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Almost Continuous Integration for the Co-Development of Highly Integrated Applications and Third Party Libraries

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Applications (APPs) and Third-Party Libraries (TPL) at SNL

Applications (APPs)	**Third Partly Libraries (TPL)**
Aleph	Trilinos
Xyce	Trilinos
Titan (VTK)	Trilinos
Charon*	Trilinos*, Xyce, Nevada
Alegra*	Trilinos*, Xyce, Nevada
SIERRA*	Trilinos*

* Some experimentation with more frequent APP + TPL Integration

- Tighter level of APP + TPL integration is needed in many cases
- Co-development of APP + TPL(s) is often needed to drive new efforts
- Current software engineering infrastructure and practices are insufficient to support desired goals
- We need new software engineering infrastructure to support these integration efforts

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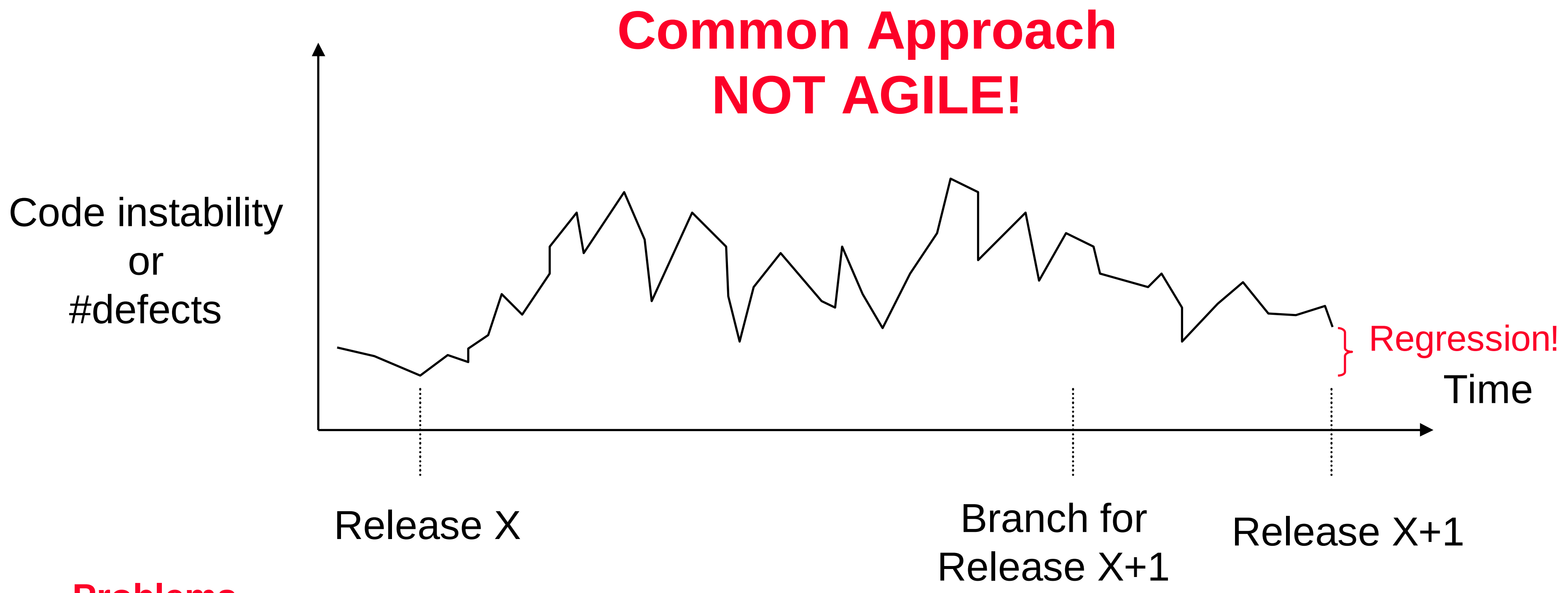
Lean/Agile Software Engineering Principles

- High quality software is developed in small increments and with sufficient testing in between sets of changes.
- High quality defect-free software is most effectively developed by not putting defects into the software in the first place (i.e. TDD, code reviews, pair programming, etc.).
- Software should be delivered to real (or as real as we can make them) customers is short intervals.
- Ruthlessly remove duplication in all areas.
- Avoid points of synchronization. Allow people to work as independently as possible and have the system set up to automatically support this.
- Most mistakes that people make are due to a faulty process/system (W. Edwards Deming).
- Automation is needed to avoid mistakes and improve software quality.

References: http://www.cs.sandia.gov/~rabartl/readingList.html

Lean/Agile Methods: Development Stability



Problems

- Cost of fixing defects increases the longer they exist in the code
- Difficult to sustain development productivity
- Broken code begets broken code (i.e. broken window phenomenon)
- Long time between branch and release
  - Difficult to merge changes back into main development branch
  - Temptation to add “features” to the release branch before a release
- High risk of creating a regression

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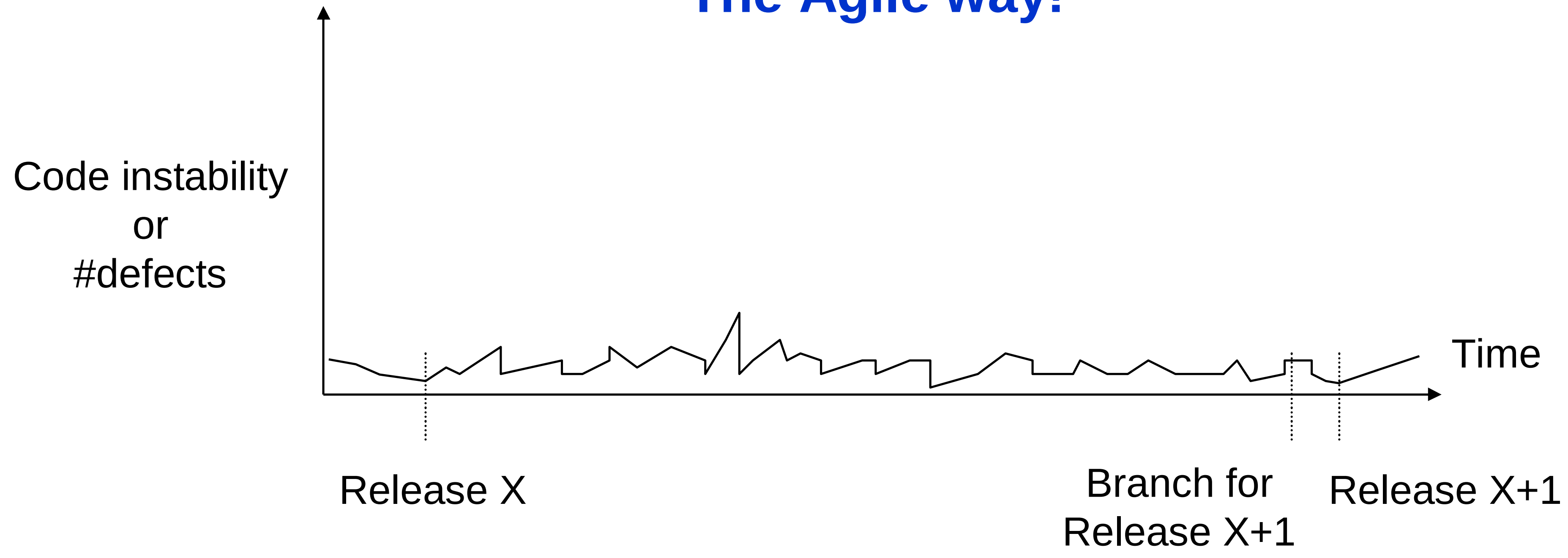
Lean/Agile Methods: Development Stability

