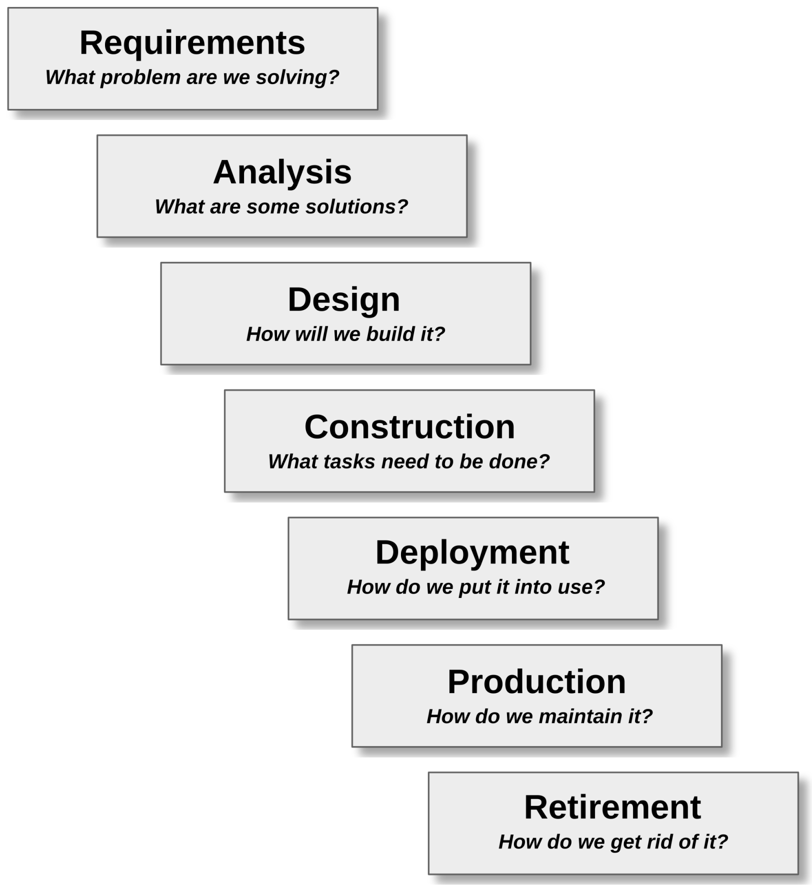
System Lifecycles and SDLCs

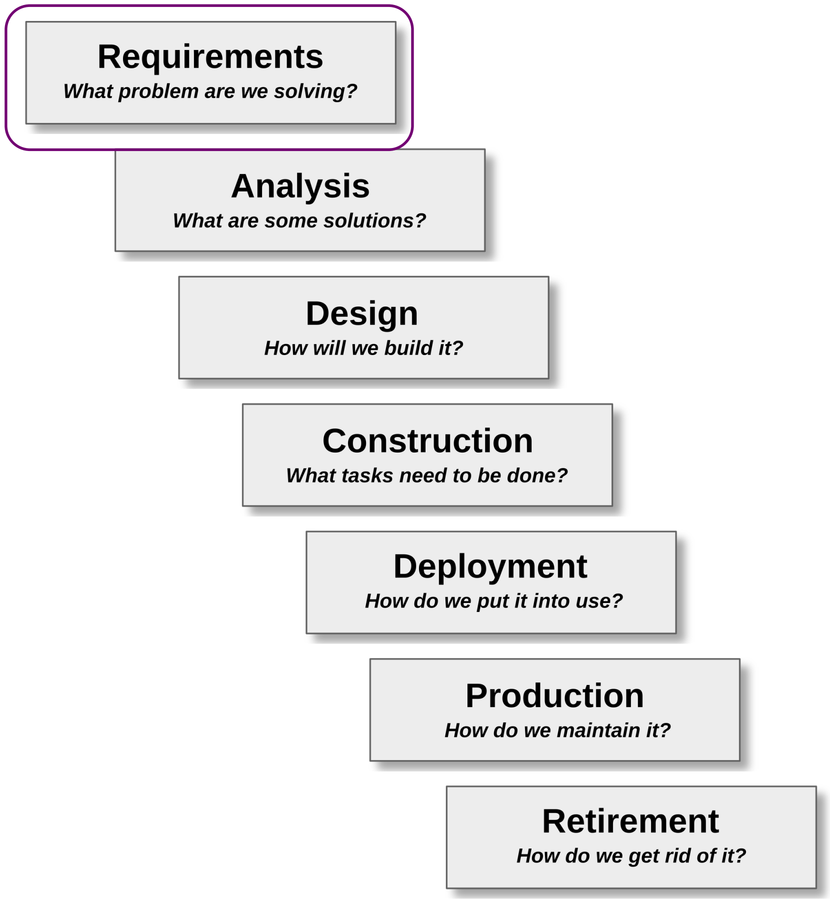
The Engineering Process

- Used whenever a product or service is engineered
  - This includes software and IoT
- Supported by
  - Classic software SDLCs
    - Including Agile and waterfall methodologies
  - SLC: System Lifecycle management
  - DevOps and DevSecOps



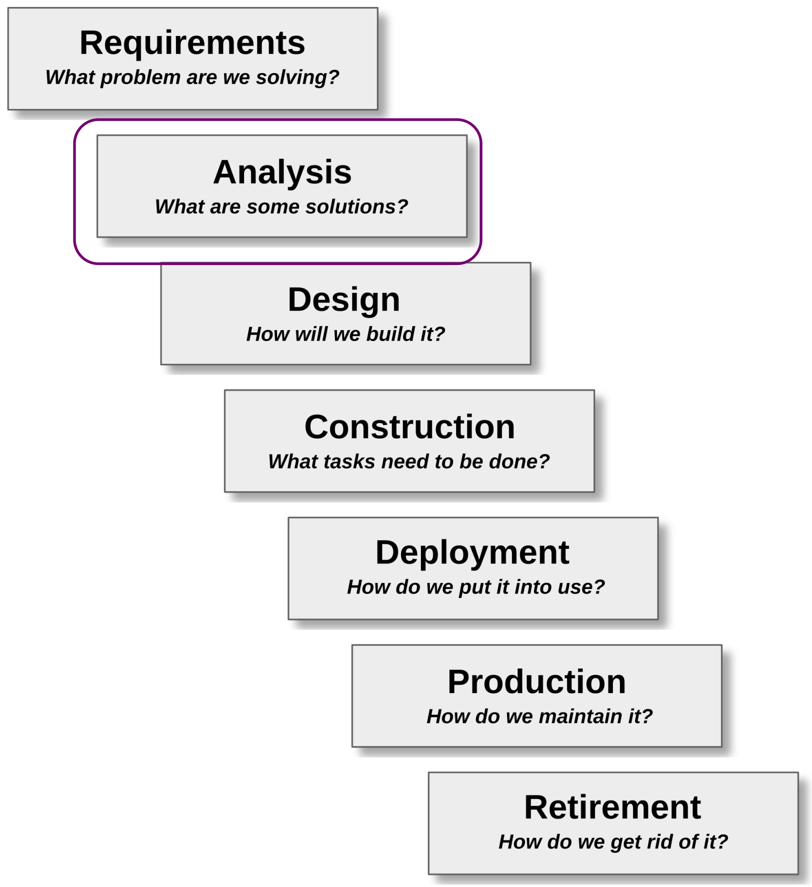
Requirements

- Identify the problem to be solved
  - What is needed by stakeholders
  - What factors constrain solutions
- Acceptance criteria
  - How will we know the problem is solved?
- Requirements types
  - Functional, non-functional (performance) and business
  - Security requirements are now considered separate from general non-functional requirements



