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# TRILINOS DEVOPS PIPELINE PLANNING

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Trilinos Users Group 2023

9:15 am October 31st, 2023

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SAND2023-11587C

# ACKNOWLEDGEMENTS

We would like to thank everyone who has helped us …

- Michael Wolf
- Mike Heroux
- Raisa Koshkin
- Phyllis Rutka
- Trilinos Survey Respondents
- Ross Bartlett
- Phil Sakievich
- Todd Gamblin
- Others …

# DRIVER FOR TRILINOS DEVOPS PIPELINE PLANNING

- There have been many complaints and perceived issues?
  - *"Trilinos is too big.  Trilinos is too complex."*
  - *"Why does Trilinos use TriBITS when there is Modern CMake and Spack?"*
  - *"Trilinos takes too long to build."*
  - *"Trilinos needs more testing."*
  - *"Need to deliver code changes more quickly to applications."*
  - ...

- These touch every component of the Trilinos DevOps Pipeline (TDOP)


- So the basic question is ***"How do we improve the Trilinos DevOps Pipeline?"***

# LEADERSHIP GUIDANCE

## Key Goals

- **Goal 1**: Have a broadly maintained and sustainable Trilinos DevOps Pipeline
  - Avoid the single person (point of failure) problem
  - Major risk for Trilinos and ASC
- **Goal 2**: Have one-day turn-around time from Trilinos commits to ASC applications
  - The pipeline should not stand in way of meeting this goal in the future
  - I.e., support stakeholder integration testing of Trilinos

## Secondary Considerations

- Use standard tools/software when possible
  - We should question ourselves when we feel that we need one-off, in-house solutions
- Should we partition Trilinos?
  - Perception that Trilinos is ”too large”
- What can we do to facilitate external adoption of Trilinos?
  - Issues encountered by ECP applications in building/testing Trilinos
  - Is there anything that we can do to lower the barrier to adoption?


https://deviq.com/terms/bus-factor

# EXECUTIVE SUMMARY (BLUF)

## Trilinos plans to …

DEVELOP
- Remain single repository to maintain developer productivity
- Retain key capabilities of TriBITS and form a support team

CONFIGURE
- Utilize ASC DevOps common Trilinos configurations (e.g., RAMSES and CompSim)
- Provide/maintain a Spack recipe that others can use (e.g., ASC Stakeholders and Spack)

BUILD
- Maintain/support CMake+TriBITS and Spack builds
- Incorporate Containers and GitHub Actions to catch build errors and keep builds clean

TEST
- Add Integration testing for Trilinos packages (e.g., Kokkos and Kokkos Kernels)
- Support application's integration testing of Trilinos to mitigate integration issues

DELIVER DEPLOY
- Support both delivery (Trilinos GitHub) and deployment (Spack)
- Steward Trilinos's Spack recipe with support from Framework and Trilinos Developers

# TRILINOS BACKGROUND AND CONTEXT

# TRILINOS PHILOSOPHY

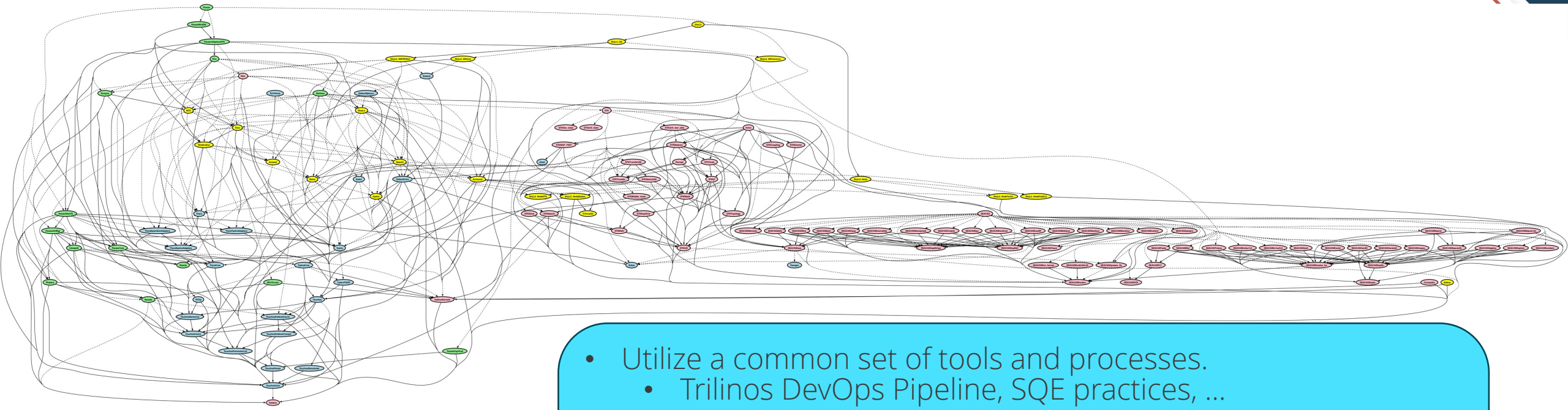
"The Trilinos Project is an effort to facilitate the design, development, integration and ongoing support of mathematical software libraries within an object-oriented framework for the solution of large-scale, complex multi-physics engineering and scientific problems. Trilinos addresses two fundamental issues of developing software for these problems: (i) ***Providing a streamlined process and set of tools for development of new algorithmic implementations*** and (ii) ***promoting interoperability of independently developed software***."

