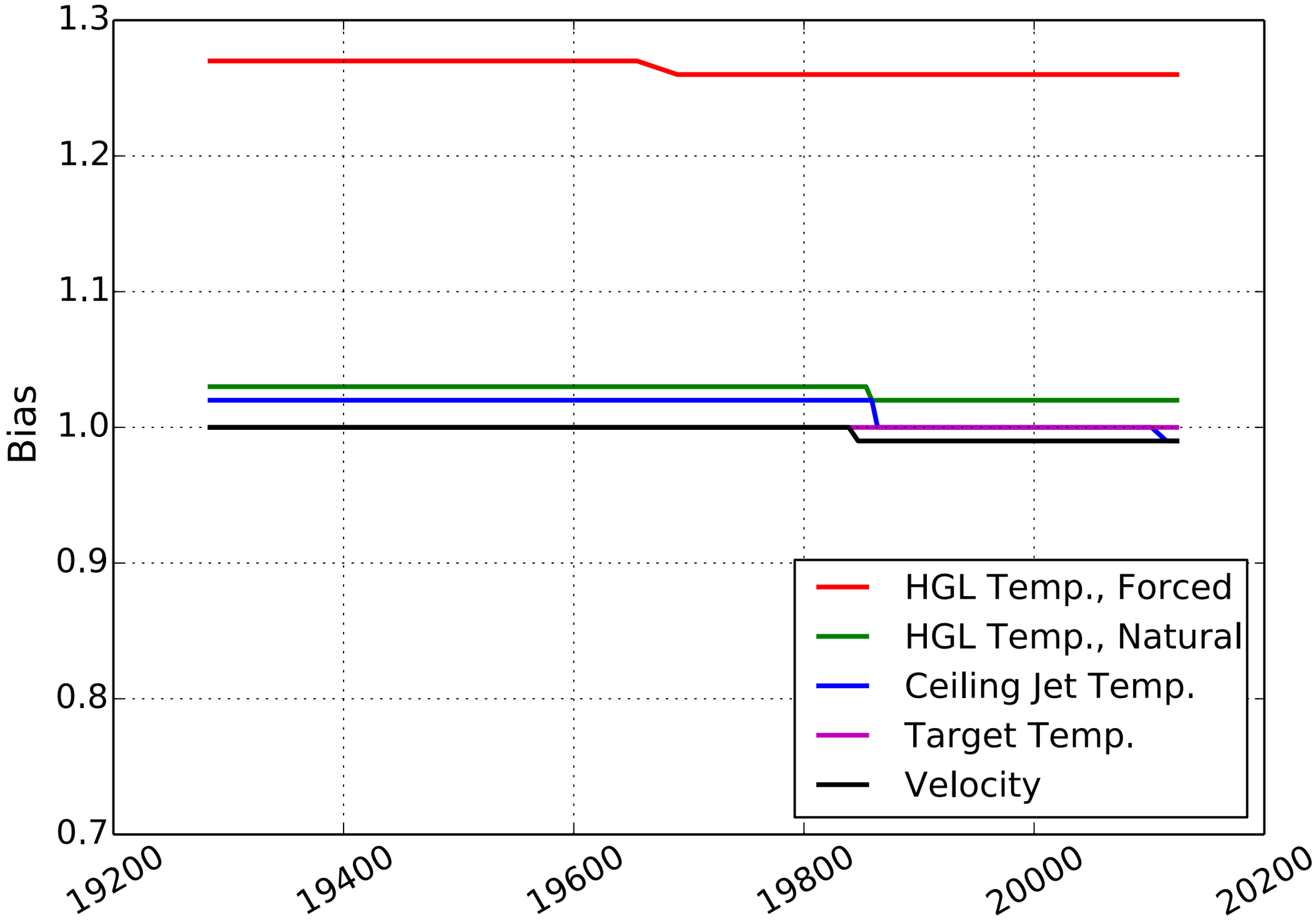
Runs all CFAST verification and validation cases on each commit

Correlationbot

Runs correlation cases on demand and generates Correlation Guide (NIST SP 1169)