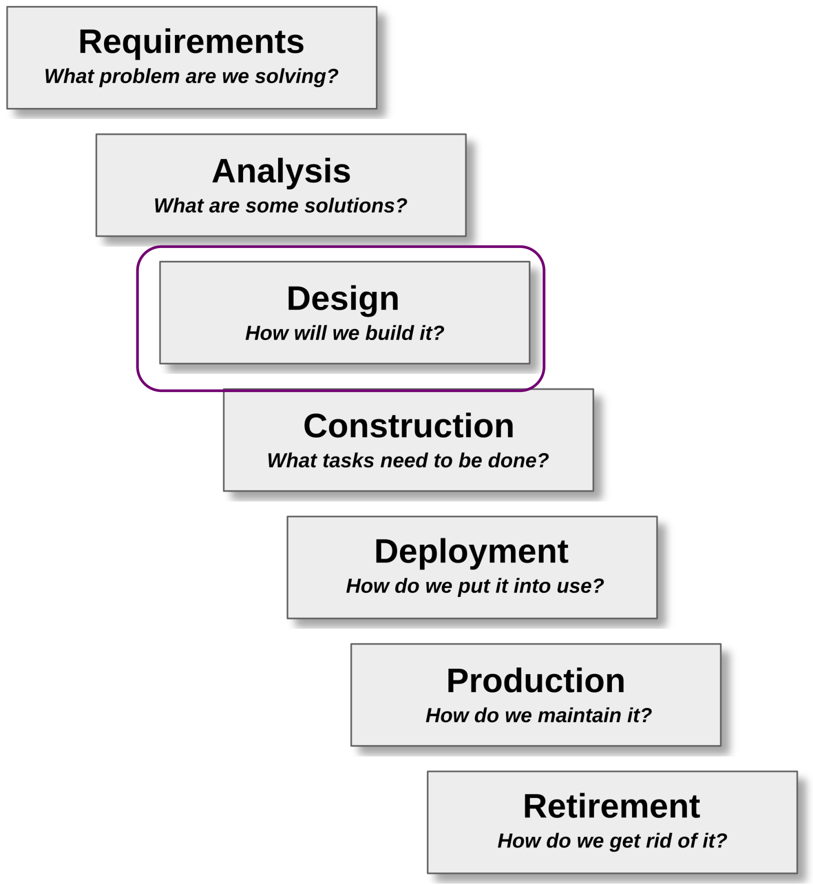
Analysis

- Evaluate possible solutions
  - What would a solution look like?
  - How would it perform?
  - How would it be organized?
  - How would it be tested?
- Evaluate possible architectural choices
  - High level design
- Initial threat analysis
  - What sort of security and operational threats does the solution raise?



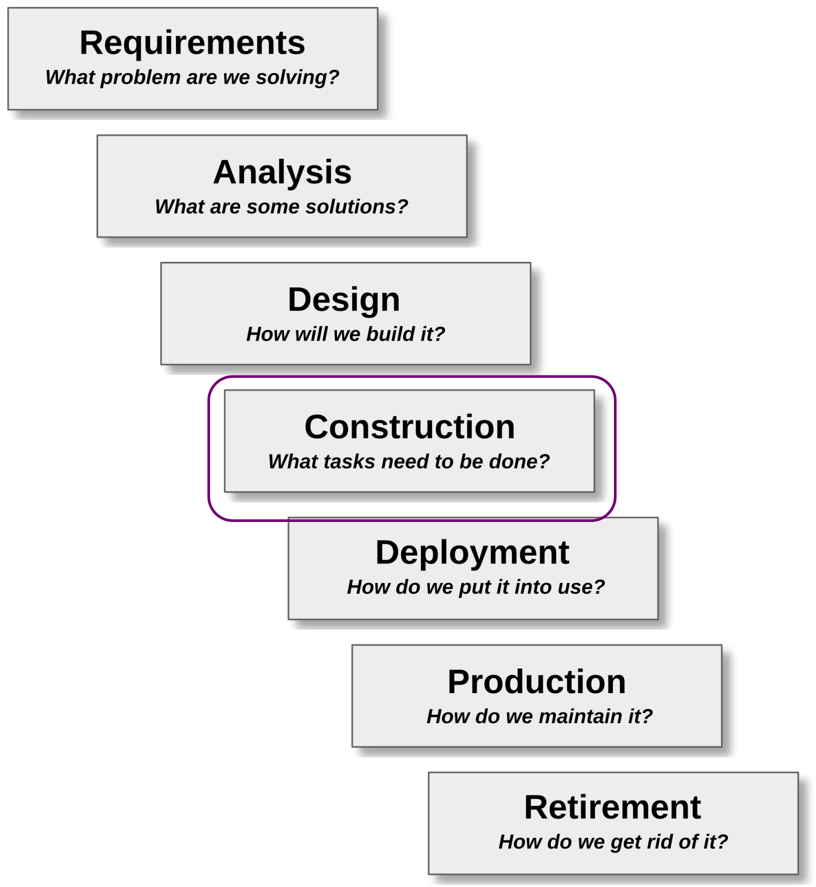
Design

- Only one solution can be built
  - What is possible with the available resources?
- Define the concrete architecture
  - Design the components
  - Design how they interact
  - Choose technologies for construction of the components
- Define the plan for construction phase
- Identify the security vulnerabilities introduced by the choice of components



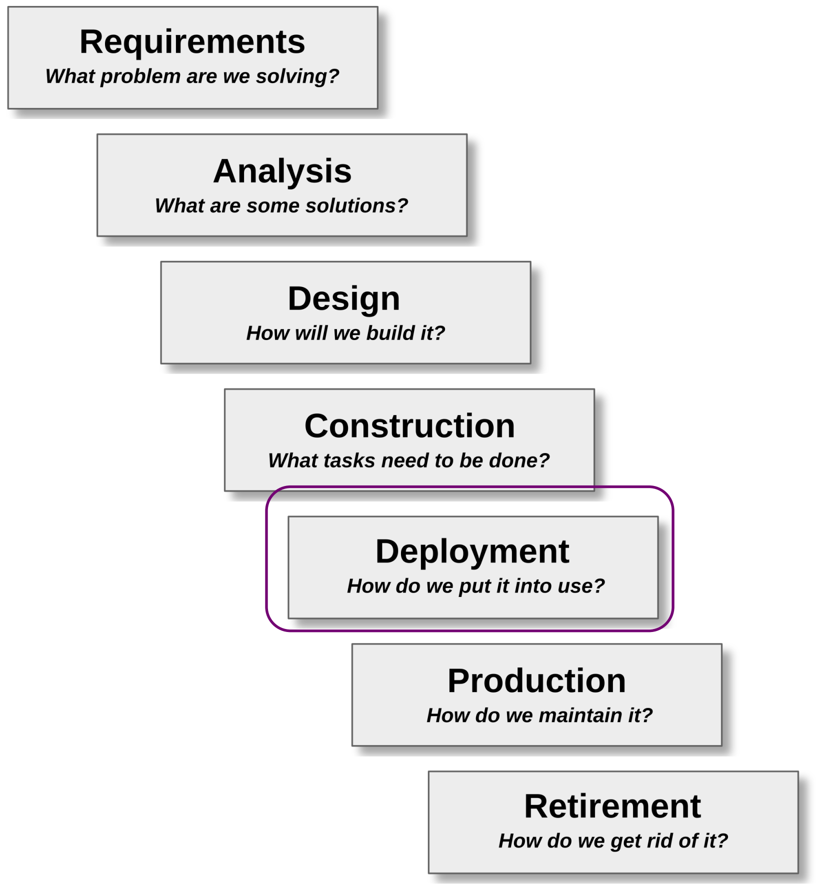
Construction

- Apply a development process
  - Roles and responsibilities
  - Testing, coding, etc.
- Define the methodology
  - Agile/Scrum, etc.
  - Code, build, test
- Identify new security issues as they arise during construction



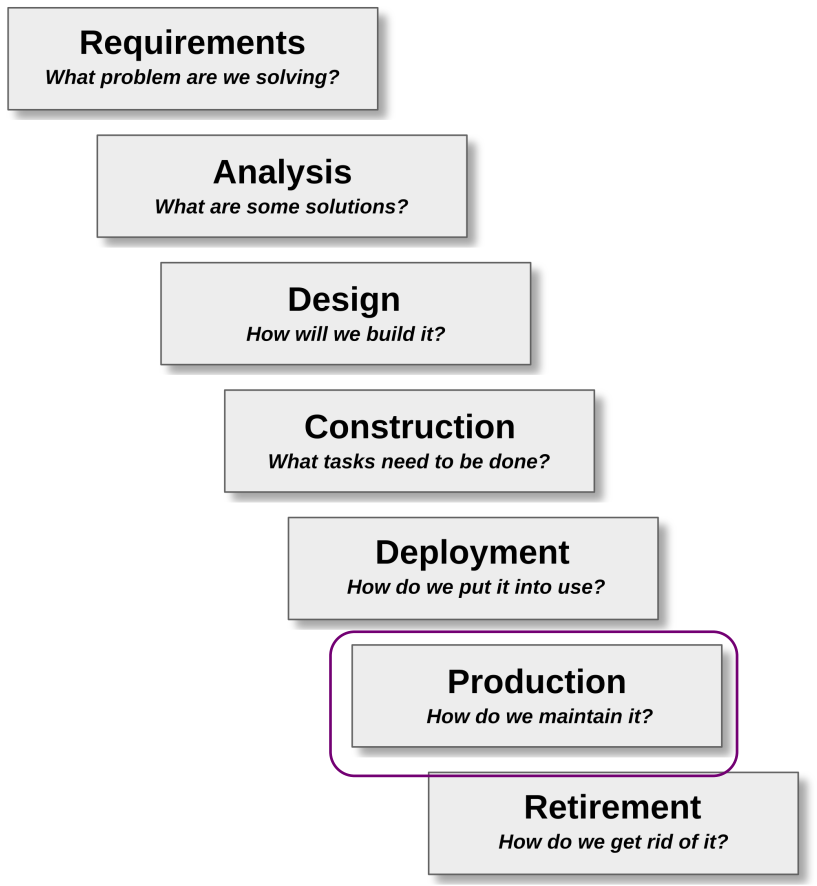
Deployment

- Get the application into production
  - Roll out logistics
  - Continuous Deployment?
- Beta test and acceptance test
- Transition existing operations to the deployed app
- Various deployment strategies can be used
  - Green/Blue
  - Canary, etc.
- Goal is to ensure a successful transition to the application



