

TriBITS

Tribal Build, Integrate, and Test System

Roscoe A. Bartlett

(bartlettra@ornl.gov)

Computational Engineering and Energy Sciences Group,
Oak Ridge National Laboratory



U.S. DEPARTMENT OF
ENERGY

The Problem => Develop and Deploy Complex Software

- **Multiple software repositories and distributed development teams**
- **Multiple compiled programming languages (C, C++, Fortran) and mixed-language programs**
- **Multiple development and deployment platforms (Linux, Windows, Super-Computers, etc.)**
- **Stringent software quality requirements**

Solution Approach

=> TriBITS custom CMake build & test framework

Why CMake?

Why TriBITS?

Why CMake?

- Open-source tools maintained and used by a large community and supported by a professional software development company (Kitware).
- **CMake:**
 - Simplified build system, easier maintenance
 - Improved mechanism for extending capabilities (CMake language)
 - Support for all major C, C++, and Fortran compilers.
 - Automatic full dependency tracking (headers, src, mod, obj, libs, exec)
 - Faster configure times (e.g. > 10x faster than autotools)
 - Shared libraries on all platforms and compilers
 - Support for MS Windows (e.g. Visual Studio projects)
 - Portable support for cross-compiling
 - Good Fortran support (parallel builds with modules with src => mod => object tracking, C/Fortran interoperability, etc.)
- **CTest:**
 - Parallel running and scheduling of tests and test time-outs
 - Memory testing (Valgrind)
 - Line coverage testing (GCC LCOV)
 - Better integration between the test system and the build system

Why TriBITS?

- Framework for large, distributed multi-repository CMake projects
- Reduce boiler-plate CMake code and enforce consistency across large distributed projects
- Subproject dependencies and namespacing architecture (packages)
- Automatic package dependency handling
- Additional tools for agile software development processes (e.g. Continuous Integration (CI))
- Additional functionality missing in raw CMake
- Change default CMake behavior when necessary

Raw CMake vs. TriBITS

Raw CMakeLists.txt File

Build and install library

```
SET(HEADERS hello_world_lib.hpp)
```

```
SET(SOURCES hello_world_lib.cpp)
```

```
ADD_LIBRARY(hello_world_lib ${SOURCES})
```

```
INSTALL(TARGETS hello_world_lib DESTINATION lib)
```

```
INSTALL(FILES ${HEADERS} DESTINATION include)
```

Build and install user executable

```
ADD_EXECUTABLE(hello_world hello_world_main.cpp)
```

```
TARGET_LINK_LIBRARIES(hello_world hello_world_lib)
```

```
INSTALL(TARGETS hello_world DESTINATION bin)
```

Test the executable

```
ADD_TEST(test ${CMAKE_CURRENT_BINARY_DIR}/hello_world)
```

```
SET_TESTS_PROPERTIES(test PROPERTIES PASS_REGULAR_EXPRESSION "Hello World")
```

Build and run some unit tests

```
ADD_EXECUTABLE(unit_tests hello_world_unit_tests.cpp)
```

```
TARGET_LINK_LIBRARIES(unit_tests hello_world_lib)
```

```
ADD_TEST(unit_test ${CMAKE_CURRENT_BINARY_DIR}/unit_tests)
```

```
SET_TESTS_PROPERTIES(unit_test PROPERTIES PASS_REGULAR_EXPRESSION "All unit tests passed")
```

TriBITS Package CMakeList.txt File

```
TRIBITS_PACKAGE>HelloWorld)
TRIBITS_ADD_LIBRARY(hello_world_lib
  HEADERS hello_world_lib.hpp SOURCES hello_world_lib.cpp)
TRIBITS_ADD_EXECUTABLE(hello_world NOEXEPREFIX SOURCES hello_world_main.cpp
  INSTALLABLE)
TRIBITS_ADD_TEST(hello_world NOEXEPREFIX PASS_REGULAR_EXPRESSION "Hello World")
TRIBITS_ADD_EXECUTABLE_AND_TEST(unit_tests SOURCES hello_world_unit_tests.cpp
  PASS_REGULAR_EXPRESSION "All unit tests passed")
TRIBITS_PACKAGE_POSTPROCESS()
```

- Library linking automatically handled
- Avoid duplication and boiler-plate code
- Fewer commands
- Install by default (most common)
- Automatic namespacing of test & exec names