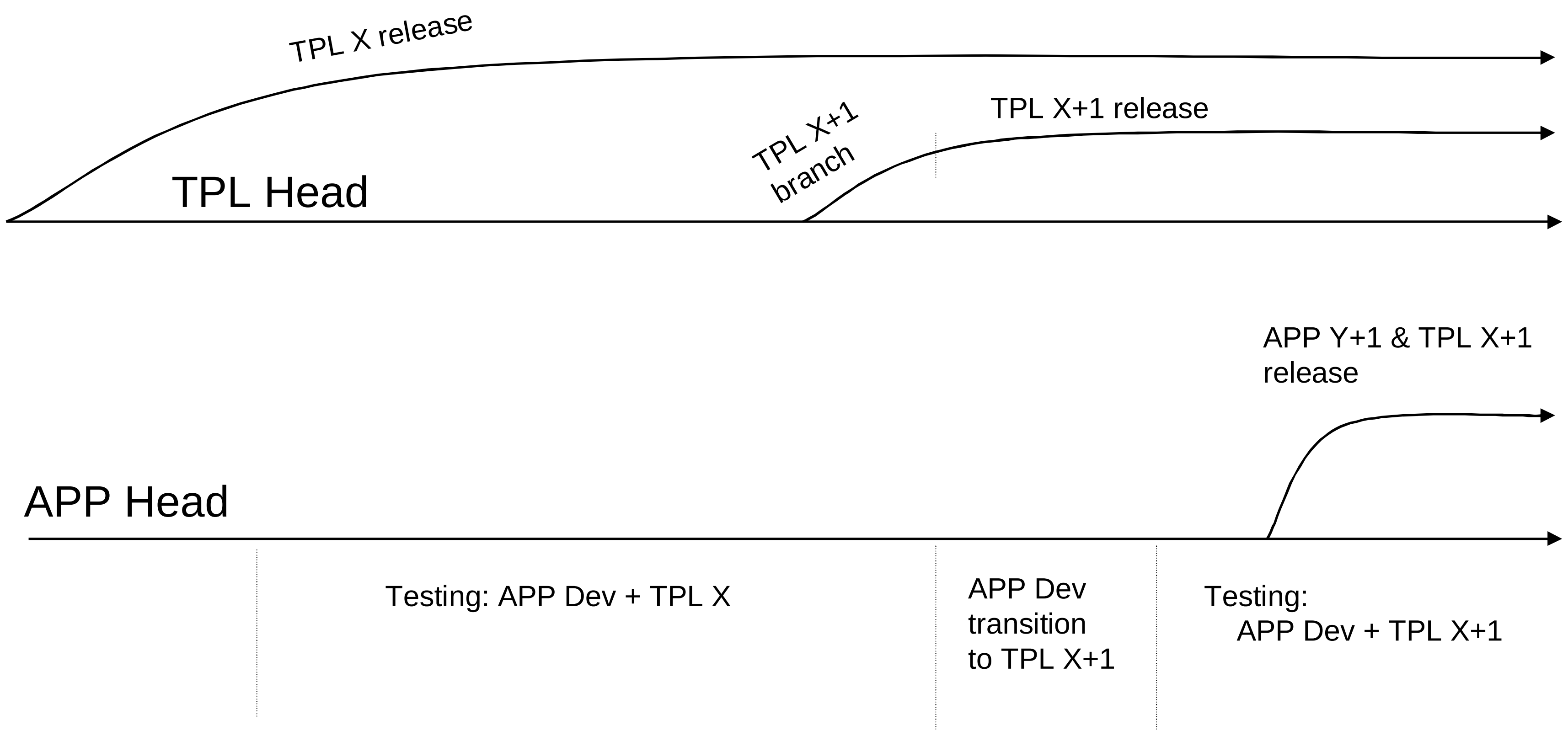
The Agile way!



Advantages

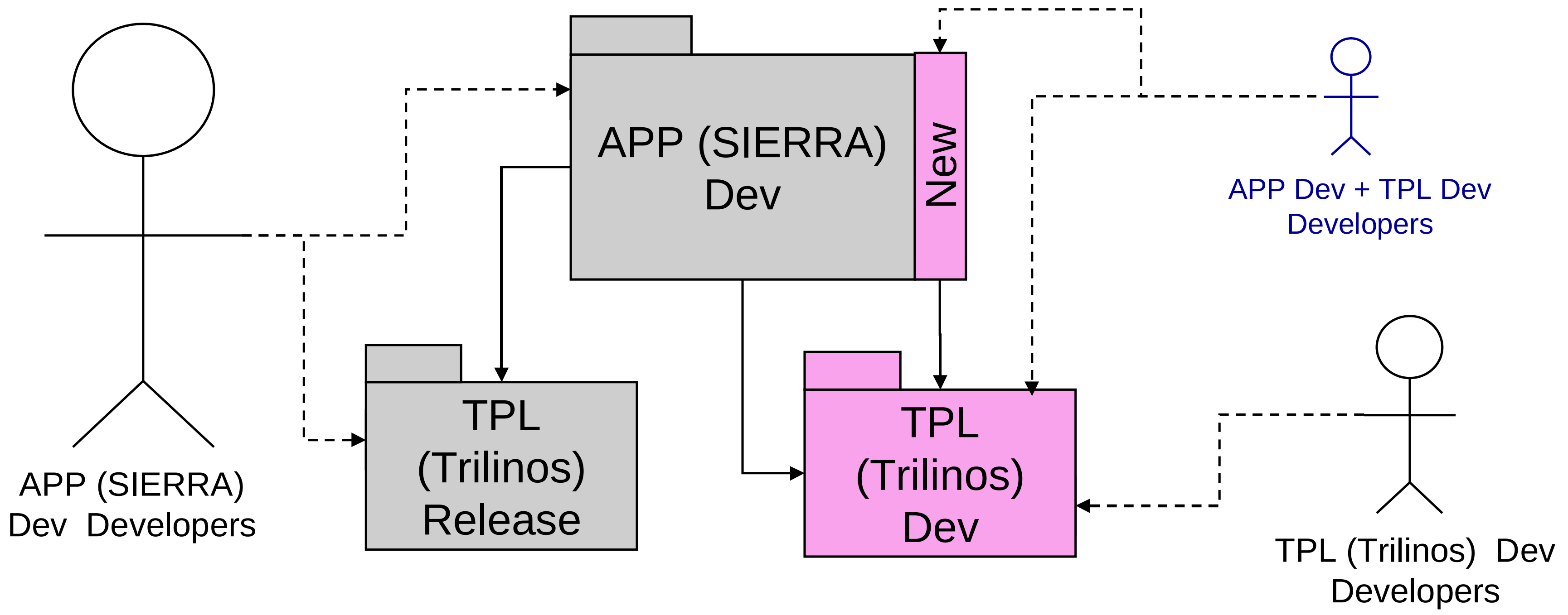
- Defects are kept out of the code in the first place
- Code is kept in a near releasable state at all times
- Shorten time needed to put out a release
- Allow for more frequent releases
- Reduce risk of creating regressions
- Decrease overall development cost

