

How To Use the Feature Coverage Tool

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- ▶ How to use the Sierra Feature Coverage Tool
- ▶ Provide evidence of code verification as a percentage of your model
- ▶ Find gaps in the Sierra test suite in the context of your application

What Is It and Why Should You Use It?

THE FEATURE COVERAGE TOOL (FCT) produces a report of application-focused evidence of code verification in just a few seconds. The report assesses to what extent each feature in your input file is present in the SIERRA test suite. The FCT output indicates whether each feature is:

verified — low risk,
tested but not verified — medium risk, or
untested — high risk.

A desired minimum standard for a feature is that it is tested in the code's nightly regression test suite (medium risk). A higher standard is verification under mesh refinement, using a verification test from the VERTS. As a result of running the FCT, a user should have a good sense of the credibility of the features used based on the available testing.

Once the features are assessed, simulation credibility is improved through identification of feature gaps (features that are not verified) by the analyst, communication with the Sierra code development teams, and the addition of verification tests to address important gaps.

How Do You Run the Feature Coverage Tool?

In Sierra 4.34 and later, the Sierra FCT will run by default when you run the `sierra` script. And as before, you can invoke the Sierra FCT from the command line to execute on its own:

First load the Sierra module to get the latest release of the codes,

```
module load sierra
```

Then run FCT exactly like you would run Sierra:

```
fct APPLICATION -i INPUTFILE
```

where `APPLICATION` is the name of a Sierra code, e.g. `aria`, `adagio`, `salinas`, etc., and `INPUTFILE` is the name of the inputfile, e.g. `input.i` or `input.inp`.

A *feature* is a unique line command that can be used in an input file. For example, a feature may be an option in a thermal radiation boundary condition or a material model parameter.

VERTS is a *verification test suite*, a set of tests run regularly by code developers to assess accuracy and correctness of the code for approximating the problems of interest. Tests contained in the VERTS usually compare the code approximation to an analytic exact solution, or a manufactured solution, and include an assessment of the order of the convergence rate.

The quality of verification tests in the *Sierra* VERTS varies widely. Just because the FCT reports that a feature is being tested in multiple tests does not necessarily mean that those tests are intended to test *exactly that* feature—the feature may be only accidentally present in those tests. Nor does it mean that the verification tests are full order-of-convergence tests. You may click test names in the FCT results to consult relevant documentation for a test.

To disable the FCT while running the `sierra` command: either add the option `--no-fct` to the `sierra` command, or change the environment variable, unset `SIERRA_ENABLE_FCT`.



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Output from FCT includes:

1. screen output of overall coverage,
2. a HTML file (INPUTFILE.fct_oneway.html) containing a colorized input file with all one-way gaps labeled—take a screenshot of it and paste it into your reports,
3. a Microsoft Excel spreadsheet (INPUTFILE.fct_twoway.xlsx) containing the colorized matrix of two-way coverage results—embed it into your Microsoft Word document, or take a screenshot, for your reports.

How Do You Interpret the Results?

The following is an example of the results obtained from running the FCT on a Sierra input file. The output on the console reports the version of the code and the test certificate, as shown in Figure 1. This certificate is a record of all the features covered in all tests in the Sierra test suite.

Both one-way and two-way coverage is reported. One-way coverage is the percent of features in your input file included in at least one verification test. Two-way coverage is the percentage of all *pairs* of features in your input file that are both included in at least one verification test. Finally, one-way nightly coverage is the percent of features in the input file included in at least one nightly test. Since the nightly tests include the verification tests, one-way nightly coverage should always be greater than one-way verification.

One-way coverage answers the question: is a feature in my input file present in a test suite?

Two-way coverage answers the question: is a pair of features in my input file present together in a single test in the test suite?

