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Software Development Models

Foundations of Software Engineering

FSE v2020.1, Block 1 Module 2

Alexey Artemov, Fall 2020

Lecture Outline

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§1. S/w development models overview [10 min]

1.1. Why models for software development?

1.2. Model classification: predictive vs. adaptive, incremental and iterative

§2. Predictive models: Waterfall [15 min]

2.1. Waterfall, V-model, Sashimi

2.2. Incremental waterfall models

Lecture Outline

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§3. Iterative models [15 min]

3.1. The spiral model

3.2. Unified process and RUP

§4. Agile models [15 min]

4.1. Challenges of traditional approaches

4.2. Agile manifesto: values and principles

4.3. Scrum Agile framework

4.4. Kanban Agile framework

The Goal:
Think Before You Code

§1. Software development models overview

Why models for software development?

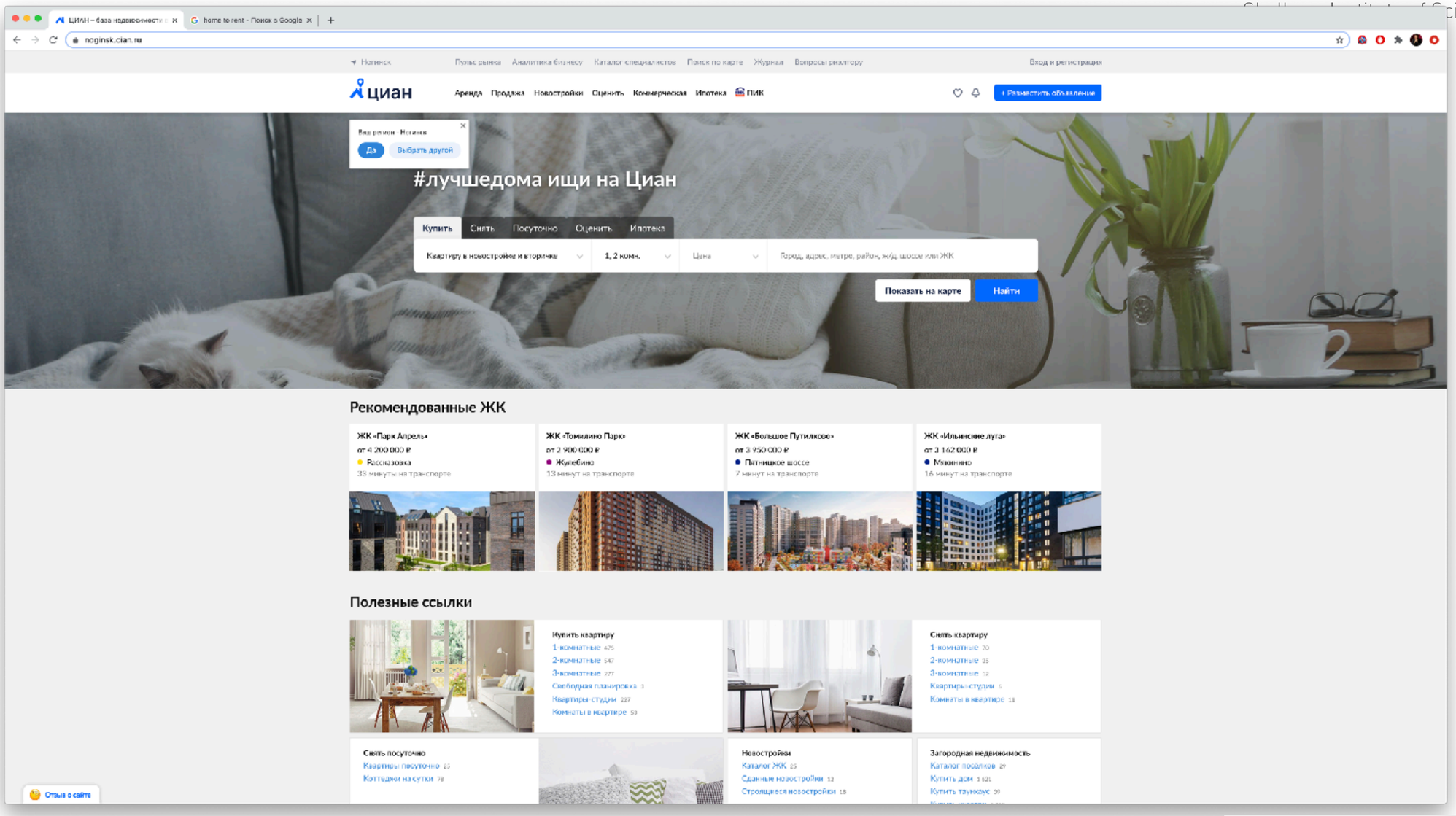
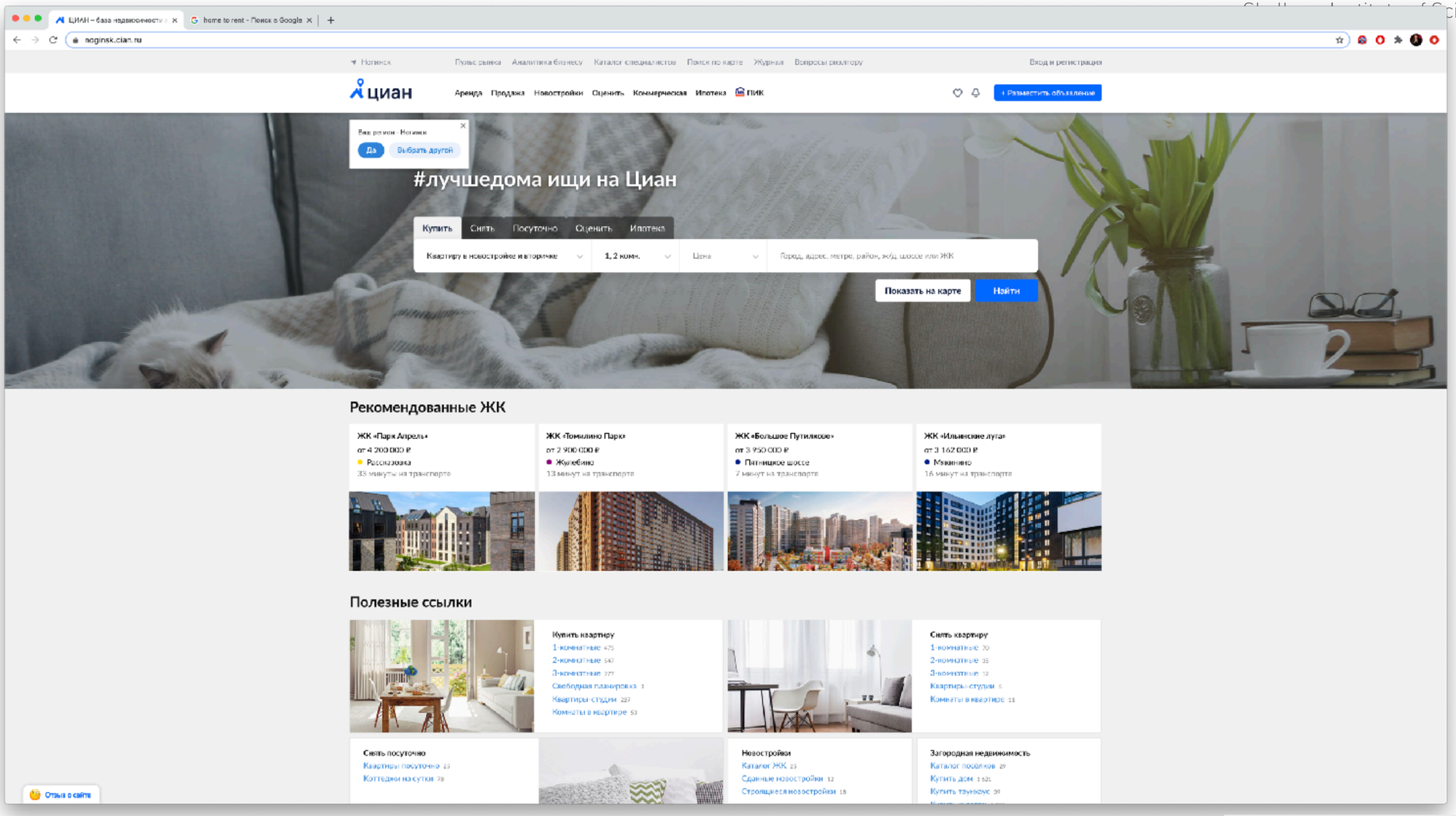