APP Only Upgrades After Each Major Release of TPL



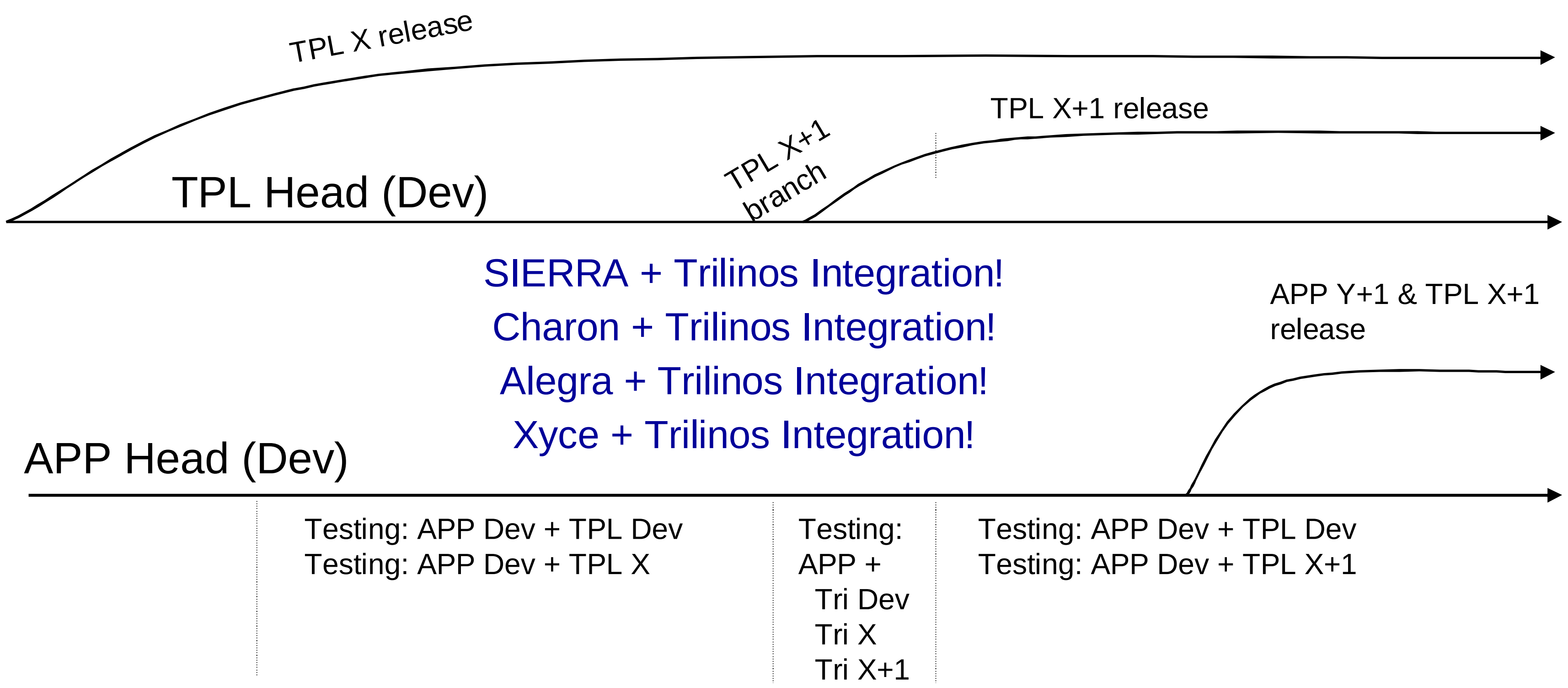
- Transition from TPL X to TPL X+1 can be difficult and open ended
- Large batches of changes between integrations
- Greater risk of experiencing real regressions
- Upgrades may need to be completely abandoned in extreme cases
- However, this is satisfactory for many APP+TPL efforts!

Build and Test APP Against both TPL Release and TPL Dev


APP (SIERRA) Dev
New
TPL (Trilinos) Release
TPL (Trilinos) Dev
APP (SIERRA) Dev Developers
APP Dev + TPL Dev Developers
TPL (Trilinos) Dev Developers

- APP (SIERRA) Dev Developers only build/test against TPL Release
- TPL (Trilinos) Dev Developers work independent from APP
- Changes between TPL Release and TPL Dev handed through a) Refactoring, b) minimal ifdefs (NO BRANCHES)! => Backward Compatibility!
- Use of staggered releases of TPL and APP
- APP + TPL Dev Developers drive new capabilities
- Difficult for APP to depend too much on TPL
- Does not support tighter levels of integration
- However, this is satisfactory for many APP+TPL efforts!

APP Dev Builds Against Both TPL Release and TPL Dev


TPL X release
TPL X+1 release
TPL X+1 branch
TPL Head (Dev)
SIERRA + Trilinos Integration!
Charon + Trilinos Integration!
Alegra + Trilinos Integration!
Xyce + Trilinos Integration!
APP Y+1 & TPL X+1 release
APP Head (Dev)
Testing: APP Dev + TPL Dev
Testing: APP Dev + TPL X
Testing: APP + Tri Dev Tri X Tri X+1
Testing: APP Dev + TPL Dev
Testing: APP Dev + TPL X+1

- All changes are tested in small batches
- Low probability of experiencing a regression
- Extra computing resources to test against 2 (3) versions of TPL
- Some difficulty flagging regressions of APP + TPL Dev
- APP developers often break APP + TPL Dev
- Difficult for APP to rely on TPL too much
- Hard to verify TPL for APP before APP release
- However, this is satisfactory for many APP+TPL efforts!

