



# Continuous Integration - An Efficient Quality Assurance Tool

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Dr. Wehner, Jungmann & Partner

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## About Myself

- 12+ years IT-experience
- Worked for various IT organizations in positions such as lead architect, technical project and partner manager
- Became an independent software consultant and co-founded WJP in 2007
- Focus on
  - Software Architecture/Architecture Documentation/Architectural Patterns
  - Development Methodologies (Domain-Driven Design, Test-Driven Development)
  - Development Processes (RUP, Scrum)
  - Tool Evaluation/Selection (Modeling, Build Environment)
  - Model-Centric Software Development
- Currently working for a medical technology manufacturer in the area of Build Management/Continuous Integration/Release Process



# Agenda

- Context and Challenges
- Continuous Integration Defined
- The Benefits of Continuous Integration
- Continuous Integration in Practice
- Summary/Outlook
- Q&A



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## The Context



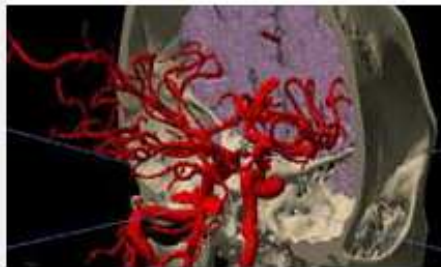
- Software development for medical devices
- Development of a family of surgical navigation software: 'Navigation Applications'
  - Each package provides a solution that allow surgeons to track, analyze, and monitor instrumentation relative to a patient's anatomy during surgical procedures
  - Orthopedics family: Knee, Hip
  - Cranial/Spine/ENT family
  - Trauma family
  - Many core supporting technologies, such as tracking technologies, imaging, licensing, ....
- A number of SW products on the market; several new products per year
- Strong orientation on product line management



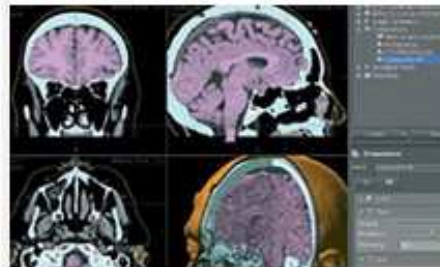
# Surgical Navigation Software



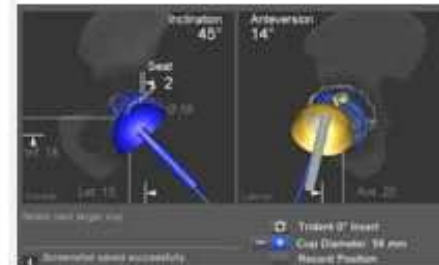
## Cranial Navigation Software



## ENT Navigation Software

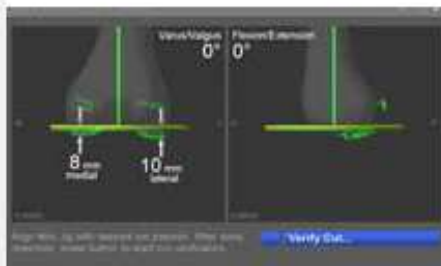


## Hip Navigation Software



[Product List](#)

## Knee Navigation Software



[Product List](#)

## Spine Navigation Software



## Trauma Navigation Software



# The Challenges



- Medical software needs to fulfill exceptionally high quality standards
  - Software faults can trigger fatal consequences
  - Product quality is an important market differentiator
  - Quality management must be very well documented (IEC 62304)
- A predictable and agile product release cycle is required
  - Marketing demands several new product releases per year
  - The development team must be able to react to market developments quickly
  - The development/QA/release cycle must be as efficient as possible
- Other
  - The team is working in a complex, volatile, distributed development environment
  - There is a need to support several platforms simultaneously



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## Continuous Integration Defined

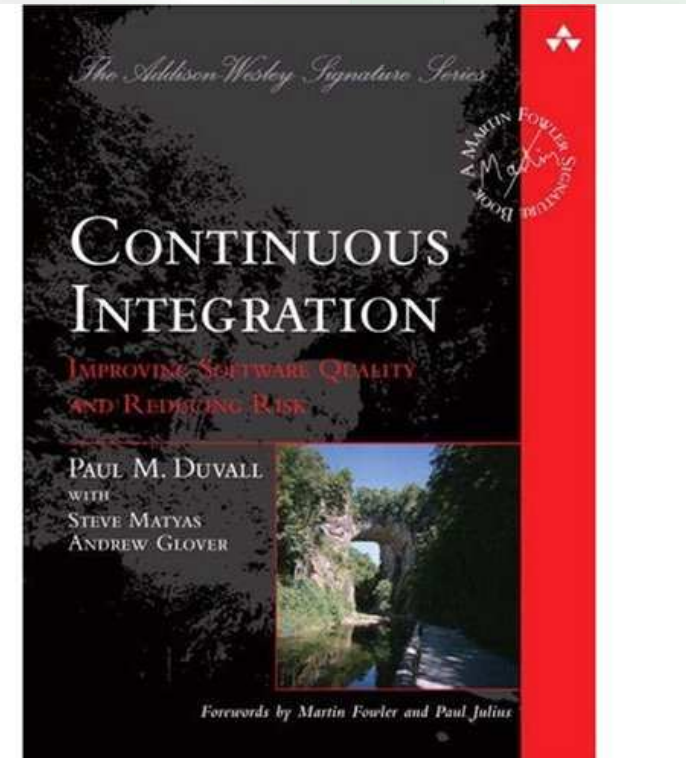
*Continuous Integration is a software development practice where members of a team integrate their work frequently, usually each person integrates at least daily - leading to multiple integrations per day. Each integration is verified by an automated build (including test) to detect integration errors as quickly as possible. Many teams find that this approach leads to significantly reduced integration problems and allows a team to develop cohesive software more rapidly.*

*<http://www.martinfowler.com/articles/continuousIntegration.html>*



## CI as a Centerpiece for Quality

“Some see CI as a process of simply putting software components together. We see CI as the centerpiece of software development, as it ensures the health of software through running a build with every change. Determining the quality of software can be as easy as checking the latest integration build.”