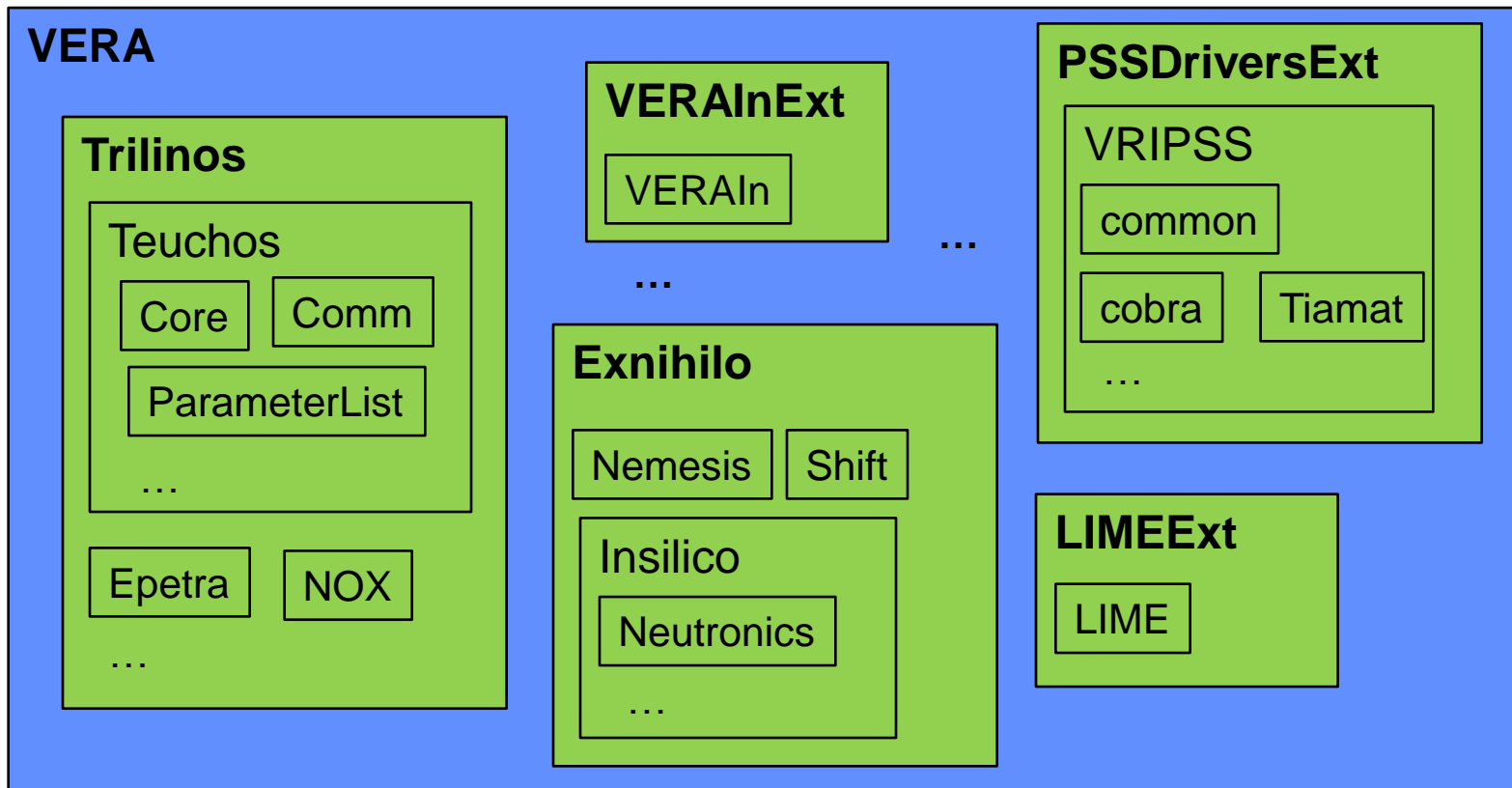
TriBITS Structural Units and Meta-Projects

TriBITS Structural Units

- **TriBITS Project:**
 - Complete CMake “Project”
 - Overall projects settings
- **TriBITS Repository:**
 - Collection of **Packages** and TPLs
 - Unit of distribution and integration
- **TriBITS Package:**
 - Collection of related software & Tests
 - Lists dependencies on **SE Packages** & TPLs
 - Unit of testing, namespacing, documentation, and reuse
- **TriBITS Subpackage:**
 - Partitioning of package software & tests
- **TriBITS TPLs (Third Party Libraries):**
 - Specification of external dependency (libs)
 - Required or optional dependency
 - Single definition across all packages

