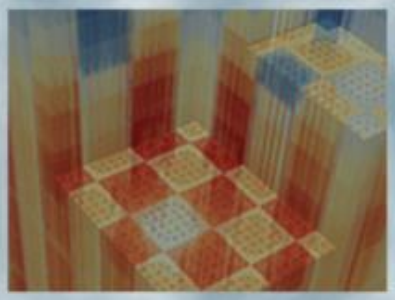
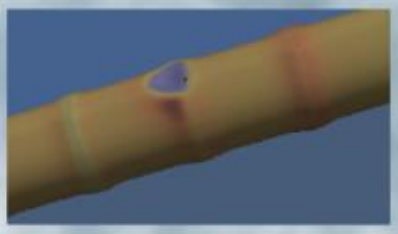
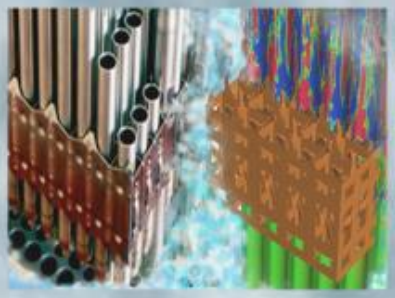
CASL-U-2017-1295-000







VERA-CS User Support Activities for PoR 14

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03/31/2017

Approved for Public Release

REVISION LOG

Revision	Date	Affected Pages	Revision Description
0	03/31/2017	All	Initial Release

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EXECUTIVE SUMMARY

The purpose of this milestone is to document the user support activities that took place between 10/1/2016 and 3/31/2017 (PoR 14). In the normal PHI workflow, that also extends to several activities within RTM, a Kanban process is followed. This involves creating tickets for specific work items and track the progress to complete these specific work items.

The PHI Kanban is the primary source for the content of this report. The reader should note that there may be items missing from the report. Missing items would not be present for one of the following reasons:

1. The work was not documented using a Kanban ticket. Typically this applies to tasks that take less than an hour. Individually this may be a small item, but collectively over the PoR this may combine to non-trivial effort.
2. Information in the Kanban ticket was not properly entered. This happens more frequently than we think.

The scope of this report summarizes all activities related to VERA-CS user support activities; where those activities may be providing direct support or indirect support.

Discussion of work related to the following components such: BISON, MAMBA, Tiamat, Cicada, and Shift, and VERAView are not included.

User support activities related to providing installations or releases to users are not discussed in this report. There is a separate milestone (L3:PHI.INF.P14.04) and report documenting these activities over PoR 14.

During PoR 14 there were approximately 108 PHI Kanban tickets related to user support activities, either directly or indirectly. In total there were 108 tickets related to user support activities for VERA-CS. There were 56 new reported defects and 34 defects fixed in PoR 14. 44 tickets were related to miscellaneous user requests and did not directly support any milestones. Work was also performed for 30 tickets related to 7 milestones. A training was also given to WEC.

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TABLES

ACRONYMS

BWR	boiling water reactor
CASL	Consortium for Advanced Simulation of Light Water Reactors
CI	Continuous Integration
CE	Combustion Engineering
CTF	COBRA-TF subchannel thermal-hydraulics code
DNB	departure from nucleate boiling
IFBA	Integral Fuel Burnable Absorber
MAMBA	MPO advanced model for boron analysis
MPACT	Michigan parallel characteristics transport code
MCNP	Monte Carlo N-Particle
NaN	Not a Number
PHI	Physics Integration
PoR	plan of record
PWR	pressurized water reactor
RIA	reactivity insertion accident
RTM	Radiation Transport Methods
UIUC	University of Illinois Urbana-Champaign
UM	University of Michigan
VERA-CS	Virtual Environment for Reactor Applications – Core Simulator
WEC	Westinghouse Electric Corporation

1. INTRODUCTION

The purpose of this milestone is to document the user support activities that took place between 10/1/2016 and 3/31/2017 (PoR 14). In the normal PHI workflow, that also extends to several activities within RTM, a Kanban process is followed. This involves creating tickets for specific work items and track the progress to complete these specific work items. The format of this documentation is an HTML website that interfaces to an SQL database. This format is very useful for providing access, navigability, and record keeping. However, it is not particularly amenable to providing a coherent, complete, and distributable summary of activities.

