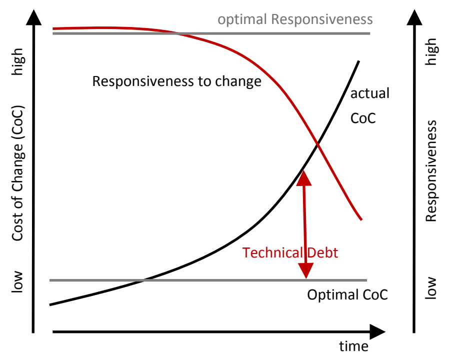
Clean Code Cheat Sheet

Software Services

Why Clean Code

Code is clean if it can be understood easily – by everyone on the team. With understandability comes readability, changeability, extensibility and maintainability. All the things needed to keep a project going over a long time without accumulating up a large amount of technical debt.



Writing clean code from the start in a project is an investment in keeping the cost of change as constant as possible throughout the lifecycle of a software product. Therefore, the initial cost of change is a bit higher when writing clean code (grey line) than quick and dirty programming (black line), but is paid back quite soon. Especially if you keep in mind that most of the cost has to be paid during maintenance of the software. Unclean code results in technical debt that increases over time if not refactored into clean code. There are other reasons leading to Technical Debt such as bad processes and lack of documentation, but unclean code is a major driver. As a result, your ability to respond to changes is reduced (red line).

In Clean Code, Bugs Cannot Hide

Most software defects are introduced when changing existing code. The reason behind this is that the developer changing the code cannot fully grasp the effects of the changes made. Clean code minimises the risk of introducing defects by making the code as easy to understand as possible.

Principles

Loose Coupling

Two classes, components or modules are coupled when at least one of them uses the other. The less these items know about each other, the looser they are coupled.

A component that is only loosely coupled to its environment can be more easily changed or replaced than a strongly coupled component.

High Cohesion

Cohesion is the degree to which elements of a whole belong together. Methods and fields in a single class and classes of a component should have high cohesion. High cohesion in classes and components results in simpler, more easily understandable code structure and design.

Change is Local

When a software system has to be maintained, extended and changed for a long time, keeping change local reduces involved costs and risks. Keeping change local means that there are boundaries in the design which changes do not cross.

It is Easy to Remove

We normally build software by adding, extending or changing features. However, removing elements is important so that the overall design can be kept as simple as possible. When a block gets too complicated, it has to be removed and replaced with one or more simpler blocks.

Smells

Rigidity

The software is difficult to change. A small change causes a cascade of subsequent changes.

Fragility

The software breaks in many places due to a single change.

Immobility

You cannot reuse parts of the code in other projects because of involved risks and high effort.

Viscosity of Design

Taking a shortcut and introducing technical debt requires less effort than doing it right.

Viscosity of Environment

Building, testing and other tasks take a long time. Therefore, these activities are not executed properly by everyone and technical debt is introduced.

Needless Complexity

The design contains elements that are currently not useful. The added complexity makes the code harder to comprehend. Therefore, extending and changing the code results in higher effort than necessary.

Needless Repetition

Code contains lots of code duplication: exact code duplications or design duplicates (doing the same thing in a different way). Making a change to a duplicated piece of code is more expensive and more error-prone because the change has to be made in several places with the risk that one place is not changed accordingly.

Opacity

The code is hard to understand. Therefore, any change takes additional time to first reengineer the code and is more likely to result in defects due to not understanding the side effects.

Class Design

Single Responsibility Principle (SRP)

A class should have one, and only one, reason to change.

Open Closed Principle (OCP)

You should be able to extend a classes behaviour without modifying it.

Liskov Substitution Principle (LSP)

Derived classes must be substitutable for their base classes.

Dependency Inversion Principle (DIP)

Depend on abstractions, not on concretions.

Interface Segregation Principle (ISP)

Make fine grained interfaces that are client-specific.

Classes Should be Small

Smaller classes are easier to grasp. Classes should be smaller than about 100 lines of code. Otherwise, it is hard to spot how the class does its job and it probably does more than a single job.

Package Cohesion

Release Reuse Equivalency Principle (RREP)

The granule of reuse is the granule of release.

Common Closure Principle (CCP)

Classes that change together are packaged together.

Common Reuse Principle (CRP)

Classes that are used together are packaged together.

