DevSecOps and Cloud Security

"Deliver resilient software capability at the speed of relevance"

Application Security Analyst and DevSecOps expert

- Web and mobile Developer
- +20 Application Security Evaluation
- SANS 540 DevSecOps and Cloud Security automation
- CTF Player/ Organizer
- I love microservices
- Cloud Native Application security advocate

What you will learn

All what you need to secure your CI/CD pipeline !

Agenda

Day 1 :

Attacking and Hardening the DevOps Toolchain

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Attacking and Hardening the DevOps Toolchain

Lab environment overview

Role	Systems(s)
Version Control	GitLab, CodeCommit
CI/CD	Jenkins, CodePipeline
Configuration manager	Ansible, CloudFormation
Container Execution	Docker, K8s
Secret Storage	Vault
Cloud Infrastructure	AWS

Lab setup summary

- Port conflict (GITLAB/JENKINS)
- HTTPS issue in GITLAB/JENKINS integration
- Authorizing local IP addresses in GitLab for WebHooks

Day 1 :Attacking and Hardening the DevOps Toolchain

- DevOps security challenges
- DevOps toolchain

DevOps success factors

CAMS (or CALMS) is a common lens for understanding DevOps and for driving DevOps change. Your organization succeeds when it reaches "CALMS":

- Culture: people come first
- Automation: rely on tools for efficiency and repeatability
- Lean: apply Lean engineering practices to continuously learn and improve
- Measurement: use data to drive decisions and improvements
- Sharing: share ideas, information, and goals across silos

DevOps Unicorns

The DNA of DevOps and DevSecOps comes from a few early leaders or"unicorns":

- Netflix: Undifferentiated heavy lifting in the cloud, Chaos Engineering
- Amazon: You Build It... You Run It, two-pizza teams dogfooding AWS
- Google: Site Reliability Engineering, fearless shared postmortems
- Twitter: Self-service security for developers, immediate feedback
- Etsy: Security in Continuous Deployment, "a Just Culture"

CALMS: Culture

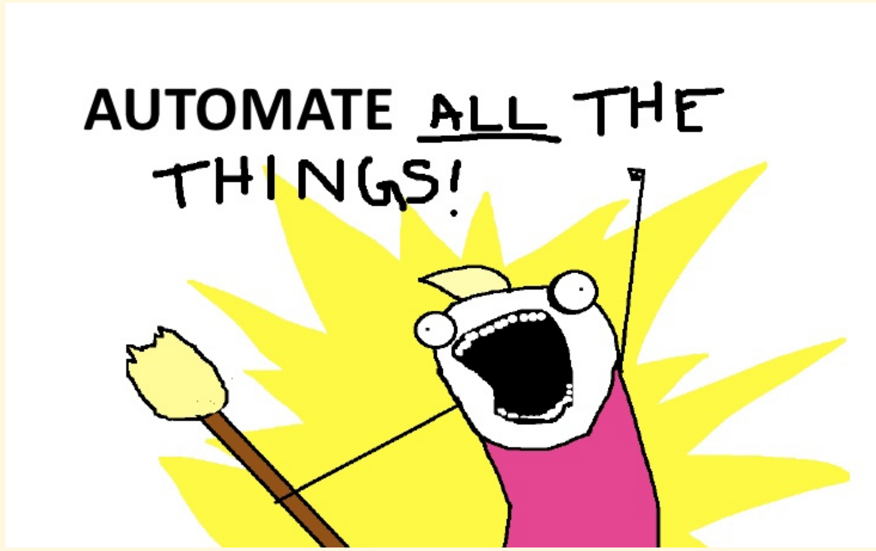
Signs of a culture that supports DevOps:

- Failures are accepted and used as learning opportunities.
  - Accept that failures can and will happen.
  - Utilize blameless postmortems to learn and improve from failures.
- Find ways to minimize impact or "blast radius."
- --Collaboration-- occurs widely across functional lines.
- Problem-solving: the problem is the enemy.
- Empower teams to take action on their own.
- Staff have a shared sense of ownership and accountability.
- --High levels of trust-- allow people to feel safe with each other.

CALMS: Automation

DevOps teams use programmable tools and cloud service APIs to:

- Take care of "undifferentiated heavy lifting" and repetitive work
- Continuously iterate and experiment in production
- Increase transparency
- Ensure consistency
- Prevent common mistakes
- Enable measurement and sharing
- Control operations at scale



CALMS: Automation "Everything as Code"

Get everything into code and check it into version control:

- Application source code/package dependencies
- Operations scripts
- Application configuration
- Tests and test scripts
- Build, deployment scripts, and runbooks
- Infrastructure provisioning and configuration
- Documentation
- Database definitions and change scripts
- Security/compliance policies
- Security tool configuration

CALMS: Lean engineering

Lean engineering improves efficiency, reduces friction, eliminates hand-offs and delays:

- Confront bureaucracy.
- Use Value Stream Mapping to identify waste, bottlenecks, and delays.
- Leverage Automation for routine work.
- Measurement: Use data to drive continuous improvements.
- Prioritize just in time-always work on what's important.

CALMS: Measurements

Measurements can help you to understand-and improve-how your teams work and where to automate:

1. Change frequency
2. Change failure/success rate
3. Correlation between change frequency and failure rate
4. MTTR recovery window instead of MTTF (time to failure)
5. Change lead time to deliver a change or fix, from check-in to deployment

CALMS: Measurements for DevSecOps

Collect security metrics along your delivery pipelines to assess how healthy your code is and how healthy your security program is.