CASL does the majority of its work scope definition and planning through milestones. However, there are regular tasks that arise that require individuals' efforts to address that were not necessarily contained within the scope of these milestones. From the software development side this can include fixing code defects, adding simple features to facilitate ease of use or analysis, adding major capabilities that enable new types of analyses, or research into potential methods to improve upon the existing methods. From an infrastructure point of view some of these activities can include deploying installations for individual users on target platforms, updating documentation or preparing a release, or providing user training or answering user questions via email. There is also analysis support to evaluate the accuracy of existing models or data and potentially improving upon these. Collectively, these activities may be thought of as user support activities.

The PHI Kanban is the primary source for the content of this report. The reader should note that there may be items missing from the report. Missing items would not be present for one of the following reasons:

1. The work was not documented using a Kanban ticket. Typically this applies to tasks that take less than an hour. Individually this may be a small item, but collectively over the PoR this may combine to non-trivial effort.
2. Information in the Kanban ticket was not properly entered. This happens more frequently than we think.

To facilitate comprehension of the remainder of this report, the following subsections provide some definitions and categories that are used throughout this document. The remainder of the document is organizes as follows: Section 2 describes all the defects fixed in PoR 14, Section 3 lists describes or summarizes the new user features added, and Section 4 lists other miscellaneous activities. Sections 5 and 6 list less relevant or indirect user support activities related to research and then anything else.

1.1 Definitions

1.1.1 VERA-CS

For the purposes of this milestone report VERA-CS constitutes the following components:

- COBRA-TF
- MPACT
- ORIGEN
- VERAIn
- Cross section library data for MPACT

Discussion of work related to other components such as: BISON, MAMBA, Tiamat, Cicada, and Shift, and VERAView are not included.

Additionally, user support activities related to providing installations or releases to users are not discussed in this report. There is a separate milestone (L3:PHI.INF.P14.04) and report [1] documenting these activities over PoR 14.

1.1.2 User support activity

This term is used in a very broad sense to encompass any activity that is performed to directly or indirectly provide support to a user.

1.1.3 Defect

A defect constitutes a problem with an existing feature that does not work as intended. These are typically identified by users.

1.1.4 Feature

A feature constitutes a capability that was not previously available that is requested by a user or on a users' behalf.

1.2 Categories of User Support Activities

1.2.1 Direct support

Activities that provide direct support include things like: providing an install for a user on some particular platform, fixing a defect, or adding a feature with a component in the input.

1.2.2 Indirect support

Activities that would be examples of indirect support are things like: updating the theory manual or documentation, developing a new algorithm that allows the code to run faster, improving nuclear data, evaluating or assessing the accuracy of an existing model, or adding a more rigorous numerical method.

2. DEFECTS

This section summarizes all the defects discovered and fixed during the PoR. Each subsection lists the defects relevant to the components of VERA-CS.

A total of 56 new defects were reported, and a total of 34 defects were resolved.

2.1 MPACT

Table 1 lists all new defects reported for MPACT. There were 37 defects reported. Table 2 lists all defects closed for MPACT. There were 23 defects that were resolved.

Table 1. New defects for MPACT reported in PoR 14

PHI Kanban Ticket #	Ticket Description
4433	(Defect) MPACT segfaults in some cases when using threads with rectangular pin meshes
4435	(Defect) resonance option for non-resonance isotopes
4436	(Defect) UIUC core follow transient case is crashing
4438	(Defect) Problem 9 mini has been failing since 9/26/16
4511	(Defect) ThermalExpandXML does not expand user axial mesh
4518	(Defect) NaN error with Power Normalization when using zero Xenon
4524	(Defect) MPACT testPlanarSynthesis failing on UM CI
4542	(Defect) Thermal Expansion of Clad Inner Radius is wrong for IFBA
4557	Fix valgrind defects in MPACT Nodal Sweeper
4561	(Defect) IFBA rods are not thermally expanded correctly
4562	(Defect) Thermal expansion code can create different pin pitches in different assembly types
4563	(Defect) Axial thermal expansion is not production ready
4564	(Defect) Refined ray spacing for IFBA is limited by memory requirements for 1000 core models
4565	(Defect) Full symmetry is non-functional for some problems
4566	(Defect) Isotope edits don't function for spatial decomposition
4567	(Defect) Isotope edits don't function without depletion
4570	(Defect) Axial remeshing works but the ends of the fuel stacks cannot be different
4572	(Defect) MPACT speedups not reliable for reload cycles
4573	(Defect) Isotope edits for inserts on the line of symmetry are half of the correct value
4583	(Defect) Non-convergence for mid-Cycle depletion statepoint using Hybrid SP3 method
4584	(Defect) Error with reduced diameter control rod tips
4585	(Defect) MAMBA-1D fails when modelling a mid-cycle shutdown with zero power input
4622	(Defect) Set default shielder ray spacing in future releases
4668	(Defect) Use of 'mod' as a material name in standard input changes results
4671	(Defect) Thermal expansion produces error with multiple IFBA materials
4696	(Defect) op_date in [STATE] block should be unset with depletion
4697	(Defect) reset_sol can not be used in two consecutive blocks
4698	(Defect) Assembly Pin Data Pin Power Edits segfault and do not identify correct symmetry for standard input
4704	(Defect) Available Partition Table in MPACT output does not reflect the options for EXPLICITRADIAL scheme
4771	(Defect) Resonance data interpolation and B-10 depletion in the simplified AMPX capability
4776	(Defect) Error reading multiple restart files and silent errors reading restart file

