



Maturing agile teams and driving quality through architecture principles

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Imagination at work



Introducing the GE Software Center

Igniting the next industrial revolution by connecting minds & machines

\$1B investment over past 3 years

- Launched in 2011 in Silicon Valley location
- Aggressive strategy for talent acquisition
- Founding member of Industrial Internet Consortium
- Introduce Predix™ platform to the world in 2015

Imagination at work



Many Industries. Many Platforms.



GE
Aviation

Asset
optimization

Operations
optimization



GE Energy
Management

Asset
optimization

Operations
optimization



GE
Healthcare

Asset
optimization

Operations
optimization



GE
Oil & Gas

Asset
optimization

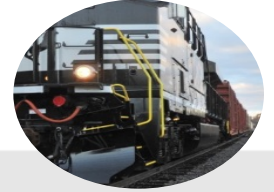
Operations
optimization



GE Power & Water

Asset
optimization

Operations
optimization



GE Transportation

Asset
optimization

Operations
optimization

Platform 1

Platform 2

...

Platform a

Platform b

...

Platform i

Platform ii

...

Platform x

Platform y

...

Platform A

Platform B

...

Platform .

Platform ..

...



State of practice pre 2011...

Many Industries. One Platform.



GE
Aviation



GE Energy
Management



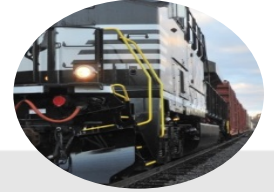
GE
Healthcare



GE
Oil & Gas



GE Power & Water



GE Transportation

Industrial Internet Apps

Solutions for industrial asset and operation optimization

Predix™ Platform

Common scalable cloud architecture for machine, network, server and UX



Today's direction...



Overview

- Context setting
- Architecture pillars for quality & maturity
 - Adopting an architecture-driven agile process
 - Defining with stakeholders key quality attributes
 - Building robust dev-test-deploy infrastructure
 - Aligning architecture with platform technology choices
 - Maintaining consistent code-level standards
 - Introducing new skillset to the teams
- Parting thoughts and conclusions



Context Setting

- Teams
 - Multiple scrum teams working on various projects from data science NTI to legacy integration
- Customer
 - GE Transportation; a 100 year market leader in Class 1 railroads; Several \$B in backlog
- Development methodology
 - Agile; various flavors of scrum; six sigma traces; rigor-less to no architecture

Objective

To standardize quality practices across teams, projects, and product releases to deliver consistent quality within planned time and budget.



Started with basic value proposition of architecture...