Packages
+
Subpackages
=
Software Engineering (SE) Packages

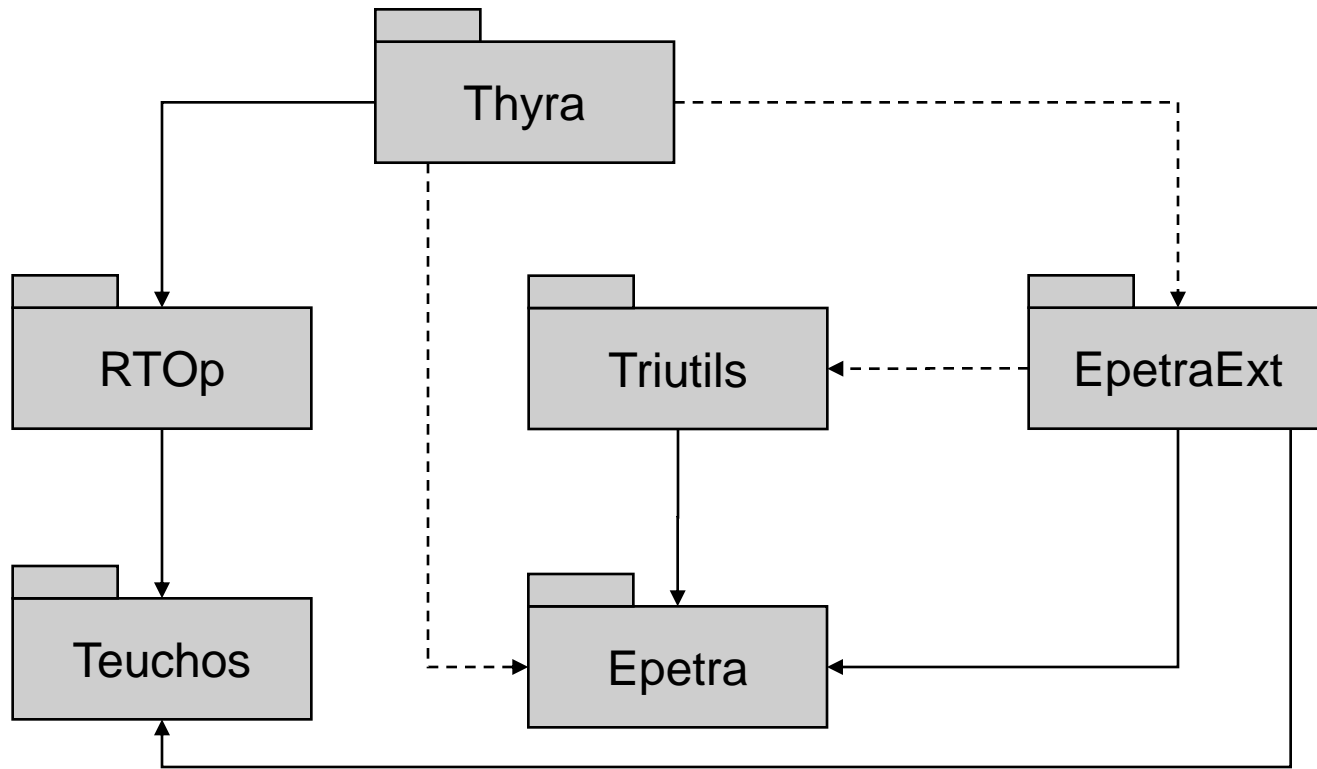
Example: VERA Meta-Project, Repositories, Packages & Subpackages



- **VERA:** Git repository and TriBITS meta-project (contains no packages)
- **Git repos and TriBITS repos:** Trilinos, VERAINExt, LIMEExt, Exnihilo, ...
- **TriBITS packages:** Teuchos, Epetra, VERAIN, Insilico, LIME, VRIPSS, ...
- **TriBITS subpackages:** TeuchosCore, InsilicoNeutronics, VRIPSS Tiamat, ...
- **TriBITS SE (Software Eng.) packages:** Teuchos, TeuchosCore, VERAIN, Insilico, InsilicoNeutronics, ...