Test Series	$\dot{Q}$ (kW)
Arup Tunnel	5344
ATF Corridors	50 – 500
Beyler Hood	8 – 30
Bryant Doorway	34 – 511
Cup Burner	0.3
FAA Cargo	5
Fleury Heat Flux	100 – 300
FM Panels	30 – 100
FM/SNL	470 – 516
Hamins CH_4	0.4 – 162
Harrison Plumes	5 – 15
Heskestad	10^2 – 10^7
LLNL Enclosure	50 – 400
McCaffrey Plume	14 – 57
NBS Multi-Room	110
NIST FSE	100 – 2500
NIST/NRC	350 – 2200
NIST RSE	50 – 600
NIST Smoke Alarms	100 – 350
NRCC Facade	5000 – 10300
NRL/HAI	50 – 520
Sandia Plume	2025 – 5450
SP AST	450
Steckler	31.6 – 158
UL/NFPRF	4400 – 10000
UL/NIST Vents	500 – 2000
Ulster SBI	30 – 60
USCG/HAI	250 – 1000
USN Hawaii	100 – 7700
USN Iceland	100 – 15700
Vettori Flat	1055
Vettori Sloped	1055
VTT Large Hall	1860 – 3640
WTC	1970 – 3240

FDS Validation Accuracy



What resources are available for users?

FDS-SMV Documentation

- FDS User's Guide
- FDS Technical Reference Guide
- FDS Verification Guide
- FDS Validation Guide
- FDS Configuration Management Plan

- Smokeview User's Guide
- Smokeview Technical Reference Guide
- Smokeview Verification Guide

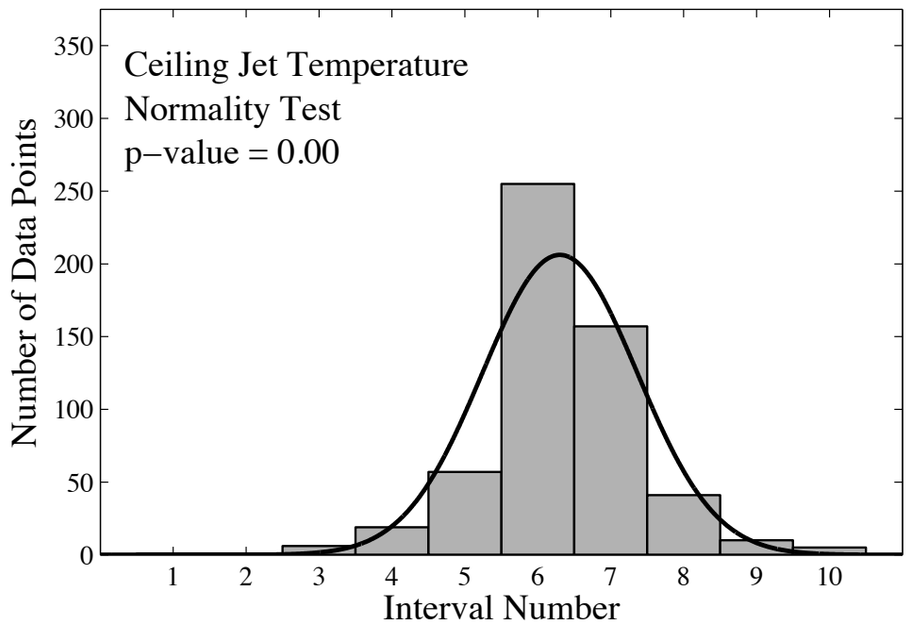
Appendix A
Summary of Verification Results