4791	(Defect) Futility doesn't compile without MPACT
4797	(Defect) Core map in HDF5 output is not correct for 16x16 assembly
4810	(Defect) Issues with parallel VERA-CS transient calculations
4813	(Defect) Isotope merging problem for O-16 in UO2 +Er2O3 for the SAMPX capability
4846	(Defect) Fix assm_map usage for shuffles
4852	(Defect) Wrong answer when setting boron to zero in stacked cases

Table 2. Closed defects for MPACT reported in PoR 14

PHI Kanban Ticket #	Ticket Description	Status/ Resolution
4566	(Defect) Isotope edits don't function for spatial decomposition	fixed
3582	(Defect) Make sure all STATE input variables are updated in each calculation	fixed
4106	(Defect) Pin Exposures Equal to Zero After Restart	fixed
4393	(Defect) Bug in Control Rod Volume Correction	fixed
4433	(Defect) MPACT segfaults in some cases when using threads with rectangular pin meshes	fixed
4435	(Defect) resonance option for non-resonance isotopes	fixed
4436	(Defect) UIUC core follow transient case is crashing	fixed
4438	(Defect) Problem 9 mini has been failing since 9/26/16	fixed
4524	(Defect) MPACT testPlanarSynthesis failing on UM CI	fixed
4565	(Defect) Full symmetry is non-functional for some problems	fixed
4622	(Defect) Set default shielder ray spacing in future releases	fixed
4810	(Defect) Issues with parallel VERA-CS transient calculations	fixed
4813	(Defect) Isotope merging problem for O-16 in UO2 +Er2O3 for the SAMPX capability	fixed
4852	(Defect) Wrong answer when setting boron to zero in stacked cases	fixed
3460	(Defect) Fix P2 scattering error with external coupling	wontfix
4585	(Defect) MAMBA-1D fails when modelling a mid-cycle shutdown with zero power input	wontfix
3840	(Defect) bug in control rod treatment when poison boundary aligns with fuel	in review
4511	(Defect) ThermalExpandXML does not expand user axial mesh	in review
4542	(Defect) Thermal Expansion of Clad Inner Radius is wrong for IFBA	in review
4562	(Defect) Thermal expansion code can create different pin pitches in different assembly types	in review
4671	(Defect) Thermal expansion produces error with multiple IFBA materials	in review
4771	(Defect) Resonance data interpolation and B-10 depletion in the simplified AMPX capability	in review
4776	(Defect) Error reading multiple restart files and silent errors reading restart file	in review

2.2 COBRA-TF

Table 3 lists all new defects reported COBRA-TF. There were 17 new defects reported. Table 4 lists all defects closed for COBRA-TF. There were a total of 9 defects resolved.

Table 3. New defects for COBRA-TF reported in PoR 14

PHI Kanban Ticket #	Ticket Description
4439	(Defect) Test_RodMesh failing in STATIC build
4442	(Defect) Input for rod radiative heat transfer model does not work
4457	(Defect) CTF manuals not getting updated on website
4503	(Defect) Heat balance output file showing wrong power to model
4509	(Defect) Fix mistake in BFBT C2A model
4532	(Defect) CTF HDF5 reader no longer works with new version of VERA-CS