*Heroux, et al, "An Overview of the Trilinos Project", ACM Transactions on Mathematical Software, Vol. V, No. N, December 2004, Pages 1–27.*

"The Trilinos project was established to address two important needs: (1) bringing teams of library developers together in order to ***leverage commonalities and produce compatible software components***, formally called packages and (2) to ***amortize the cost and efforts associated with more formal software engineering requirements***. With a modest level of coordination and without unduly compromising package team autonomy, Trilinos project members could leverage each other's efforts, consolidate commonly needed tools, make packages compatible, and define a common set of software engineering tools and processes."

*Heroux and Willenbring, "A new overview of the Trilinos project", Scientific Programming 20 (2012) 83–88*

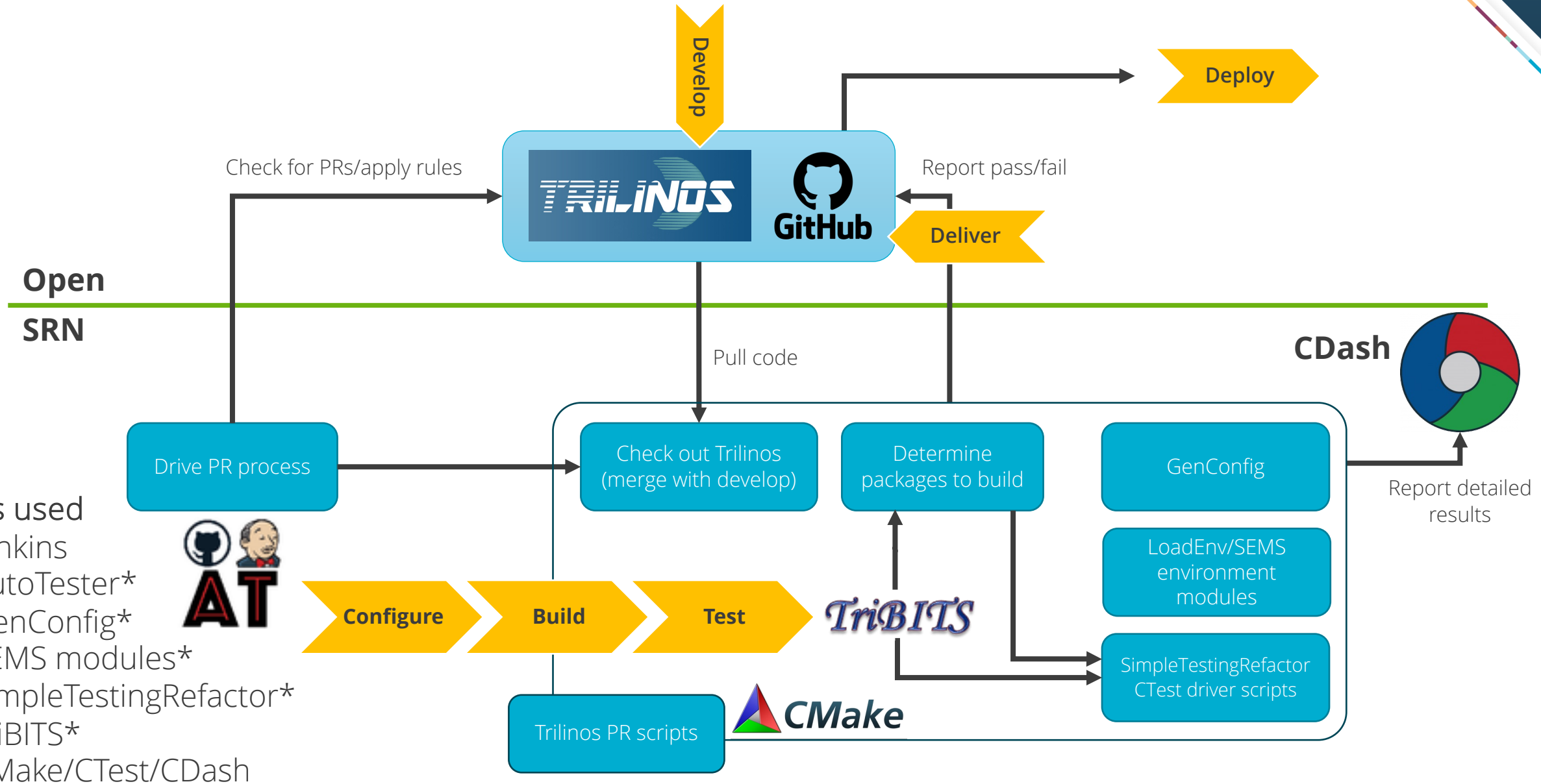
# WHY IS TRILINOS A SINGLE REPOSITORY?