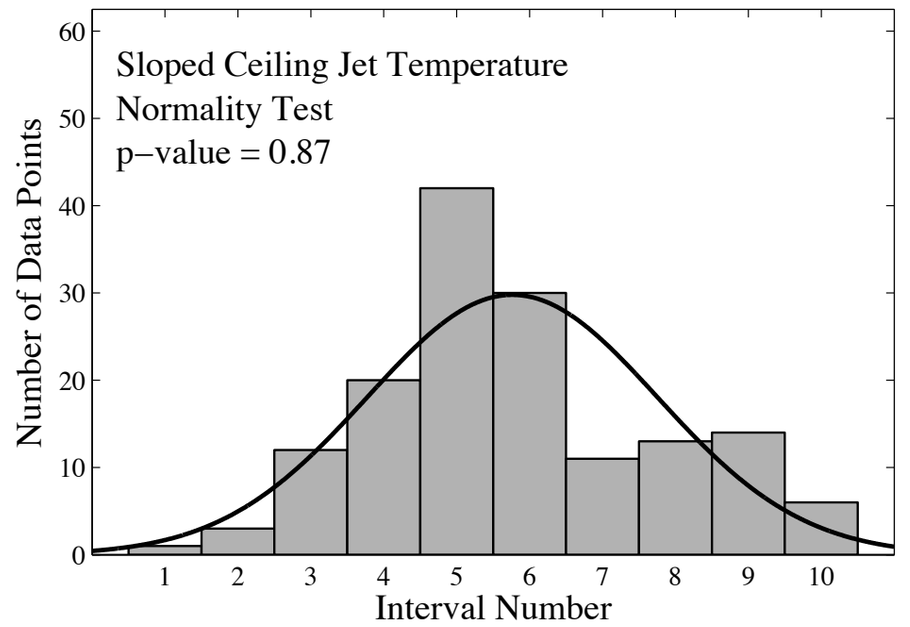
Case Name	Expected Metric	Predicted Metric	Type of Error	Error	Error Tolerance	Within Tolerance
activate_vents	1.00e+00	1.00e+00	Relative	0.00e+00	0.00e+00	Yes
activate_vents	1.00e+00	1.00e+00	Relative	0.00e+00	0.00e+00	Yes
activate_vents	1.00e+00	1.00e+00	Relative	0.00e+00	0.00e+00	Yes
aspiration_detector	4.57e+01	4.62e+01	Relative	1.03e-02	2.00e-02	Yes
box_burn_away1	1.28e+00	1.27e+00	Relative	8.85e-03	2.00e-02	Yes
box_burn_away2	1.28e+00	1.26e+00	Relative	1.40e-02	2.00e-02	Yes
box_burn_away3	1.28e+00	1.27e+00	Relative	5.26e-03	2.00e-02	Yes
box_burn_away4	9.60e-01	9.56e-01	Relative	4.27e-03	2.00e-02	Yes
box_burn_away_2D	1.28e+00	1.27e+00	Relative	6.11e-03	2.00e-02	Yes
box_burn_away_2D	1.00e-12	1.00e-12	Relative	0.00e+00	2.00e-02	Yes
box_burn_away_2D_residue	6.40e-01	6.40e-01	Relative	7.22e-04	2.00e-02	Yes
box_burn_away_2D_residue	1.00e-12	1.00e-12	Relative	0.00e+00	2.00e-02	Yes
bucket_test	9.00e+01	8.87e+01	Relative	1.46e-02	2.00e-02	Yes
bucket_test_2	5.00e+00	4.95e+00	Relative	9.19e-03	2.00e-02	Yes
bucket_test_3	8.00e-03	7.98e-03	Relative	2.77e-03	2.00e-02	Yes
cable_11_insulation	2.44e+04	2.51e+04	Relative	2.90e-02	3.00e-02	Yes
cable_23_insulation	2.34e+04	2.35e+04	Relative	4.75e-03	1.00e-02	Yes
cable_701_insulation	1.27e+04	1.26e+04	Relative	5.60e-03	1.00e-02	Yes
cable_11_jacket	8.10e+03	7.89e+03	Relative	2.55e-02	5.00e-02	Yes
cable_23_jacket	7.34e+03	7.14e+03	Relative	2.76e-02	5.00e-02	Yes
cable_701_jacket	1.41e+04	1.41e+04	Relative	4.46e-03	1.00e-02	Yes
cell_burn_away	3.25e-03	3.19e-03	Relative	2.01e-02	4.00e-02	Yes