Package Coupling

Acyclic Dependencies Principle (ADP)

The dependency graph of packages must have no cycles.

Stable Dependencies Principle (SDP)

Depend in the direction of stability.

Stable Abstractions Principle (SAP)

Abstractness increases with stability

General

Follow Standard Conventions

Coding-, architecture-, design guidelines (check them with tools)

Keep it Simple, Stupid (KISS)

Simpler is always better. Reduce complexity as much as possible.

Boy Scout Rule

Leave the campground cleaner than you found it.

Root Cause Analysis

Always look for the root cause of a problem. Otherwise, it will get you again and again.

Multiple Languages in One Source File

C#, Java, JavaScript, XML, HTML, XAML, English, German …

Environment

Project Build Requires Only One Step

Check out and then build with a single command.

Executing Tests Requires Only One Step

Run all unit tests with a single command.

Source Control System

Always use a source control system.

Continuous Integration

Assure integrity with Continuous Integration

Overridden Safeties

Do not override warnings, errors, exception handling – they will catch you.

Dependency Injection

Decouple Construction from Runtime

Decoupling the construction phase completely from the runtime helps to simplify the runtime behaviour.

Design

Keep Configurable Data at High Levels

If you have a constant such as default or configuration value that is known and expected at a high level of abstraction, do not bury it in a low-level function. Expose it as an argument to the low-level function called from the high-level function.

Don't Be Arbitrary

Have a reason for the way you structure your code, and make sure that reason is communicated by the structure of the code. If a structure appears arbitrary, others will feel empowered to change it.

Be Precise

When you make a decision in your code, make sure you make it precisely. Know why you have made it and how you will deal with any exceptions.

Structure over Convention

Enforce design decisions with structure over convention. Naming conventions are good, but they are inferior to structures that force compliance.

Prefer Polymorphism To If/Else or Switch/Case

"ONE SWITCH": There may be no more than one switch statement for a given type of selection. The cases in that switch statement must create polymorphic objects that take the place of other such switch statements in the rest of the system.

Symmetry / Analogy

Favour symmetric designs (e.g. Load – Save) and designs that follow analogies (e.g. same design as found in .NET framework).

Separate Multi-Threading Code

Do not mix code that handles multi-threading aspects with the rest of the code. Separate them into different classes.

Misplaced Responsibility

Something put in the wrong place.

Code at Wrong Level of Abstraction

Functionality is at wrong level of abstraction, e.g. a PercentageFull property on a generic IStack<T>.

Fields Not Defining State

Fields holding data that does not belong to the state of the instance but are used to hold temporary data. Use local variables or extract to a class abstracting the performed action.

Over Configurability

Prevent configuration just for the sake of it – or because nobody can decide how it should be. Otherwise, this will result in overly complex, unstable systems.

Micro Layers

Do not add functionality on top, but simplify overall.

Dependencies

Make Logical Dependencies Physical

If one module depends upon another, that dependency should be physical, not just logical. Don't make assumptions.

Singletons / Service Locator

Use dependency injection. Singletons hide dependencies.

Base Classes Depending On Their Derivatives

Base classes should work with any derived class.

Too Much Information

Minimise interface to minimise coupling

Feature Envy

The methods of a class should be interested in the variables and functions of the class they belong to, and not the variables and functions of other classes. When a method uses accessors and mutators of some other object to manipulate the data within that object, then it envies the scope of the class of that other object. It wishes that it were inside that other class so that it could have direct access to the variables it is manipulating.

Artificial Coupling

Things that don't depend upon each other should not be artificially coupled.

Hidden Temporal Coupling

If, for example, the order of some method calls is important, then make sure that they cannot be called in the wrong order.

Transitive Navigation

Aka Law of Demeter, writing shy code.
A module should know only its direct dependencies.

Naming

Choose Descriptive / Unambiguous Names

Names have to reflect what a variable, field, property stands for. Names have to be precise.

Choose Names at Appropriate Level of Abstraction

Choose names that reflect the level of abstraction of the class or method you are working in.

Name Interfaces After Functionality They Abstract

The name of an interface should be derived from its usage by the client, such as IStream.

Name Classes After How They Implement Their Interfaces

The name of a class should reflect how it fulfils the functionality provided by its interface(s), such as MemoryStream : IStream

Name Methods After What They Do

The name of a method should describe what is done, not how it is done.