Image Credit: Alexey Artemov



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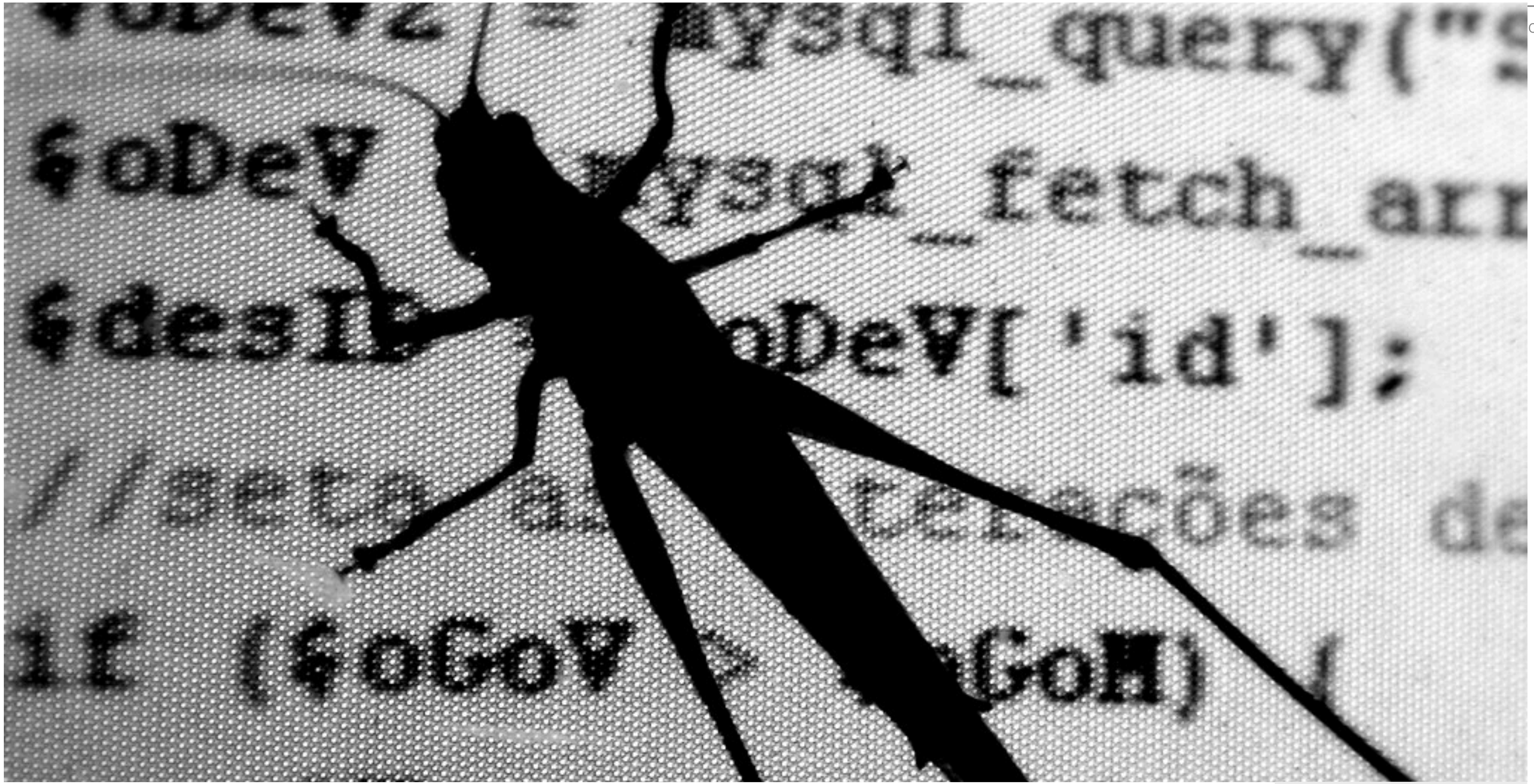


Image Credit: Guilherme Tavares

Image Credit: wikimedia commons

§1. S/w development models overview

1.1. Why models for software development?

- Address s/w engineering problems by adopting a methodology
- Goal for software development process models: create **a workflow that a team can use**
- Increase chances of produce high-quality software reasonably close to on time and within your budget

- Why many models?
  - Emphasize one part of development or another
  - Organisations are different
  - Many models so you can select the right one

How to classify software development process models?