Automated Package Dependency Handling

Package Dependency Structure (Example: Trilinos)



Required Dependence 

Optional Dependence 

Package Dependencies.cmake Files

Teuchos

```
TRIBITS_PACKAGE_DEFINE_DEPENDENCIES(  
  LIB_REQUIRED_TPLS BLAS LAPACK  
  LIB_OPTIONAL_TPLS Boost )
```

Epetra

```
TRIBITS_PACKAGE_DEFINE_DEPENDENCIES(  
  LIB_REQUIRED_TPLS BLAS LAPACK )
```

RTOp

```
TRIBITS_PACKAGE_DEFINE_DEPENDENCIES(  
  LIB_REQUIRED_PACKAGES Teuchos )
```

Triutils

```
TRIBITS_PACKAGE_DEFINE_DEPENDENCIES(  
  LIB_REQUIRED_PACKAGES Epetra )
```

EpetraExt

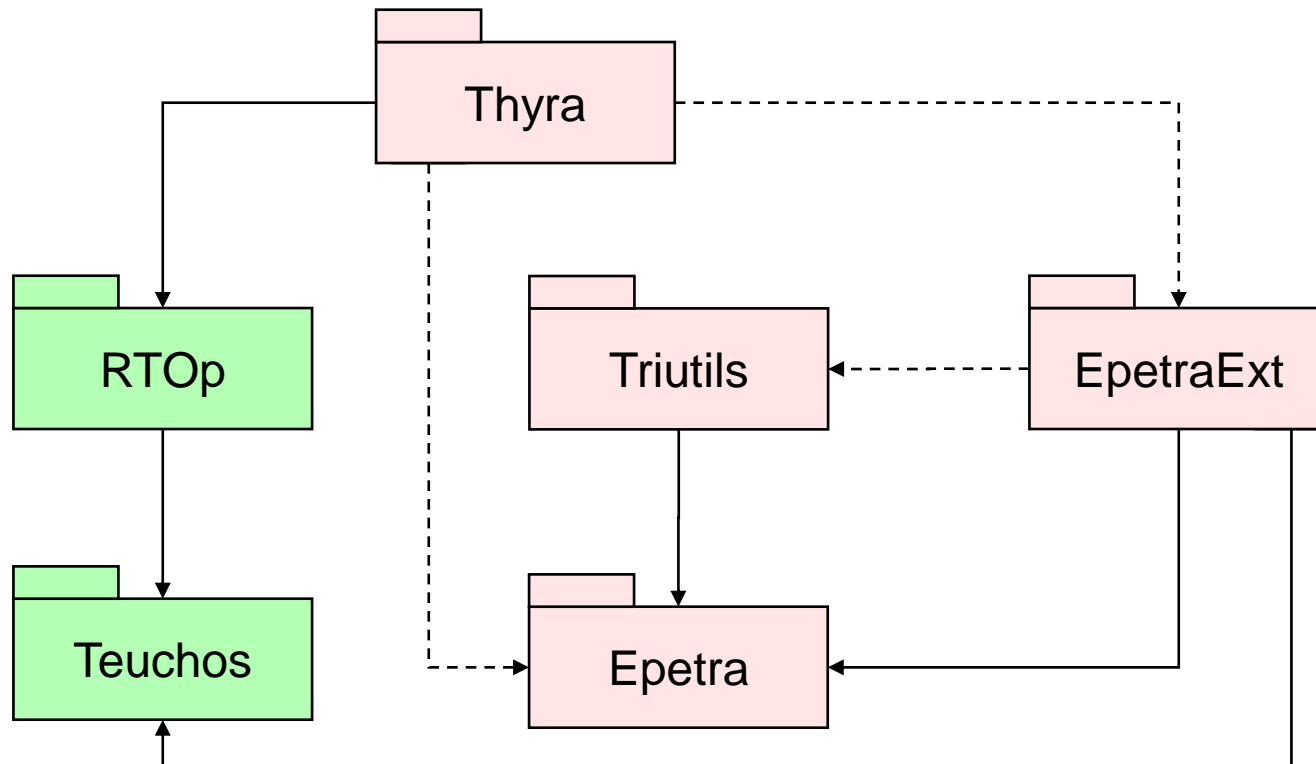
```
TRIBITS_PACKAGE_DEFINE_DEPENDENCIES(  
  LIB_REQUIRED_PACKAGES Epetra Teuchos  
  LIB_OPTIONAL_PACKAGES Triutils )
```