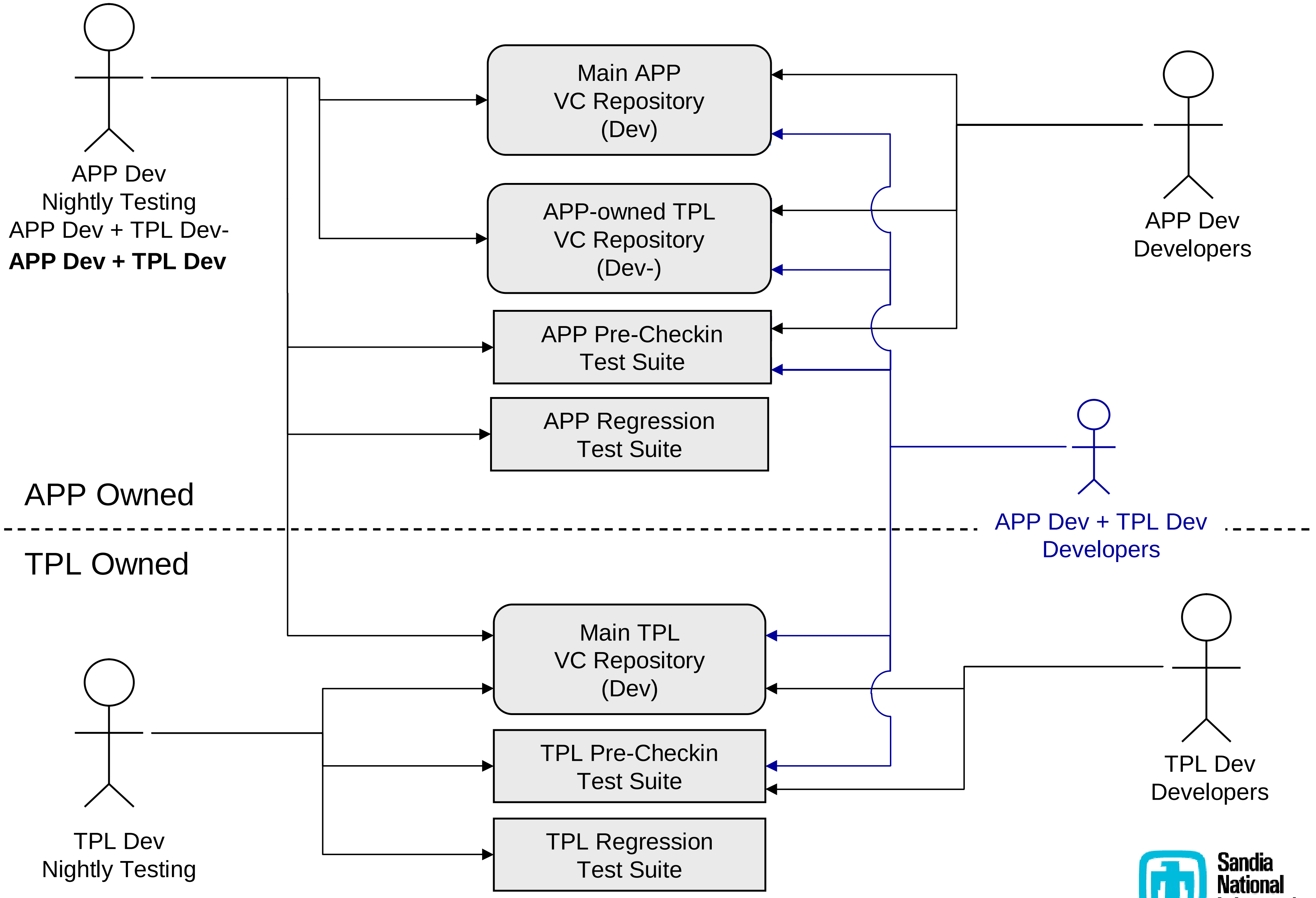
APP + TPL Integration: Different Collaboration Models

- APP Dev only upgraded after each major release of TPL
  - Little to no testing of APP + TPL Dev in between TPL releases
- APP Dev builds against both TPL Release and TPL Dev
  - APP developers work against TPL Release
  - APP + TPL team(s) build against TPL Dev
  - Daily integration testing done for both APP + TPL Release and Dev
  - Staggered releases of TPL and APP
- APP Dev developed only against TPL Dev (with “Almost” Continuous Integration)
  - Regular APP developers work independently using very recent APP-owned VC copy of TPL Dev-
  - Regular TPL developers work independently
  - APP Dev + TPL Dev developers
    - Check-out and modify APP Dev
    - Check-out and modify TPL Dev
    - Run both APP and TPL pre-checkin test suites
    - Check into both APP-owned and main TPL VC repositories
  - Nightly testing of APP Dev + TPL Dev automatically updates APP-owned TPL Dev- VC Repository
  - Releases best handled as combined releases of APP and TPL

General Development & Testing Principles

- Regular TPL developers only build and run TPL pre-checkin test suite.
- Regular APP developers should only check out code that has already built and passed the pre-checkin APP test suite.
- Nightly APP regression (and other) tests should only be run on code that has already been shown to build and pass the pre-checkin APP test suite.
- Code that builds and passes the pre-checkin test suite is safe to check in.