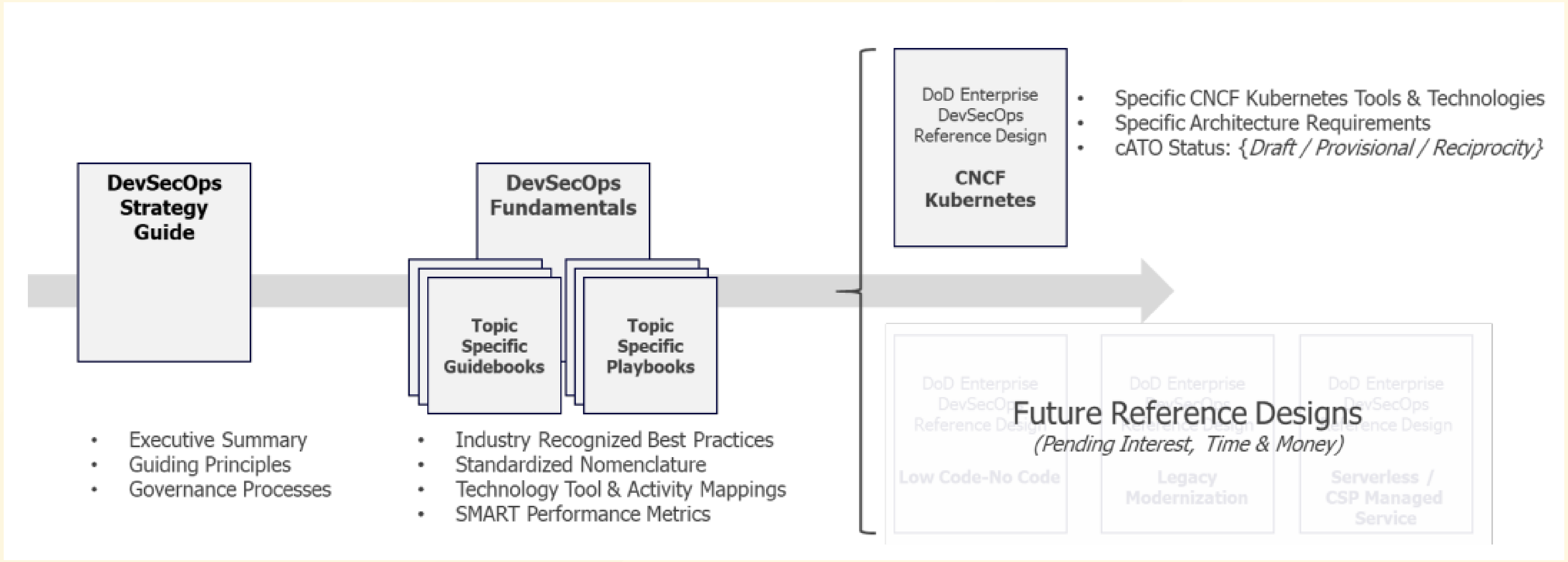
- Measure automated test coverage for high-risk code
- Track # of vulnerabilities found… and where they were found in the pipeline
- Track # of vulnerabilities fixed
- How long vulnerabilities remain open (window of exposure)
- Type of vulnerability (OWASP Top 10) for Root Cause Analysis
- Elapsed time for security testing-make feedback loops as short as possible
- False positives versus true positives-improve quality of feedback
- Vulnerability escape rate to production

CALMS: Sharing

Information should be shared freely across the organization.

- Everyone has access to all information that they need to do their job.
- Eliminate hand-offs where information/knowledge is often lost.
  Open up communications channels across teams/functional lines.
- Chat and ChatOps, shared code repos, backlog tools, dashboards, etc.
  Share goals and accountability across Dev, Ops, and Security.
- Everyone has a stake in success and preventing failures.
  Evangelism through conferences, blogs, articles, podcasts, etc.
- DevOps has an active, open community (DevOpsDays, open-source tools…).
- Vendors have latched on to this hyperactivity.

CALMS: US DOD case study


DevSecOps Strategy Guide
DevSecOps Fundamentals
Topic Specific Guidebooks
Topic Specific Playbooks
DoD Enterprise DevSecOps Reference Design
CNCF Kubernetes
Specific CNCF Kubernetes Tools & Technologies
Specific Architecture Requirements
cATO Status: {Draft / Provisional / Reciprocity}
Executive Summary
Guiding Principles
Governance Processes
Industry Recognized Best Practices
Standardized Nomenclature
Technology Tool & Activity Mappings
SMART Performance Metrics
Future Reference Designs
(Pending Interest, Time & Money)
DoD Enterprise DevSecOps Reference Design
Low Code-No Code
DoD Enterprise DevSecOps Reference Design
Legacy Modernization
DoD Enterprise DevSecOps Reference Design
Serverless / CSP Managed Service

Security culture vs DevOps

DevOps culture conflicts with traditional security culture:

- Top-down risk management instead of team-based decision-making
- Need to know restrictions versus extended information sharing
- Zero failure versus fail fast and fail forward
- Limiting change: Security is always ready to say "No!"

Security Challenges in DevOps

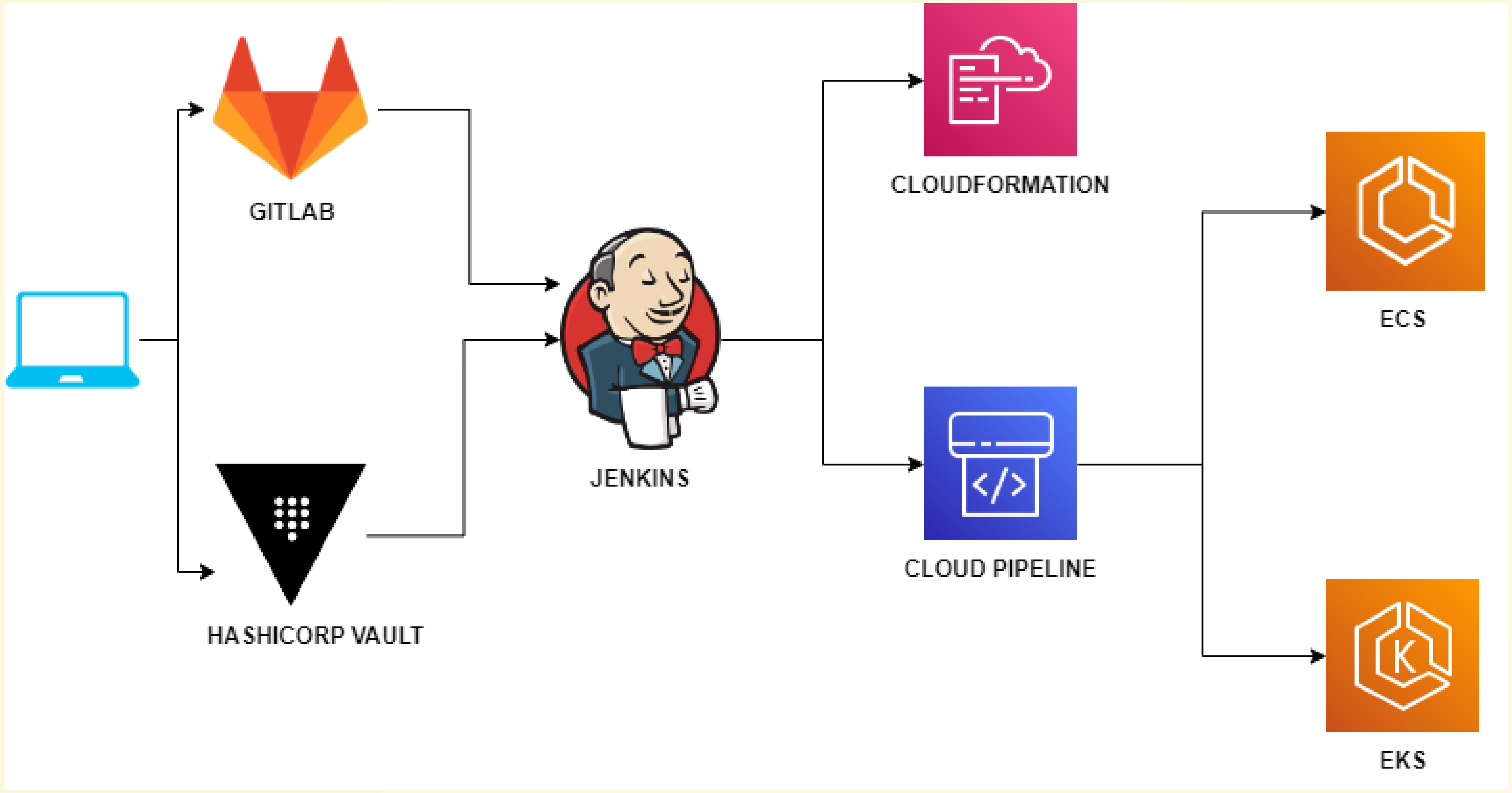
Powerful new technologies create opportunities for attackers-and new risks for organizations:

- Weaknesses in the DevOps toolchain can compromise the entire stack.
- Cloud platform misconfigurations can easily allow unauthorized access to data.
- Containers and orchestrators introduce a new attack surface, often not supported by traditional security scanners.
- Microservice-based architectures, new languages, and frameworks compound security guidelines.
- Delivery at the speed of DevOps requires enhanced detection and automated remediation.

Day 1 :Attacking and Hardening the DevOps Toolchain

DevOps toolchain

DevOps toolchain



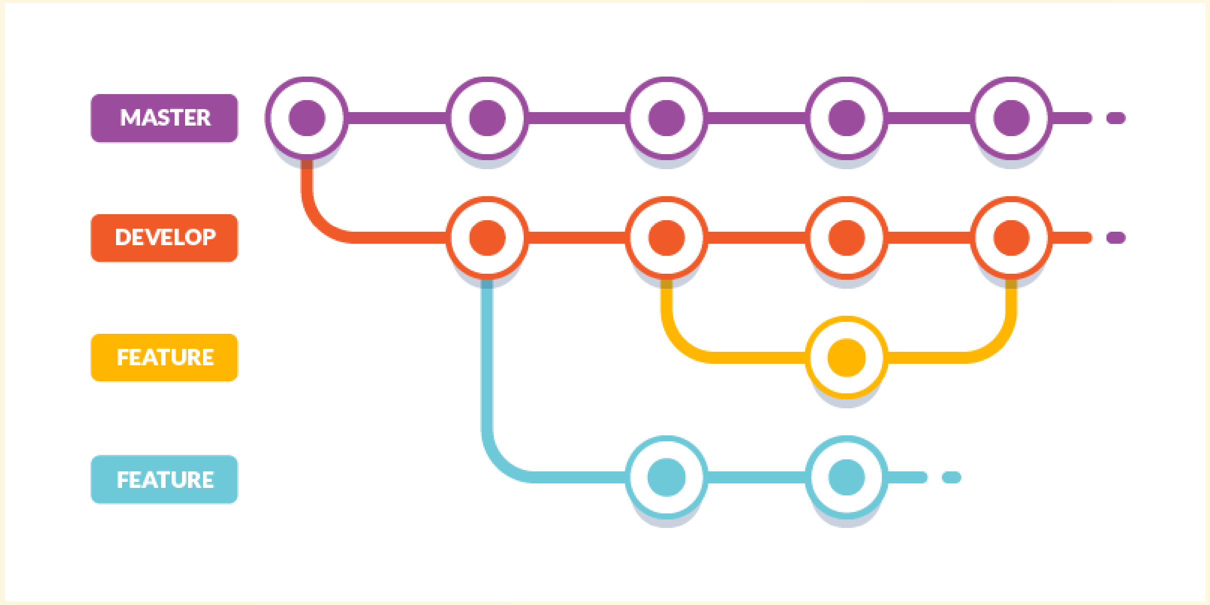
Version control

- The DevOps toolchain starts with pushing code to a version control system.
- The most common version control systems include:

GitFlow

Understanding GitFlow is important for security teams to:

- Contribute to development and operations workflows
- Prevent attackers from compromising the workflow



Continuous Integration

Approving and completing a merge request creates a commit on the "main" branch and automatically triggers a pipeline:

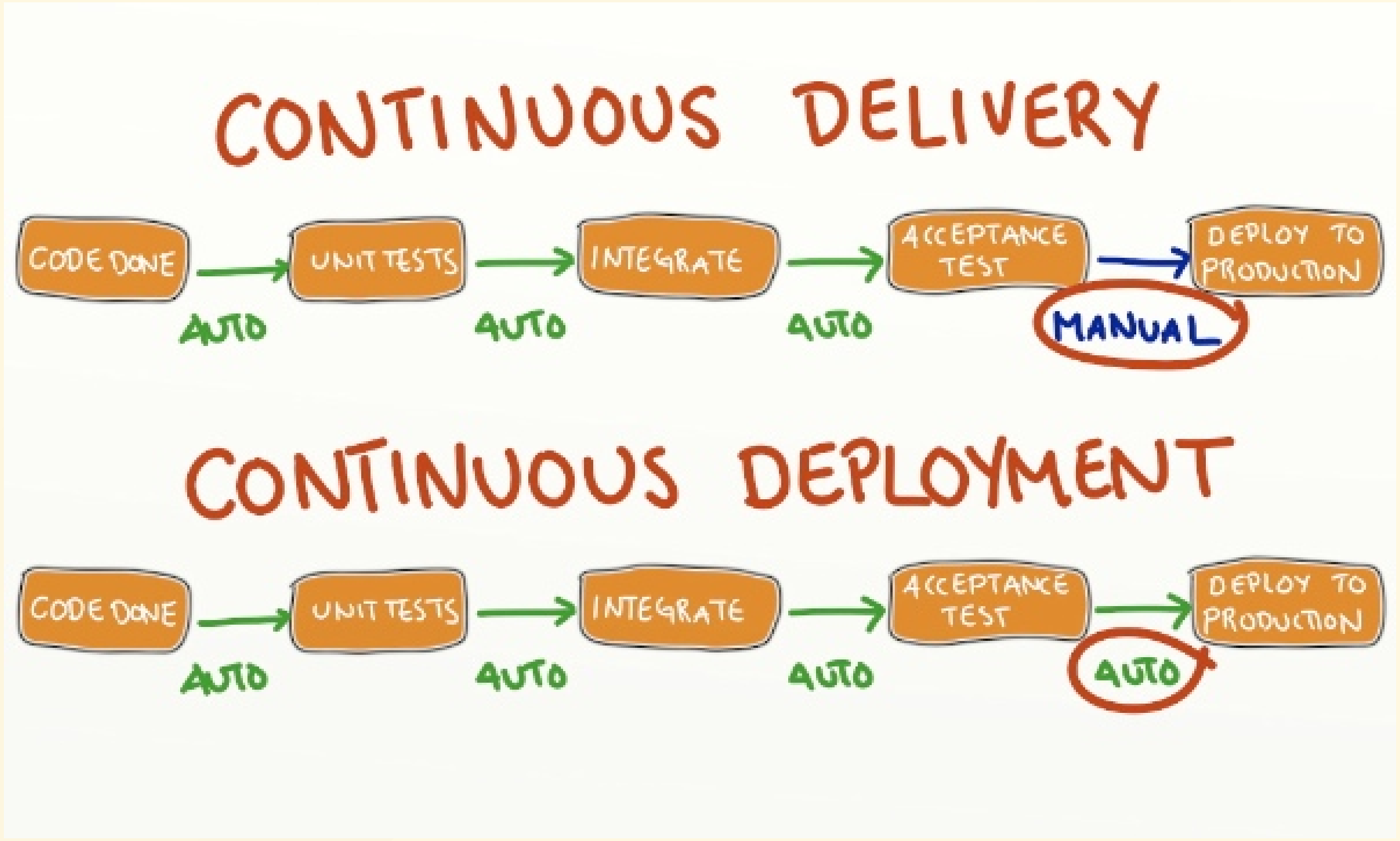
- Ensure that changes integrate successfully with the rest of the codebase
- Executes automated unit tests and other automated checks
  - Red: no other check-ins are allowed until the build is fixed
  - Green: creates build artifacts for next steps in CD pipeline
- Fast feedback - build and test steps need to run in a few minutes to encourage iterative development (small, frequent changes)