# CI Ingredients



- Continuous build
  - Running automated builds
- Continuous testing
  - Executing unit/component tests
- Continuous inspection
  - Test coverage
  - Static/dynamic code analysis
- Continuous deployment
  - Release builds (including install kit)
  - Automatic installation + tests
- Continuous feedback
  - Sending the right information to the right people at the right time



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## CI Benefits: Risk Reduction



- CI incorporates regular integration, test, and inspection runs
- Defects are detected and fixed sooner
  - Defects are detected when they are introduced
- Health of software is measurable
  - Health attributes can be tracked over time
- Reduce assumptions
  - Status is known at every point of time
- Business values
  - Reduces the amount of rework
  - Leads to immediate savings and decreased time-to-market

**Latest Status:** NATSTP-SFF-1129 failed 



# CI Benefits: Repetitive Process Reduction



- CI relies heavily on automation, executing an ordered process every time a relevant change occurs
- Reduction of labor on repetitive processes
  - People are free to do more thought-provoking, higher-level work
- Overcoming resistance to implement improvements
  - The effectiveness and coverage of quality measures can be increased
- Business values
  - Better employment of scarce human resources
  - Cost savings by automation

```
<target name="buildAndTestAllGenericPackage" description="builds and tests all configurations"
  <antcall target="cleanTestResultsGenericPackage"/>
  <antcall target="buildAllGenericPackage"/>
  <antcall target="testAllGenericPackage"/>
  <antcall target="createGenericPackageMetricsReport"/>
</target>

<target name="buildAllGenericPackage" description="executes release and debug configurations"
  <antcall target="buildGenericPackageDebug"/>
  <antcall target="buildGenericPackageRelease"/>
</target>

<target name="testAllGenericPackage" description="executes release and debug test configurati
  <antcall target="testGenericPackageDebug"/>
  <antcall target="coverGenericPackageTest"/>
  <antcall target="testGenericPackageRelease"/>
</target>
```

## CI Benefits: Deployable Software Generation



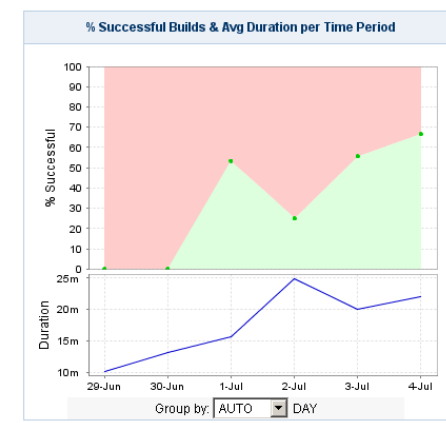
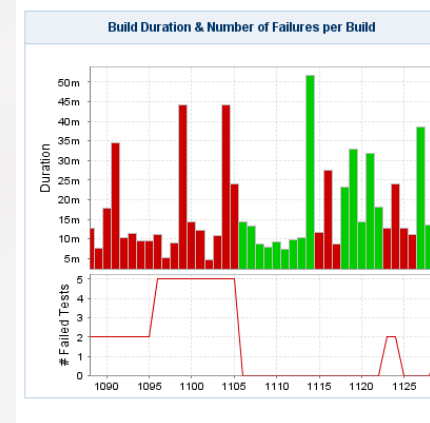
- CI produces a deployable, tested piece of software as tangible asset
- Integration/Portability problems can be detected and fixed immediately
- Improving application quality before reaching the system testing and QA process
  - Testers spend less time with routine technical quality issues
- Business values
  - Leads to higher service-level to the business
  - Better end-customer satisfaction



# CI Benefits: Better Project Visibility



- CI provides a wealth of project-related quality data automatically ('quality management dashboard')
- Effective decisions
  - Provision of just-in-time information on the recent build status and quality metrics
- Noticing trends
  - Project trends in build/test success or failure or overall quality become clearly visible
- Business values
  - Project steering decisions can be based on relevant, timely data
  - Innovations can be introduced with less risk



# CI Benefits: Support for Compliance Rqmnts



- CI can be customized to meet compliance requirements for particular domains (such as CEI 62304 for medical device software)
- Compliance reports
  - Compilation of all compliance-related information (code-freeze documentation)
- Compliance warnings ('quality notices')
  - Timely reminder of compliance-related problems
- Business values
  - Audits can be prepared and executed more efficiently
  - The risk of non-compliances can be reduced significantly

```
~~ Project Quality Profile ~~
```

| Type | Count | Percent | Quality Notice   |
|------|-------|---------|--|
| 3    | 1     | 0.02    | Ellipsis "..." are identified as function parameters   |
| 13   | 30    | 0.58    | "switch" statement does not have a "default"           |
| 15   | 3     | 0.06    | Friend class has been identified                       |
| 27   | 203   | 3.93    | Number of function return points > 1                   |
| 29   | 4     | 0.08    | Number of function parameters > 7                      |
| 30   | 3050  | 59.02   | TAB character has been identified                      |
| 35   | 313   | 6.06    | Class specification contains public data               |
| 37   | 22    | 0.43    | Base Class does not contain a virtual destructor       |
| 38   | 37    | 0.72    | Exception Handling "try"- "catch" has been identified  |
| 42   | 27    | 0.52    | Multiple inheritance has been identified               |
| 51   | 1396  | 27.01   | No comment preceding a function block                  |
| 52   | 63    | 1.22    | No comment preceding a class block                     |
| 53   | 4     | 0.08    | No comment preceding a struct block                    |
| 117  | 3     | 0.06    | C style macro identified                               |
| 201  | 10    | 0.19    | A class identifier does not conform to the naming conv |
| 202  | 2     | 0.04    | An attribute identifier does not conform to the naming |

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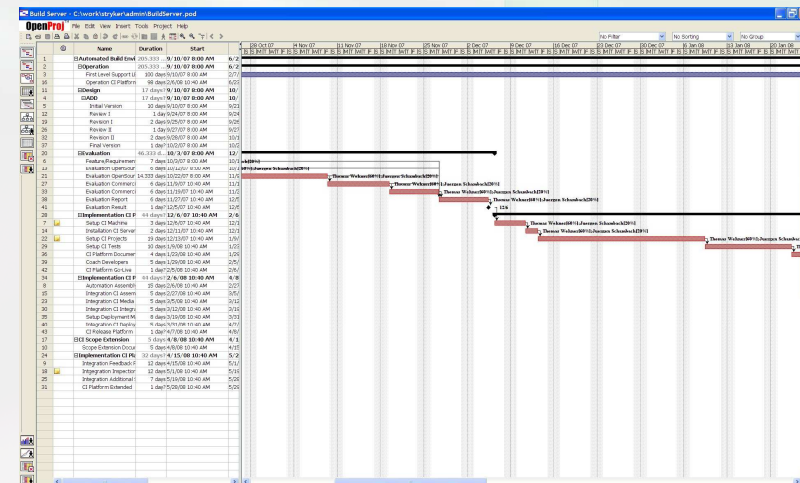
# The 'Build Server' Project