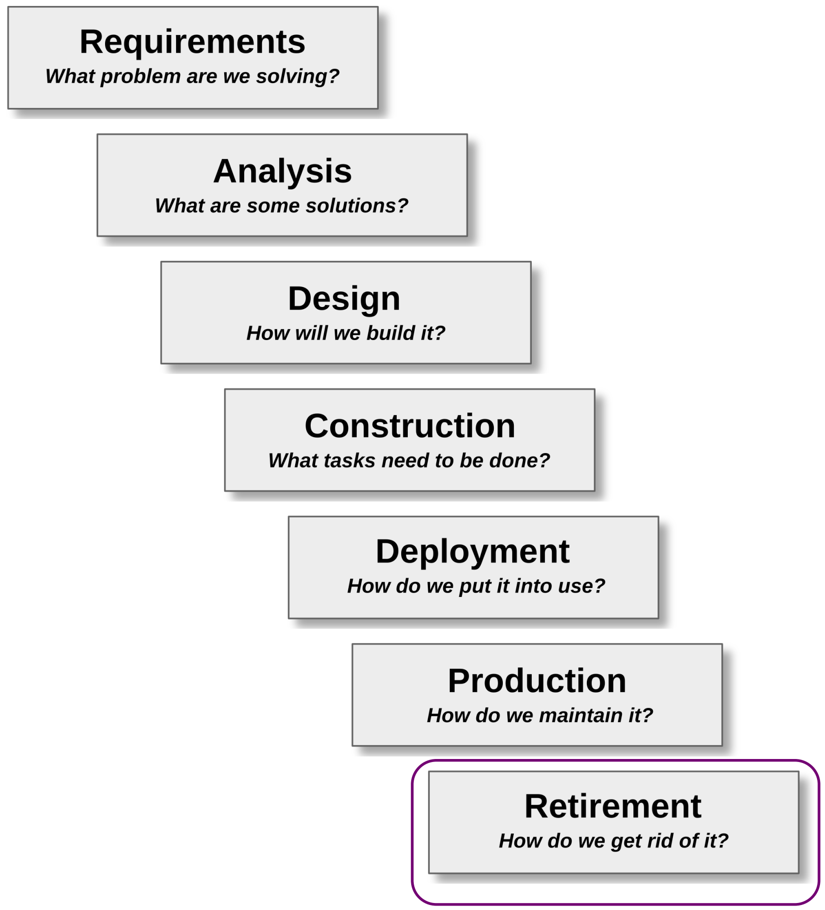
Production

- Monitor performance
  - Manage changing requirements
  - Collect data for future development
  - Evaluate service level agreements
- Look for “gotchas” in the real world
- Identify new or emerging security threats
  - Exploits may be developed after deployment
  - Want to avoid 0-day exploits by getting patches and mitigations rolled out ASAP



Retirement

- How do we take the application out of production?
  - What are the implications for other systems that interact with our application?
- How do we transition users to the application's replacement?
- Ensure that once the application is removed, there are no security holes left behind