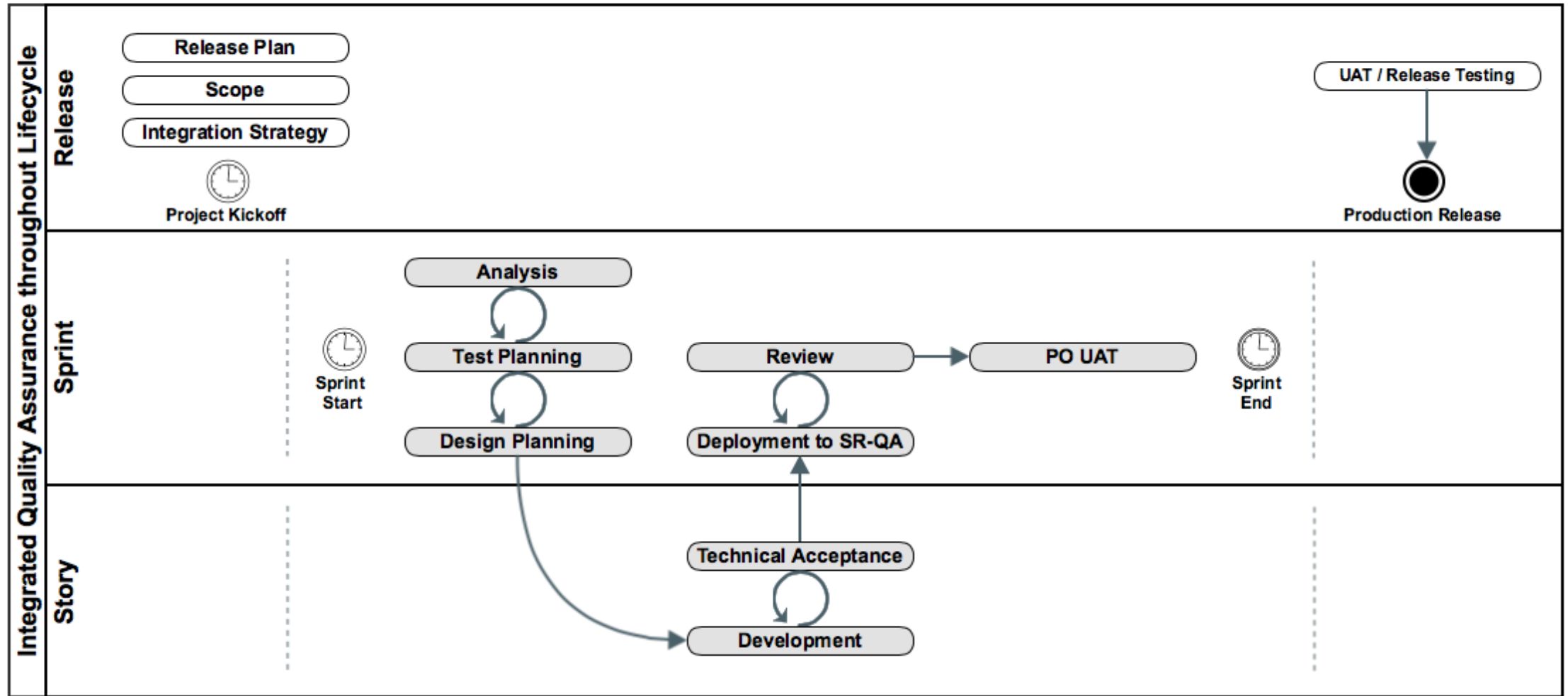
“Quality and architecture are two sides of the same coin.”

Regardless of development methodology (agile or otherwise), software quality is assessed from two complimentary perspectives:

- **Functional:** achieved through unit, functional, and user acceptance tests
- **Structural:** achieved through evaluating key quality attributes such as security, performance, maintainability, and user experience



Adopted an architecture-driven agile process...



Established clear Definition of Ready (DoR) and Definition of Done (DoD) for each phase

Defined with stakeholders key quality attributes...

Structural quality is concerned with cross-cutting concerns represented as key quality attributes:

- **Security:** Static analysis, dynamic analysis, defense-in-depth, and pen-testing
- **Compliance:** Sarbanes-Oxley
- **Performance:** Load testing
- **Functionality:** 100% implementation meeting acceptance & quality criteria
- **Usability:** User-centric design + consistent UI standards
- **Maintainability:** Coding standards + modular architecture + documentation
- **Testability:** Unit & functional testing + Automation
- **Integrate-ability:** 1.0/2.0 Integration + Continuous Integration (CI)
- **Deployability:** Deployment architecture + Continuous Deployment (CD)