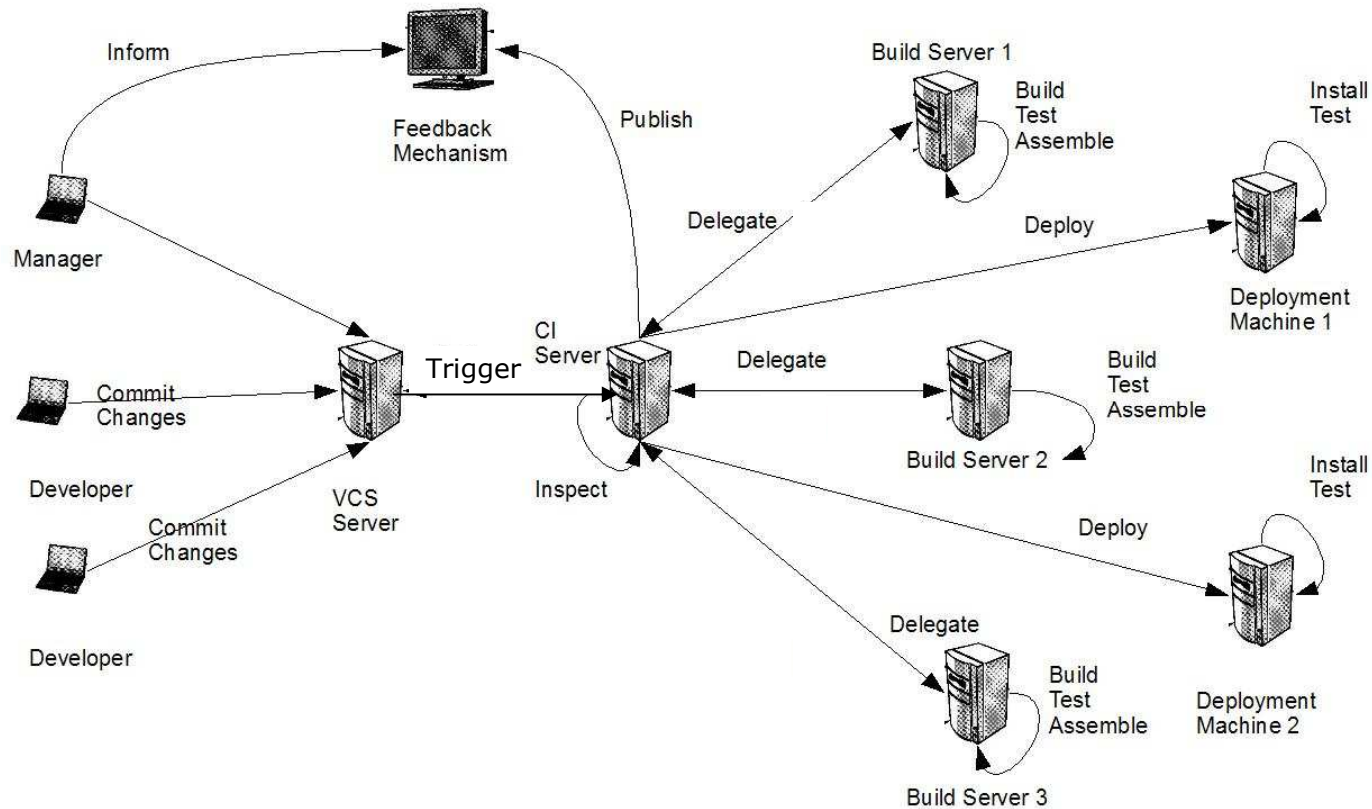
- Goal: Setup a Continuous Integration Environment (CIE) to support quality aspects in software engineering

## Steps:

- Requirements specification
- Architecture description
- CI server evaluation/selection
- CI server setup/project migration
- Go live
- Integration release build with CIE
- Integration test coverage with CIE
- Integration static code analysis with CIE



# CIE: Overview



# Build Server Project: Core Requirements



- Flexible Platform Support (Execution/Project/Target)
- Stability/Robustness
- User Management (Authorization/Authentication)
- Performance (Feedback/Nightly)
- Scalability/Remote Builds
- UI (Observers/Administrators)
- Reporting/Statistics
- Extensibility
- Ease-of-use
- VCS Support
- Scheduling
- Parallel Builds
- Test Result Rendering
- Automated Release Build

SR5\_BuildServer\_1.0\_Rev004.doc - Microsoft Word

| #      | Requirement Definition             | Just. to have | Characteristics & Numerical Specifications (low/high must)   | VERIFICATION & VALIDATION |             |               |            |
|--------|------------------------------------|---------------|--|---------------------------|-------------|---------------|------------|
|        |                                    |               |  | Method                    | Responsible | V&V Reference | Successful |
| 321-1  | Target Platform - Windows          | ✓             | The build process must support building of software for a Windows environment.                                       | Component Test            | R&D         |               | Yes        |
| 321-2  | Target Platform - Linux            | ✓             | The build process must support building of software for a Linux environment.   | Component Test            | R&D         |               | Yes        |
| 321-3  | Target Platform - Embedded Devices | ✓             | The build process must support building of software targeted at embedded devices.                                    | Architecture Review       | R&D         |               | Yes        |
| 321-4  | Project Platform - C++             | ✓             | The build process must be capable of building C++ based projects.  | Component Test            | R&D         |               | Yes        |
| 321-5  | Project Platform - All             | ✓             | The build process shall be capable of building projects for arbitrary implementation technologies.                   | Architecture Review       | R&D         |               | Yes        |
| 321-6  | Multiple Project Support           | ✓             | The CI server must support the configuration of multiple projects.   | Component Test            | R&D         |               | Yes        |
| 321-7  | Stability                          | ✓             | CI server shall be available continuously.   | Integration Test          | R&D         |               | Yes        |
| 321-8  | Data Security                      | ✓             | There must be a mechanism which allows for the backup of build project data on a regular basis.                      | Component Test            | R&D         |               | Yes        |
| 321-9  | Notification                       | ✓             | The CI server must support a notification mechanism configurable.  | Component Test            | R&D         |               | Yes        |
| 321-10 | User Management - Authentication   | ✓             | The CI server must include a user authentication facility.   | Component Test            | R&D         |               | Yes        |
| 321-11 | User Management - Authorization    | ✓             | The CI server must support user-based access controls.   | Component Test            | R&D         |               | Yes        |
| 321-12 | User Management - LDAP             | Yes           | It should be possible to hook up the CI user management facility to a corporate LDAP facility.                       | Component Test            | R&D         |               | Yes        |
| 321-13 | Performance - Feedback Build       | ✓             | The build server shall not unduly delay regular development activities.  | Integration Test          | R&D         |               | Yes        |
| 321-14 | Performance - Integration Build    | ✓             | The build server must be capable of building the clean build for all CI projects shall not take longer than 6 hours. | Integration Test          | R&D         |               | Yes        |
| 321-15 | Scalability                        | ✓             | The CI environment must be capable of dealing  | Architecture Review       | R&D         |               | Yes        |