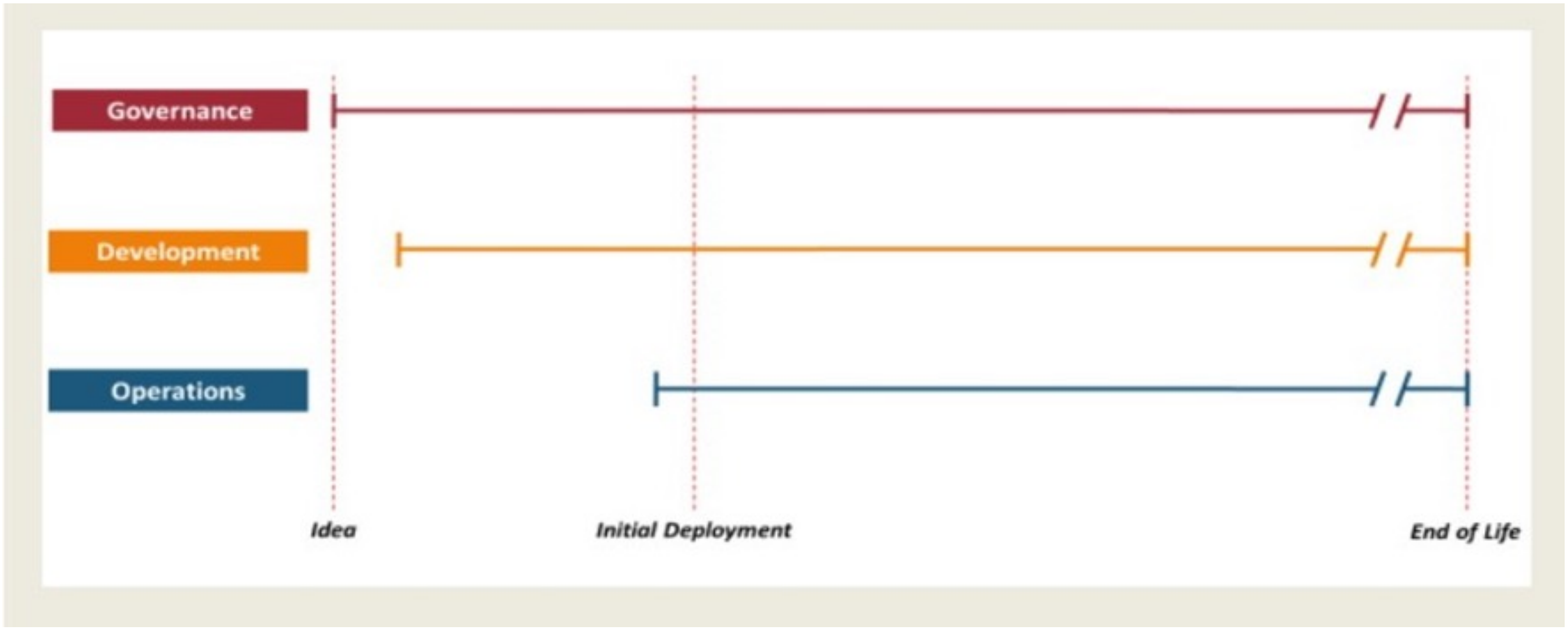
System Lifecycles and SDLCs

System Lifecycles

System Lifecycle Management

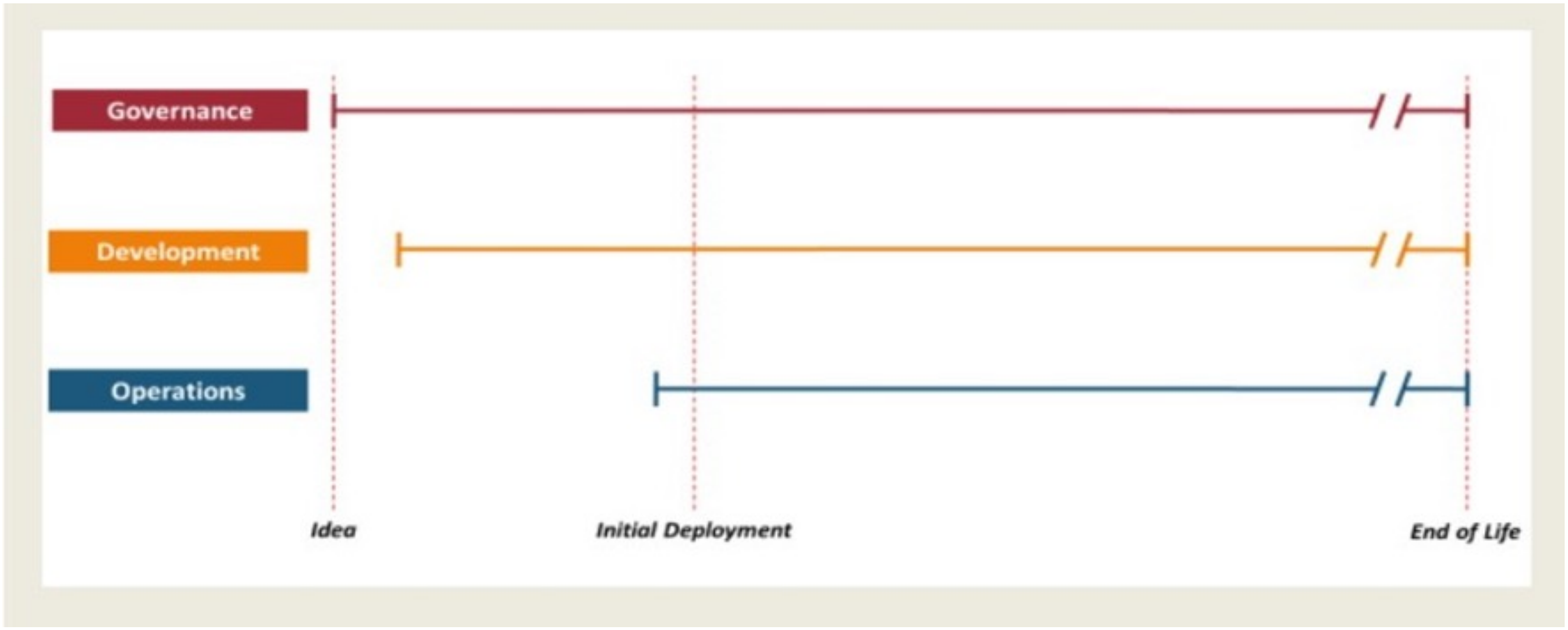
- Also referred to as Application Lifecycle Management (ALM)
- Most development processes only deal with activities up to the delivery of the finished product
- SLC takes the larger view of treating any software-based product, or cyber-physical product, like any other product
  - The whole of the engineering process is managed
- Does not replace a software development lifecycle (SDLC)
  - The application lifecycle is defined to be:
    - "the entire time an organization spends money of the product from the initial idea to the end of the application's life when it is no longer in use."
- Also requires the evaluation of the product from three points of view:
  - The business perspective
  - The development perspective
  - The operations perspective

System Lifecycle Management



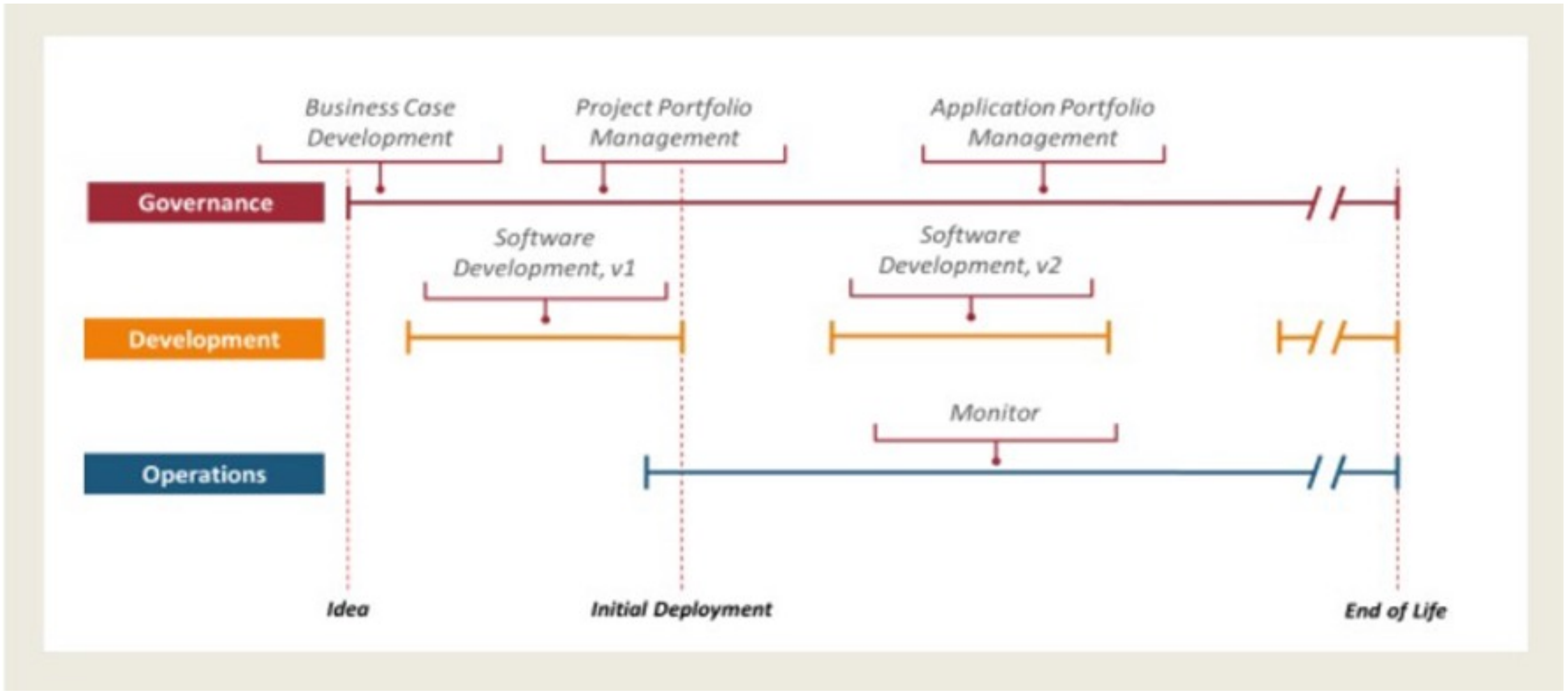
- Three main milestones
- Idea or Inception:
  - Before the start of the development process
  - Usually involves evaluating the business case, portfolio management issues and feasibility considerations
  - Provides a Go/NoGo decision before development starts

System Lifecycle Management



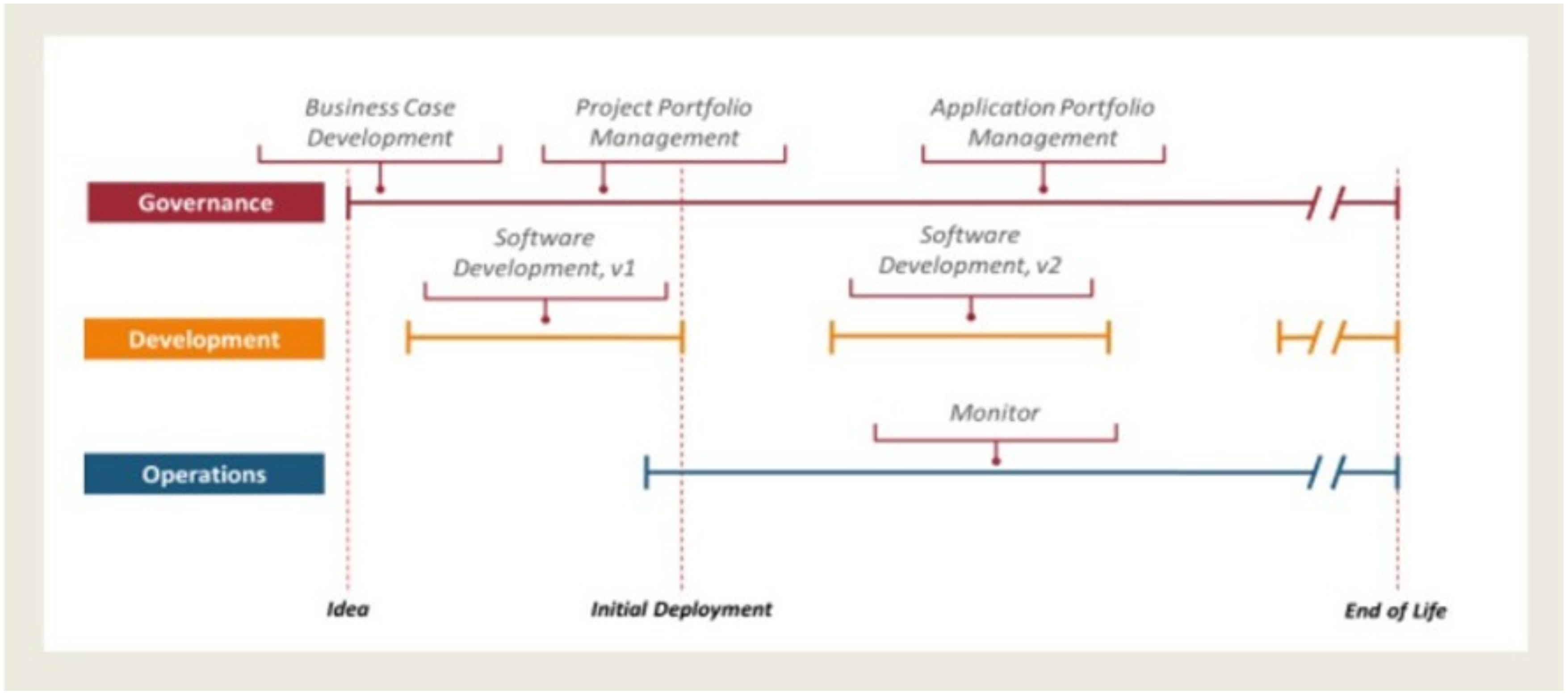
- Deployment:
  - Occurs when the finished product is moved into production and made available to users
- Retirement:
  - Ensures that at the end of life for the product, it can be taken out of production safely and without business or technical risk