§1. S/w development models overview

1.3. Model classification: predictive vs. adaptive, incremental and iterative

- How to classify models? Predictive vs. Adaptive
- **Predictive:**
  - You have a good understanding of the requirements (customers know exactly what they want)
  - You go through all phases, e.g. development and testing, in one shot

Image Credit: torange.biz

§1. S/w development models overview

1.3. Model classification: predictive vs. adaptive, incremental and iterative

- How to classify models? Predictive vs. Adaptive
- **Predictive:**
  - You have a good understanding of the requirements (customers know exactly what they want)
  - You go through all phases, e.g. development and testing, in one shot
- **Adaptive**
  - Customers have an idea
  - Developers build something to start
  - Customers provide feedback

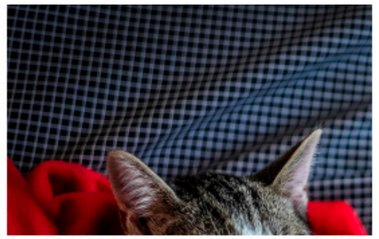
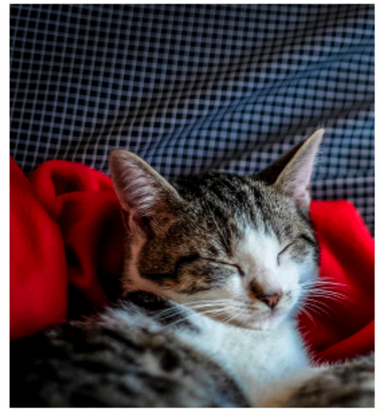
Image Credit: JISC

§1. S/w development models overview

1.3. Model classification: predictive vs. adaptive, incremental and iterative

- How to classify models? Predictive vs. Adaptive or Incremental vs. Iterative
- **Incremental:**
  - You have a good idea of what you need
  - Build in increments
- **Iterative:**
  - Build on top of simpler existing products
- Iterative is not incremental

Incremental development

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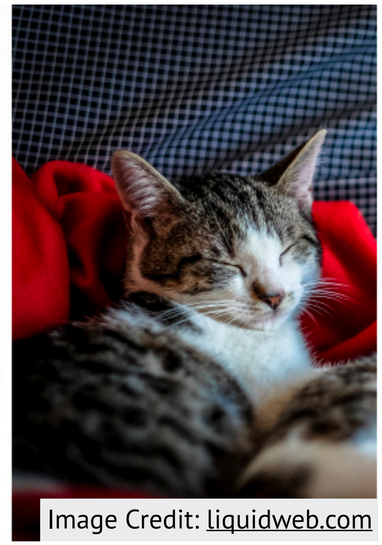
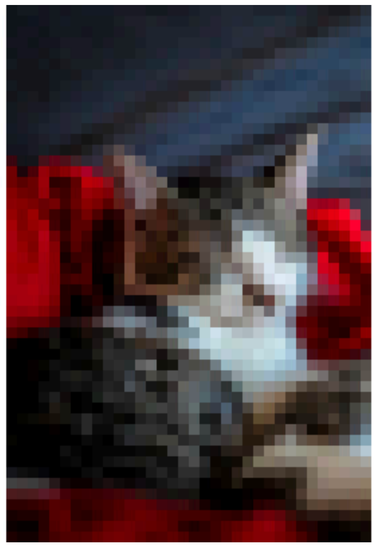
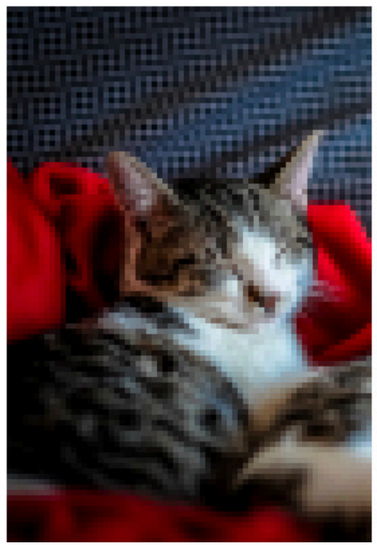
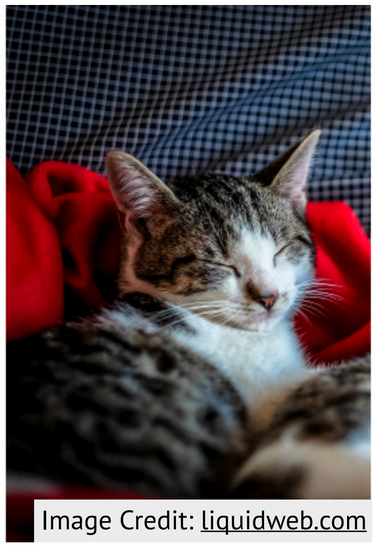