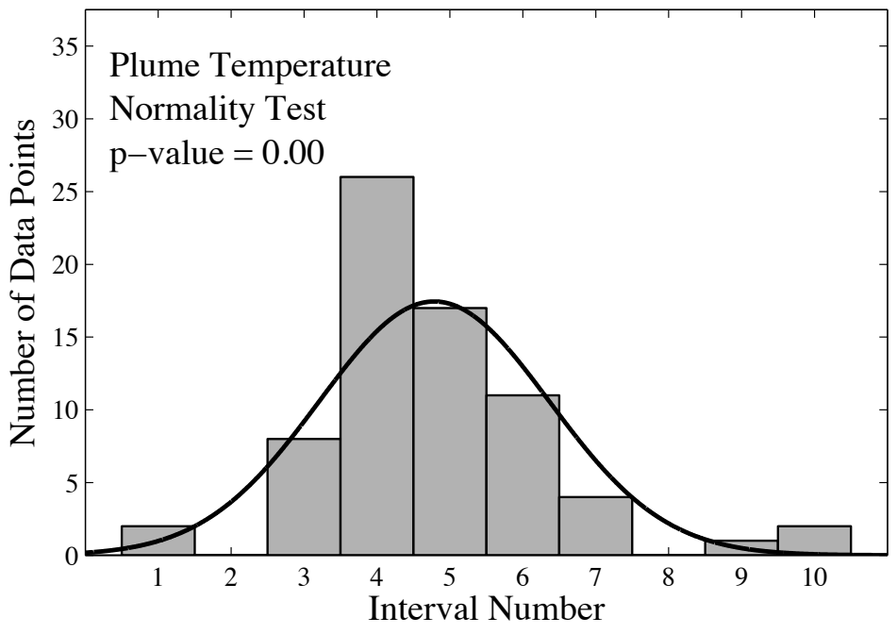
15.1 Summary of FDS Model Uncertainty Statistics

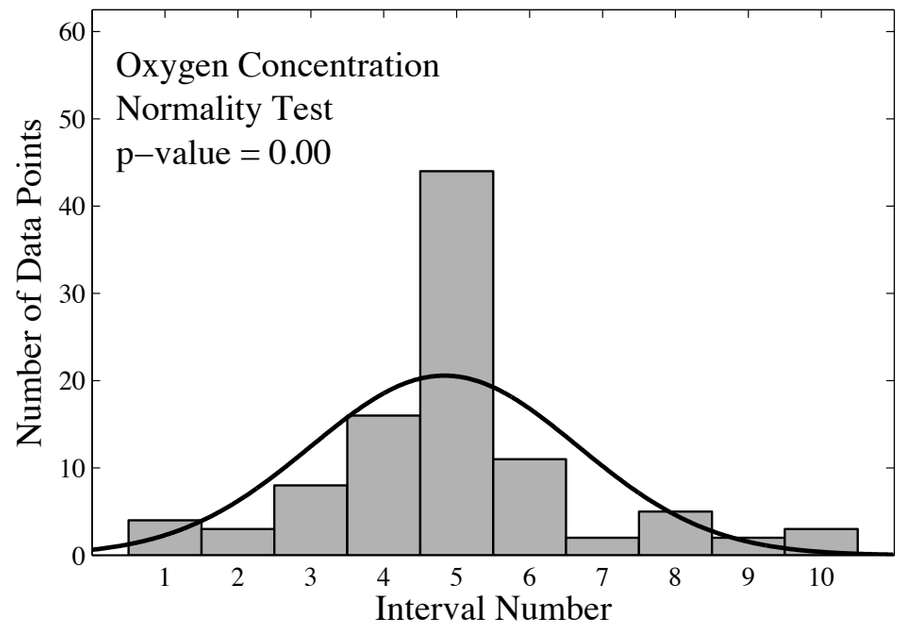
Quantity	Section	Datasets	Points	$\widetilde{\sigma}_E$	$\widetilde{\sigma}_M$	Bias
HGL Temperature, Forced Ventilation	5.12	4	111	0.07	0.22	1.27
HGL Temperature, Natural Ventilation	5.12	9	160	0.07	0.07	1.03
HGL Temperature, No Ventilation	5.12	3	32	0.07	0.13	1.23
HGL Depth	5.12	9	177	0.05	0.05	1.03
Ceiling Jet Temperature	7.1.13	11	552	0.07	0.11	1.02
Sloped Ceiling Jet Temperature	7.1.13	2	152	0.07	0.20	0.93
Plume Temperature	6.1.6	7	71	0.07	0.19	1.13
Oxygen Concentration	9.1.4	5	98	0.08	0.11	0.99
Carbon Dioxide Concentration	9.1.4	6	95	0.08	0.11	0.98
Smoke Concentration	9.2.1	1	14	0.19	0.60	2.63
Compartment Over-Pressure	10.3	2	39	0.21	0.23	0.98
Open Compartment Over-Pressure	10.3	2	14	0.15	0.27	1.02
Target Temperature	11.2.4	4	819	0.07	0.21	1.00
THIEF Temperature	11.3.3	2	94	0.07	0.16	1.06
Surface Temperature	11.1.5	3	845	0.07	0.13	1.04
Target Heat Flux	12.2.5	3	267	0.11	0.27	0.98
Flame Impinging Heat Flux	12.1.8	4	52	0.11	0.36	0.93
Surface Heat Flux	12.1.8	2	342	0.11	0.16	0.91
Velocity	8.7	6	211	0.08	0.09	1.00
Sprinkler Activation Time	7.2.1	5	232	0.06	0.15	0.93
Smoke Detector Activation Time	7.3	1	142	0.26	0.26	0.62
Smoke Detector Activation Time, Temp. Rise	7.3	1	142	0.29	0.29	0.86