Governance



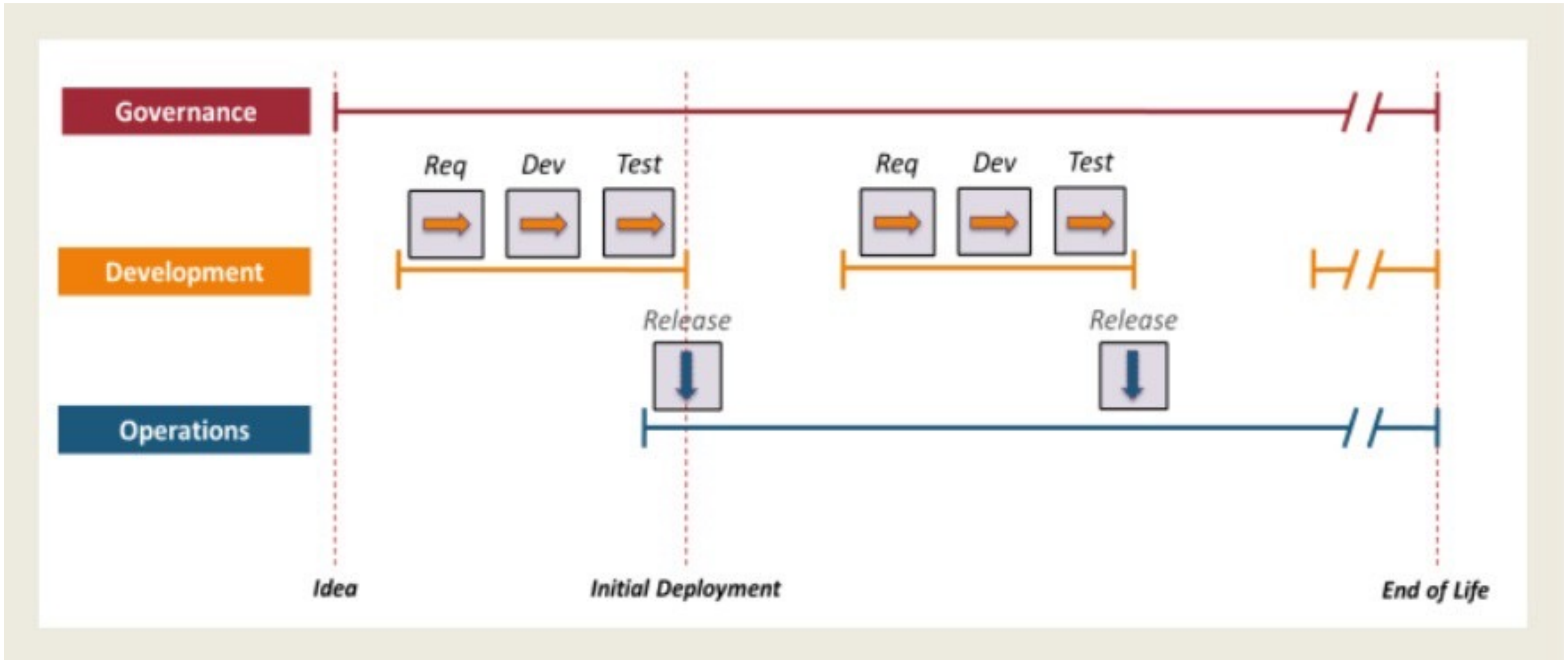
- Begins with business case and feasibility studies
- Portfolio management
  - Ensuring no overlap with other applications or any gaps that could create risk
  - Evaluation of risk, legal, social and other concerns
  - Makes mangement related decisions (like when to deploy)

Development

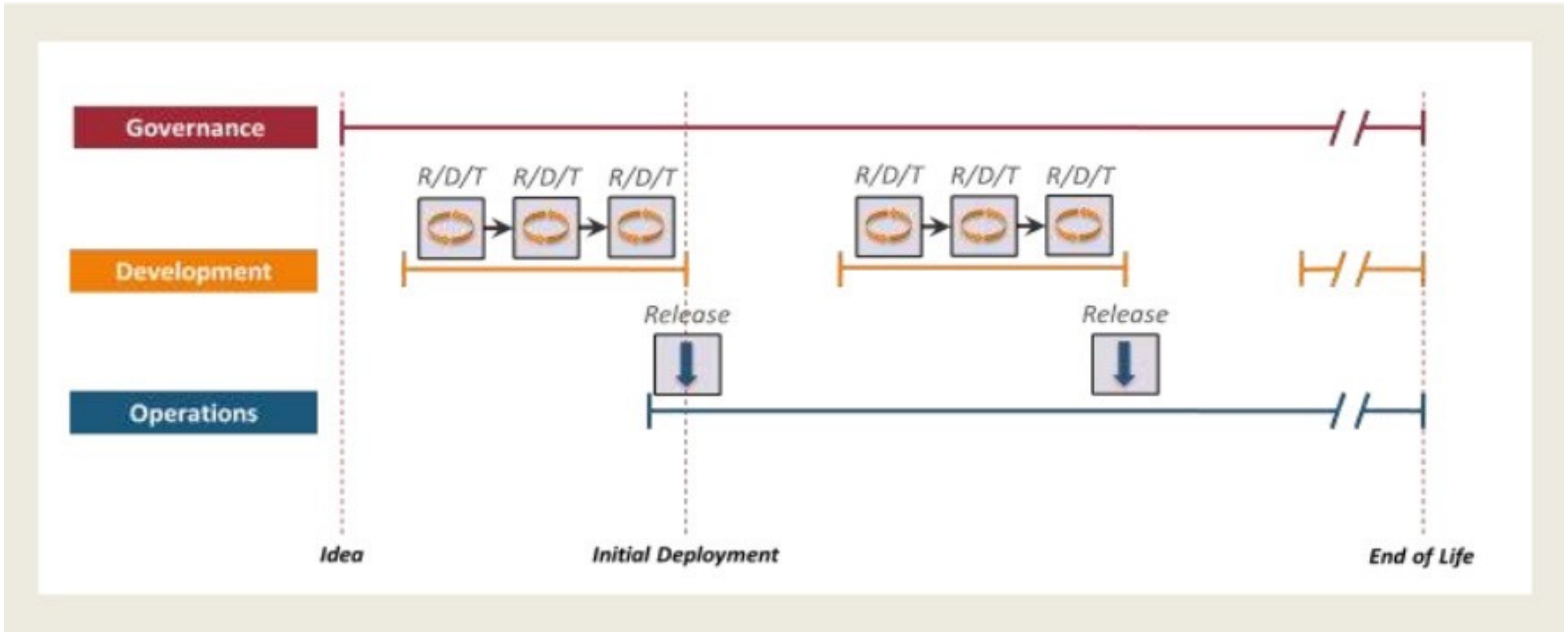


- Only concerned about the choice of methodology
- Integration with:
  - Records management, PM policies, security, etc.
  - Ensures that the development process is executed correctly
  - Requirements, Development, Test (RDT) is executed