Basic Setup for APP + TPL Almost Continuous Integration



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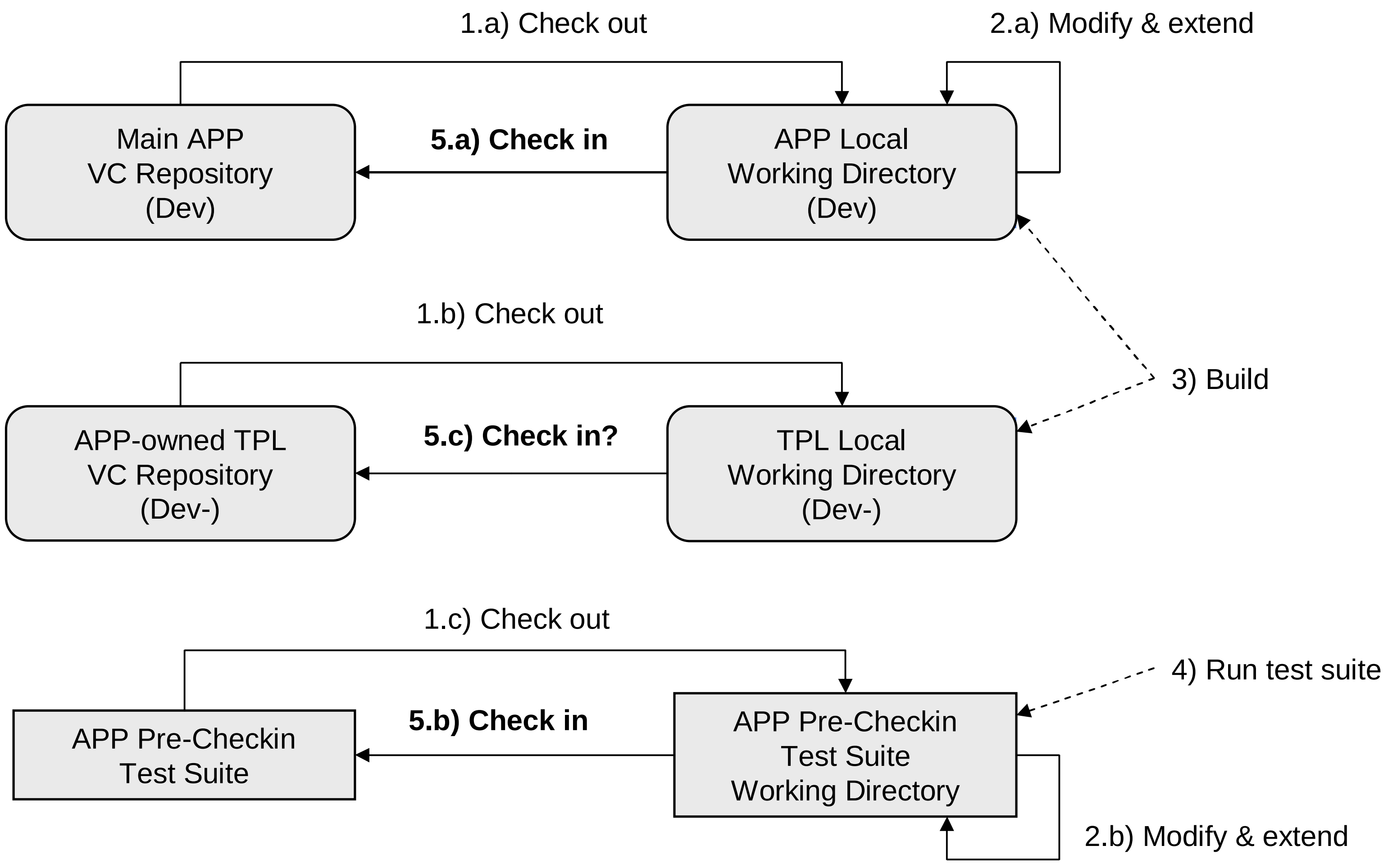
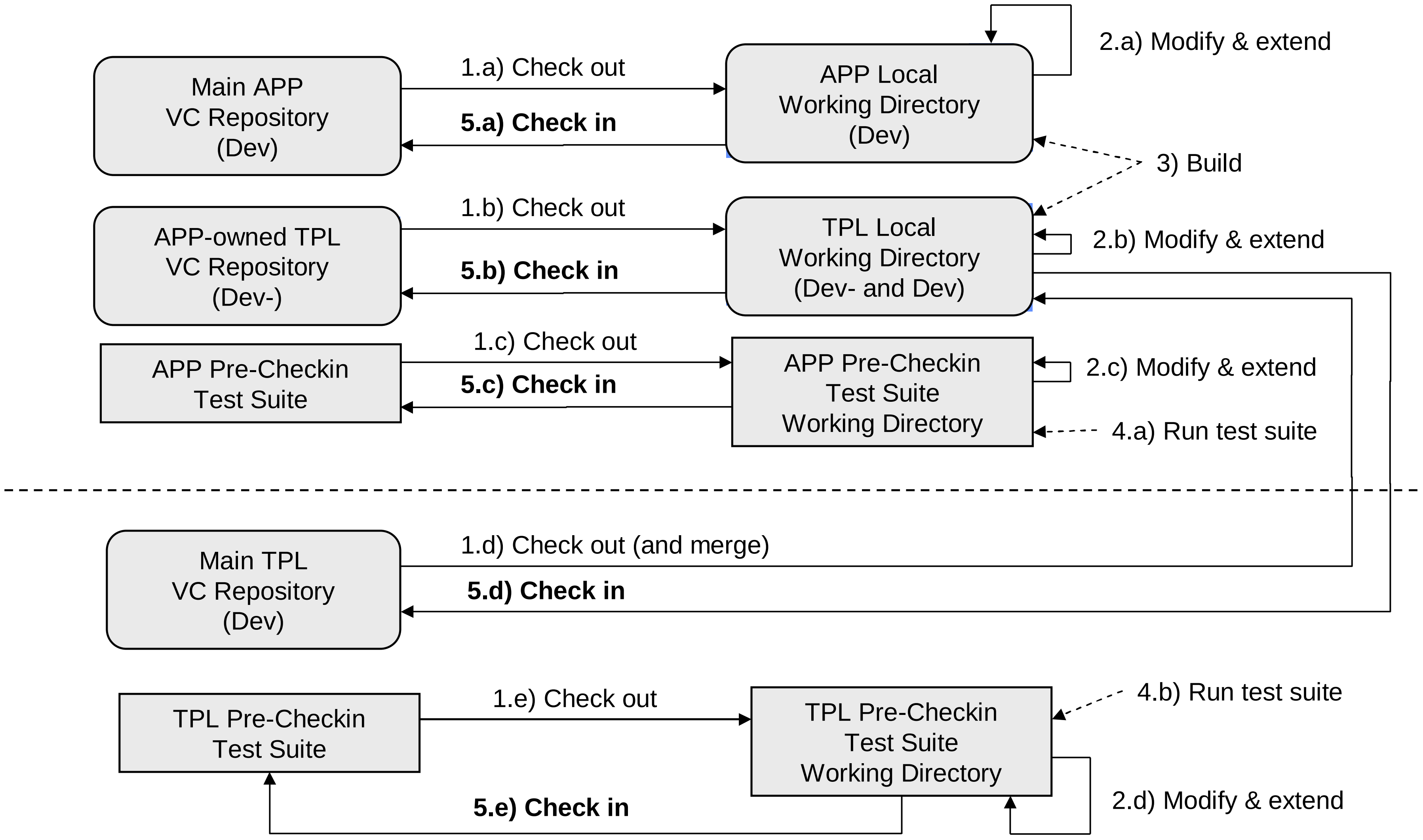
Standard APP Development Process



1.a) Check out
2.a) Modify & extend
Main APP VC Repository (Dev)
5.a) Check in
APP Local Working Directory (Dev)
1.b) Check out
3) Build
APP-owned TPL VC Repository (Dev-)
5.c) Check in?
TPL Local Working Directory (Dev-)
1.c) Check out
4) Run test suite
APP Pre-Checkin Test Suite
5.b) Check in
APP Pre-Checkin Test Suite Working Directory
2.b) Modify & extend

- TPL (Dev-) code is typically not modified by average APP developers!
- However, small changes can be made and can be good!