Seite 10 Ab 8 10/17 Bei 14:8cm Ze 30 Sp 12 MAX AND ERW UB Englisch (US)

# CI Server Feature Matrix



| Microsoft Excel - CIserverFeatureMatrix.xls                     |   |                   |                                 |  |   |   |                                     |
|---|---|-------------------|---------------------------------|--|---|---|-------------------------------------|
| Datei Bearbeiten Ansicht Einfügen Format Extras Daten Fenster ? |   |                   |                                 |  |   |   |                                     |
| Frage hier eingeben   |   |                   |                                 |  |   |   |                                     |
| C7  |   |                   |                                 |  |   |   |                                     |
| A   | B   | C                 | D                               | E  | F   | G                                       | H                                   |
| 1   | Tool/Product                              |                   | LuntBuild                       | TeamCity   | Bamboo                                    | QuickBuild                              | Parabuild Se                        |
| 2   | Origin/Vendor                             |                   | PMEase                          | JetBrains  | Atlassian                                 | PMEase                                  | Viewtier System                     |
| 3   | URL                                       |                   | http://luntbuild.javaforge.com/ | http://www.jetbrains.com/teamcity                            | www.atlassian.com/software/bamboo/        | http://www.pmease.com/                  | http://www.viewt                    |
| 4   | Implementation Language                   |                   | Java                            | Java   | Java                                      | Java                                    | Java                                |
| 5   | Current Release/1.0 Release Date          |                   | 15.2/09.04                      | 2.1.1/10.06  | 1.2.3/02.07                               | 1.2.1/01.06                             | 3.1/?(2004-5)                       |
| 6   | OpenSource/Source Available               |                   | ?                               | -  | X   | X                                       |                                     |
| 7   | License Cost                              |                   | Free                            | \$200 (per user account(!) includes support and maintenance) | \$1,200 (per server + 1 year maintenance) | \$2,200 (site license + 1 year support) | \$950-\$4000 (pe likely cost \$2-4k |
| 8   | Reference Customers/Customers Total       |                   | ?                               | ~200 (company overall)?                                      | 65/300+                                   | 65/?                                    | ~50/?                               |
| 9   | Eval License                              |                   | n/a                             | 60 day trial   | Available                                 | 30 days                                 | 'Limited-term'                      |
| 10  |   |                   |                                 |  |   |   |                                     |
| 11  | <b>Mandatory Features</b>                 | <b>SRS Rqmnt#</b> | <b>Weight</b>                   |  |   |   |                                     |
| 12  | <b>General</b>                            |                   |                                 |  |   |   |                                     |
| 13  | Runs on Windows                           |                   | 3                               | X  | X   | X                                       | X                                   |
| 14  | Supports multiple CI projects             | 321-6             | 3                               | X  | X   | X                                       | X                                   |
| 15  | User Management/Authentication            | 321-10            | 2                               | X  | X   | X                                       | X                                   |
| 16  | Configuration Data Authorization          | 321-11            | 2                               | X  | ?   | X                                       | X                                   |
| 17  | Project/User-based Notification Policy    | 321-9             | 3                               | X/-  | X   | X                                       | X/-                                 |
| 18  | 'Web-based' 'dashboard'                   | 321-16            | 3                               | X  | X   | X                                       | X                                   |
| 19  | Configuration GUI                         | 321-17            | 2                               | X  | X   | X                                       | X                                   |
| 20  | Text File-Based Configuration             | 321-18            | 2                               | -  | X   | X                                       | -                                   |
| 21  | Support for command line-based tasks      | 321-19            | 3                               | X  | X   | X                                       | X                                   |
| 22  | Fine-grained logging configuration        | 321-24            | 1                               | X  | X   | X                                       | X                                   |
| 23  | Support Contract/Active Forum             | 321-25            | 2                               | X  | X   | X                                       | X                                   |
| 24  | Usable Documentation                      |                   | 2                               | X  | X   | X                                       | X                                   |
| 25  | <b>Build</b>                              |                   |                                 |  |   |   |                                     |
| 26  | Support for Perforce                      | 322-1             | 3                               | X  | X   | X                                       | X                                   |
| 27  | VCS/CI User Mapping                       | 322-2             | 3                               | X  | X   | X                                       | X                                   |
| 28  | Configurable Number of Parallel Builds    | 322-5             | 2                               | X  | X   | X                                       | X                                   |
| 29  | Manual Build Start/Stop                   | 322-7             | 2                               | X  | X   | X                                       | X                                   |
| 30  | VCS Poll-Based Builds                     | 322-8             | 3                               | X  | X   | X                                       | X                                   |
| 31  | Scheduled Builds                          | 322-9             | 3                               | X  | X   | X                                       | X                                   |
| 32  | Schedule Dependencies                     | 323-4             | 1                               | X  | X   | X                                       | X                                   |
| 33  | Configurable Number of History Builds     |                   | 1                               | X  | X   | X                                       | X                                   |
| 34  | Clean/Incremental Builds                  | 322-15            | 2                               | X  | X   | ?                                       | X                                   |
| 35  | <b>Testing/Inspection</b>                 |                   |                                 |  |   |   |                                     |
| 36  | <b>Assembly/Media Creation/Deployment</b> |                   |                                 |  |   |   |                                     |
| 37  | <b>Feedback</b>                           |                   |                                 |  |   |   |                                     |
| 38  | Support for Email Notifications           | 328-1             | 3                               | X  | X   | X                                       | X                                   |
| 39  | Report Generation Facility                | 328-4             | 2                               | -  | X   | X                                       | -                                   |
| 40  |   |                   |                                 |  |   |   |                                     |
| 41  | <b>Optional Features</b>                  |                   |                                 |  |   |   |                                     |
| 42  | <b>General</b>                            |                   |                                 |  |   |   |                                     |
| 43  | Runs on Linux                             |                   | 2                               | X  | X   | X                                       | X                                   |
| 44  | Support for MySQL                         |                   | 1                               | X  | X   | X                                       | X                                   |