A gap in coverage is a feature (or pair of features) in your input not covered by the test suites.

all the tests in code test suite that are regularly run nightly

```
$ module load sierra
$ fct aria -i free_bar3d.i
FCT one way coverage: verified 97% tested 100% free_bar3d.i.fct_oneway.html
FCT two way coverage: verified 93% free_bar3d.i.fct_twoway.xlsx
```

verified tests (VERTS) are a higher quality subset of the test suite; this number is equal to or less than tested

Output files from the FCT tool contain details of the coverage results; one-way results are viewed in your favorite browser, and two-way results may be viewed in Microsoft Excel

The output also indicates the name of the output files that can be used to view feature coverage. They are INPUTFILE.cov.html for one-way and INPUTFILE.two_way.verification.csv.xls for two-way coverage. An excerpt from a one-way coverage file for a simple Sierra input file is shown in Figure 2.

At the top of the html file, the one-way and two-way screen output is repeated. The colors are used later to indicate the level of coverage for each feature. Anything **black** is a comment and ignored; **green** indicates features

Figure 1: Running the FCT on the command line. Console output includes the matching version number of the code and test certificate and a summary of both verification suite one-way and two-way coverage and the nightly test suite one-way coverage results.

When auxiliary text input files are included in your main input file—for example using the Sierra includefile command—they are expanded in-place, analyzed, and also displayed in the one-way coverage results.

covered by verification tests; **amber** indicates features tested but not verified; and **red** indicates untested features.

The number shown on the right of each feature in the one-way result is the number of unique tests that include the feature at least once. By clicking on the plus (the **+** button), the list of test names is displayed below the feature in gray. Clicking again on the minus (the **-** button) hides the list.

Color Key

```

verified
  * one-way:91%
  * two-way:73%
tested
  * one-way:100%
untested
ignored

```

Input File

```

# input file for aria, linear heat conduction, one-dimensional
#   heat transfer in a square block for a fixed temperature difference

BEGIN SIERRA myJob 864 ±

begin Dakota 1 +
  This is a test 1 ±
end

# This is a bad test of multicolumn tables but it's all I have for now.
Begin Definition for Function Water 299 +
  # Source Appendix 2 from "Transport Processes and # Unit Operations" by C. J. Geankolis
  Type is 299 ± Multicolumn Piecewise Linear 3 ±
  Column Titles Temperature Density Thermal_Conductivity 3 ±
  fuego_rtest/fuego/concentration_plumeB_lam/concentration_plumeB_lam.test|np4
  fuego_rtest/fuego/concentration_plumeA_lam/concentration_plumeA_lam.test|np1
  fuego_rtest/fuego/concentration_plumeB_trb/concentration_plumeB_trb.test|np4

  Begin Values 163 +
    # K kg * m^-3
    273.15 999.87 401.0 163 ±
    277.15 1000.00 401.0 163 ±
    283.15 999.73 401.0 163 ±
    293.15 998.23 401.0 163 ±
    298.15 997.08 401.0 163 ±
    303.15 995.68 401.0 163 ±
    313.15 992.25 401.0 163 ±
    323.15 988.07 401.0 163 ±
    333.15 983.24 401.0 163 ±
    343.15 977.81 401.0 163 ±
    353.15 971.83 401.0 163 ±
    363.15 965.34 401.0 163 ±
    373.15 958.38 401.0 163 ±
  End
End

BEGIN ARIA MATERIAL Kryptonite 88 +
  Density           = CONSTANT rho = 0.1 77 ±
  Thermal Conductivity = User_Function Name=Water_Thermal_Conductivity X=Temperature 2 ±

```

Click the ± links to expand and contract the list of tests that use this feature in your input file.

Each verification test may have associated documentation. Clicking an active link will open the relevant document related to the test.

Figure 2: An example of the one-way coverage report for a Sierra input file, the *.html output by the tool. Here the file is viewed inside the Mozilla Firefox browser.

An excerpt from a two-way coverage file for one Sierra input file is shown in Figure 3, which is output in Microsoft Excel format.