Use Long Names for Long Scopes

fields → parameters → locals → loop variables
long → short

Names Describe Side Effects

Names have to reflect the entire functionality.

Standard Nomenclature Where Possible

Don't invent your own language when there is a standard.

Encodings in Names

No prefixes, no type/scope information

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Understandability

Consistency
If you do something a certain way, do all similar things in the same way: same variable name for same concepts, same naming pattern for corresponding concepts.

Use Explanatory Variables
Use locals to give steps in algorithms names.

Encapsulate Boundary Conditions
Boundary conditions are hard to keep track of. Put the processing for them in one place, e.g. nextLevel = level + 1;

Prefer Dedicated Value Objects to Primitive Types
Instead of passing primitive types like strings and integers, use dedicated primitive types: e.g. AbsolutePath instead of string.

Poorly Written Comment
Comment does not add any value (redundant to code), is not well formed, not correct grammar/spelling.

Obscured Intent
Too dense algorithms that lose all expressiveness.

Obvious Behaviour Is Unimplemented
Violations of "the Principle of Least Astonishment". What you expect is what you get.

Hidden Logical Dependency
A method can only work when invoked correctly depending on something else in the same class, e.g. a DeleteItem method must only be called if a CanDeleteItem method returned true, otherwise it will fail.

Methods

Methods Should Do One Thing
Loops, exception handling, …encapsulate in sub-methods.

Methods Should Descend 1 Level of Abstraction
The statements within a method should all be written at the same level of abstraction, which should be one level below the operation described by the name of the function.

Method with Too Many Arguments
Prefer fewer arguments. Maybe functionality can be outsourced to a dedicated class that holds the information in fields.

Method with Out/Ref Arguments
Prevent usage. Return complex object holding all values, split into several methods. If your method must change the state of something, have it change the state of the object it is called on.

Selector / Flag Arguments
public int Foo(bool flag)
Split method into several independent methods that can be called from the client without the flag.

Inappropriate Static
Static method that should be an instance method

Source Code Structure

Vertical Separation
Variables and methods should be defined close to where they are used. Local variables should be declared just above their first usage and should have a small vertical scope.

Nesting
Nested code should be more specific or handle less probable scenarios than unnested code.

Structure Code into Namespaces by Feature
Keep everything belonging to the same feature together. Don't use namespaces communicating layers. A feature may use another feature; a business feature may use a core feature like logging.

Conditionals

Encapsulate Conditionals
if (this.ShouldBeDeleted(timer)) is preferable to if (timer.HasExpired && !timer.IsRecurrent).

Positive Conditionals
Positive conditionals are easier to read than negative conditionals.

Useless Stuff

Dead Comment, Code
Delete unused things. You can find them in your version control system.

Clutter
Code that is not dead but does not add any functionality

Inappropriate Information
Comment holding information better held in a different kind of system: product backlog, source control. Use code comments for technical notes only.

Maintainability Killers

Duplication
Eliminate duplication. Violation of the "Don't repeat yourself" (DRY) principle.

Magic Numbers / Strings
Replace Magic Numbers and Strings with named constants to give them a meaningful name when meaning cannot be derived from the value itself.

Enums (Persistent or Defining Behaviour)
Use reference codes instead of enums if they have to be persisted. Use polymorphism instead of enums if they define behaviour.

Exception Handling

Catch Specific Exceptions
Catch exceptions as specific as possible. Catch only the exceptions for which you can react in a meaningful manner.

Catch Where You Can React in a Meaningful Way
Only catch exceptions when you can react in a meaningful way. Otherwise, let someone up in the call stack react to it.

Use Exceptions instead of Return Codes or null
In an exceptional case, throw an exception when your method cannot do its job. Don't accept or return null. Don't return error codes.

Fail Fast
Exceptions should be thrown as early as possible after detecting an exceptional case. This helps to pinpoint the exact location of the problem by looking at the stack trace of the exception.

Using Exceptions for Control Flow
Using exceptions for control flow: has bad performance, is hard to understand and results in very hard handling of real exceptional cases.

Swallowing Exceptions
Exceptions can be swallowed only if the exceptional case is completely resolved after leaving the catch block. Otherwise, the system is left in an inconsistent state.