# CI Server Setup




- Install server software
  - Server/Agents
- Setup build plans (configurations)
  - Automated build procedure (command line tools, batch scripts, ANT, Maven, ...)
  - Integrate with VCS (poll vs. trigger)
  - Distribute builds on agents
- Setup users/permissions/notifications
  - Local users vs. LDAP/AD
  - Define access policy (check status, trigger/kill builds, setup new plans, administrate server)
  - Define notification policy (every build, failures/fixes only, committer, watcher)
- Integrate additional tools
  - Code coverage, static code analysis (loose vs. tight integration)
  - Custom server extensions (API, Plugins)



# CI Server - Go Live



 **BAMBOO**

[Home](#)

### Login to Bamboo

Username: \*

The name to use to login to Bamboo.

Password: \*



Remember my login on this computer

# CIE – Continuous Activity



## Build Queues

Enable all | Disable all

| NavAppsTrunk_Ortho   |  | Disable  |
|--|--|--|
| 1. <a href="#">NavAppsTrunk Ortho - Hip Resurfacing Feedback</a>   | <b>Building for 2 minutes.</b><br>Approximately 14 minutes remaining |    |
| 2. <a href="#">NavAppsTrunk Ortho - Pinless Knee Feedback</a>      | Waiting ...  |  |
| 3. <a href="#">NavAppsTrunk Ortho - Total Hip Feedback</a>         | Waiting ...  |  |
| 4. <a href="#">NavAppsTrunk Ortho - Total Knee Feedback</a>        | Waiting ...  |  |
| 5. <a href="#">NavAppsTrunk Ortho - Domain Testframes Feedback</a> | Waiting ...  |  |
| NavAppsTrunk_STP   |  | Disable  |
| 1. <a href="#">NavAppsTrunk STP - Cranial Feedback</a>             | <b>Building for 2 minutes.</b><br>Approximately 39 minutes remaining |  |
| 2. <a href="#">NavAppsTrunk STP - Femoral Nailing Feedback</a>     | Waiting ...  |  |
| 3. <a href="#">NavAppsTrunk STP -</a>                              | Waiting ...  |  |

## Recently Completed Builds

| Build Number                    | Reason                        | Completed      | Duration    | Test         |
|---------------------------------|-------------------------------|----------------|-------------|--------------|
| <a href="#">NATSTP-SFF-1137</a> | Updated by Peter Zimmermann   | 18 minutes ago | 12 minutes  | 60 pa        |
| <a href="#">NATSTP-SFF-1136</a> | Updated by Manpreet Singh     | 35 minutes ago | 15 minutes  | 62 pa        |
| <a href="#">NATSTP-SFF-1135</a> | Updated by Udo Pfrengle       | 50 minutes ago | 10 minutes  | 62 pa        |
| <a href="#">NATSTP-SFF-1134</a> | Updated by Annette Schneider  | 1 hour ago     | 61 minutes  | 62 pa        |
| <a href="#">NATG-GLB-19</a>     | Manual build                  | 1 hour ago     | 112 minutes | No te found  |
| <a href="#">NATSTP-SFF-1133</a> | Updated by Annette Schneider  | 2 hours ago    | 67 minutes  | 62 pa        |
| <a href="#">NATSTP-SFF-1132</a> | Updated by Peter Zimmermann   | 3 hours ago    | 15 minutes  | 62 pa        |
| <a href="#">NATSTP-SFF-1131</a> | Updated by Trudbert Schwoerer | 3 hours ago    | 4 minutes   | 1 out failed |
| <a href="#">NATSTP-GPF-760</a>  | Updated by Trudbert Schwoerer | 3 hours ago    | 6 minutes   | 6 pas        |
| <a href="#">NATSTP-FTF-626</a>  | Updated by Trudbert Schwoerer | 3 hours ago    | 18 minutes  | 300 p        |
| <a href="#">NATSTP-FNF-790</a>  | Updated by Trudbert Schwoerer | 4 hours ago    | 4 minutes   | 28 pa        |
| <a href="#">NATSTP-CF-797</a>   | Updated by Trudbert Schwoerer | 4 hours ago    | 23 minutes  | 18 pa        |
| <a href="#">NATO-DTF-515</a>    | Updated by Trudbert Schwoerer | 4 hours ago    | 1 minute    | No te found  |

# CIE – Failure Detection



Project: [NavAppsTrunk\\_STP](#) Plan: [Shape Fitting Feedback](#) Build: [1129](#)

Latest Status:

## Build Result NATSTP-SFF-1129

Labels: NONE [Add](#)

- Summary
- Tests
- Changes
- Artifacts
- Logs
- Comments
- Metadata

**❗ Build NATSTP-SFF-1129 failed with 1 failing tests.**

There were **1** new failing tests.

Build completed on **Jul 4, 2008 5:13:43 PM** - 1 day ago

Build took **14 minutes**

### Code Changes

This build was the

Compartment segmentation improved and curves o

### Tests

**31** tests in total    **1** tests failed    **1** are new failure(s)

**New Test Failures (1)**

[shape\\_fitting\\_test\\_debug\\_TestSegmentation\\_C : Tibplateau segmentation](#) (TestTibplateauSegmentation) History

# CIE – Failure Notification



**[Bamboo] NavAppsTrunk\_STP - Shape Fitting Feedback build 1129 has FAILED (1 tests failed). Change made by [REDACTED]**

Bamboo [bamboo@stryker.com]

Die unnötigen Zeilenumbrüche des Nachrichtentextes wurden automatisch entfernt.