Image Credit: liquidweb.com

Iterative development

progressive JPEG

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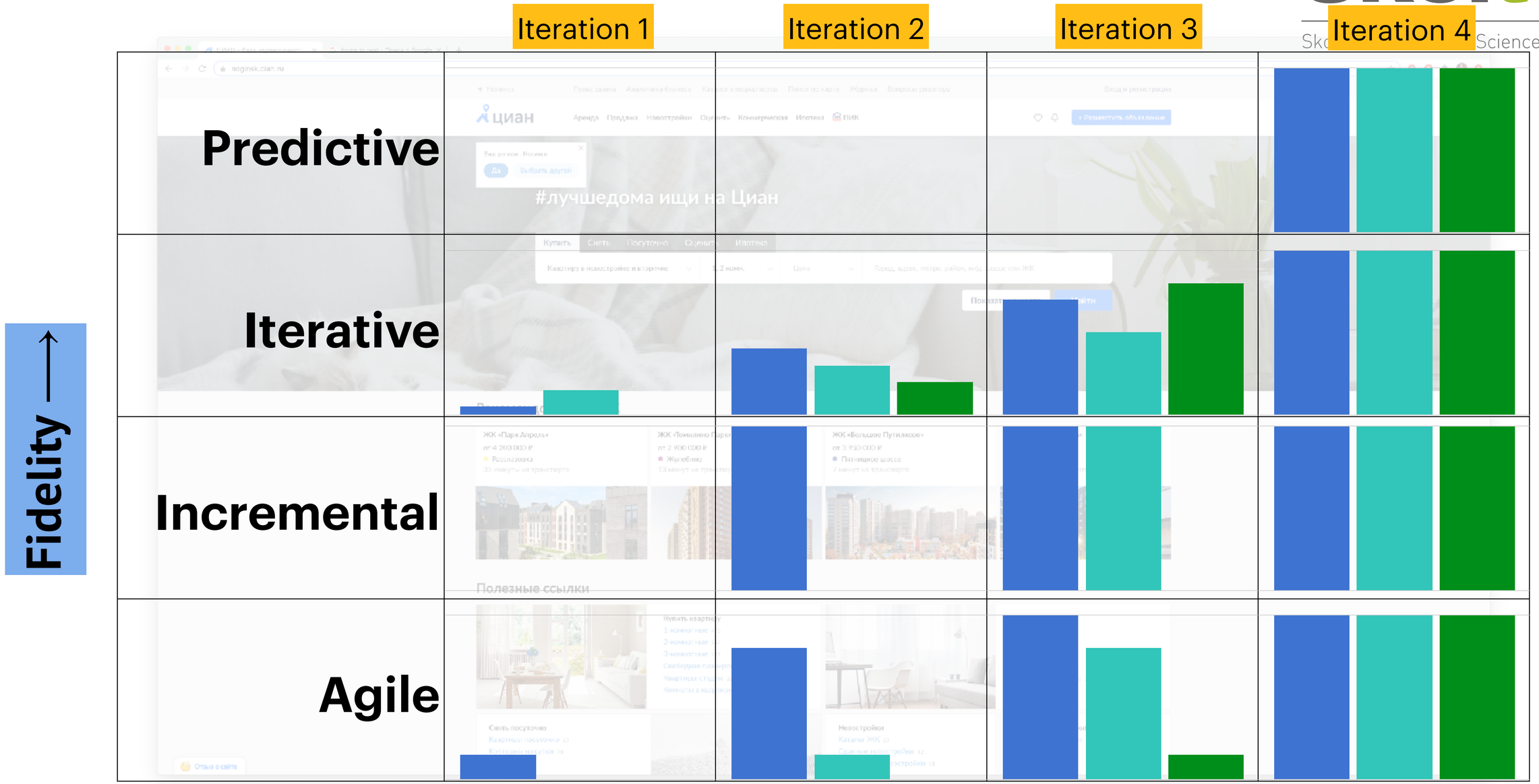