From Legacy Code to Clean Code

Always have a Running System
Change your system in small steps, from a running state to a running state.

1) Identify Features
Identify the existing features in your code and prioritise them according to how relevant they are for future development (likelihood and risk of change).

2) Introduce Boundary Interfaces for Testability
Refactor the boundaries of your system to interfaces so that you can simulate the environment with test doubles (fakes, mocks, stubs, simulators).

3) Write Feature Acceptance Tests
Cover a feature with Acceptance Tests to establish a safety net for refactoring.

4) Identify Components
Within a feature, identify the components used to provide the feature. Prioritise components according to relevance for future development (likelihood and risk of change).

5) Refactor Interfaces between Components
Refactor (or introduce) interfaces between components so that each component can be tested in isolation of its environment.

6) Write Component Acceptance Tests
Cover the features provided by a component with Acceptance Tests.

7) Decide for Each Component: Refactor, Reengineer, Keep
Decide for each component whether to refactor, reengineer or keep it.

8a) Refactor Component
Redesign classes within the component and refactor step by step (see Refactoring Patters). Add unit tests for each newly designed class.

8b) Reengineer Component
Use ATDD and TDD (see Clean ATDD/TDD cheat sheet) to re-implement the component.

8c) Keep Component
If you anticipate only few future changes to a component and the component had few defects in the past, consider keeping it as it is.

Refactoring Patterns

Reconcile Differences – Unify Similar Code
Change both pieces of code stepwise until they are identical.

Isolate Change
First, isolate the code to be refactored from the rest. Then refactor. Finally, undo isolation.

Migrate Data
Move from one representation to another by temporary duplication of data structures.

Temporary Parallel Implementation
Refactor by introducing a temporary parallel implementation of an algorithm. Switch one caller after the other. Remove old solution when no longer needed.

Demilitarized Zone for Components
Introduce an internal component boundary and push everything unwanted outside of the internal boundary into the demilitarized zone between component interface and internal boundary. Then refactor the component interface to match the internal boundary and eliminate the demilitarized zone.

How to Learn Clean Code

Pair Programming
Two developers solving a problem together at a single workstation. One is the driver, the other is the navigator. The driver is responsible for writing the code. The navigator is responsible for keeping the solution aligned with the architecture, the coding guidelines and looks at where to go next (e.g. which test to write next). Both challenge their ideas and approaches to solutions.

Commit Reviews
A developer walks a peer developer through all code changes prior to committing (or pushing) the changes to the version control system. The peer developer checks the code against clean code guidelines and design guidelines.

Coding Dojo
In a Coding Dojo, a group of developers come together to exercise their skills. Two developers solve a problem (kata) in pair programming. The rest observe. After 10 minutes, the group rotates to build a new pair. The observers may critique the current solution, but only when all tests are green.

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Legend:
- DO
- DON'T

Clean ATDD/TDD Cheat Sheet

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Kinds of Automated Tests

ATDD – Acceptance Test Driven Development
Specify a feature first with a test, then implement.

TDD – Test Driven Development
Red – green – refactor. Test a little – code a little.

DDT – Defect Driven Testing
Write a unit test that reproduces the defect – Fix code – Test will succeed – Defect will never return.

POUTing – Plain Old Unit Testing
Aka test after. Write unit tests to check existing code. You cannot and probably do not want to test drive everything. Use POUT to increase sanity. Use to add additional tests after TDDing (e.g. boundary cases).

Design for Testability

Constructor – Simplicity
Objects have to be easily creatable. Otherwise, easy and fast testing is not possible.

Constructor – Lifetime
Pass dependencies and configuration/parameters into the constructor that have a lifetime equal to or longer than the created object. For other values use methods or properties.

Abstraction Layers at System Boundary
Use abstraction layers at system boundaries (database, file system, web services, COM interfaces ...) that simplify unit testing by enabling the usage of mocks.

Structure

Arrange – Act – Assert
Structure the tests always by AAA. Never mix these three blocks.

Test Assemblies (.Net)
Create a test assembly for each production assembly and name it as the production assembly + ".Test".

Test Namespace
Put the tests in the same namespace as their associated testee.

Unit Test Methods Show Whole Truth
Unit test methods show all parts needed for the test. Do not use SetUp method or base classes to perform actions on testee or dependencies.