Continuous Delivery

Pipeline model and control framework extending Continuous Integration:

- It uses the latest good build from CI, packages for deployment, and release.
- Changes are automatically pushed to test/staging environments to conduct more realistic/comprehensive tests.
- It can insert manual reviews/testing/approvals between pipeline stages.
- Log steps and results to provide audit trail from check-in to deploy.
- Any failures will "stop the line."
- No additional changes can be accepted until the failure is corrected.
- This ensures that code is always ready to be deployed.
- Changes may be batched up before production release.

Continuous Delivery vs Continuous Deployement



Continuous Deployment

Continuous Deployment is how organizations like Netflix, Etsy, and Amazon push out changes n times per day/hour/minute:

- Changes are deployed directly and automatically to production using the CD pipeline once all tests/checks pass.
- Self-service - Changes are pushed to production by developers.
- Blue/Green Deployment - Deploy changes and switch between production environments using load balancing
- Canaries - Incremental deployment that stops and rolls back if errors occur
- A/B testing - Measuring the effect/acceptance of a change or new feature in production
- Dark Launching - Protect changes behind "feature switches"

CI/CD Systems

Version control push events on the develop/main branches trigger workflow pipelines for building, testing, and deploying the changes.

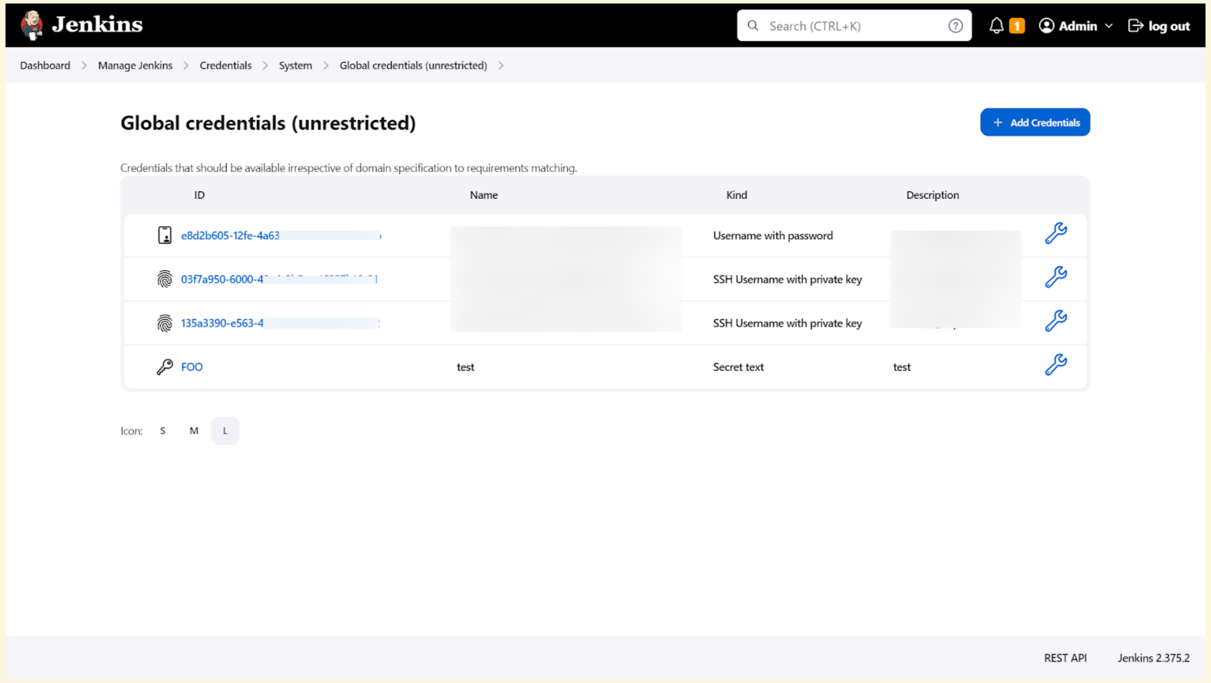
Actions

Jenkins pipeline as code declarative syntax

Jenkins pipeline building a docker image

```
pipeline {
    agent { dockerfile true }
    stages {
        stage('Test') {
            steps {
                sh 'node --version'
                sh 'svn --version'
            }
        }
    }
}
```

Jenkins credential manager



Jenkins | Search (CTRL+K) | Admin | log out

Dashboard > Manage Jenkins > Credentials > System > Global credentials (unrestricted) >

Global credentials (unrestricted)

+ Add Credentials

Credentials that should be available irrespective of domain specification to requirements matching.