Thyra

```
TRIBITS_PACKAGE_DEFINE_DEPENDENCIES(  
  LIB_REQUIRED_PACKAGES RTOp Teuchos  
  LIB_OPTIONAL_PACKAGES EpetraExt Epera )
```

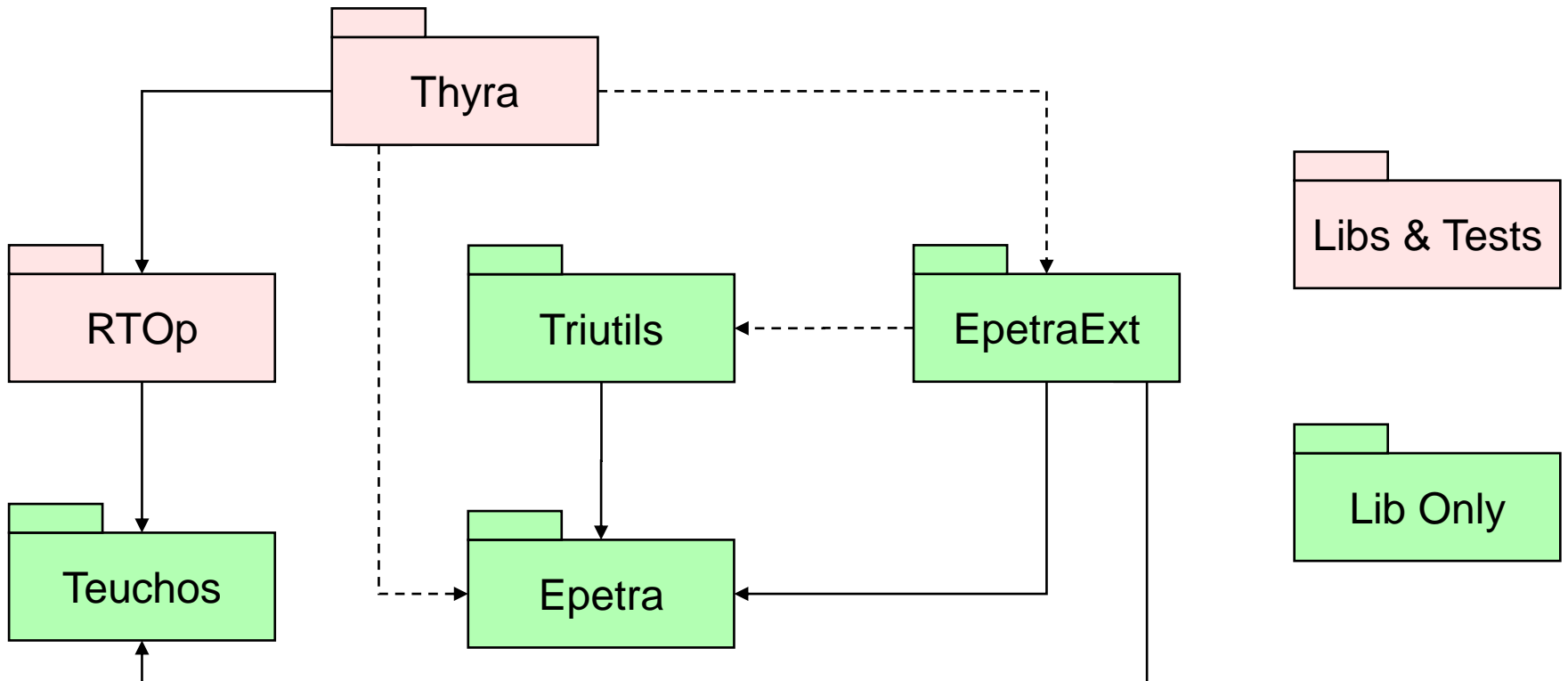
Pre-Push Testing: Change Epetra

```
$ ./do-configure \  
-D Trilinos_ENABLE_Epetra:BOOL=ON \  
-D Trilinos_ENABLE_ALL_FORWARD_DEP_PACKAGES:BOOL=ON \  
-D Trilinos_ENABLE_TESTS:BOOL=ON
```