SetUp / TearDown for Infrastructure Only
Use the SetUp / TearDown methods only for infrastructure that your unit test needs. Do not use it for anything that is under test.

Test Method Naming
Names reflect what is tested, e.g. FeatureWhenScenarioThenBehaviour.

Single Scenario per Test
One test checks one scenario only.

Resource Files
Test and resource are together: FooTest.cs, FooTest.resx

Naming

Naming SUT Test Variables
Give the variable holding the System Under Test always the same name (e.g. testee or sut). Clearly identifies the SUT, robust against refactoring.

Naming Result Values
Give the variable holding the result of the tested method always the same name (e.g. result).

Anonymous Variables
Always use the same name for variables holding uninteresting arguments to tested methods (e.g. anonymousText).

Don't Assume

Understand the Algorithm
Just working is not enough, make sure you understand why it works.

Incorrect Behaviour at Boundaries
Always unit test boundaries. Do not assume behaviour.

Faking (Stubs, Fakes, Spies, Mocks ...)

Isolation from environment
Use fakes to simulate all dependencies of the testee.

Faking Framework
Use a dynamic fake framework for fakes that show different behaviour in different test scenarios (little behaviour reuse).

Manually Written Fakes
Use manually written fakes when they can be used in several tests and they have only little changed behaviour in these scenarios (behaviour reuse).

Mixing Stubbing and Expectation Declaration
Make sure that you follow the AAA (arrange, act, assert) syntax when using mocks. Don't mix setting up stubs (so that the testee can run) with expectations (on what the testee should do) in the same code block.

Checking Fakes instead of Testee
Tests that do not check the testee but values returned by fakes. Normally due to excessive fake usage.

Excessive Fake Usage
If your test needs a lot of mocks or mock setup, then consider splitting the testee into several classes or provide an additional abstraction between your testee and its dependencies.

Unit Test Principles

Fast
Unit tests have to be fast in order to be executed often. Fast means much smaller than seconds.

Isolated
Clear where the failure happened. No dependency between tests (random order).

Repeatable
No assumed initial state, nothing left behind, no dependency on external services that might be unavailable (databases, file system ...).

Self-Validating
No manual test interpretation or intervention. Red or green!

Timely
Tests are written at the right time (TDD, DDT, POUTing)

Unit Test Smells

Test Not Testing Anything
Passing test that at first sight appears valid but does not test the testee.

Test Needing Excessive Setup
A test that needs dozens of lines of code to set up its environment. This noise makes it difficult to see what is really tested.

Too Large Test / Assertions for Multiple Scenarios
A valid test that is, however, too large. Reasons can be that this test checks for more than one feature or the testee does more than one thing (violation of Single Responsibility Principle).

Checking Internals
A test that accesses internals (private/protected members) of the testee directly (Reflection). This is a refactoring killer.

Test Only Running on Developer's Machine
A test that is dependent on the development environment and fails elsewhere. Use continuous integration to catch them as soon as possible.

Test Checking More than Necessary
A test that checks more than it is dedicated to. The test fails whenever something changes that it checks unnecessarily. Especially probable when fakes are involved or checking for item order in unordered collections.

Irrelevant Information
Test contains information that is not relevant to understand it.

Chatty Test
A test that fills the console with text – probably used once to manually check for something.

Test Swallowing Exceptions
A test that catches exceptions and lets the test pass.

Test Not Belonging in Host Test Fixture
A test that tests a completely different testee than all other tests in the fixture.

Obsolete Test
A test that checks something no longer required in the system. May even prevent clean-up of production code because it is still referenced.

Hidden Test Functionality
Test functionality hidden in either the SetUp method, base class or helper class. The test should be clear by looking at the test method only – no initialisation or asserts somewhere else.

Bloated Construction
The construction of dependencies and arguments used in calls to testee makes test hardly readable. Extract to helper methods that can be reused.

Unclear Fail Reason
Split test or use assertion messages.

Conditional Test Logic
Tests should not have any conditional test logic because it's hard to read.

Test Logic in Production Code
Tests depend on special logic in production code.

Erratic Test
Sometimes passes, sometimes fails due to left overs or environment.

TDD Principles

A Test Checks One Feature
A test checks exactly one feature of the testee. That means that it tests all things included in this feature but not more. This includes probably more than one call to the testee. This way, the tests serve as samples and documentation of the usage of the testee.