15.2 Normality Tests









15.3 Summary of FDS Validation SVN Statistics

Dataset	Last Changed SVN Date	Last Changed SVN Revision
FM_Parallel_Panels	2014-07-03	19830
Harrison_Spill_Plumes	2014-07-04	19843
Fleury_Heat_Flux	2014-07-06	19850
LEMTA_Spray	2014-07-06	19855
LLNL_Enclosure	2014-07-08	19861
McCaffrey_Plume	2014-07-09	19866
Moody_Chart	2014-07-11	19887
NBS_Multi-Room	2014-07-12	19893
NIST_He_2009	2014-08-11	20197
Backward_Facing_Step	2014-08-11	20198
NIST_NRC	2014-08-21	20289
NIST_Smoke_Alarms	2014-08-22	20310
Heskestad_Flame_Height	2014-09-04	20389

Accessing_Subversion_Repository

Instruction on using SmartSVN to Connect to the FDS-SMV SVN repository.

Featured, Phase-Deploy

Updated Jan 22, 2014 by shostikk

Introduction

Google Code uses Subversion (SVN) for version control. Subversion is widely considered as an improved versioning method over CVS. This Wiki page provides instructions on using a browser called *SmartSVN* or the command line to obtain files from the FDS-SMV SVN Repository.

Using SVN via the Browser SmartSVN

SmartSVN is available as freeware. A for-purchase version of *SmartSVN* is available that has additional capabilities, but for most users the free version will suffice.

Checking out the Repository via SVN ¶

The First Time

- After installing *SmartSVN*, launch the program.
- The program will open with a *Welcome to SmartSVN* window. Select **Check out project from repository**.
- A *Check Out Repository* window will open.
- In the **Server Name** box, for anonymous checkout, type

```
http://fds-smv.googlecode.com/svn/trunk/FDS/trunk/
```

or if you have commit privileges, type

```
https://fds-smv.googlecode.com/svn/trunk/FDS/trunk/
```

- Click **Next**
- *SmartSVN* will scan the repository in display a directory tree.
- Click **Next**
- Click **No** to avoid checking out files up to the project root.
- Type in or browse to a **Local directory** where the files will be stored on your computer.
- Ensure that the **Check Out: Directly into the above directory** and **Check out recursively** options are selected.
- Click **Next**.
- Enter a name for the new project, e.g., **FDS-SMV**.
- Click **Finish** to check out the files to your machine.