- Utilize a common set of tools and processes.
  - Trilinos DevOps Pipeline, SQE practices, …
- Promote interoperability of independently developed software
  - A lot of code reuse!
  - A lot of capabilities built from multiple packages!
- Rapid/Coupled software development requires “SHA sync’ing”
- Partitioning the DAG introduces integration overhead
- Complexity only reduced through fewer packages/dependencies


Excluding archived/Framework packages
135 Packages and Subpackages
566 Required (solid) and Optional (dashed) Dependencies

# OVERVIEW OF CURRENT TRILINOS DEVOPS PIPELINE

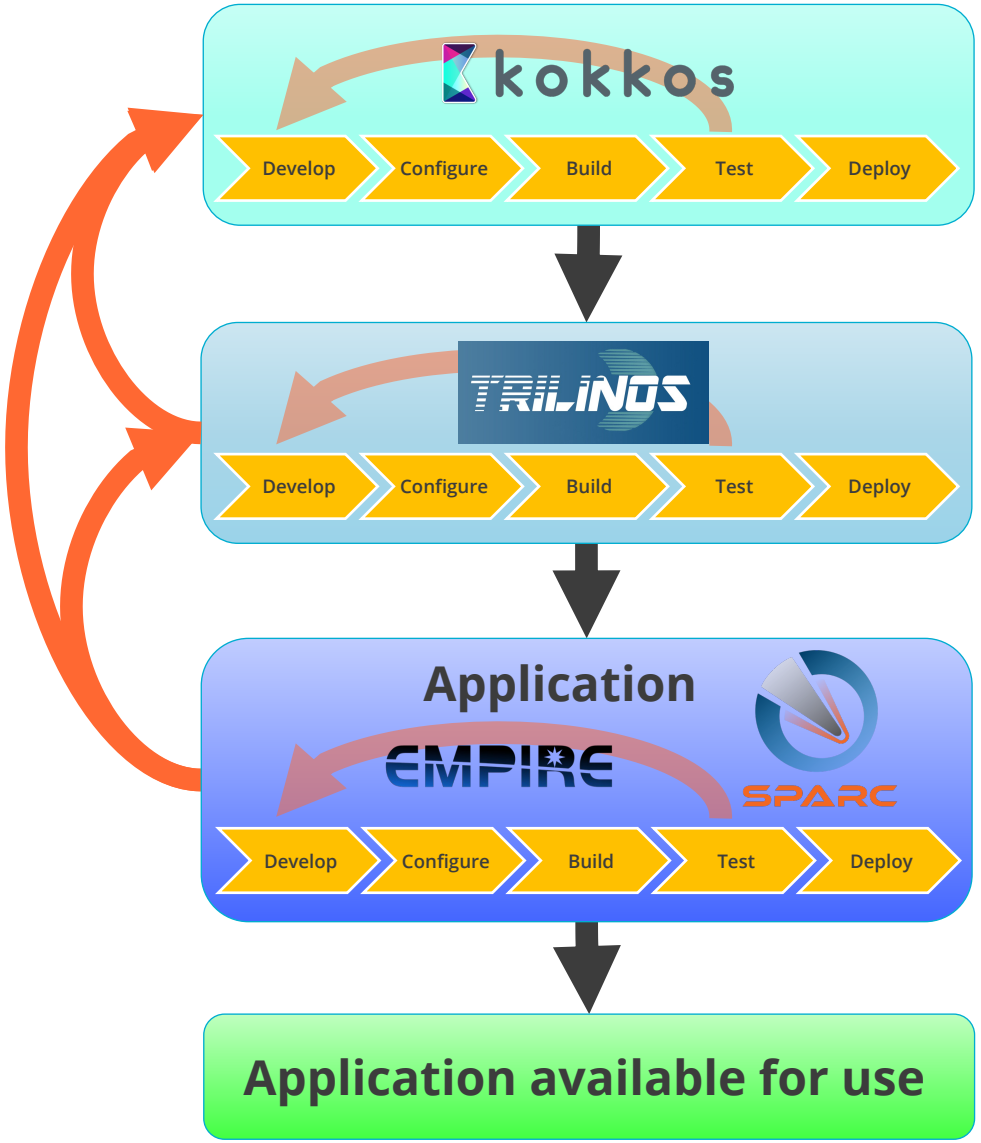



Tools used

- Jenkins
- AutoTester*
- GenConfig*
- SEMS modules*
- SimpleTestingRefactor*
- TriBITS*
- CMake/CTest/CDash

# UPSTREAM PACKAGE INTEGRATION PROCESS

- Stakeholders request code changes
- Upstream packages may need to
  - Develop code
  - Fix bugs
  - Iterate with Stakeholders
  - Collaborate with other upstream packages
- Upstream packages then perform internal and/or integration testing
- If a simple internal fix, most packages can turn this around in a few hours
- Things that cause delays
  - Integration Testing
    - Package coordination
    - Cascading changes / issues
  - Will get worse with more packages
- Ways to improve
  - Incorporate downstream build configurations and representative use-cases



# TRILINOS DEVOPS PIPELINE PLAN

DEVELOP

# TRILINOS REMAIN SINGLE REPO; RETAIN KEY CAPABILITIES OF TRIBITS

- What are the complaints and perceived issues?
  - "Trilinos is too big.  Trilinos is too complex." → Too many packages/dependencies
  - Should Trilinos be "partitioned"?
  - Why do we have TriBITS?
- Points to Consider
  - Survey says …  **76% - favored single Trilinos repository**
    - Large loss of productivity with multiple repos for developers and applications
  - TriBITS provides CMake layer of common/consistent functionality across Trilinos packages
    - Most large software projects have some CMake layer (e.g., LNLL's BLT and VTK modules)
  - Recent and ongoing TriBITS improvements (e.g., modern CMake and external builds)
- Planned solution/response
  - Remain single repository for Trilinos to maintain developer productivity
  - Retain key capabilities of TriBITS and form a support team
  - Review packages/dependencies to ensure we have the minimum set
  - Consider not using (and removing) subpackages capability from TriBITS/Trilinos