4538	(Defect) Fix VUQCore_CTF_verain_small_singlerod_HFP
4549	(Defect) CTF standalone build tests failing (but not VERA-CS builds)
4552	(Defect) Sort through standalone CTF test failures on Redhat
4554	(Defect) Biasi correlation not consistent with literature
4571	(Defect) Release Candidate 0 is using COBRATF.ini rather than the new CTF preprocessor defaults
4673	(Defect) Issues with multistate diff tool printout
4694	(Defect) xml2ctf doesn't get centroids right for boundary channels with shroud
4754	(Defect) bwr-p6-test doesn't build with xml2ctf anymore
4838	(Defect) linear heat rate does not update every state in CTF HDF5 output
4860	(Defect) VERA-CS crashes when 'parallel' not in COBRA-TF block
4863	(Defect) Fix BFBT P6 series input decks

Table 4. Closed defects for COBRA-TF reported in PoR 14

PHI Kanban Ticket #	Ticket Description	Status/ Resolution
4076	(Defect) Pin steam rate not printed correctly to HDF5 file for symmetry cases	fixed
4125	(Defect) Annular/mist interfacial drag model in CTF is not consistent with theory manual	fixed
4284	(Defect) Interfacial drag/heat transfer not implemented correctly	fixed
4367	(Defect) Specifying zero noncondensable gas void in CTF crashes code	fixed
4407	(Defect) New CTF Preprocessor does not support older cases	fixed
4439	(Defect) Test_RodMesh failing in STATIC build	fixed
4538	(Defect) Fix VUQCore_CTF_verain_small_singlerod_HFP	fixed
4571	(Defect) Release Candidate 0 is using COBRATF.ini rather than the new CTF preprocessor defaults	wontfix
4403	(Defect) BWR preproc uses geometric center instead of centroids	in review

2.3 ORIGEN

Table 5 lists all new defects reported for ORIGEN. Table 6 lists all defects closed for ORIGEN. There was a total of 1 new defect reported and one defect resolved.

Table 5. New defects for ORIGEN reported in PoR 14

PHI Kanban Ticket #	Ticket Description
4569	(Defect) Lithium depletion is degraded with 4.2m5 cross section library

Table 6. Closed defects for ORIGEN reported in PoR 14

PHI Kanban Ticket #	Ticket Description	Status/ Resolution
4566	(Defect) Isotope edits don't function for spatial decomposition	in review
4569	(Defect) Lithium depletion is degraded with 4.2m5 cross section library	in review

2.4 VERAIn

Table 7 lists all new defects reported VERAIn. Table 8 lists all defects closed for VERAIn. There was a total of 1 new defect reported and one defect closed.

Table 7. New defects for VERAIn reported in PoR 14

PHI Kanban Ticket #	Ticket Description
4672	(Defect) Cannot change the incore detector type through input

Table 8. Closed defects for VERAIn reported in PoR 14

PHI Kanban Ticket #	Ticket Description	Status/ Resolution
4672	(Defect) Cannot change the incore detector type through input	wont fix

3. ACTIVITIES RELATED TO OTHER MILESTONES

This section summarizes the tickets documenting work related to other milestones. The milestones that received user support during this PoR are given in Table 9.

Table 9. Milestones supported during PoR 14

CASL Milestone	Description
L2:RTM.P14.01	Develop and deliver nuclear cross section data libraries supporting Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR) designs
L2:RTM.P15.02	Development of transient MPACT-CTF capability for RIA (with DNB)
L3:PHI.VCS.P13.03	Restart file improvements for performance and coupling
L4:PHI.VCS.P14.01	coupled MPACT+CTF for transient analysi
L3:PHI.RIA.P15.01	Initial implementation of transient VERA-CS
L3:AMA.RX.P14.08	Evaluation and Testing of VERA for CE System-80 Design
ACT:PHI.FY17.02	Training

3.1 L2:RTM.P14.01

This milestone was about delivering an improved cross section capability for VERA-CS/MPACT. This involved the generation of new cross section libraries, the addition of a capability to read a simplified AMPX library, and substantial evaluation of these new libraries. Improving and delivering the new data is direct user support. The additional features and evaluation is indirect user support. For a complete description of this milestone work please see the milestone report [2]. A list of relevant tickets is provided in the table below.