**An:** Wehner, Thomas

The project NavAppsTrunk\_STP - Shape Fitting Feedback has the following 1 change by 1 author:

[REDACTED] made the following changes at

Comment:

Compartment segmentation improved and curves order of tibial anterior cortex fixed

```
> ...
> //depot/nav_apps/trunk/src/apps/shape_fitting/settingfiles/shape_fitti
> ng_factory.def (91212) ...
> //depot/nav_apps/trunk/src/apps/shape_fitting/shape_fitting_core/sfit_
> factory_file_reader.cpp (91212) ...
```



# CIE – Failure Cause



Project: [NavAppsTrunk\\_STP](#) Plan: [Shape Fitting Feedback](#) Build: [1129](#)

## Build Result NATSTP-SFF-1129

Labels: NONE [Add](#)

Summary

Tests

Changes

Artifacts

Logs

Comments

Metadata

### Code Changes

This build was the result of the following change:



Compartment segmentation improved and curves order of tibial anterior cortex fixed

- [...//depot/nav\\_apps/trunk/src/apps/shape\\_fitting/settingfiles/shape\\_fitting\\_factory.def \(version 91212\) \(diffs\)](#)
- [...//depot/nav\\_apps/trunk/src/apps/shape\\_fitting/shape\\_fitting\\_core/sfit\\_factory\\_file\\_reader.cpp \(version 91212\) \(diffs\)](#)
- [...//depot/nav\\_apps/trunk/src/apps/shape\\_fitting/shape\\_fitting\\_core/sfit\\_factory\\_file\\_reader.h \(version 91212\) \(diffs\)](#)
- [...//depot/nav\\_apps/trunk/src/apps/shape\\_fitting/shape\\_fitting\\_jig/sfit\\_segmentation.cpp \(version 91212\) \(diffs\)](#)

```
Test name: TestSegmentation_C::TestTibplateauSegmentation
double equality assertion failed
- Expected: 46.5
- Actual   : 49.1629942131274
- Delta    : 1.4142
Failures !!!
Run: 31   Failure total: 1   Failures: 1   Errors: 0
```



# CIE – Failure Removal



Project: [NavAppsTrunk\\_STP](#) Plan: [Shape Fitting Feedback](#) Build: [1132](#)

Latest Status: [Currently in](#)

## Build Result NATSTP-SFF-1132

Labels: NONE [Add](#)

- Summary
- Tests
- Changes
- Artifacts
- Logs
- Comments
- Metadata



**✓ Build NATSTP-SFF-1132 fixed 1 tests.**

It is the first to pass since [NATSTP-SFF-1129](#) failed (Updated by [\[Avatar\]](#) 2 days before).

Build completed on **Jul 7, 2008 10:57:04 AM** - 3 hours ago

Build took **15 minutes**

### Code Changes

This build was the result of the following

- [\[Avatar\]](#)  
Test frame failure fixed

[See full changes](#)

## Tests

62 tests in total 1 tests were fixed

### Fixed Tests (1)

| Test Suite  | Test Case  | Failing Since Build   |
|---|--|---|
| <a href="#">shape_fitting_test_debug_TestSegmentation_C</a> | <a href="#">Tibplateau segmentation</a> (Show History) | <a href="#">NATSTP-SFF-1129</a> (Updated by <a href="#">[Avatar]</a> 2 days before) |

# CIE – Quality Attributes Summary



Project: [NavAppsTrunk\\_STP](#) Plan: [Generic Package Feedback](#) Build: [759](#)

Latest Status: [NATSTP-GPF-759](#) was successful

## Build Result NATSTP-GPF-759

[\\_labels: NONE](#) [Add](#)

Summary

Tests

Changes

Artifacts

Logs

Comments

Metadata

Clover



### Code Coverage

#### Test Coverage

**Build Coverage:**

66.0% (0.1%)

The overall percentage of code base in this plan that is covered by tests. The second value in brackets is the change in coverage percentage since the previous successful build.

**Statement Coverage:**

63.1%

The percentage of statements covered by tests

**Methods Coverage:**

88.0%

The percentage of methods covered by tests.

**Conditionals Coverage:**

-

The percentage of conditional branches covered by tests.

#### Build Statistics

**LOC:**

4709

The lines of code in the build.

**NCLOC:**

2489

The non-comment lines of code in the build.

**Files:**

6

**Methods:**

125

**Classes:**

6

**Packages:**

0



# CIE – Quality Attributes Details



```
static bool IsEqual(const QString& s1, const QString& s2)
10 {
10     if ( s1 != s2 ) {
0         return s1.isEmpty() && s2.isEmpty();
    }
    return true;
10 }
```

## ~~ Project Quality Profile ~~

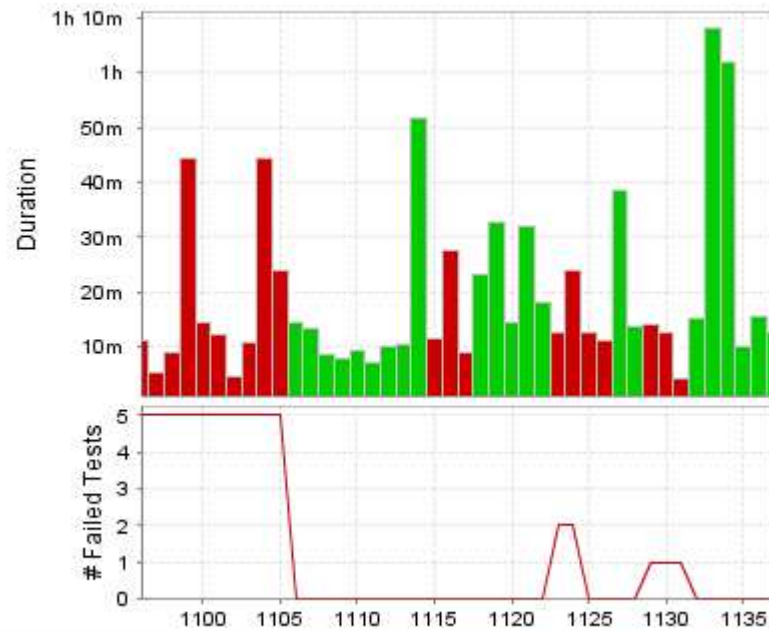
| Type | Count | Percent | Quality Notice   |
|------|-------|---------|--|
| 3    | 1     | 0.02    | Ellipsis "..." are identified as function parameters                     |
| 13   | 30    | 0.58    | "switch" statement does not have a "default"                             |
| 15   | 3     | 0.06    | Friend class has been identified   |
| 27   | 203   | 3.93    | Number of function return points > 1                                     |
| 29   | 4     | 0.08    | Number of function parameters > 7  |
| 30   | 3050  | 59.02   | TAB character has been identified  |
| 35   | 313   | 6.06    | Class specification contains public data                                 |
| 37   | 22    | 0.43    | Base Class does not contain a virtual destructor                         |
| 38   | 37    | 0.72    | Exception Handling "try"- "catch" has been identified                    |
| 42   | 27    | 0.52    | Multiple inheritance has been identified                                 |
| 51   | 1396  | 27.01   | No comment preceding a function block                                    |
| 52   | 63    | 1.22    | No comment preceding a class block                                       |
| 53   | 4     | 0.08    | No comment preceding a struct block                                      |
| 117  | 3     | 0.06    | C style macro identified   |
| 201  | 10    | 0.19    | A class identifier does not conform to the naming conventions (NC1)      |
| 202  | 2     | 0.04    | An attribute identifier does not conform to the naming conventions (NC1) |