Tiny Steps
Make tiny little steps. Add only a little code in test before writing the required production code. Then repeat. Add only one Assert per step.

Keep Tests Simple
Whenever a test gets complicated, check whether you can split the testee into several classes (Single Responsibility Principle)

Prefer State Verification to Behaviour Verification
Use behaviour verification only if there is no state to verify.

Test Domain Specific Language
Use test DSLs to simplify reading tests: helper methods, classes.

TDD Process Smells

Using Code Coverage as a Goal
Use code coverage to find missing tests but don't use it as a driving tool. Otherwise, the result could be tests that increase code coverage but not certainty.

No Green Bar in the last ~10 Minutes
Make small steps to get feedback as fast and frequent as possible.

Not Running Test Before Writing Production Code
Only if the test fails, then new code is required. Additionally, if the test, surprisingly, does not, fail then make sure the test is correct.

Not Spending Enough Time on Refactoring
Refactoring is an investment in the future. Readability, changeability and extensibility will pay back.

Skipping Something Too Easy to Test
Don't assume, check it. If it is easy, then the test is even easier.

Skipping Something Too Hard to Test
Make it simpler, otherwise bugs will hide in there and maintainability will suffer.

Organising Tests around Methods, Not Behaviour
These tests are brittle and refactoring killers. Test complete "mini" use cases in a way which reflects how the feature will be used in the real world. Do not test setters and getters in isolation, test the scenario they are used in.

Red Bar Patterns

One Step Test
Pick a test you are confident you can implement and which maximises learning effect (e.g. impact on design).

Partial Test
Write a test that does not fully check the required behaviour, but brings you a step closer to it. Then use Extend Test below.

Extend Test
Extend an existing test to better match real-world scenarios.

Another Test
If you think of new tests, then write them on the TO DO list and don't lose focus on current test.

Learning Test
Write tests against external components to make sure they behave as expected.

Green Bar Patterns

Fake It ('Til You Make It)
Return a constant to get first test running. Refactor later.

Triangulate – Drive Abstraction
Write test with at least two sets of sample data. Abstract implementation on these.

Obvious Implementation
If the implementation is obvious then just implement it and see if test runs. If not, then step back and just get test running and refactor then.

One to Many – Drive Collection Operations
First, implement operation for a single element. Then, step to several elements.

Acceptance Test Driven Development

Use Acceptance Tests to Drive Your TDD tests
Acceptance tests check for the required functionality. Let them guide your TDD.

User Feature Test
An acceptance test is a test for a complete user feature from top to bottom that provides business value.

Automated ATDD
Use automated Acceptance Test Driven Development for regression testing and executable specifications.

Component Acceptance Tests
Write acceptance tests for individual components or subsystems so that these parts can be combined freely without losing test coverage.

Simulate System Boundaries
Simulate system boundaries like the user interface, databases, file system and external services to speed up your acceptance tests and to be able to check exceptional cases (e.g. a full hard disk). Use system tests to check the boundaries.

Acceptance Test Spree
Do not write acceptance tests for every possibility. Write acceptance tests only for real scenarios. The exceptional and theoretical cases can be covered more easily with unit tests.

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Continuous Integration

Pre-Commit Check
Run all unit and acceptance tests covering currently worked on code prior to committing to the source code repository.

Post-Commit Check
Run all unit and acceptance tests on every commit to the version control system on the continuous integration server.

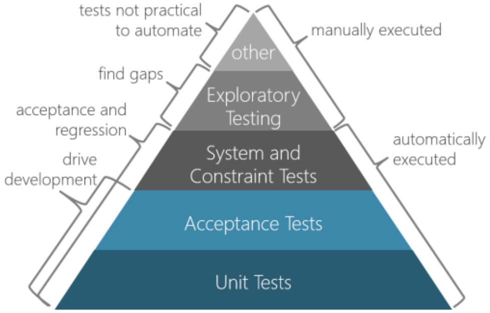
Communicate Failed Integration to Whole Team
Whenever a stage on the continuous integration server fails, notify whole team in order to get blocking situation resolved as soon as possible.

Build Staging
Split the complete continuous integration workflow into individual stages to reduce feedback time.