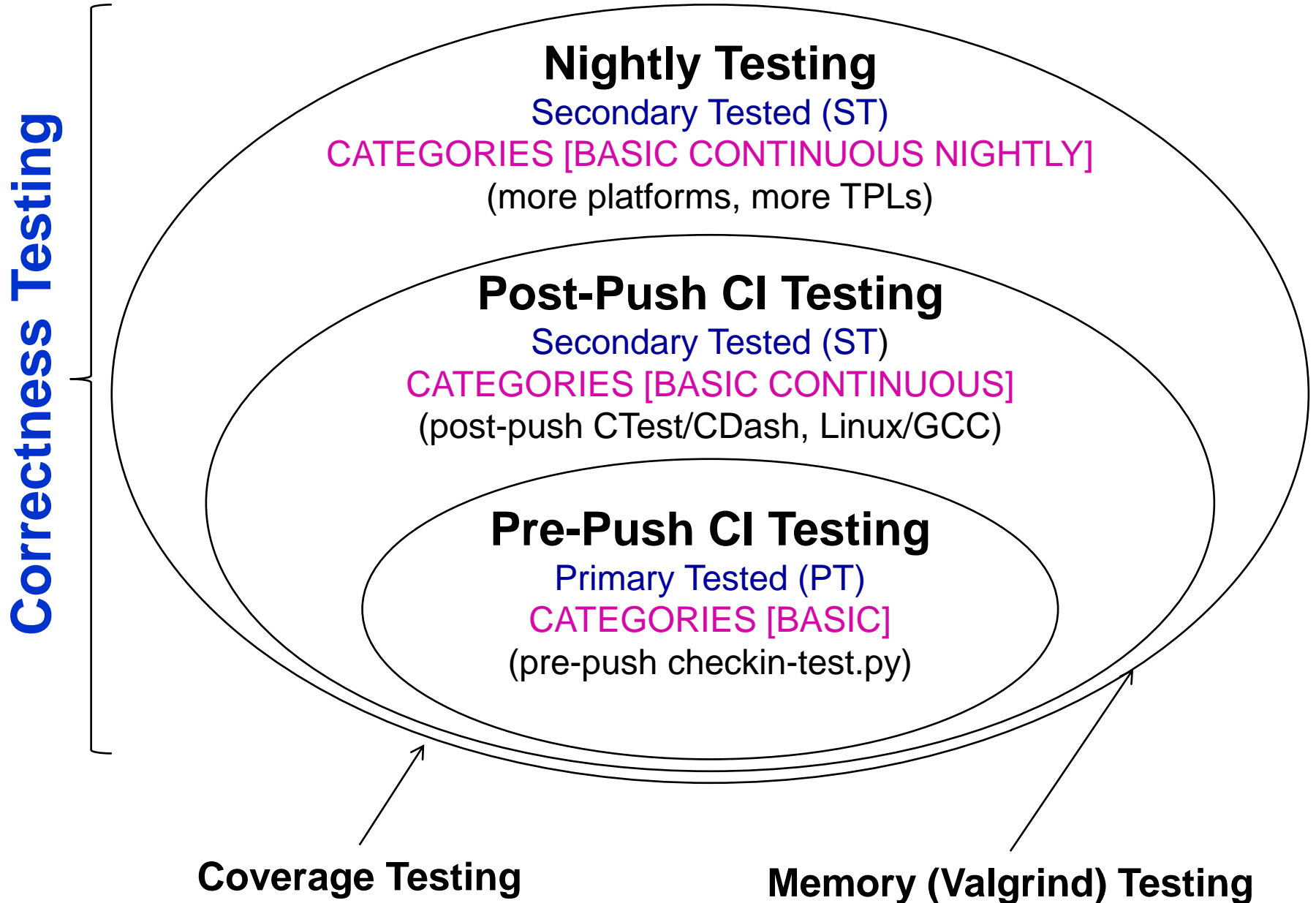
Pre-Push Testing: Change RTOp

```
$ ./do-configure \  
-D Trilinos_ENABLE_RTOp:BOOL=ON \  
-D Trilinos_ENABLE_ALL_FORWARD_DEP_PACKAGES:BOOL=ON \  
-D Trilinos_ENABLE_TESTS:BOOL=ON
```



Extended Testing Support

TriBITS Standard Testing Layers



Pre-Push CI Testing: `checkin-test.py`

`checkin-test.py --do-all --push`

- Integrates with latest version in remote git repositories
- Figures out modified packages

Modified file: 'packages/teuchos/CMakeLists.txt'

=> Enabling 'Teuchos'!