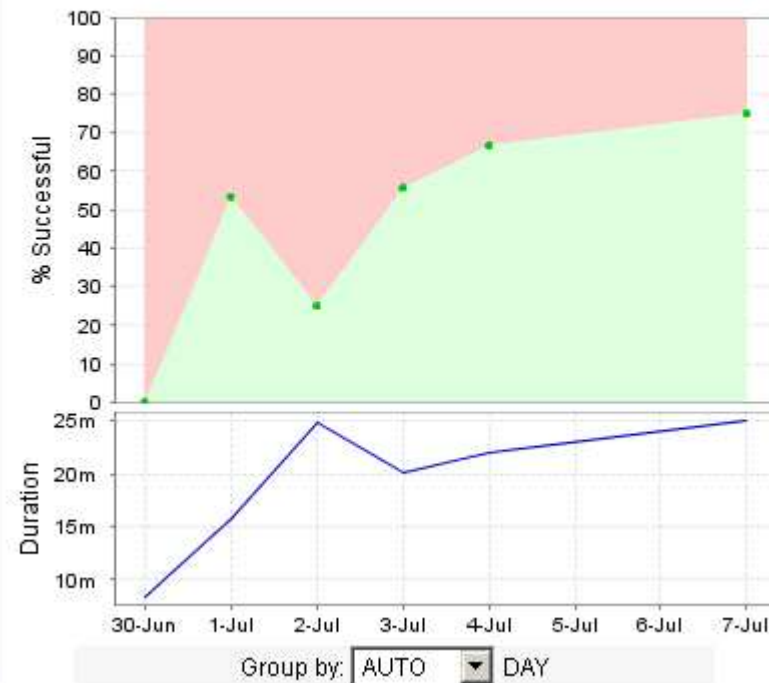
# CIE – Project Trends I



Build Duration & Number of Failures per Build



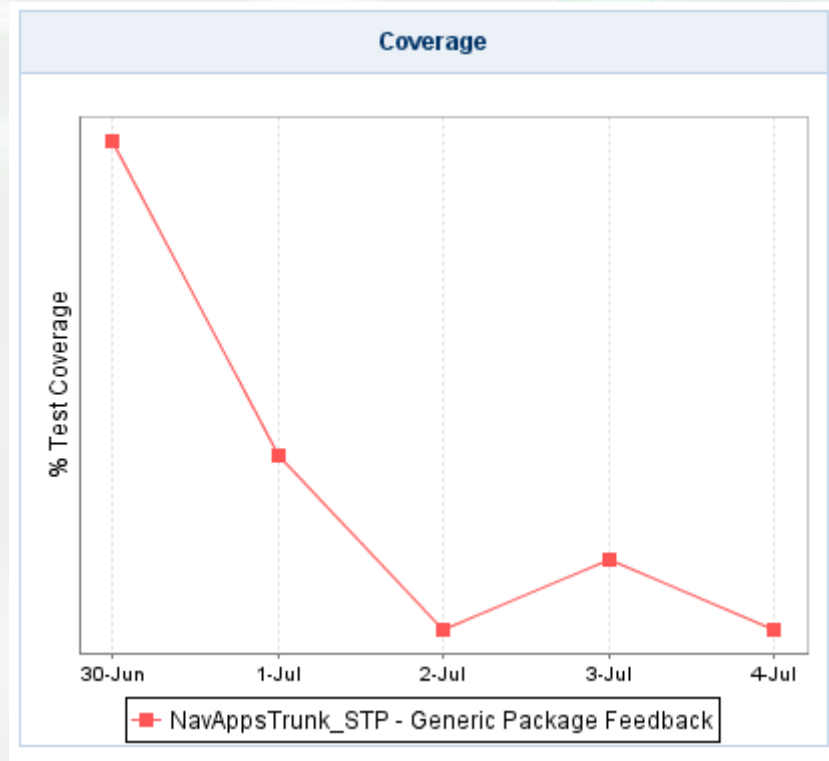
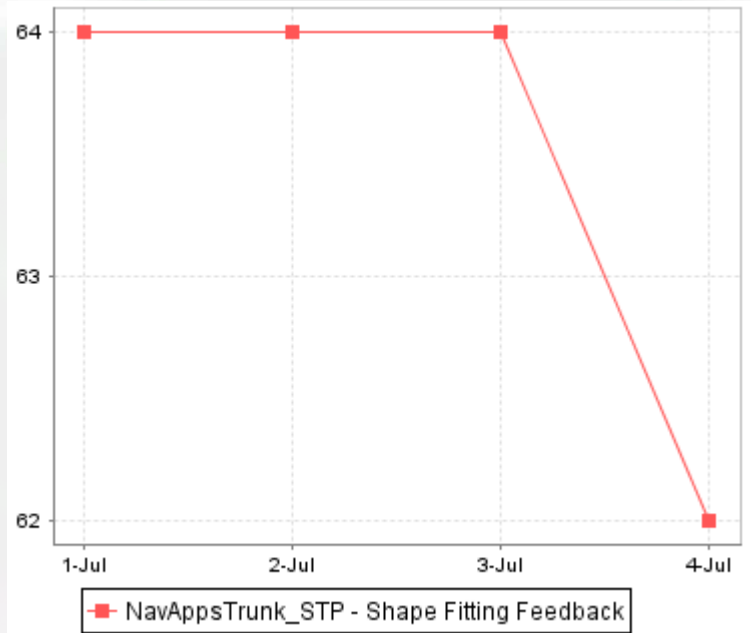
% Successful Builds & Avg Duration per Time Period



# CIE – Project Trends II



# Tests



# CIE – Project Statistics



[Top 10 Most Failing Tests](#)

[Top 10 Longest to Fix Tests](#)

[Top 10 Longest Running Tests](#)