ID	Name	Kind	Description
e8d2b605-12fe-4a63 [redacted]	[redacted]	Username with password	[redacted]
03f7a950-6000-4 [redacted]	[redacted]	SSH Username with private key	[redacted]
135a3390-e563-4 [redacted]	[redacted]	SSH Username with private key	[redacted]
FOO	test	Secret text	test

Icon: S M L

REST API Jenkins 2.375.2

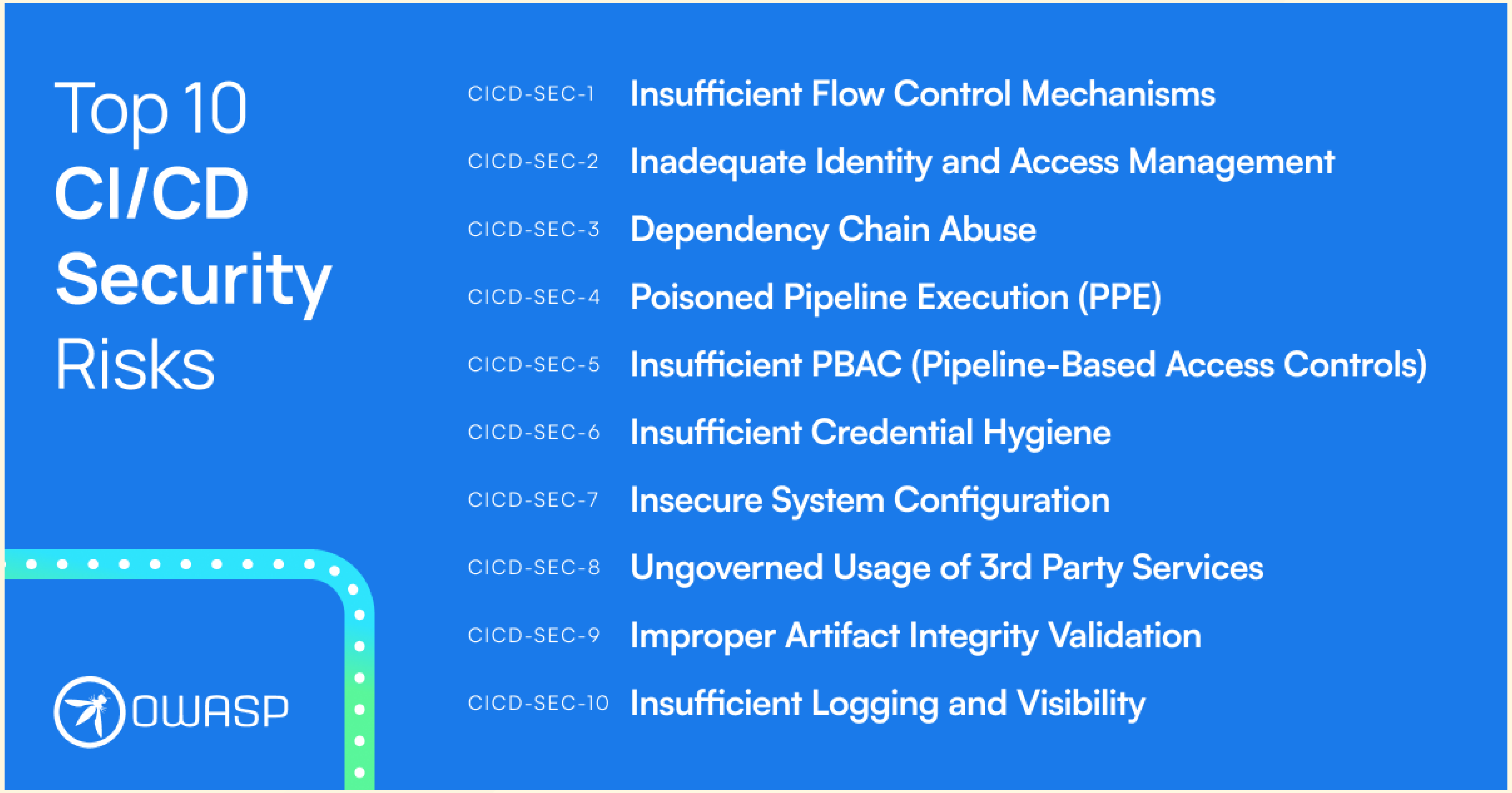
```
AWS_ACCESS_ID = ${env.AWS_ACCESS_ID}
AWS_SECRET = ${env.AWS_SECRET}
```

CI/CD Attacks

SOLARWINDS

CODECOV

CI/CD Security Risks



Top 10 CI/CD Security Risks

CICD-SEC-1	Insufficient Flow Control Mechanisms
CICD-SEC-2	Inadequate Identity and Access Management
CICD-SEC-3	Dependency Chain Abuse
CICD-SEC-4	Poisoned Pipeline Execution (PPE)
CICD-SEC-5	Insufficient PBAC (Pipeline-Based Access Controls)
CICD-SEC-6	Insufficient Credential Hygiene
CICD-SEC-7	Insecure System Configuration
CICD-SEC-8	Ungoverned Usage of 3rd Party Services
CICD-SEC-9	Improper Artifact Integrity Validation
CICD-SEC-10	Insufficient Logging and Visibility

OWASP

DevOps toolchain summary:

Security teams must understand how the CI/CD pipeline works, the tools involved, and how the teams use them before they start looking how and where to add security checks

Day 1 :Attacking and Hardening the DevOps Toolchain

Securing DevOps toolchain

DevOps / DevSecOps

Incremental, iterative development and rapid delivery in DevOps can significantly reduce this window of exposure:

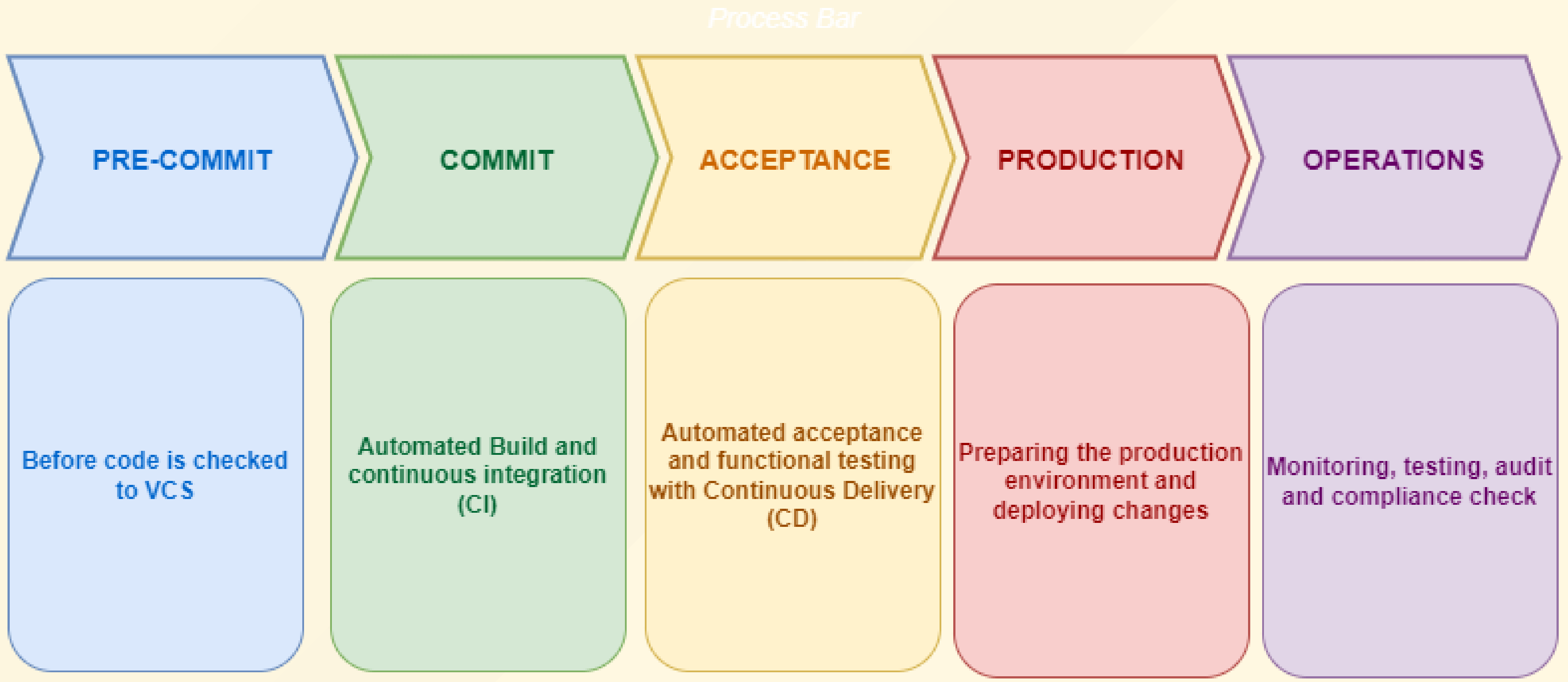
- DevOps teams follow "just-in-time prioritization"
- Automated testing cheap and safe to push out changes quickly.
- DevOps teams follow Lean techniques.
- Automated security checks in the CI/CD pipeline will catch many vulnerabilities.
- Security fixes are "standard changes".
- DevOps encourages developers and ops and security specialists to work together.

Security Champions: Breaking Down DevOps Silos

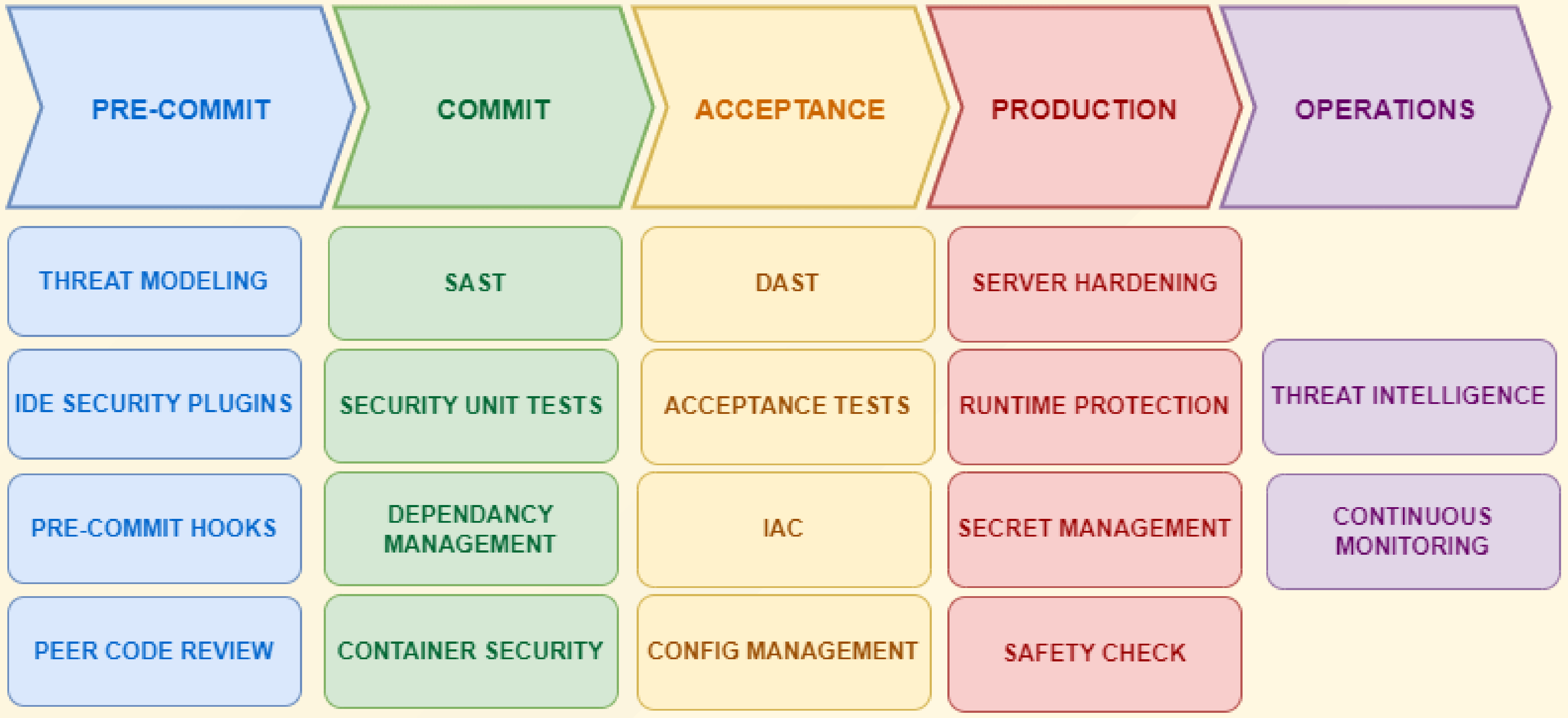
- Security experts embedded into the development organization
- Break down barriers between the central Security and DevOps teams
- Requires funding and support from upper management
- Provides several ancillary benefits:
    - The reputation of the company
    - Teaches valuable leadership skills
    - Increased employee retention