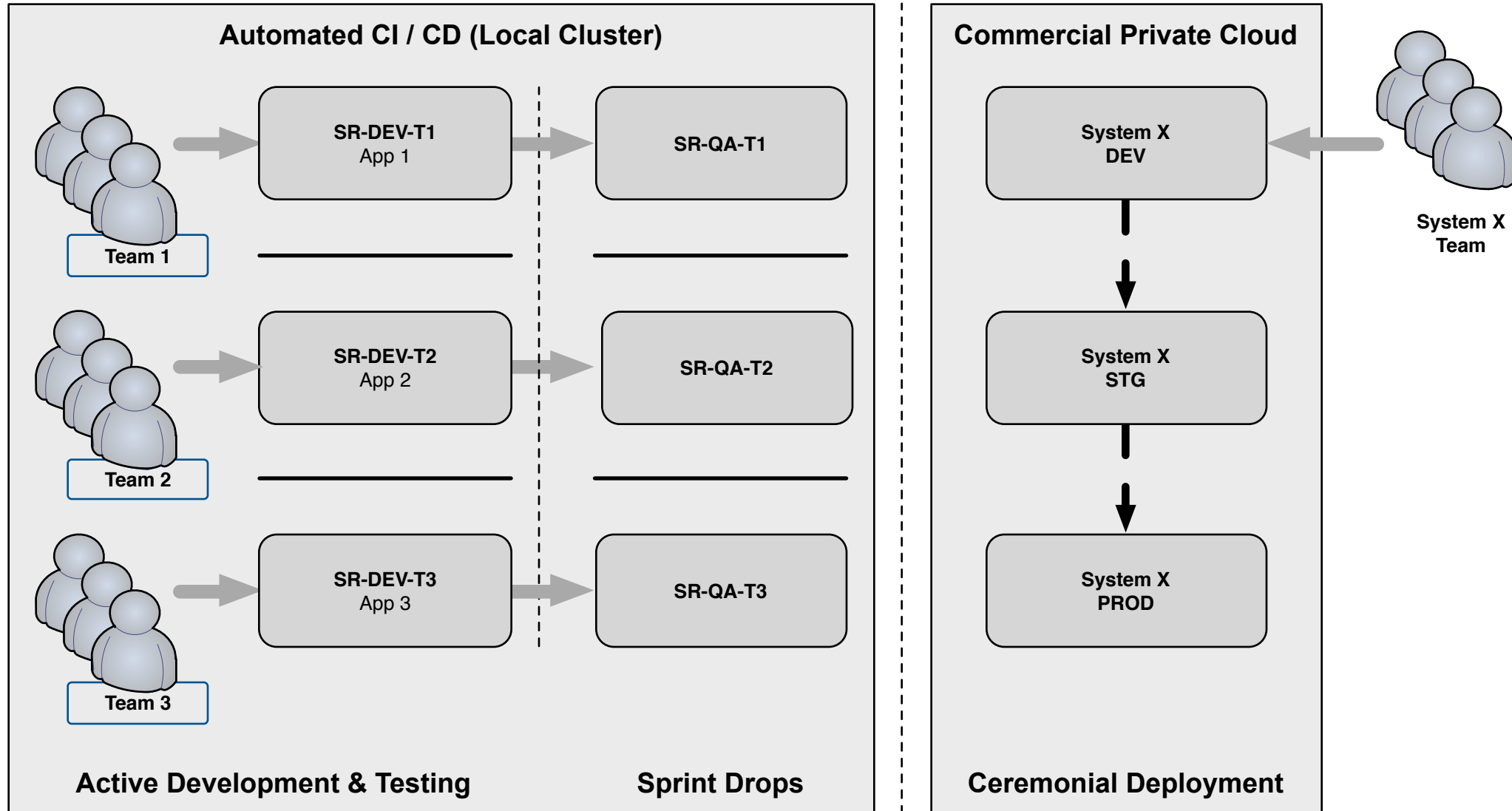


Established quality matrix & test plan templates...