- Enables all forward/downstream packages & tests
- Configures, builds, and runs tests
- Does the push (if all builds/tests pass)
- Sends notification emails
- Fully customizable (enabled packages, build cases, etc.)
- Documentation: `checkin-test.py --help`

Post-Push Testing: TRIBITS_CTEST_DRIVER()

My CDash All Dashboards Log Out Monday, May 05 2014 20:48:48 EDT

VERA
Dashboard Calendar Previous Current Next Project Settings

No update data as of Sunday, April 06 2014 - 23:00 EDT Show Filters Advanced View Auto-refresh Help

Nightly

Site	Build Name	Update			Configure		Build		Test			Build Time	Labels
		Files	Error	Warn	Error	Warn	Not Run	Fail	Pass				
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_RELEASE_GCC461	0	0	74	0	60	0	1	625	Apr 07, 2014 - 01:11 EDT	(13 labels)		
james007.ornl.gov	Linux-GCC-4.6.1-MPI_RELEASE_GCC461_WEEKLY	0	0	74	0	60	0	1	634	Apr 07, 2014 - 01:15 EDT	(13 labels)		
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461	0	0	74	0	61	0	0	626	Apr 07, 2014 - 01:11 EDT	(13 labels)		

Continuous

Site	Build Name	Update			Configure		Build		Test			Build Time	Labels
		Files	Error	Warn	Error	Warn	Not Run	Fail	Pass				
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461_CI	0	0	15	0	1	0	0	320	Apr 07, 2014 - 21:38 EDT	(2 labels)		
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461_CI	0	0	15	6	1	0	0	53	Apr 07, 2014 - 19:14 EDT	(2 labels)		
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461_CI	0	0	44	0	120	0	0	594	Apr 07, 2014 - 04:06 EDT	(11 labels)		

CDash Dashboard for 4/6/2014

- Rolled-up summaries for each build case
- Nightly, CI, Experimental build cases

My CDash All Dashboards Log Out Monday, May 05 2014 20:48:52 EDT

VERA
Dashboard Calendar Previous Current Next Project Settings

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Continuous

Site	Build Name	Update			Configure		Build		Test			Build Time	Labels
		Files	Error	Warn	Error	Warn	Not Run	Fail	Pass				
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461_CI	0	0	13	0	1 ⁺⁵⁴ ₋₁₄	0	0	53 ₋₄₇	Apr 07, 2014 - 19:18 EDT	VRIPSS		
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461_CI	0	0	2	6 ^{cc}	0				Apr 07, 2014 - 19:14 EDT	COBRA_TF		

CDash CI Iterations

- Individual packages built in sequence
- Targeted emails for failed package build & tests
- Failed packages disabled in downstream packages

=> Don't propagate failures!

My CDash All Dashboards Log Out Monday, May 05 2014 20:51:59 EDT

VERA
Dashboard Calendar Previous Current Next Project Settings

No update data as of Sunday, April 06 2014 - 23:00 EDT Show Filters Advanced View Auto-refresh Help

Continuous

Site	Build Name	Update			Configure		Build		Test			Build Time	Labels
		Files	Error	Warn	Error	Warn	Not Run	Fail	Pass				
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461_CI	0	0	13	0	1 ⁺⁵ ₋₃₄	0	0	100 ⁺⁴⁷	Apr 07, 2014 - 21:45 EDT	VRIPSS		
pu241.ornl.gov	Linux-GCC-4.6.1-MPI_DEBUG_GCC461_CI	0	0	2	0 ₋₈	0 ⁺²	0	0	220 ⁺²³³	Apr 07, 2014 - 21:38 EDT	COBRA_TF		

TriBITS Miscellaneous Facts

- **TriBITS System Dependencies:**
 - TriBITS Core: Basic configure, build, test & install
=> **Only raw CMake (2.8.4+)**
 - TriBITS Extra SE tools (checkin-test.py, ...)
=> **Git (1.7.0.4+) and Python 2.4**
- **Usage of TriBITS:**
 - Trilinos (SNL, originating project)
 - ORNL: SCALE, Exnihilo, DataTransferKit
 - Non-ORNL: MPACT (Univ. of Misc.), COBRA-TF (Penn. State)
 - CASL-Related: VERA
- **TriBITS Development & Distribution:**
 - 3-clause BSD-like license, Copyright SNL
 - Current: Trilinos (trilinos.sandia.gov), CASL (casl-dev)
 - Near future: **Github** (public repo, global pull)

- **Contact:** bartlettra@ornl.gov
- **Sponsors:**
 - CASL: Consortium for the Advanced Simulation of Lightwater reactors