DevOps workflow

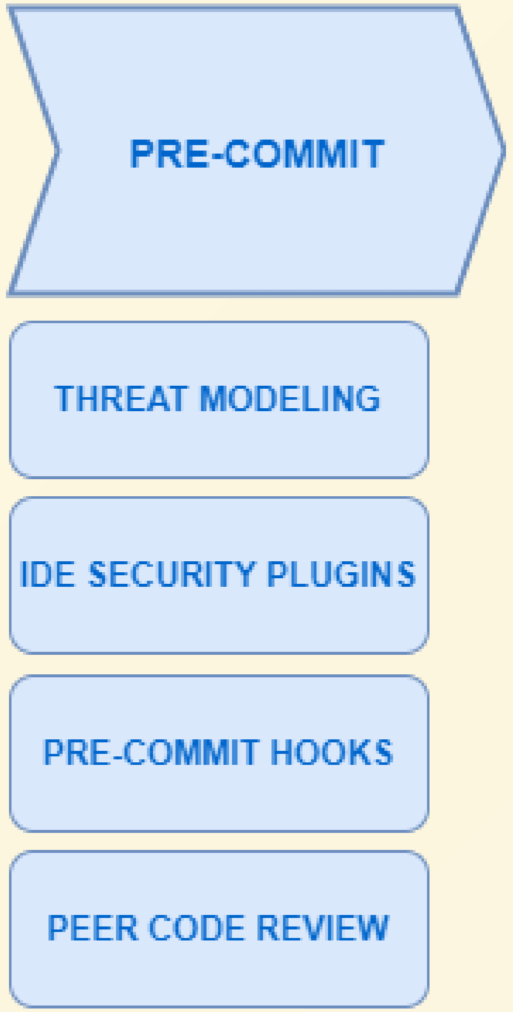
The DevOps workflow is based on five key phases:
-Manual work done before merging code into a delivery branch
-Automated Continuous Integration (CI) & Continuous Delivery (CD) process


Process Bar
PRE-COMMIT
COMMIT
ACCEPTANCE
PRODUCTION
OPERATIONS
Before code is checked to VCS
Automated Build and continuous integration (CI)
Automated acceptance and functional testing with Continuous Delivery (CD)
Preparing the production environment and deploying changes
Monitoring, testing, audit and compliance check

DevOps workflow



DevOps workflow



RRA

- **Quick!** The RRA takes 30 to 60 minutes maximum.
- **Very high-level**. Details are for complete threat models. The RRA can become a complete threat model over time though!
- **Concise, readable**. Short and with clear risk levels.
- **Easy to update**. Can be run during any phase of the project development and continuously updated.
- **Informative**. Collects risk impact and a data dictionary. Also, collections information about how the service functions.
- **Let you know what to do**. The RRA includes the list of recommendations from the security team with a priority for each item.

Threat Modeling

Ask a few basic questions:

1. Are you changing the attack surface of the system in a material way? Are you adding a new API or opening a new port, adding a new user type/role, adding or changing a data store/sink, calling out to a new service or system?
2. Are you changing the technology stack? Are you adding or significantly upgrading a framework or important library or language or runtime component?
3. Are you changing security controls: authentication or session management code, cryptologic, access control code or rules, auditing logic...?
4. Are you adding confidential/sensitive data or changing data classifications?
5. Are you modifying high-risk code?

Store Markdown RRA and Threat Modeling in the repository /docs directory

Code Inventory

```
$ scc path/to/your/code
───────────────────────────────────────────────────────────────────────────────
Language             Files        Lines         Code      Comments       Blanks
───────────────────────────────────────────────────────────────────────────────
Go                     112        50145        38876          5449         5838
Markdown                 8         2228         1710           163          355
Shell                   11          799          598            97          104
YAML                     6          515          408            10           97
───────────────────────────────────────────────────────────────────────────────
Total                  137        53687        41670          5719         6394
───────────────────────────────────────────────────────────────────────────────
```

Code Analysis: IDE Security Extensions

The VS Code Marketplace contains thousands of security-focused plugins:

- Semgrep
- Checkov/CFN Nag
- SonarLint/ ESLint
- Hadolint
- InSpec

Version Control Security

Version control systems and git provide workflow capabilities for locking down the remainder of the pre-commit security controls:

- Git Hooks
- Mandatory peer reviews
- Mandatory security reviews
- High risk code approvals

Git Commit Hooks

Run script automatically, checking for embedded secrets, code correctness at different point in the workflow :

- Local repository : pre-commit, commit, post-commit ...
- Remote repository: pre-receive, post-receive
- Implement team-wide workflow policies before CI

Manual Code Reviews

Take advantage of code review workflows for security reviews

- Security team sets policies and train developers on how to de security code reviews. Create a checklist for them.
- Look for problems that static analysis tools don't find.
- Tag High-risk code

Branch Protection

All version control providers provides a branch protection capability:

- Require merge requests to commit to the branch
- It defines the role that can complete a merge request.
- It prevents users to directly push to the main branch
- it enables the CodeOwners approval workflow

Code Owners

Inventory high risk code and identify groups and individuals responsible for approvals :

- Create CODEOWNERS file in the repository root directory
- Define directories or individual files in the CODEOWNERS file
- Require one or many approvers during the pull request to review changes
- The security team can participate in the GitFlow workflow

Code Owners

```
# This is a comment.
# Each line is a file pattern followed by one or more owners.
# Specify the owners for the entire repository
*       @all-developers
# Specify the owners for security-related files
/security/ @security
# Specify the owners for user experience-related files
/frontend/ @user-experience
# Example for specific files
README.md @all-developers
# Example for a specific directory
docs/ @all-developers
# Example for specific file types
*.js @all-developers
CODEOWNERS @security @admin
```