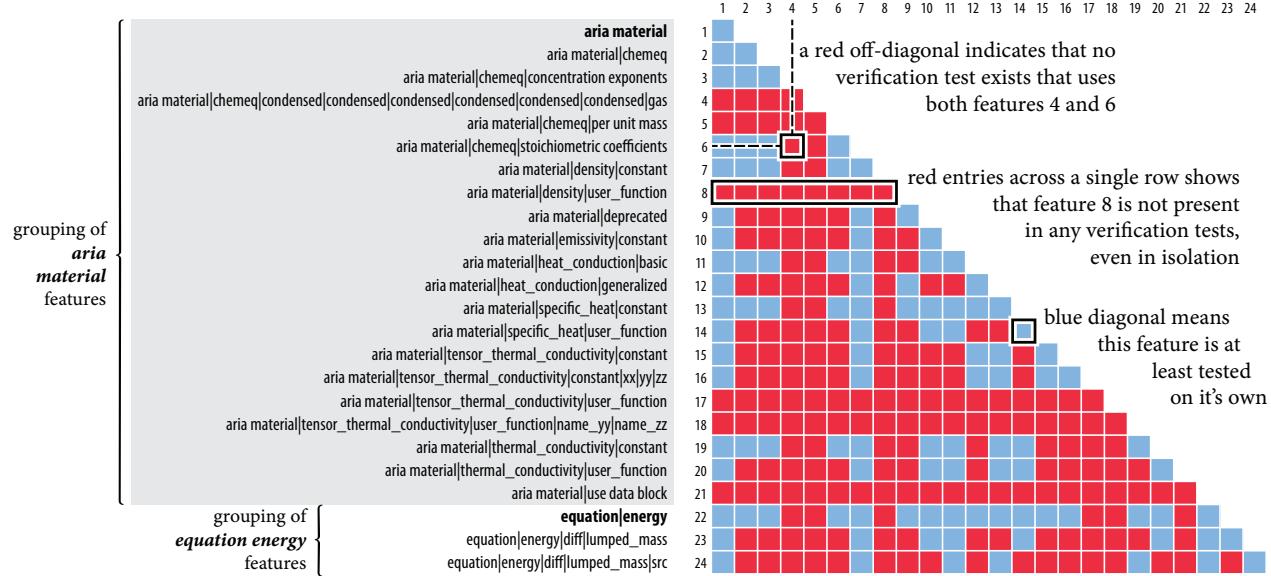


Figure 3: An example of the two-way coverage report for a Sierra input file, viewed and formatted within Microsoft Excel. The pairs of feature interactions that are not tested within the verification tests are colored red, while pairs tested at least once, are colored blue.

What are the Limitations?

The FCT works with Sierra release version 4.30.1 and later. It is improved and maintained in all later releases. The FCT does not yet work for non-Sierra codes. The FCT does not look at meshes, so it does not consider such details as the element type used. It will not analyze the input lines inside the Sierra include statement (although it will work for Salinas (Sierra/SD) include statements).

Further, the FCT cannot report on inputs containing *Aprepro* syntax; the workaround is to use the output of *Aprepro* as the input to the FCT. Input defaults are not handled in any special way, therefore the FCT results contain only what is explicitly contained in your input file. The FCT does not tell you anything about the quality of verification tests, only that they exist. Any *Sierra User Plugins* are not in the Sierra VERTS, and so the FCT cannot report on them.

Where to Go for More Information

- Sierra General Documentation Index: <http://compsim.sandia.gov/compsim/Docs/Sierra>
- FCT wiki website: <http://tiny.sandia.gov/fct>

Who to Contact for Help

- E-mail help: VnV-Tools-Help@sandia.gov
- Kevin Coppins kdcoppins@sandia.gov, Brian Carnes bcarnes@sandia.gov, Adam Hetzler ahetzle@sandia.gov and Walt Witkowski wrwitko@sandia.gov, (Org. 1544)