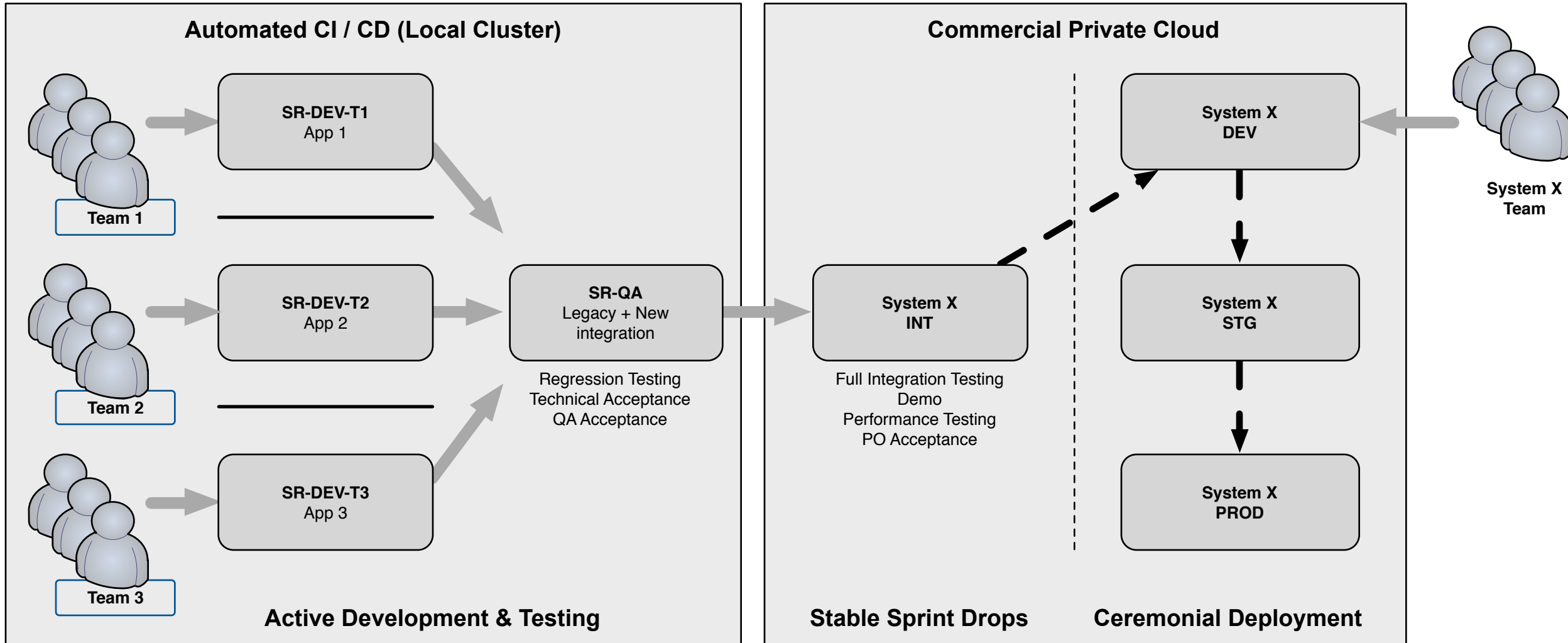
Quality Attribute	Supporting Indicator	Measurement	Target	Status
Security / Compliance	Static analysis using Checkmarx & JSHint	Identified security violations	0 Blocker and 0 Critical violations	
	GrayBox Testing	Identified security violations	Pass Requirements	
	Defense in Depth	Identified security violations	Pass Requirements	
	SOX compliance	Checklist of requirements	Pass Requirements	
Performance	Performance testing - Release	Establish test cases and SLAs	<= ? sec / step	
Functionality	Functional coverage	Are all functionality implemented?	>95%	
	Functionality acceptance	Do all functionality meet acceptance criteria?	>95%	
	Defects	# of open defects associated with functionality	No S1 or S2	
Usability	UX Design standards followed	UX design review	Code to UX Design artifacts	
Maintainability	Tech stack consistency	Architecture review	Code to architecture	
	Code duplication	Sonar	<= 10%	
	Complexity	Sonar	<= 10%	
	Coding style	Coding style document	Code to standards	
	Release documentation	Release document to ship with product	Complete Document	
	Documentation	% in sonar	20%	
Testability	Test coverage	% unit test coverage (back end)	80%	
	Test coverage	% unit test coverage (front end)	80%	
	Test coverage	% functional coverage	95%	
	Automation (Regression)	Whether testing is fully automated	Yes	
Integratability	Integration with legacy application	Ensure data integration is done	Code to architecture	
	Automation (CI)	Whether integration is fully automated	Yes	
Deployability	Continuous Deployment	Deployment architecture followed	Deploy based on architecture	
	Automation (CI)	Whether deployment is fully automated	Yes	