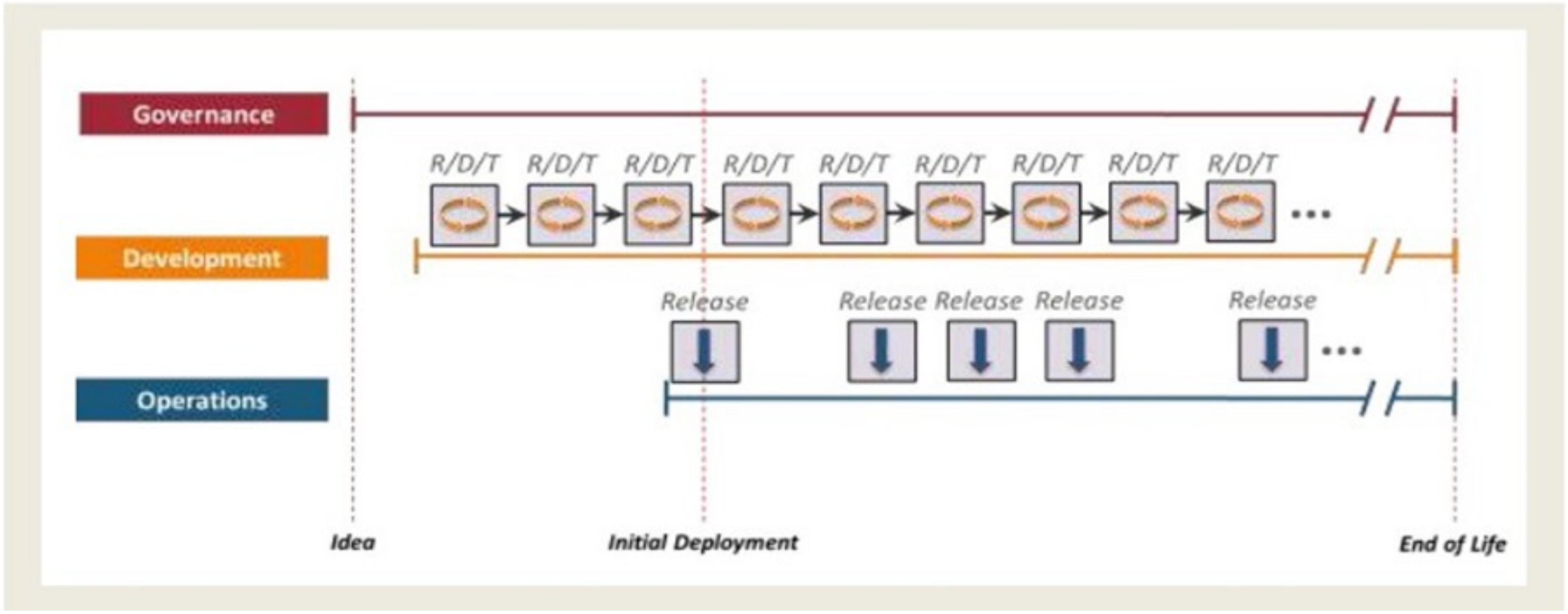
Development - Waterfall



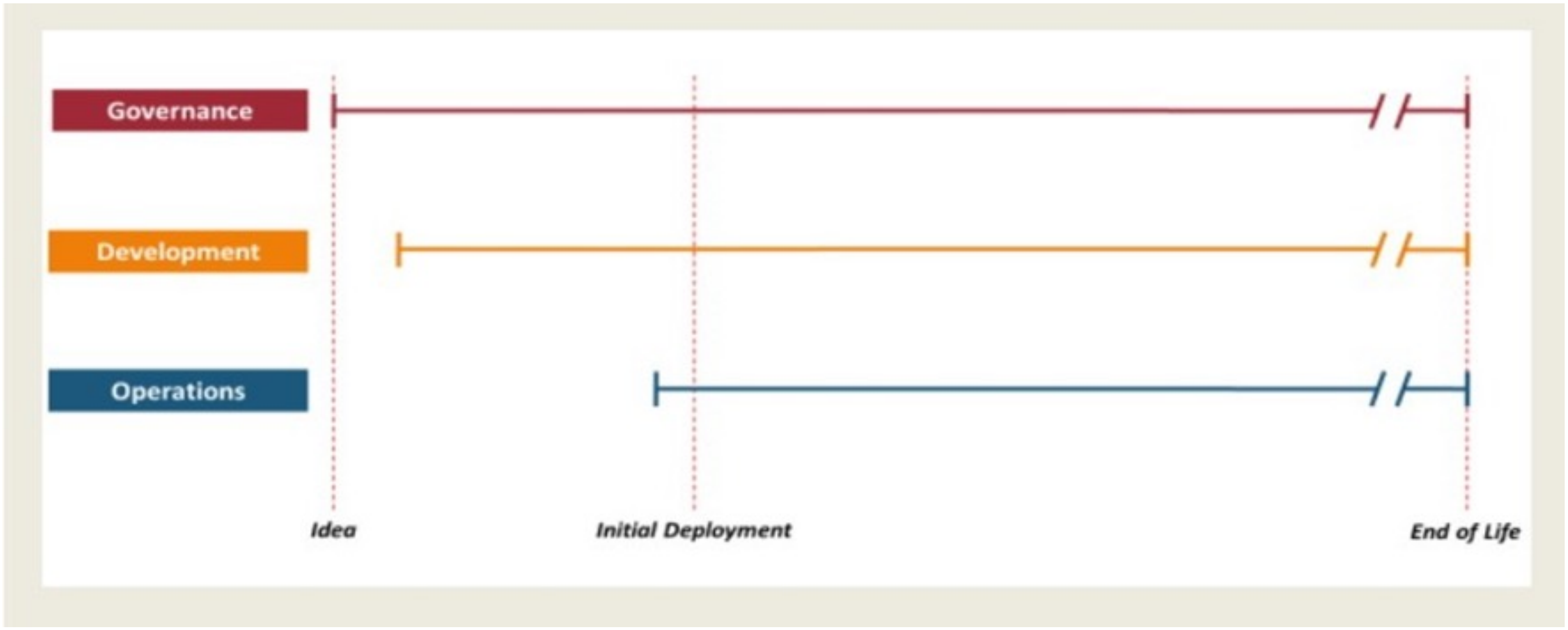
Development - Agile



Development – Continuous Deliver



Operations



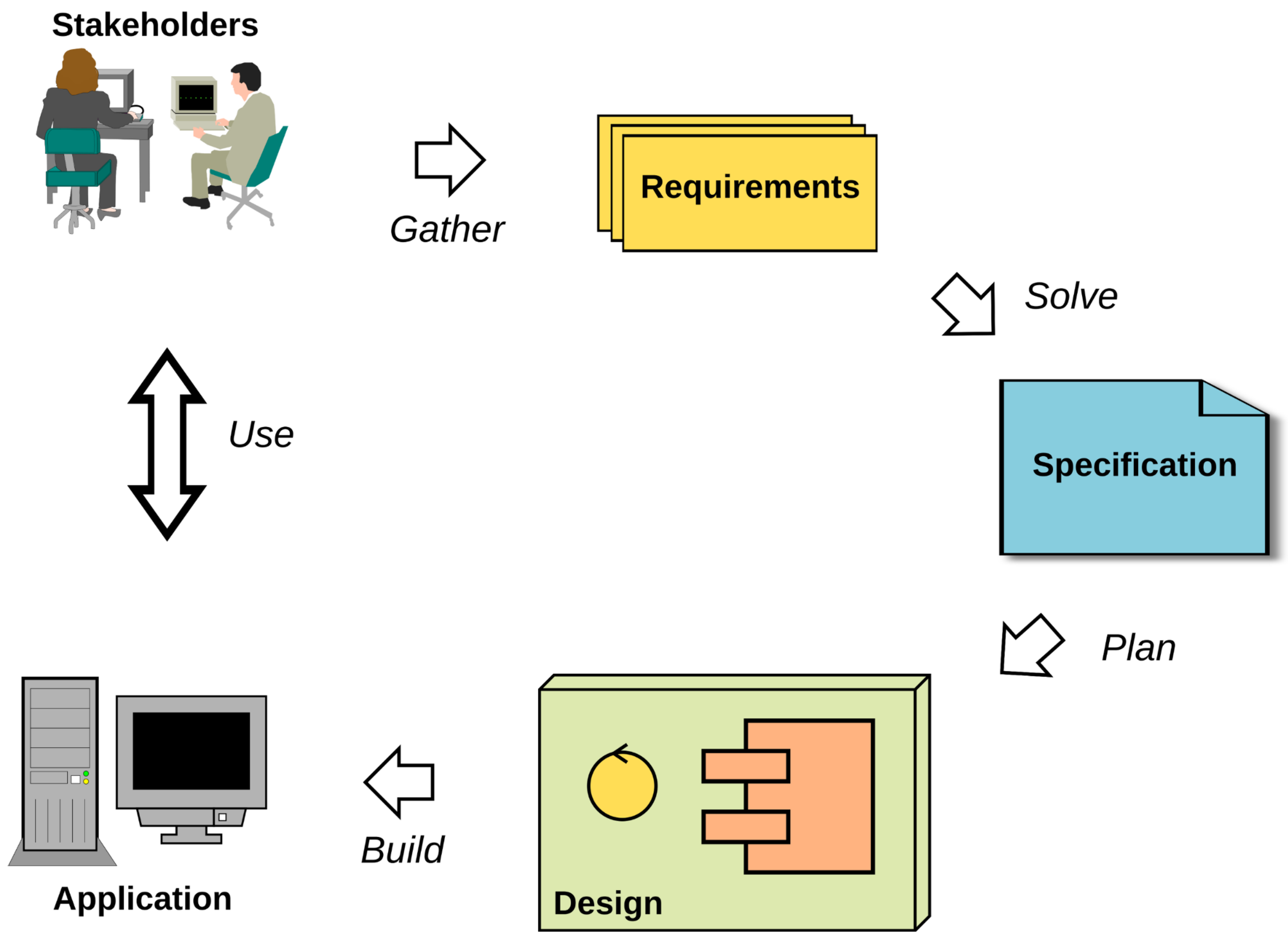
- During deployment, governance makes decisions and development makes changes
  - Ops provides context for making dev and govern work together
  - Ops monitors usage, performance, service level targets, change requests and bug reports
  - Also monitors changes in the application's technical environment that could impact the application