At this point, the entire FDS-SMV project will be copied from the repository to your computer.

fds-smv

Fire Dynamics Simulator (FDS) and Smokeview (SMV)

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Firebot_Build_Status

Displays FDS-SMV build status for recent build/test cycles.

Updated Today (8 hours ago) by fds.firebot

FDS Automatic Verification and Validation Test Bot

Firebot Build Status

This page displays the build status for up to 100 of the most recent build/test cycles.

For additional information on Firebot, please refer to the FDS Configuration Management Plan.

The latest nightly versions of the documentation/manuals from Firebot can be viewed here.

Revision 20124: Build failure.
Wed Aug 6 07:21:24 2014

Revision 20115: Build success, with warnings.
Tue Aug 5 10:25:20 2014

Revision 20102: Build success!
Mon Aug 4 16:07:00 2014

Revision 20097: Build failure.
Mon Aug 4 03:54:51 2014

Revision 20093: Build failure.
Sun Aug 3 08:07:09 2014

Revision 20090: Build failure.
Sat Aug 2 11:14:27 2014

Revision 20076: Build success, with warnings.
Fri Aug 1 08:55:37 2014

Revision 20071: Build failure.
Fri Aug 1 01:52:59 2014

Revision 20042: Build success!
Thu Jul 31 03:58:36 2014

Revision 20034: Build failure.
Wed Jul 30 02:47:19 2014

Revision 20028: Build success!
Tue Jul 29 03:35:58 2014

Revision 20018: Build success!
Mon Jul 28 03:35:52 2014

FDS-SMV Website

FDS Nightly Manuals

View the unofficial nightly FDS manuals that are generated by the automated verification and validation testing process, Firebot.

Third-party Tools

View a list of third-party tools provided by the FDS-SMV community, including graphical user interfaces and various pre- and post-processing tools.

FDS-SMV Online Resources

Visit our FDS-SMV YouTube Channel for tutorials and examples of FDS and Smokeview.

Follow us on Twitter at @fdssmv.

FDS Validation Test Reports

View the collection of publicly available reports for experimental data sets referenced in the FDS Validation Guide.

Research Road Maps

Read the FDS Road Map and the Smokeview Road Map to learn about ongoing research plans to advance the capabilities of FDS and Smokeview.

How can users contribute?

fds-smv

Fire Dynamics Simulator (FDS) and Smokeview (SMV)

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- ⊞ Discussion Group and Issue Tracker
- ⊟ Developer Resources
  - ⊞ FDS Developer Resources
  - ⊞ SMV Developer Resources
  - Firebot Build Status
  - Auxiliary Web Services
  - Accessing the SVN Repository
  - **Guide to Contributing**
  - Developer Commit Guidelines
  - Subscribing to the Issue Tracker
- ⊞ Parallel Computation Resources

☆ **Contribution_Guide**

Guide on how to contribute to FDS-SMV development.

Updated Feb 21, 2013 by randy.mcdermott

How Can I Best Contribute to FDS?

Historically, FDS development has been the result of the efforts of a small number of people. With the move towards web based tools for version control and user support, it has become much easier for outside parties to have an opportunity to contribute to FDS. We, the developers, recognize that this path is a bit of a tightrope. We never had as much time and resources as we would like for development and user support, so the aid of the user community could be a great benefit. On the other side is the historical recognition that very few people and organizations are willing or able to work within the existing framework to make a long term concerted effort towards development. The result is incomplete algorithms which are not validated, too limited in their application, unworkable within the overall FDS framework, or unmaintainable by the core development team. As a result, these efforts never make their way into FDS. This is of course a frustration both to the developers and to the organization/individual that expended the effort. The goal of this document is to discuss ways in which interested users can make contributions to the development of FDS that are of lasting value.

A Few Words on Open Source Development

Open source development can be a great thing. The concept of a worldwide pool of software developers working in tandem for the greater good is a noble one. There are hundreds of thousands of open source projects in existence; however, six months from now 99,999 of 100,000 projects will be for all purposes dead in the water. Why?