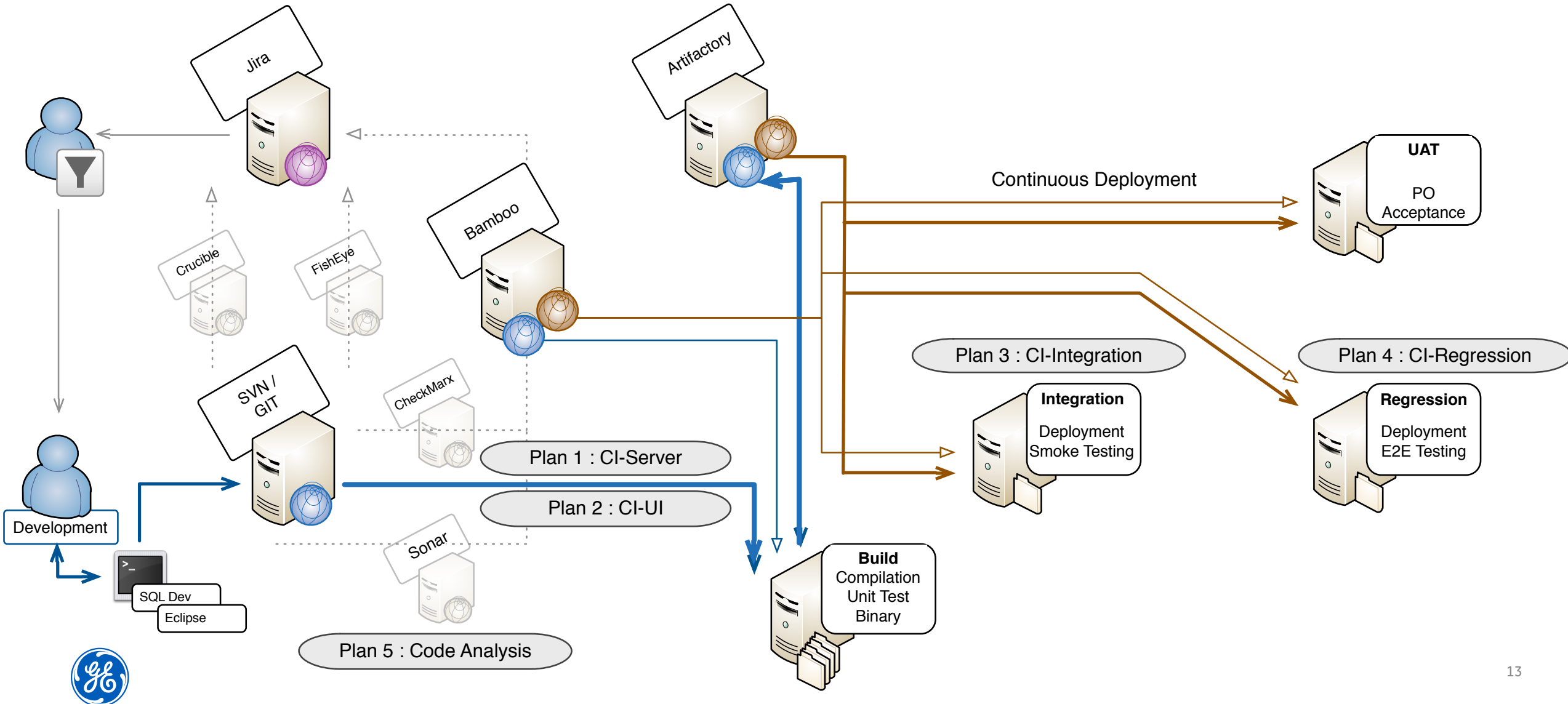
Started from a defragmented infrastructure...



Built robust dev-test-deploy infrastructure...