Automatically Build an Installer for Test System
Automatically build an installer as often as possible to test software on a test system (for manual tests, or tests with real hardware).

Continuous Deployment
Install the system to a test environment on every commit or manual request. Deployment to production environment is automated, too.

Test Pyramid



Constraint Test = Test for non-functional requirements.

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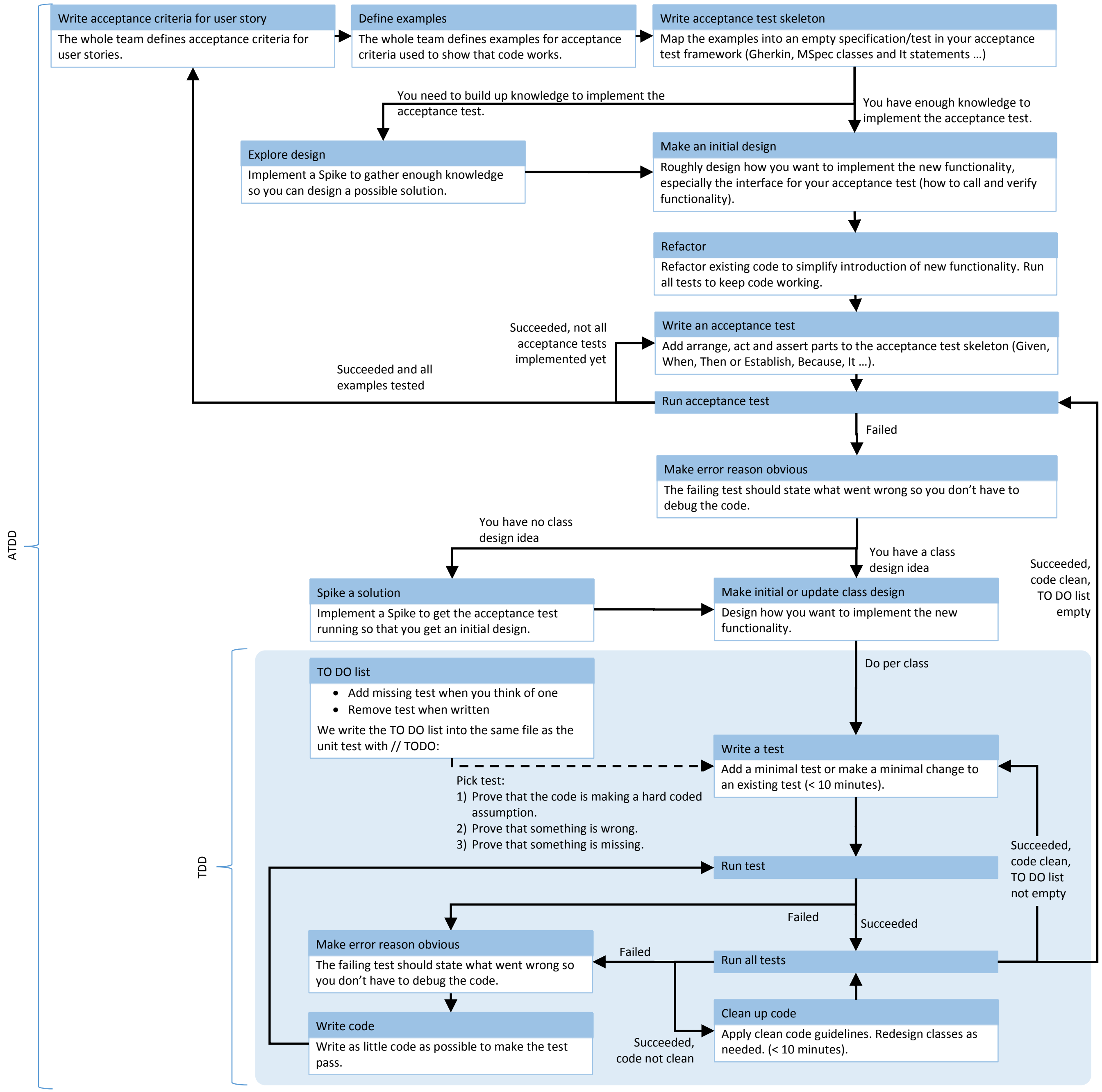
Legend:

DO

DON'T

ATDD, TDD cycle



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