- Too few developers or not enough resources to bring the project to completion
- Interest in continued development and/or support following a release wanes
- Disagreements in the direction of the project result in splinter projects being created which dilute the development effort into nothingness

The successful, long lasting open source projects are few (Linux, Mozilla, and OpenOffice? are a few). They have been those with large enough user+developer bases to survive as project members come and go or have committed, long-term institutional support.

What can I do to contribute?

User Support

If the posting logs of the Discussion Forum and the Issue Tracker are examined, you will find that only a few names represent the bulk of responses to user questions and bug fixes. A very valuable contribution would be for you to spend time on either. If you know the answer to a question on the forum, post a response. If you can compile FDS on your own and have a case that gives an error message, compile a debug version and attempt to locate at least the general source of the error before making an issue report. Time we don't spend on user support is time we have to spend doing development.

Documentation

This is an area where you can easily make meaningful contributions and in doing so free up time of the core developers. We attempt to write clear documentation in both the Theory Manual and in the User's Guide. However, we do not always explain well concepts that we consider "obvious". As a result documentation may not be as clear or complete is it should be. If you have struggled with some FDS concept or had to make multiple tries to get an input to work correctly, then help us by writing changes for that portion of the Theory Manual or User's Guide. A new LaTeX file is preferred, but even pasting text from the pdf file into a word processor and sending changes as, for example, a Word document would help us.

fds-smv

Fire Dynamics Simulator (FDS) and Smokeview (SMV)

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  - FDS Verification Process
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  - FDS Validation Process
  - Smokeview Verification Process
  - Media Gallery
  - External Dependencies
- ⊞ Discussion Group and Issue Tracker
- ⊞ Developer Resources
- ⊞ Parallel Computation Resources

Verification_Case_Setup_Example

An example step-by-step procedure for authoring a verification case, from setting up the input files to compiling the FDS Verification Guide.

Prerequisites

Before getting started, are you conversant in Matlab and LaTeX? No? Do yourself a favor: take a week out of your busy life and learn the basics of these tools. I guarantee your investment will payoff a thousand fold!

Introduction

The purpose of this page is to document, through example, all of the minute steps required to get a verification case from conception to full automation, such that the FDS Verification Guide can be built without error by pressing a single button. Similar procedures also apply to the FDS Validation Guide. Here we will follow the development of the "heated channel" test case series developed by Kiyoung Moon of Yonsei University.

One difference between the verification suite and the validation suite is that the user is expected to run all the verification cases in order to compile the guide. That is, from a pristine download of the FDS code project, the output files necessary to generate the plots in the guide are not committed to the repository. For validation this is not the case. All necessary output files are committed and just need to be processed by the appropriate Matlab scripts.

The reader should take note of the files that need to be committed. In the text below, these files will be highlighted with a **(commit)** tag. The most common problem we encounter when compiling the guides is that an author will assume their case is fully committed because they are able to compile the guide on their machine, but if they have not committed all the necessary files the guide will not compile for the other project members.

Let's get started.

Case Setup

For this particular test series Kiyoung wants to compare FDS results for the mean streamwise temperature profile in the wall-normal direction to the heated channel flow DNS calculations of Kim and Moin (1987). He will run four cases at different molecular Prandtl numbers (Pr). His goal is to verify the implementation of a new wall heat flux model.

The FDS-SMV project embraces

1) Open-source development
2) Continuous integration
3) Software quality testing
4) Performance metrics
5) Parallel and high performance computing
6) Cross-platform compatibility
7) Contributions and participation from users and community

Ways for users to contribute

1) Feature testing

2) Documentation

3) Participating in discussion group

4) Verification cases

5) Validation data sets

6) Bug reporting

7) Improving submodels

References:

NUREG-1824, Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications, US Nuclear Regulatory Commission

NIST SP 1169, Verification and Validation of Commonly Used Empirical Correlations for Fire Scenarios

National Institute of Standards and Technology
U.S. Department of Commerce