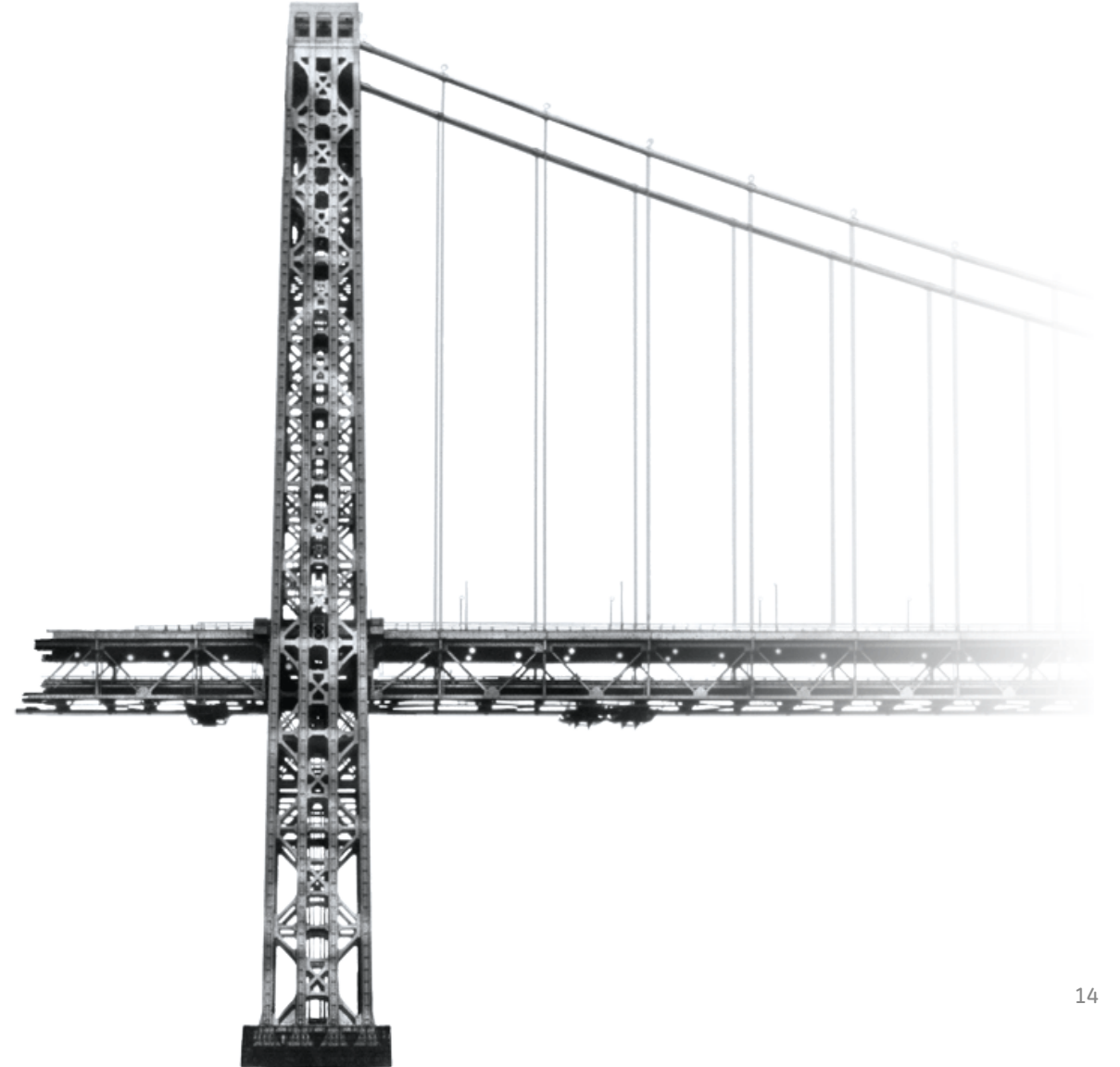


Implemented automated CI/CD process...



Aligned architecture with platform technology choices...

Insert any of your favorite architecture views here...



Maintained consistent code-level standards...

Maintenance metric: Code adherence to style

- Never copy any code from any place outside of company
- Brand your code
- Use descriptive names
- Organize source file consistently
- Enhance code readability
- Explain your code: Consistent JavaDoc
- Get a step ahead of debugging: Logging
- Write code in a consistent way



Introduced new practices and skillset to the teams...

- Code reviews: each story has an owner and reviewer in Jira
 - Encouraged teams to do as-needed pair programming
- A tech lead is designated to lead a team, and an SDM manages 1-3 teams
- Added QA engineers to teams to drive quality implementation
- Customers assigned dedicated Product Owners and IT Subject Matter Expert to each team
- Added Build & Release engineers as shared resources among teams





In summary...

- Adopting an architecture-driven agile process
- Defining with stakeholders key quality attributes
- Building robust dev-test-deploy infrastructure
- Aligning architecture with platform technology choices
- Maintaining consistent code-level standards
- Introducing new skillset to the teams



Parting thoughts...

- Critical role of product owner, and authority to make decisions:
 - Voice of the customer and big influence of architecture tradeoffs
- Architecture successful implementation:
 - Dependence on key skillset within agile teams
- Quality visibility:
 - Dependence on infrastructure for iterative development (CI/CD)
- Testing:
 - Different levels of testing; different stages of development



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