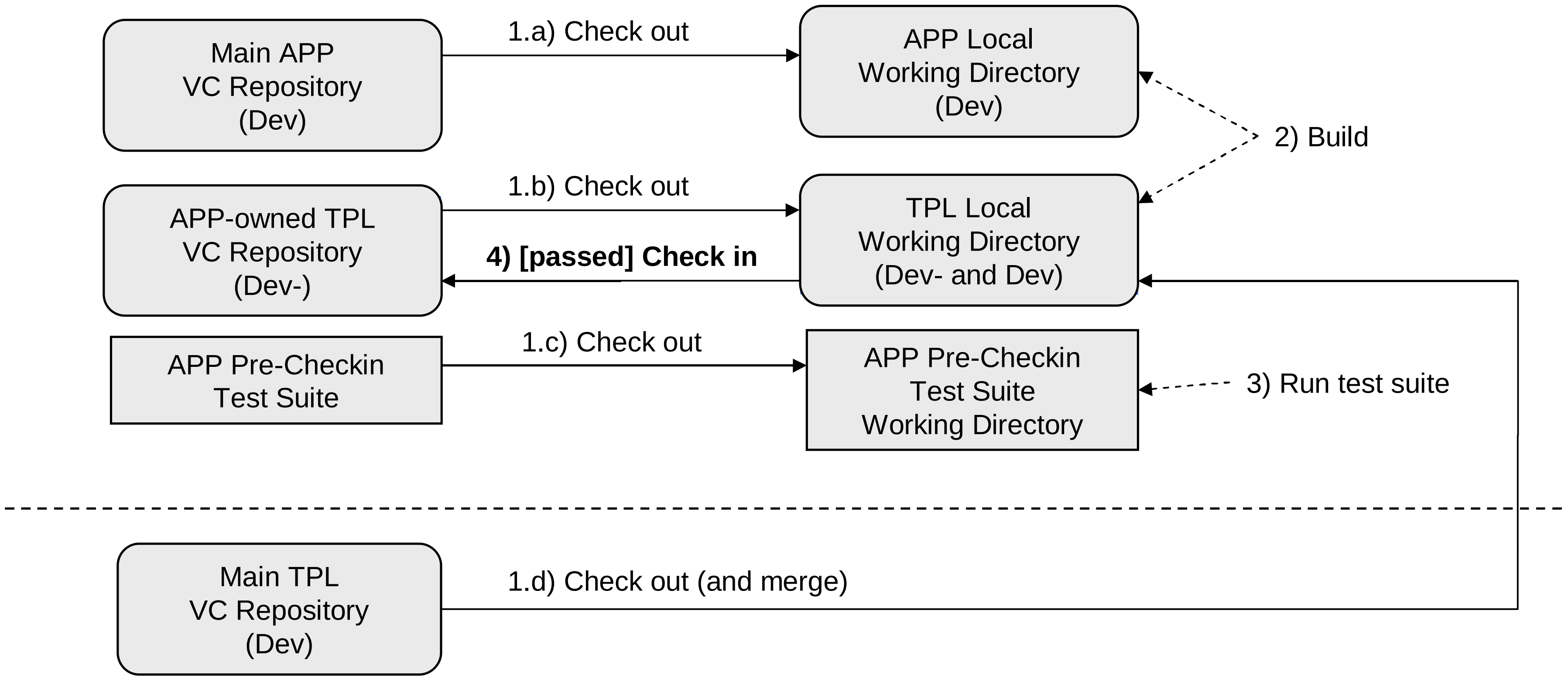
APP Dev + TPL Dev Development Process



Main APP VC Repository (Dev)
1.a) Check out
5.a) Check in
APP Local Working Directory (Dev)
2.a) Modify & extend
3) Build
APP-owned TPL VC Repository (Dev-)
1.b) Check out
5.b) Check in
TPL Local Working Directory (Dev- and Dev)
2.b) Modify & extend
APP Pre-Checkin Test Suite
1.c) Check out
5.c) Check in
APP Pre-Checkin Test Suite Working Directory
2.c) Modify & extend
4.a) Run test suite
Main TPL VC Repository (Dev)
1.d) Check out (and merge)
5.d) Check in
TPL Pre-Checkin Test Suite
1.e) Check out
TPL Pre-Checkin Test Suite Working Directory
4.b) Run test suite
2.d) Modify & extend
5.e) Check in

- Pre-checkin test suites for APP and TPL are both run before checkin
- Simultaneous checks into APP-owned TPL Dev- and Main TPL Dev VC Repositories!
  - Changes in APP-owned TPL VC Dev- Repos get back into Main TPL VC Dev Repos!

Nightly APP + TPL Dev Testing and Checkins of TPL Dev-


Main APP VC Repository (Dev)
1.a) Check out
APP Local Working Directory (Dev)
2) Build
APP-owned TPL VC Repository (Dev-)
1.b) Check out
4) [passed] Check in
TPL Local Working Directory (Dev- and Dev)
APP Pre-Checkin Test Suite
1.c) Check out
APP Pre-Checkin Test Suite Working Directory
3) Run test suite
Main TPL VC Repository (Dev)
1.d) Check out (and merge)

- Only runs pre-checkin test suite and then only on the primary development platform! (just like a regular APP developer)
- TPL Dev- VC Repository is automatically updated by nightly testing process if a) merge, b) build, and c) pre-checkin test suite all pass!
  - This is the same criteria we have for any regular APP developer checkin!
- Integration build is checked throughout the day with continuous integration (but without the auto-updates of TPL Dev- VC repository to avoid conflicts)

APP + TPL Development and Testing Details and Policies

- Nightly Testing:
  - Nightly APP Dev + TPL Dev testing and checking in only run on primary development platform and only runs pre-checkin test suite

    => Minimizes extra testing computer resources!
  - Nightly APP regression (and other stronger) tests are only run on APP Dev + TPL Dev- and *not* with TPL Dev (but on the same day after upgrade of APP Dev-)
    - Only one version of Dev code goes through extended testing (e.g. porting, regression, performance, scalability).
    - If APP Dev + TPL Dev testing and updating of TPL Dev- succeeds, then extended testing will involve all changes to APP Dev and TPL Dev in the last 24 hours.

- Continuous Integration Testing:
  - Build and test APP Dev + TPL Dev throughout the day to flag problems and to help support co-development of APP Dev + TPL Dev

- Open Questions:
  - How are multiple TPL handled in nightly testing ?
    - Are all TPL updated at the same time in nightly testing process?
    - Are TPL updated and testing separately in a chain (TPL 1 followed by TPL 2, etc.)?
  - What about intra-TPL dependencies (i.e. Nevada and Xyce => Trilinos)?
    - Do all TPL need to follow this process as well?