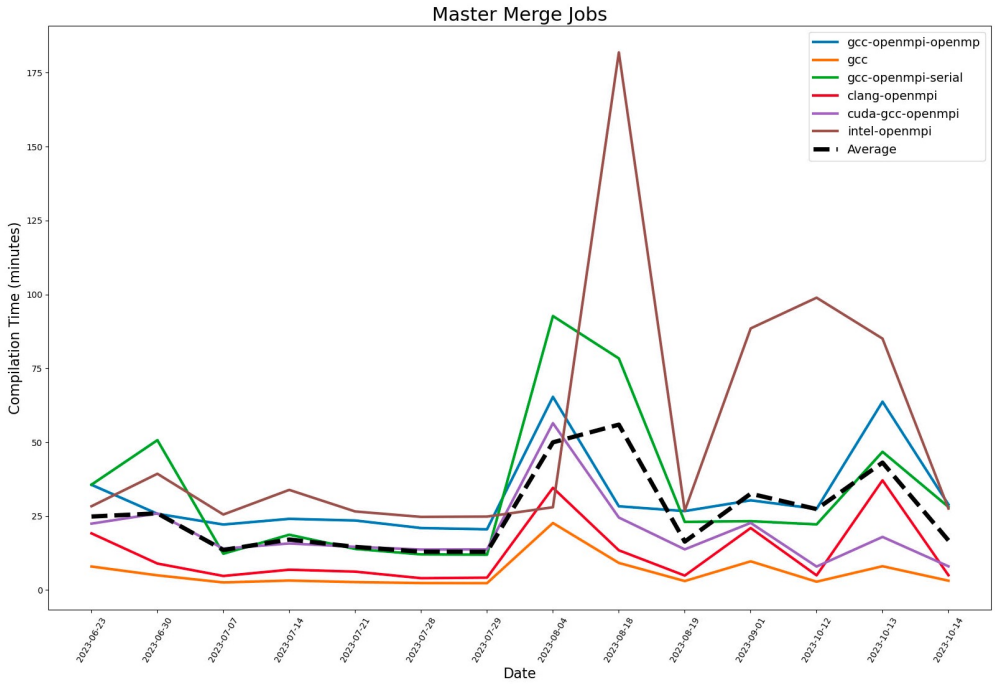
# CONFIGURE

# USE COMMON TRILINOS CONFIGURATIONS; PROVIDE SPACK RECIPE

- What are the complaints and perceived issues?
  - Too many configuration options to get the build you would like
  - Not easy to configure/build for a single/few package(s)
- Points to Consider
  - Survey says …
    - Configuration preference - CMake/TriBITS (35%), CMake/Scripting (32%), CMake/Package Manager/Scripting (23%)
    - Documentation on configuring/building needs improvement.  New users have difficulty.
- Planned solution/response
  - Improve documentation for configuration options and provide examples
  - Provide "recommended" configure defaults based on PR testing
  - Utilize ASC DevOps common Trilinos configurations (e.g., RAMSES and CompSim)
  - Review dependencies to ensure required and optional dependencies are correctly defined
  - Provide/maintain a Spack recipe that others can use (e.g., ASC Stakeholders and Spack)
  - Generate intra-package/TPL dependencies with TriBITS for CMake+TriBITS and Spack recipe

BUILD

# MAINTAIN CMAKE+TRIBITS AND SPACK BUILDS; INCORPORATE CONTAINERS AND GITHUB ACTIONS




- What are the complaints and perceived issues?
  - Build times are long.
- Points to Consider
  - Survey says …
    - Trilinos build times are not long compared to application build times. (21 to 9 respondents)
    - >90% build times less than an hour
  - Container usage is dependent on CEE LAN RHEL 8
- Planned solution/response
  - Continue CMake+TriBITS builds (more for developers/power users)
  - Expand support for Spack+CMake builds (more for Stakeholders/future usage/sysadmins)
  - Add a Spack PR build (meaning a Spack build must pass to commit)
  - Incorporate Containers and GitHub Actions to catch build errors and keep builds clean
  - Utilize build caches (ccache) to increase speed