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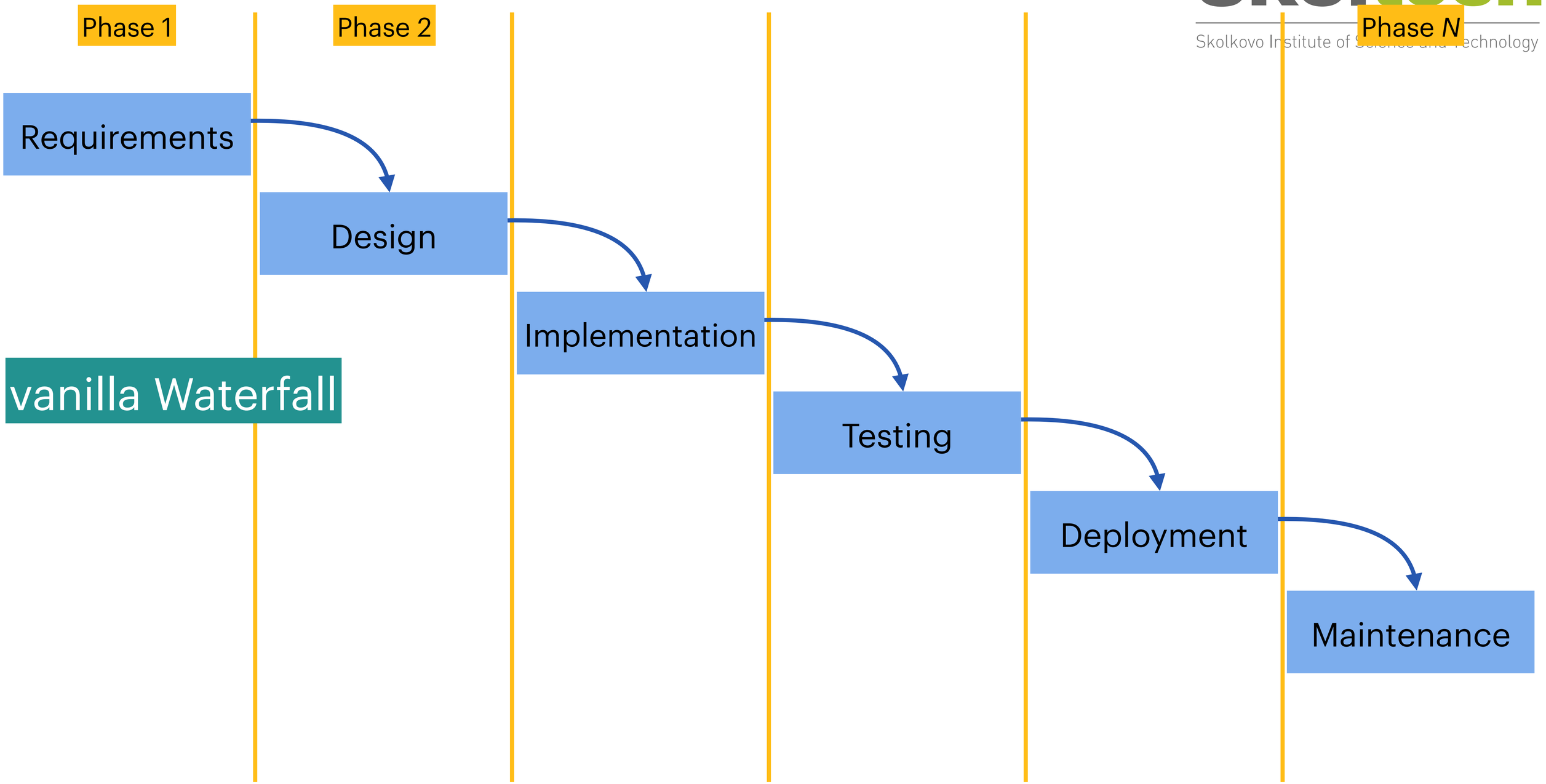
§1. Summary: s/w development models