Table 10. Tickets supporting L2:RTM.P14.01 completed during PoR 14

PHI Kanban Ticket #	Description	Status/ Resolution	Support
4221	Generate 51- and 252-group libraries for MPACT in July 2016	fixed	direct
4245	Automate the reactivity analysis for MPACT cross section library	fixed	direct
4380	Improve the ENDF/B-7.0 and 7.1 MPACT 51-g libraries	fixed	direct
4469	Merge Simplified AMPX to master and assess accuracy	fixed	direct
4495	Extends the simplified AMPX capability for depletion	fixed	direct
4678	Print group-wise reaction rate error in text with the reaction rate analysis tool	fixed	direct
4526	Split natural isotopes for the simplified AMPX capability	in review	direct
4240	Generate MPACT-MCNP pincell comparisons for depleted cases	fixed	indirect
4276	Investigate large eigenvalue sensitivities to number of radial rings in fuel	fixed	indirect
4363	Update MCNP-MPACT pincell comparison report for 51g library	fixed	indirect
4364	Update MCNP-MPACT assembly comparison report for 51g library	fixed	indirect
4452	Evaluate mpact51g_v4.2m2 library	fixed	indirect
4461	Evaluate memory and computing time requirements for new AMPX library	fixed	indirect
4492	Evaluate mpact51g_v4.2m4 library	fixed	indirect
4743	BWR benchmark calculations by using the SAMPX 51 & 252-g libraries	fixed	indirect
4392	Generate isotopic analysis comparisons with data and SCALE codes	in review	indirect
4577	Run DIMPLE Criticals with mpact51g_70_v4.2m3_10272016_sph.fmt	in review	indirect

3.2 L2:RTM.P15.02

This milestone is about providing an upgraded transient capability. Some initial effort was provided to support this milestone. The full extent of the efforts related to this milestone will be documented in the future milestone report. The list of relevant tickets are given in the table below.

Table 11. Tickets supporting L2:RTM.P15.02 completed during PoR 14

PHI Kanban Ticket #	Description	Status/ Resolution	Support
4812	Implement MPACT edits for transient calculations	in progress	direct
4493	Improve and Document Transient Input Cards	closed	direct
	Enable exponential transformation	closed	direct

3.3 L3:PHI.VCS.P13.03

This milestone was about delivering improved features to the restart capability. The full description of this work can be found in the milestone report [3]. This work constitutes direct user support. The relevant tickets completed during PoR 14 are given in the table below.

Table 12. Tickets supporting L3:PHI.VCS.P13.03 completed during PoR 14

PHI Kanban Ticket #	Description	Status/ Resolution	Support
3575	Add axial re-mesh option during core shuffle	fixed	direct
3736	Add MAMBA scratch arrays to restart file	in review	direct
4211	Write all STATE values to the HDF output file and restart file	fixed	direct
4314	Read all STATE values from the restart file to the state type	fixed	direct

3.4 L4:PHI.VCS.P14.01

This work was primarily research, but some of the efforts here were leveraged for the L3:PHI.RIA.P15.01 milestone. See the section on the L3:PHI.RIA.P15.01 milestone for more detail.

3.5 L3:PHI.RIA.P15.01

This milestone was about providing an initial capability to run VERA-CS (e.g. MPACT and CTF coupled) for transients. For a complete description of this work see the milestone report [4]. The list of tickets relevant to this milestone are given in the table below.

Table 13. Tickets supporting L3:PHI.RIA.P15.01 completed during PoR 14

PHI Kanban Ticket #	Description	Status/ Resolution	Support
4256	Merge MPACT Transient branch into master	closed	direct
4628	Implement basic coupled transient capability in CTF	closed	direct
4640	Modify MPACT to handle transient coupled with CTF	closed	direct

3.6 L3:AMA.RX.P14.08

This milestone was about extending the capability of VERA-CS to combustion engineering designs. During this work, several issues were identified and addressed. This constitutes direct user support. Further information about this milestone can be found in the milestone report [5]. The list of tickets supporting this milestone are given in the table below.

Table 14. Tickets supporting L3:AMA.RX.P14.08 completed during PoR 14

PHI Kanban Ticket #	Description	Status/ Resolution	Support
4735	Add coupling support between MPACT/CTF for CE-16 models	in review	direct
4477	Allow "large4" control rods for CE-16x16 lattices	fixed	direct
4517	Generate the v4.2m5 MPCT 51-g libraries including Er-162, 164 and 170	fixed	direct

3.7 ACT:PHI.FY17.02

This is a PHI milestone about administering training. The relevant training activities from PoR 14 included a training provided by Scott Palmtag to engineers from WEC.

4. MISCELLANEOUS USER SUPPORT ACTIVITIES

The following table lists all other tickets that do not fit in any of the above categories.