TEST

# ADD INTEGRATION TESTING FOR TRILINOS PACKAGES; AND SUPPORT INTEGRATION TESTING OF TRILINOS

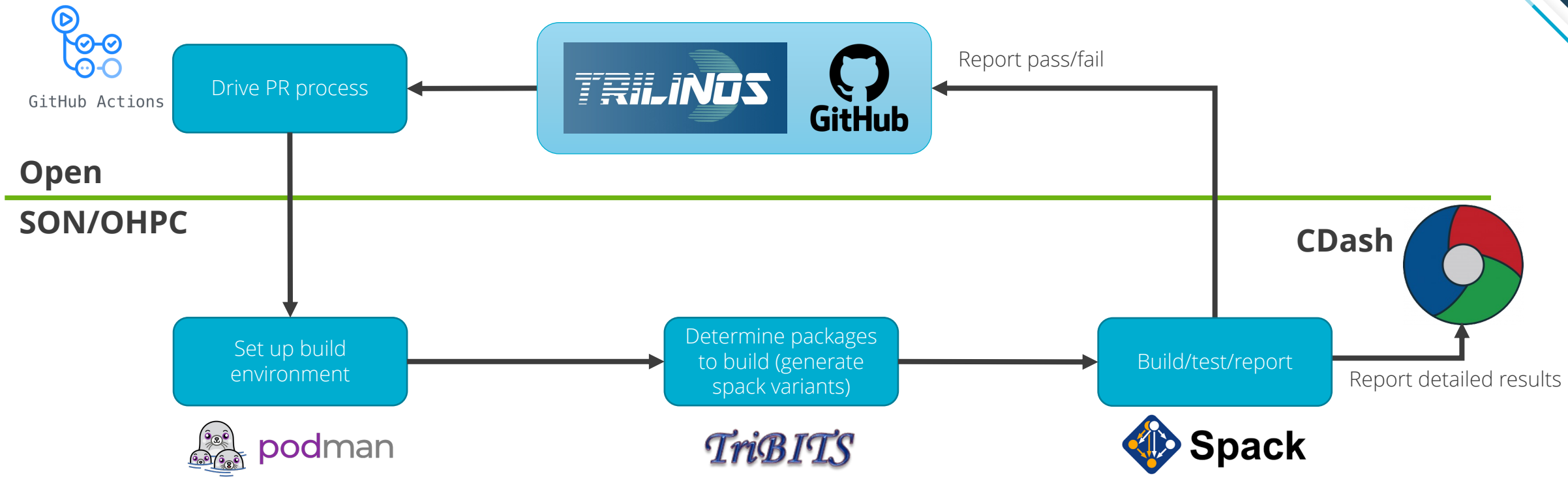
- What are the complaints and perceived issues?
  - Pull Request (PR) testing results not visible to foreign nationals and external developers
  - Trilinos needs greater performance testing
  - Lengthy process to snapshot packages like Kokkos → integration takes too long
- Points to Consider
  - Trilinos testing covers CTS/testbed (SRN) platforms
  - There are gaps in PR testing due to hardware availability (e.g., AMD GPUs)
  - Integration testing between
    - Trilinos packages would introduce additional overhead
    - Upstream packages/Trilinos/applications can reduce turn-around time
  - Trilinos has internal “performance” dashboard
- Planned solution/response
  - Add Integration testing for Trilinos packages (e.g., Kokkos and Kokkos Kernels)
  - Support application’s integration testing of Trilinos to mitigate integration issues
  - Add application use cases for performance monitoring
  - Expand performance testing and memory monitoring (e.g., Watchr)
  - Move PR and Nightlies to SON/OHPC for foreign nationals and external collaborators
  - Leverage cloud and other institution resources to provide external testing

DELIVER
DEPLOY

# SUPPORT BOTH TRILINOS GITHUB AND SPACK; STEWARD TRILINOS'S SPACK RECIPE

- What are the complaints and perceived issues?
  - "Need to deliver code changes more quickly to applications."
  - Difficult to use Spack's recipe for Trilinos
- Points to Consider
  - Survey Says …
    - Preference is to use CMake installation over package manager (20 to 6 respondents)
    - Package Manager (e.g., Spack) is path forward for the future
  - In the past, primarily only delivered Trilinos and applications deployed.
- Planned solution/response
  - Support both delivery (Trilinos GitHub) and deployment (Spack)
  - Steward Trilinos's Spack recipe with support from Framework and Trilinos Developers

# PLANNED TRILINOS DEVOPS PIPELINE – LEVERAGE EXISTING TOOLS




Tools used

- GitHub Actions
- Podman
- Spack
- TriBITS*
- CMake/CTest/CDash

- Move from 5 internally-developed products to 1!
- Manage configurations as opposed to tools
- Move results to SON/OHPC to allow for better communication and development

# BENEFITS OF PLANNED TRILINOS DEVOPS PIPELINE

- Lower maintenance costs
  - Use industry-standard externally-developed software solutions (e.g., GitHub Actions)
  - Maintain configurations of external toolkits (e.g., Dockerfiles) than owning toolkits (e.g., LoadEnv and SEMS modules)
- Allows easier reproduction of automated builds
  - Container images will be able to be shared vs. SEMS modules only existing on internal machines
  - Spack is a more-common language than GenConfig across ECP-related customers
- GitHub Actions maintains current security requirements of AutoTester
- Enhances current security
  - Force all jobs to run in container, which is more-isolated from the system
  - Also run as new entity account (unprivileged) which only has very select machine accounts
  - Also run on SON/OHPC vs. SRN, greatly reducing any concerns about ECI/etc.
- Standardized tooling may not support current capabilities
  - E.g., per-package breakdown on CDash may require specialized code in/around Spack