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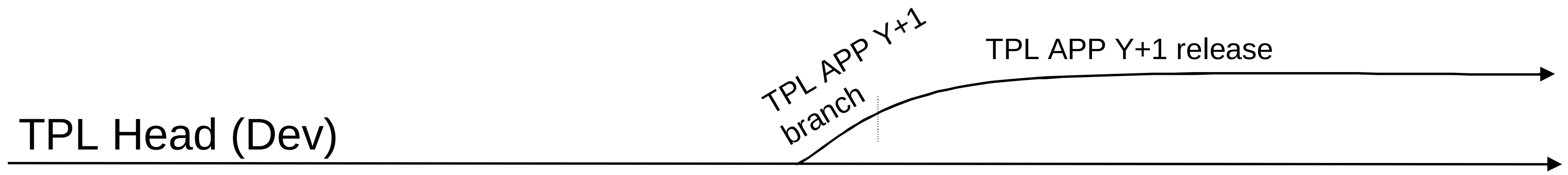
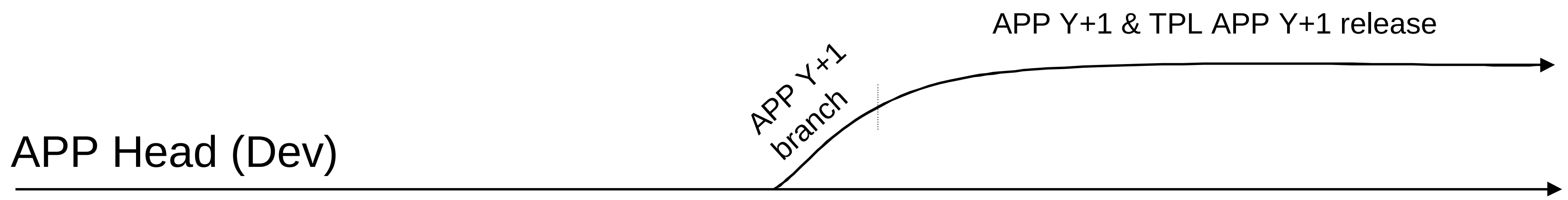
APP + TPL Almost Continuous Integration and Releases



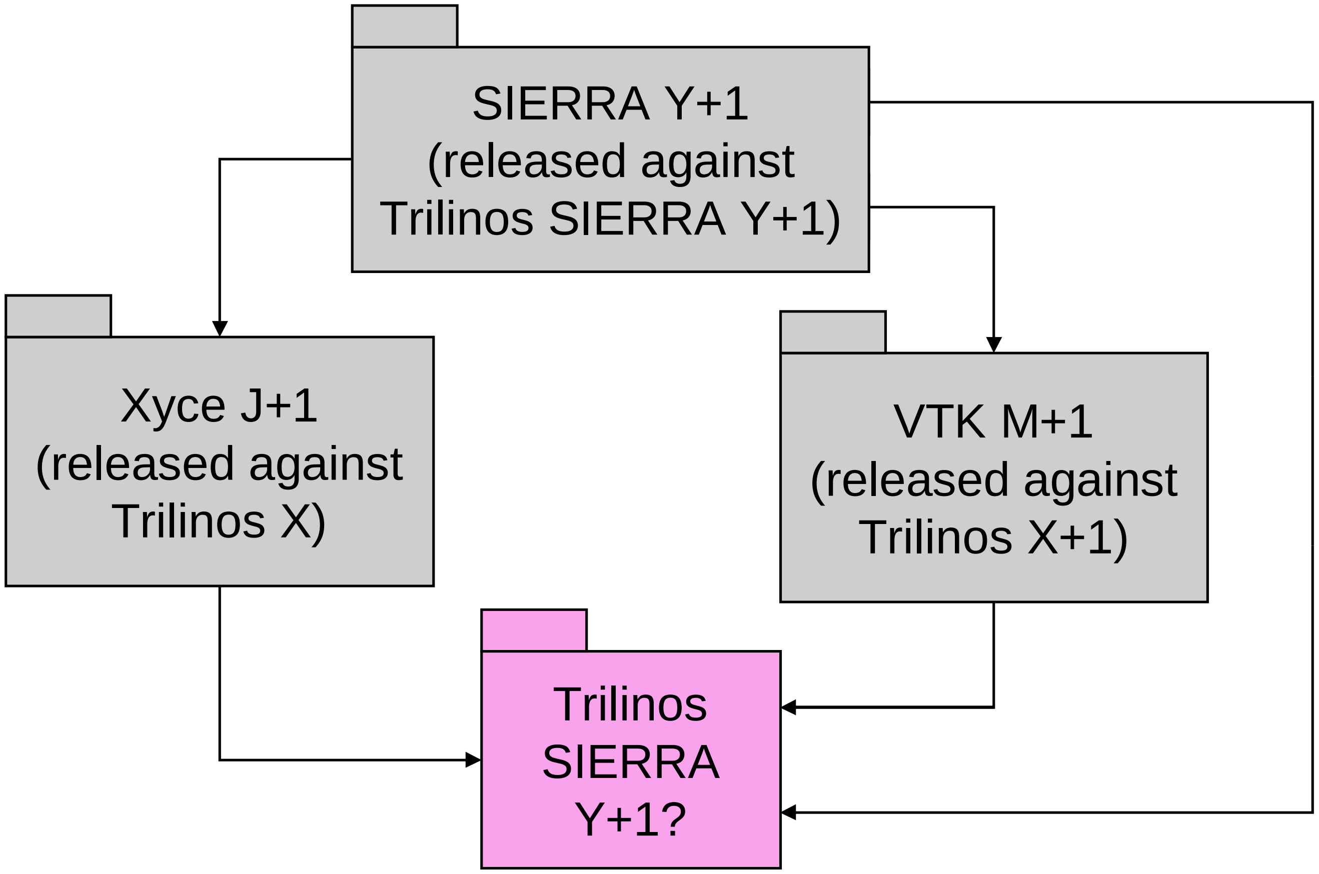
The Future of APP + TPL Integration?



Nightly Testing: APP Dev + TPL Dev (pre-checkin tests only, TPL Dev- checkin)
Nightly Testing: APP Dev + TPL Dev- (complete test suites)
Supported with asynchronous continuous integration testing of APP Dev + TPL Dev

- All changes are tested in small batches
- Low probability of experiencing a regression between major releases
- Less computing resources for detailed nightly testing (only one TPL version)
- All tested regressions are flagged in less than 24 hours
- Allows code to flow freely between the APP and TPL
- Supports rapid development of new capabilities from top to bottom
- All code checked out by APP Dev developers has passed pre-checkin build/test
- More complex processes (i.e. requires some tools?)
- APP Dev developers spend more time spent recompiling TPL code
- Recommended for projects requiring high levels of integration & collaboration!

Challenges with APP-Specific TPL Releases


SIERRA Y+1 (released against Trilinos SIERRA Y+1)
Xyce J+1 (released against Trilinos X)
VTK M+1 (released against Trilinos X+1)
Trilinos SIERRA Y+1?