Table 15. Miscellaneous support activities completed during PoR 14

PHI Kanban Ticket #	Description	Status/ Resolution	Support
3445	Add ability to input material mixtures by atom density	fixed	direct
3473	Run case with thermal expansion and quantify effects on ITC	fixed	indirect
3594	Add Warning messages to MPACT	in review	direct
3599	Add CTF preprocessor support for unique instrument tubes	fixed	direct
3603	Integrate Burnup-dependent Fuel Conductivity in CTF	fixed	direct
3674	Add ability to model in-core detectors for Watts Bar Unit 2	fixed	direct
4090	Add capability to compute water + soluble boron by two methods	fixed	direct
4158	Improve Full Core Partition Performance in MPACT	wontfix	indirect
4159	Design Control Rod Depletion in MPACT	fixed	indirect
4169	Design and Prototype Fortran Interfaces for Main Trilinos Solvers	fixed	indirect
4188	Make quarter rotational symmetry model for parallel 4x option in CTF	fixed	direct
4193	Add support for vanadium_response and vanadium_mesh	in review	direct
4206	Move MPACT-specific input files from VERAIn repo to MPACT repo	fixed	indirect
4209	Implement Embedded Pin Cell Solver(s) for Partially Inserted Rods	fixed	indirect
4236	Add grid effects on TKE for CTF/MAMBA simulations	fixed	direct
4257	Add comparison to BFBT axial void measurements	invalid	indirect
4261	Consolidate Logic for Executing Subgroup	fixed	indirect
4286	Evaluate what needs to be done to turn on dynamic gap conductance from VERAIn	fixed	indirect
4305	Write MPACT Fast Flux to HDF5 File	fixed	direct
4320	Fix axial mesh tolerance in MPACT & CTF	in review	direct
4321	BWR Control Blade Movement Implementation	fixed	direct
4345	Perform verificaiton of fuel temperature solution	fixed	indirect
4353	Implement shuffle map label format input option	fixed	dri
4357	Update Theory Manual To Include Chapter for 1D-Axial Nodal Kernels	fixed	indirect
4368	Make CTF assume uniform axial power if no power profile given	fixed	indirect
4378	Inplement VERA input for MOX	fixed	direct
4391	Add verification testing to new residual formulation	fixed	indirect
4423	Demonstrate VERA-CS/BISON Load-Follow on Single rod	fixed	indirect
4460	Change default for react2xml to use --Init	fixed	direct
4475	Add capability to produce normalized MPACT FSR mesh output	in review	direct
4476	Add Erbia mixing option to MPACT	fixed	direct
4501	Implement PETSc Nonlinear Solver(SNES) and Eigenvalue Solver	fixed	indirect
4527	Allow Partition Data to be Processed From Input, Without External File	fixed	direct
4531	Update Theory Manual to Include 1-group Subgroup	fixed	indirect
4533	Update Theory Manual on Overall Iteration Scheme (Power Iterations, Wielandt shift, and Convergence Criteria)	fixed	indirect
4541	COBRA_TF Multistate issues	fixed	direct
4551	Add support to ctfReader for chan.out files with no table 3	fixed	direct
4586	Add Transient chapter to MPACT Theory Manual	fixed	indirect
4618	Add cmfd flux update relaxation to MPACT & VERA input	fixed	direct
4753	Expand pyCTF reader to read bundle-average properties	in review	direct
4762	Fix C5G7 and Takeda Inputs in Repo	fixed	indirect
4794	Enhance the HELIOS library processing for the upcoming HELIOS-2 library	in review	direct

4855	Add defaults for xlabel/ylabel	fixed	direct
4871	Write utility to detect feedback for use in scripts	in review	direct

5. CONCLUSIONS

During PoR 14 there were approximately 108 PHI Kanban tickets related to user support activities, either directly or indirectly. In total there were 108 tickets related to user support activities for VERA-CS. There were 56 new reported defects and 34 defects fixed in PoR 14. 44 tickets were related to miscellaneous user requests and did not directly support any milestones. Work was also performed for 30 tickets related to 7 milestones. A training was also given to WEC.

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[1] "L3 PHI.INF.P14.04 Completion Memo," CASL Memo, CASL-U-2017-1304-000, March (2017).

[2] K. S. Kim, et al., "Development of the V4.2m5 and V5.0m0 Multigroup Cross Section Libraries for MPACT for PWR and BWR," CASL Technical Report, CASL-U-2017-1280-000, Feb. (2017).

[3] B. Kochunas, D. Jabaay, and R. Salko, "Restart File Improvements for MPACT," CASL Technical Report, CASL-U-2016-1120-000, Jan. (2017).

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[5] Scott Palmtag, "Evaluation and Testing of VERA for CE System-80 Design," CASL Technical Report, CASL-U-2017-1300-000, March (2017).