System Lifecycles and SDLCs

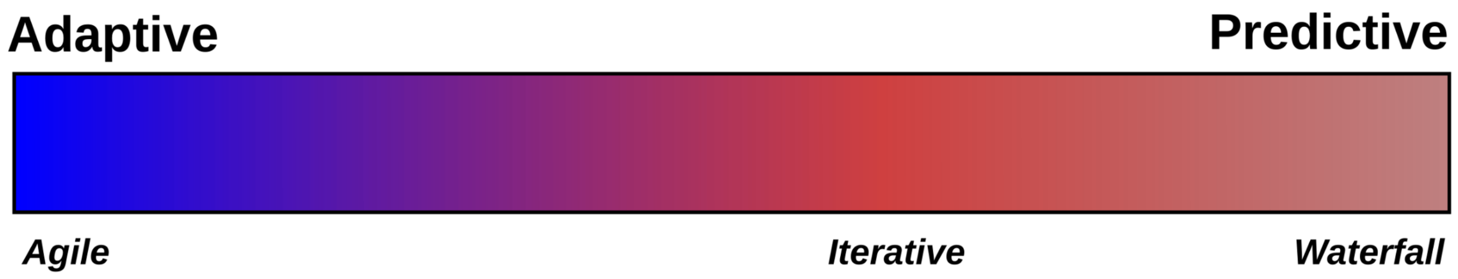
Software Development Lifecycles

SDLC

- Software Development Lifecycle
  - Defines the organization of work during the construction phase
  - Follows the Engineering process from requirements to deployment



SDLC Types



- Depends on how many of the requirements are knows at the start of the project
- Two basic endpoints on a continuum:
  - Predictive: We know all the requirements so we can predict exactly what the delivered product should be
  - Adaptive: We only have partial requirements, so we deploy prototypes iteratively in order to explore unknown requirements
  - Most projects will lie somewhere on the scale of adaptability
- Predictive methods go through the engineering process once
- Adaptive method go through the engineering process multiple times
  - Each iteration adds an increment of development

Predictive Processes

- All the requirements are known at the project start
  - Characteristic of projects that have high amounts of risk
  - Usually implemented as a waterfall SDLC
- The final result or target can be accurately specified
  - Very important for mission critical systems like software that runs a nuclear reactor cooling system or a heart pacemaker
- Often not suited for software that users interact with
- Predictive SLDCs start to become very inefficient and ineffective when requirements change quickly or are not completely known
  - Especially true of new or innovative software

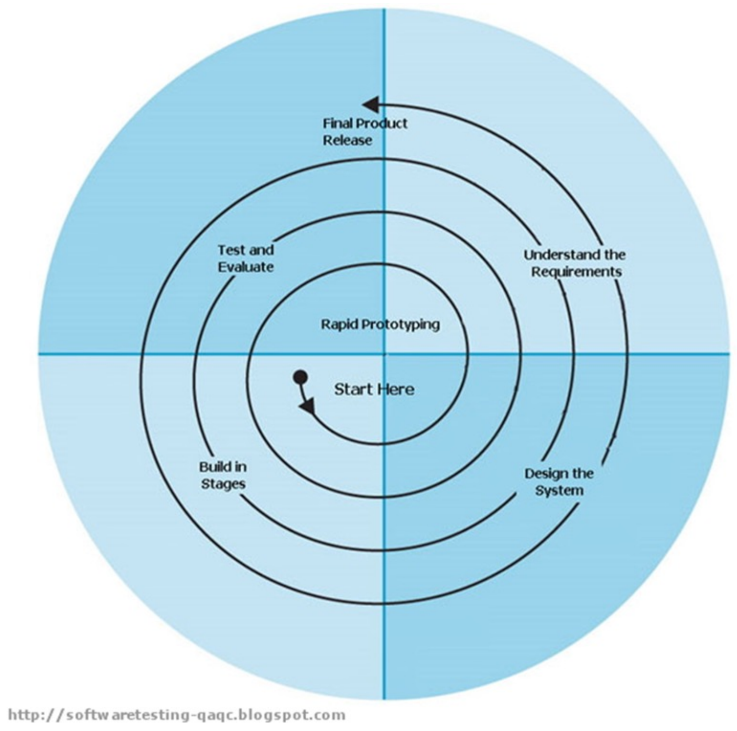
Adaptive Processes

- Many of the requirements are not known at the project start
- Very often we are focused on solving a problem but the nature of the solution is unknown
  - We must take a trial and error approach
- We may be deploying new technology where requirements are not yet known
- Stakeholders have no idea what their requirements would be and often need to have a prototype to play with to start to identify their requirements
- Most commonly needed when requirements are fluid (like with user interfaces or automating interactions

Iterative Processes

- Most of the requirements are known at the project start
- Some new or some changes to requirements are anticipated
- Process works in iterations which are mini-projects
- At the end of each iteration, there is a re-evaluation of the requirements, specification and design
- Tends to be used a lot in developing cyber-physical systems
- Often used instead of a predictive process when risk is important but not all the requirements are available

Non-Agile Adaptive SDLCs



Barry Boehm's Spiral methodology from 1986 defined a series of iterations with the objective of producing prototypes which were used to provide inputs into the subsequent iterations.

Another adaptive methodology is James Martin's Rapid Application Development (RAD) developed in the 1980s at IBM.

Both SDLCs was built around the idea that for some sorts of development, like working with user interfaces, the requirements are too fluid for a predictive approach.

The RAD approach, like the Spiral methodology, centred around getting a prototype into the hands of the users to start generating feedback that would be used to continuously develop the

The Specification

- The specification is produced during the analysis activities
- The specification describes how what is being build
  - Will function and perform
  - Will interact with users and other systems
  - Will interact with the organizational environment
- The specification can take many forms
  - A common part of Agile specs is a complete set of acceptance tests
- Role of the spec
  - Developers must define exactly how their code will work
  - Enables testers to develop the quality control criteria for testing
- A critical part of the specification is how the system will meet the security and safety requirements

"If there is not enough information to write a test to a spec item, you don't have enough information to write code to implement it."

Test, Test and Test Again

More than the act of testing, the act of designing tests is one of the best bug preventers known.

The thinking that must be done to create a useful test can discover and eliminate bugs at every stage in the creation of software, from conception to specification, to design, coding and the rest.

If you can't test it, don't build it.
If you don't test it, rip it out.