Multiple releases of TPL (Trilinos) presents a possible problem with complex APPs

Solution:

=> Provide perfect backward compatibility of Trilinos (TPL) X through Trilinos SIERRA Y+1

Assorted Ideas for APP Dev + TPL Dev Nightly Testing

- Nightly and continuous updating, testing, and checkin algorithm
  - Check out APP Dev and + TPL Dev- from APP-owned TPL Dev- VC Repository(s)
  - Build and run pre-checkin APP test suite (for APP Dev + TPL Dev-)
  - For each TPL (i = 0 ... N-1) [In order of increasing dependencies]
    - Perform update of TPL i Dev from main TPL i VC Dev repository
    - Build and run pre-checkin APP test suite
    - If all passed, check into APP-owned TPL i Dev- VC repository [Nightly only]
    - Otherwise, skip checkin into APP-owned TPL i Dev- VC repository

- Advantages
  - Failures with one TPL do not automatically bring down integration with all TPL
    - Example: If Trilinos Dev works with Charon but Xyce Dev does not, at least Trilinos Dev would get updated and used by Charon Dev.
  - Provides additional information on where regressions are coming from
    - Example: A test passes with APP Dev + TPL Dev- but fails with APP Dev + TPL Dev

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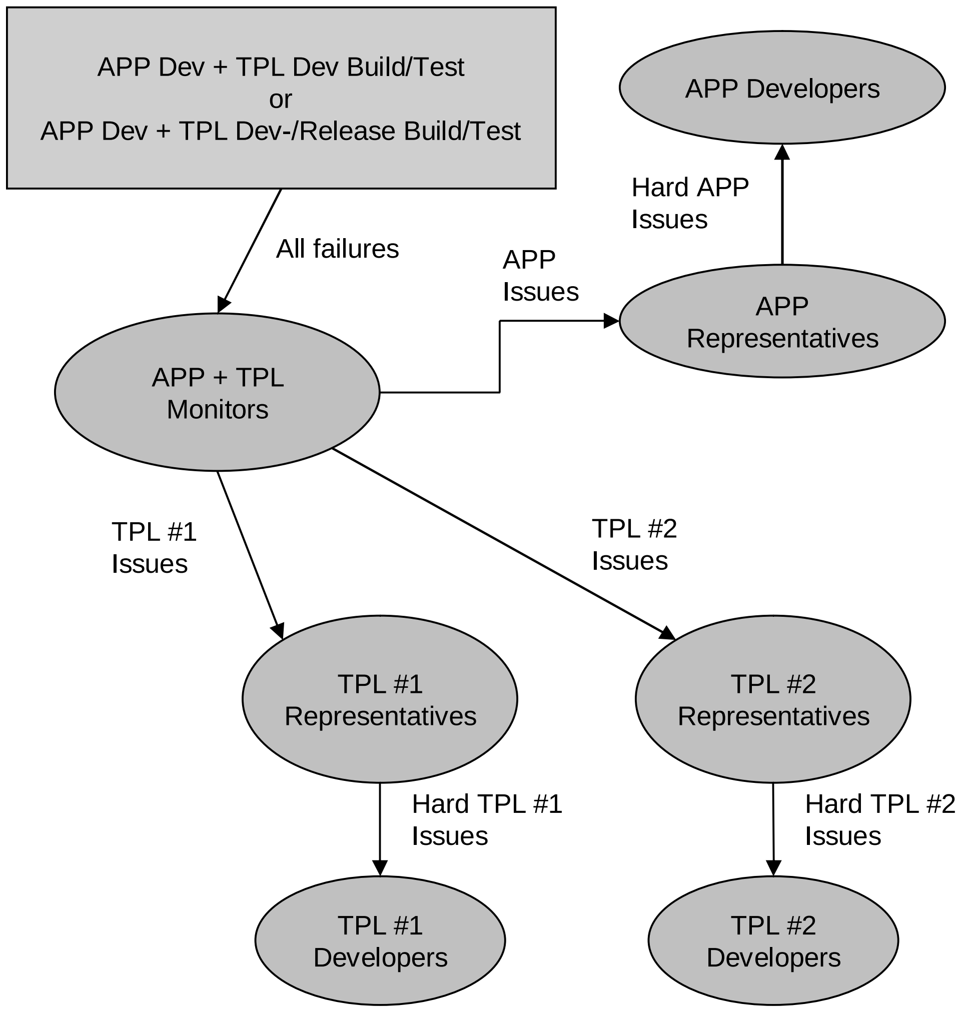
Maintenance of APP + TPL Integration



- APP + TPL Monitor:
  - Member of the APP development team
  - Has good familiarity with the TPLs
  - Performs first-round triage (APP or TPL?)
  - Forwards issues to APP or TPL Reps
  - Ultimate responsibility to make sure issues are resolved
- APP Representative:
  - Member of the APP development team
  - Second-round triage of APP issues
  - Forwards hard APP issues to APP developers
- TPL Representative:
  - Member of the TPL development team
  - Has some familiarity with the APPs
  - Second-round triage for TPL issues
  - Forwards hard TPL issues to TPL developers
- General principles:
  - Roles of authority and accountability (Ordained by management)
  - At least two people serve in each role
  - Rotate people in roles

Summary #1

- Nightly building and testing of the development versions of the application and TPLs:
  - results in better production capabilities and better research,
  - brings TPL developers and APP developers closer together allowing for a better exchange of ideas and concerns,
  - refocuses TPL developers on customer efforts,
  - helps drive continued research-quality TPL development, and
  - reduces barriers for new TPL algorithms to have impact on production applications.
- APP Dev developed only against TPL Dev (with “Almost” Continuous Integration)
  - Regular APP developers work independently using very recent APP-owned VC copy of TPL Dev-
  - Regular TPL developers work independently
  - APP Dev + TPL Dev developers
    - Check-out and modify APP Dev
    - Check-out and modify TPL Dev
    - Run both APP and TPL pre-checkin test suites
    - Check into both APP-owned and main TPL VC repositories
  - Nightly testing of APP Dev + TPL Dev automatically updates APP-owned TPL Dev- VC Repository
  - Releases best handled as combined releases of APP and TPL

Summary #2

- Integration Models:
  - APP Dev only upgraded after each major release of TPL
    - Little to no testing of APP + TPL Dev in between TPL releases
  - APP Dev builds against both TPL Release and TPL Dev
    - Daily Integration testing done for both APP + TPL Release and Dev
    - Staggered releases of TPL and APP
  - APP Dev developed only against TPL Dev (with “Almost” Continuous Integration)
    - APP Dev + TPL Dev developers update both APP-owned and main TPL repositories
    - Nightly testing of APP Dev + TPL Dev automatically updates APP-owned TPL Dev- VC Repository
    - Releases best handled as combined releases of APP and TPL
    - TPL Dev- checkins can be dialed back approaching TPL Release and Dev Integration!
- Final thoughts
  - Each of these different integration models will be appropriate for a particular APP+TPL situation.
  - The particular integration model can be switched during the life-cycles of the APP and TPL depending on several factors:
    - How critical is the TPL functionality currently to the APP?
    - Are there alternatives to a particular TPL that can duplicate functionality?
    - How actively is the TPL being developed?
    - Is it critical for the APP to continue to accept new releases of the TPL?
    - How active is the collaboration between APP and TPL developers?
    - Is the TPL a fundamental part of the infrastructure of the APP?
    - ...