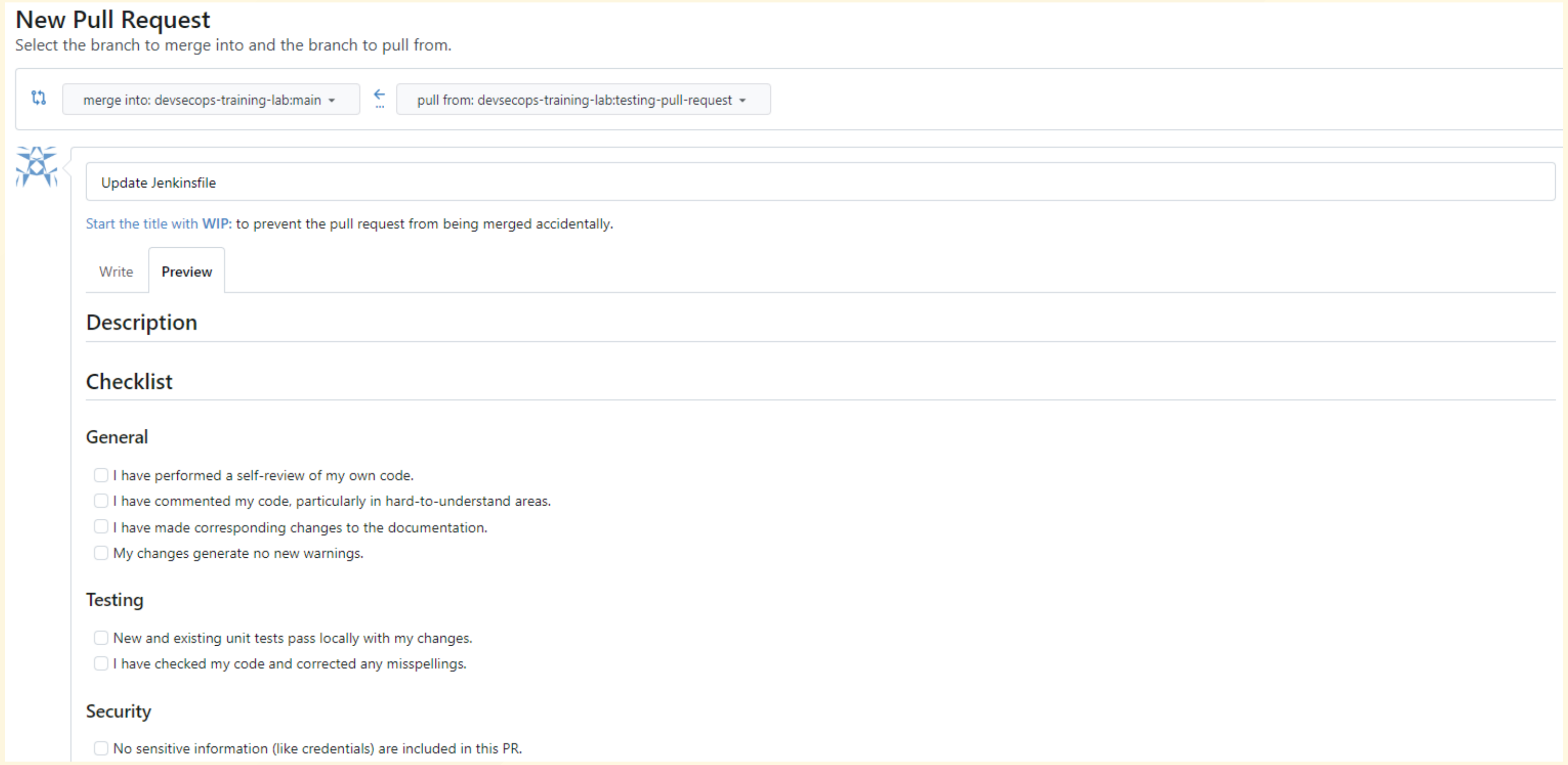
Detecting High Risk Code

Using unit tests to check if a high-risk code file changed.

```
describe('HighRiskCode Checksum Test', () => {
    const testCases = [
        { file: 'path/to/Jenkinsfile', checksum: '2bf33b66ddb07616f882ceed0718826af298a7' },
        { file: 'path/to/Dockerfile', checksum: 'fe83bf6f453698c5f78cabl67bca14c72daf32c0' },
    ];
    testCases.forEach(({ file, checksum }) => {
        it(`should verify the checksum of ${file}`, () => {
            const alertSpy = sinon.spy(requestCodeReview);
            const actualChecksum = getChecksum(file);
            const match = checksum === actualChecksum;
            if (!match) {
                requestCodeReview(file);
            }
        });
    });
});
```

Security Checklist: Pull Request Templates

Markdown based templates for starting a pull request can include checklists, including security tasks



New Pull Request
Select the branch to merge into and the branch to pull from.

merge into: devsecops-training-lab:main
pull from: devsecops-training-lab:testing-pull-request

Update Jenkinsfile

Start the title with WIP: to prevent the pull request from being merged accidentally.

Write | Preview

Description

Checklist

General

- [ ] I have performed a self-review of my own code.
- [ ] I have commented my code, particularly in hard-to-understand areas.
- [ ] I have made corresponding changes to the documentation.
- [ ] My changes generate no new warnings.

Testing

- [ ] New and existing unit tests pass locally with my changes.
- [ ] I have checked my code and corrected any misspellings.

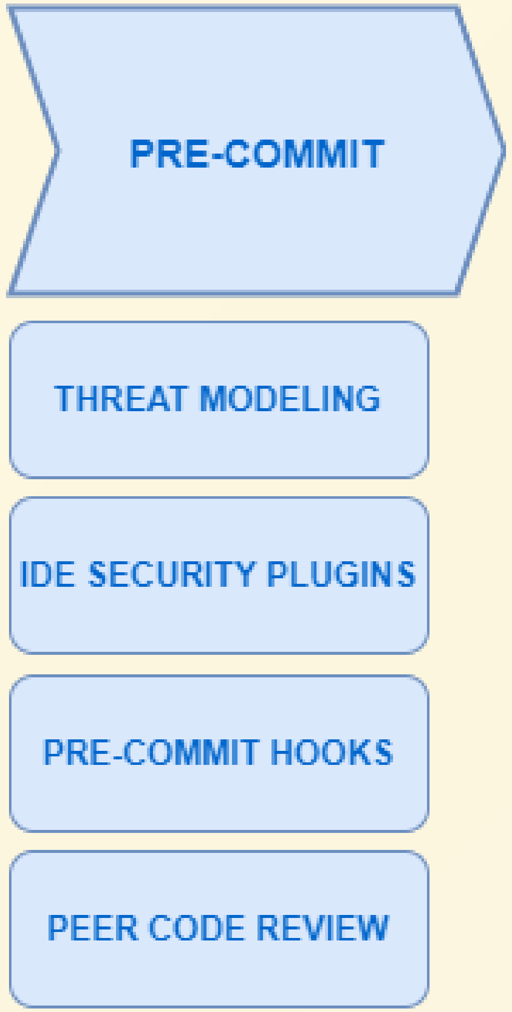
Security

- [ ] No sensitive information (like credentials) are included in this PR.

Summary

Secure your Version Control System

DevOps workflow - Security Controls


PRE-COMMIT
THREAT MODELING
IDE SECURITY PLUGINS
PRE-COMMIT HOOKS
PEER CODE REVIEW