Boris Beizer

IEEE Best Practices for Specs

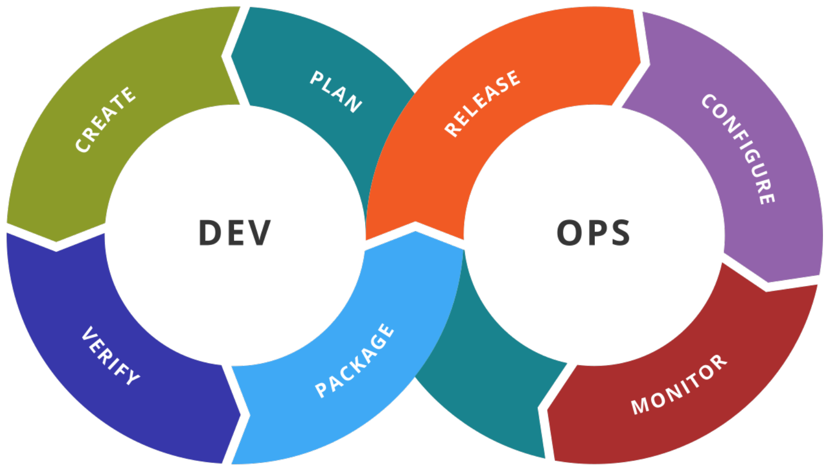
Complete	*The specfication covers all possible inputs and conditions, both valid and expected as well as invalid and unexpected.*
Consistent	*No two specification items require the system to behave differently under the same conditions, inputs and system state.*
Correct	*The described functionality for a spec item is consistent with the approp-riate business logic, processes and documentation.*
Testable	*Each specification item is quantified and measurable so that a pass/fail test can be written for it.*
Verifiable	*There is a finite cost effective process for ensuring each specification item is in the final product and can be evaluated.*
Unambiguous	*There is only possible interpretation of each specification item.*
Valid	*All stakeholders can read and understand each specification item so they can formally approve the item.*
Modifiable	*The specification items are organized in a way so that they are easy to use, modify and update.*
Ranked	*The specification items are in a priority order that both the business and technical sides agree on.*
Traceable	*Every specification item can be traced back to the original requirements criteria that it is intended to satisfy.*

System Lifecycles and SDLCs

DevOps and DevSecOps

The Rise of DevOps

- DevOps is not a development methodology
- It is a response to the virtualization like cloud providers
  - Infrastructure is now developed virtually
  - E.g., Terraform, Ansible, etc.
- Infrastructure as code (IaC)
- DevOps is the merging of the roles of Dev and Ops
  - Developers write code, Ops now write code
  - DevOps integrates the two roles through common tools
  - Enables *continuous integration* and *continuous deployment* (CICD)



Why IaC?

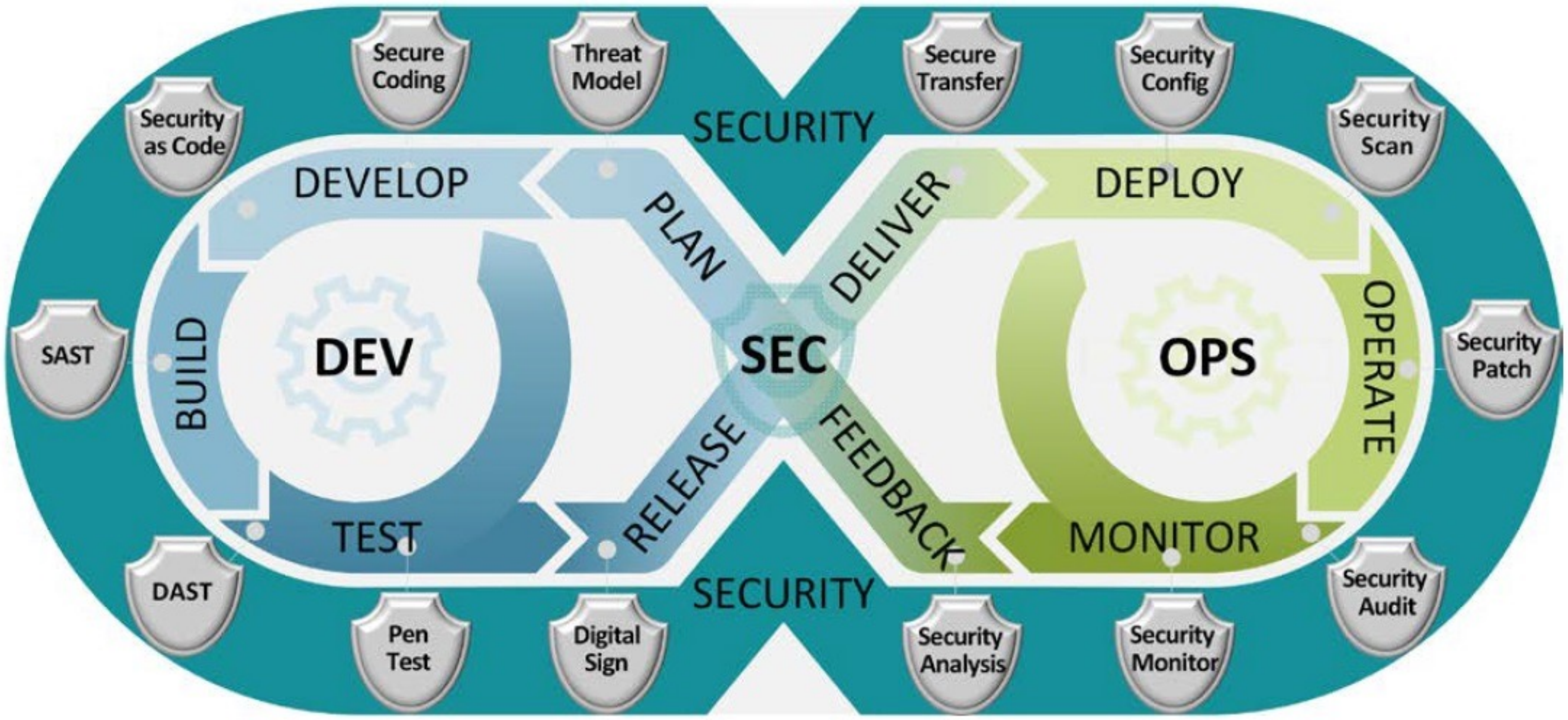
- Speed and simplicity
  - – Entire deployments can be set up or torn down by running a script
  - – Configuration consistency
  - – Identical copies of configurations can be created for testing or development
- Minimization of risk
  - – Reduces human procedural errors
  - – Allows for testing, reviews and other quality measures
- Increased efficiency in development
  - – Infrastructure code is not a bottleneck
  - – Allows for more efficient development and operations management
- Supported by main IoT development and operations platforms
  - – Cloud IoT development environments
  - – IioT development tools (e.g. IBM Engineering Lifecycle)

Why IaC?

- Self-service
  - Infrastructure deployment with scripts does not rely on an administrator
  - Speed and safety
  - Infrastructure is deployment and updated faster and with fewer errors
- Documentation
  - The IaC source files *are* infrastructure documentation
- Version control
  - Previous deployments can be maintained in source control for regression or audit need, or to satisfy regulatory requirements
- Validation
  - For every single change, code reviews and dynamic testing can be performed
- Reuse
  - New infrastructure deployments can be derived quickly from previous deployments

DevSecOps

- Automatically bakes in security at every phase of the software development lifecycle



"The purpose and intent of DevSecOps is to build on the mindset that everyone is responsible for security with the goal of safely distributing security decisions at speed and scale to those who hold the highest level of context without sacrificing the safety required," describes Shannon Lietz, co-author of the "DevSecOps Manifesto."

DevSecOps Advantages

- Rapid, cost-effective software delivery
  - Security problems can lead to huge time delays
  - Fixing security issues can be time-consuming and expensive The rapid
  - DevSecOps saves time and reduces costs by minimizing the need to repeat a process to address security issues after the fact
  - Integrated security cuts out duplicative reviews and unnecessary rebuilds, resulting in more secure code
- Improved, proactive security
  - Throughout development, code is reviewed, audited, scanned, and tested for security issues
  - Security problems are fixed before additional dependencies are introduced
- Compatible with modern development
  - Cybersecurity testing can be integrated into an automated test suite for operations teams

DevSecOps Advantages

- Repeatable and adaptive process
  - Ensures security is applied consistently across the operational and development environment
  - As the environment changes, security development adapts to new security requirements

DevSecOps Best Practices

- Shift left
  - Moves security from the end of a process left to the start of the development process
  - Security is an integral part of the development process from the start
- Security education
  - Combination of engineering and compliance
  - Requires development engineers, operations teams, and compliance teams work together
  - Ensures everyone understands the required security posture and follows the same standards
- Traceability, auditability, and visibility
  - *Traceability*: tracking configuration items across the development cycle from requirements to implemented code
  - *Auditability*: ensuring compliance with security protocols
  - *Visibility*: solid monitoring system in place during whole product lifecycle