**Overall, drive towards more community-supported tooling, more nimble automation, and more visible results to enable a wider community to develop more quickly on Trilinos**

# PIPELINE – ADDRESSING KEY GOALS

**Goal 1**: Have a broadly maintained and sustainable Trilinos DevOps Pipeline
- Framework team is mentoring and spreading knowledge across new team members
- Retain key capabilities of TriBITS and form a support team

**Goal 2**: Work towards one-day turn-around time for Trilinos commits to ASC applications
- Basic Trilinos changes are merged (Delivered) within a few hours
- Utilize ASC DevOps common Trilinos configurations (e.g., RAMSES and CompSim)
- Add Integration Testing for packages (e.g., Kokkos and Kokkos Kernels)
- Add ASC use cases for performance monitoring and improved integration testing

## Secondary Considerations

- Use standard tools/software when possible
  - Replace 4 internally developed tools with standard tools
  - Utilize Containers and GitHub Actions to catch build errors and keep builds clean
- Should we partition Trilinos?
  - Remain a single repository to maintain developer productivity
  - Review packages/dependencies to ensure we have the minimum needed set
  - Consider not using (and removing) subpackages capability from TriBITS/Trilinos
  - Review dependencies to ensure required and optional dependencies are correctly defined
- What can we do to facilitate external adoption of Trilinos?
  - Improve documentation for configuration options and provide examples
  - Maintain/support CMake+TriBITS and Spack builds
  - Provide/maintain a Spack recipe that others can use (e.g., ASC Stakeholders and Spack)

# NEXT STEPS …

- Timeline
  - FY24
    - Epetra-Tpetra Transition for Trilinos packages
    - Current planned tasks
      - Test/support CompSim and RAMSES Trilinos configurations (coordinating with ASC DevOps)
      - Ownership/support of Spack-based Trilinos build added to nightly/PR testing
      - Transition from SEMS Autotester to GitHub Actions + Containers
      - Transition from GenConfig to Spack for configuration management*
    - Continued planning of TDOP
  - FY25
    - Epetra-Tpetra transition for Stakeholders
    - Start other planned TDOP responses

# EXECUTIVE SUMMARY (BLUF)

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**CONFIGURE**
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**BUILD**
- Maintain/support CMake+TriBITS and Spack builds
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**TEST**
- Add Integration testing for Trilinos packages (e.g., Kokkos and Kokkos Kernels)
- Support application's integration testing of Trilinos to mitigate integration issues

**DELIVER DEPLOY**
- Support both delivery (Trilinos GitHub) and deployment (Spack)
- Steward Trilinos's Spack recipe with support from Framework and Trilinos Developers

# BACKUP SLIDES

# SUMMARY OF PLANNED TDOP RESPONSES

**DEVELOP**

- Develop
  - Remain single repository for Trilinos to maintain developer productivity
  - Retain key capabilities of TriBITS and form a support team
  - Review packages/dependencies to ensure we have the minimum set
  - Consider not using (and removing) subpackages capability from TriBITS/Trilinos

**CONFIGURE**

- Configure
  - Improve documentation for configuration options and provide examples
  - Provide "recommended" configure defaults based on PR testing
  - Utilize ASC DevOps common Trilinos configurations (e.g., RAMSES and CompSim)
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**BUILD**

- Build
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  - Add a Spack PR build (meaning a Spack build must pass to commit)
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**TEST**

- Test
  - Add Integration testing for Trilinos packages (e.g., Kokkos and Kokkos Kernels)
  - Support application's integration testing of Trilinos to mitigate integration issues
  - Add application use cases for performance monitoring
  - Expand performance testing and memory monitoring (e.g., Watchr)
  - Move PR and Nightlies to SON/OHPC for foreign nationals and external collaborators
  - Leverage cloud and other institution resources to provide external testing

**DELIVER DEPLOY**

- Deliver and Deploy
  - Support both delivery (Trilinos GitHub) and deployment (Spack)
  - Steward Trilinos's Spack recipe with support from Framework and Trilinos Developers