[Number of Tests](#)

| Test   | Times Failed | Most Recent                               |
|--|--------------|---|
| <b>Femoral shaft segmentation</b><br>shape_fitting_test_debug_TestSegmentation_C   | 16           | 1105, 1104, 1103, 1102, 1101 (11 more...) |
| <b>Tibia reference system</b><br>shape_fitting_test_debug_TestTibiaReference_C     | 16           | 1105, 1104, 1103, 1102, 1101 (11 more...) |
| <b>Tibplateau segmentation</b><br>shape_fitting_test_debug_TestSegmentation_C      | 15           | 1131, 1130, 1129, 1124, 1123 (10 more...) |
| <b>Tib cortex segmentation</b><br>shape_fitting_test_debug_TestSegmentation_C      | 10           | 1105, 1104, 1103, 1102, 1101 (5 more...)  |
| <b>Condyle segmentation</b><br>shape_fitting_test_debug_TestSegmentation_C         | 10           | 1105, 1104, 1103, 1102, 1101 (5 more...)  |
| <b>Anterior cortex segmentation</b><br>shape_fitting_test_debug_TestSegmentation_C | 2            | 1124, 1123                                |



# CIE – Custom Reports



Compare trends between different plans. You can choose the different reports and the plans you wish to compare in the form below.

### Report Parameters

Report:

How many builds are triggered in a given time period? This indicates the level of activity for the plan.

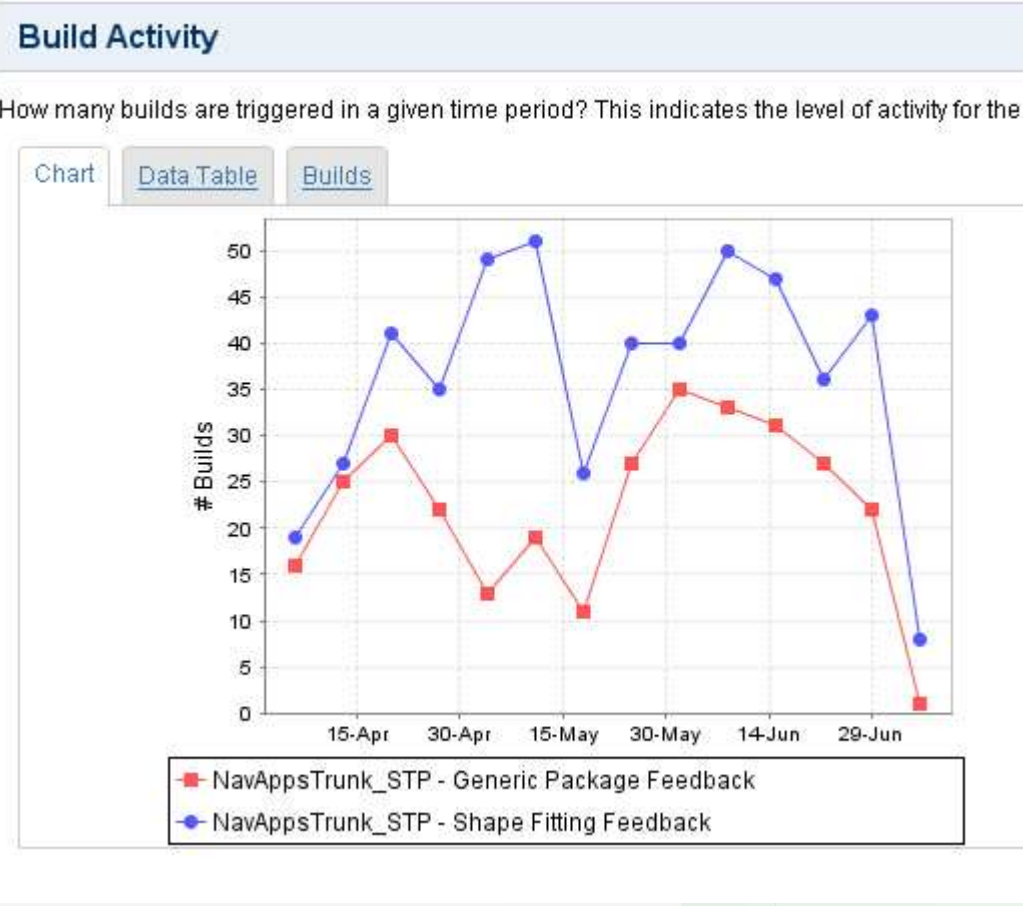
Build Plans:

- Total Knee Nightly
- NavAppsTrunk\_STP
- Cranial Feedback
- Cranial Nightly
- Documentation
- Femoral Nailing Feedback
- Femoral Nailing Nightly
- Framework Tests Coverage
- Framework Tests Feedback
- Framework Tests Nightly
- Generic Package Feedback**
- Generic Package Nightly
- Shape Fitting Feedback**
- Shape Fitting Nightly
- Plugins Trunk
- Nightly
- Patient Backup Feedback
- Patient Backup Nightly
- Videolib Feedback

Group By:

Report is grouped by Week.

Date Filter:



# Agenda

- Context and Challenges
- Continuous Integration Defined
- The Benefits of Continuous Integration
- Continuous Integration in Practice
- ➔ Summary/Outlook
- Q&A



## CIE – Core Competence Areas

- Tools: Market overview, strengths/weaknesses of individual offerings
- Processes: How to set up a CI environment, what to look for, pitfalls to avoid
- Scope: Efforts involved in introducing CI, social aspects
- Technologies: Integration of non-standard languages and tools (C++, VS, CPPUnit, CoverageValidator, ...)
- Compliance: How CI can help you to comply with medical device software standards (such as IEC 62304)



## CIE – Extension Points

- Quality data for the management
  - Single-page summary of relevant data ('Quality Management Dashboard')
  - Role-based dashboards (Developer, Project Manager, CIO, ...)
  - IT governance (compliance financial as well as technical)
- Scope Extension
  - GUI/System Tests
- Compliance requirements
  - Reports of quality management tools can be integrated in the dashboard as artifacts
  - CI server provides an API/plugin mechanism which allows for the extension of the dashboard with custom reports, statistics, and panels



## CIE – Conclusion

- Build server project was a major step forward in terms of software quality assurance
- The relevance of its results extends beyond the technical into the business domain
- The quality management framework that has been set up allows for coverage of additional relevant aspects - both technical and non-technical
- CI can help you to raise your software quality level



# Q&A



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