- Process models: ways to organise workflow of your team
- Increase chances of produce high-quality software reasonably close to on time and within your budget

- Predictive vs. adaptive
- Incremental vs. iterative
- Agile

§2. Predictive models: Waterfall

Waterfall, V-model, and Sashimi


Phase 1
Phase 2
Phase N
Requirements
Design
Implementation
Testing
Deployment
Maintenance
vanilla Waterfall

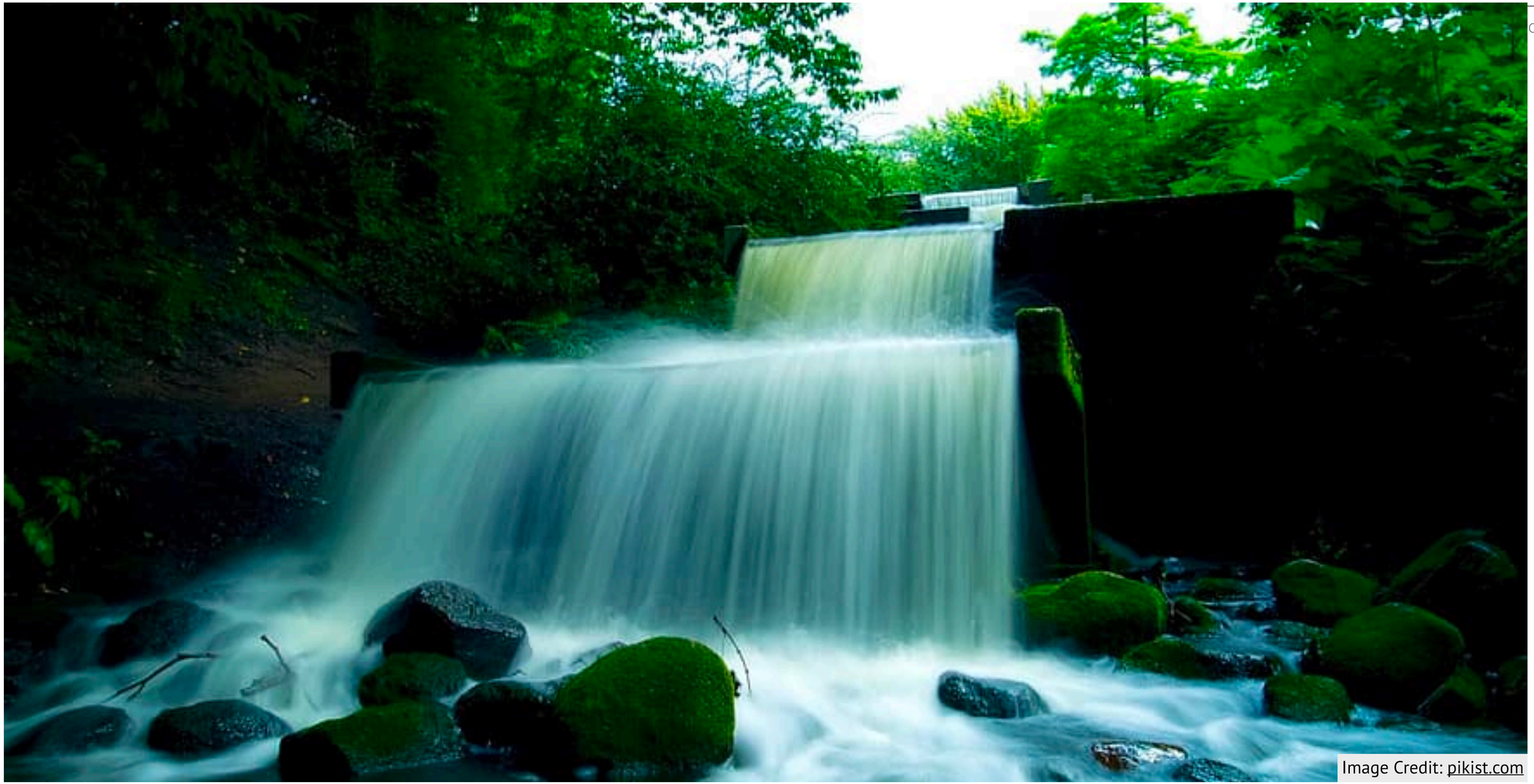


Image Credit: pikist.com

§2. Waterfall models

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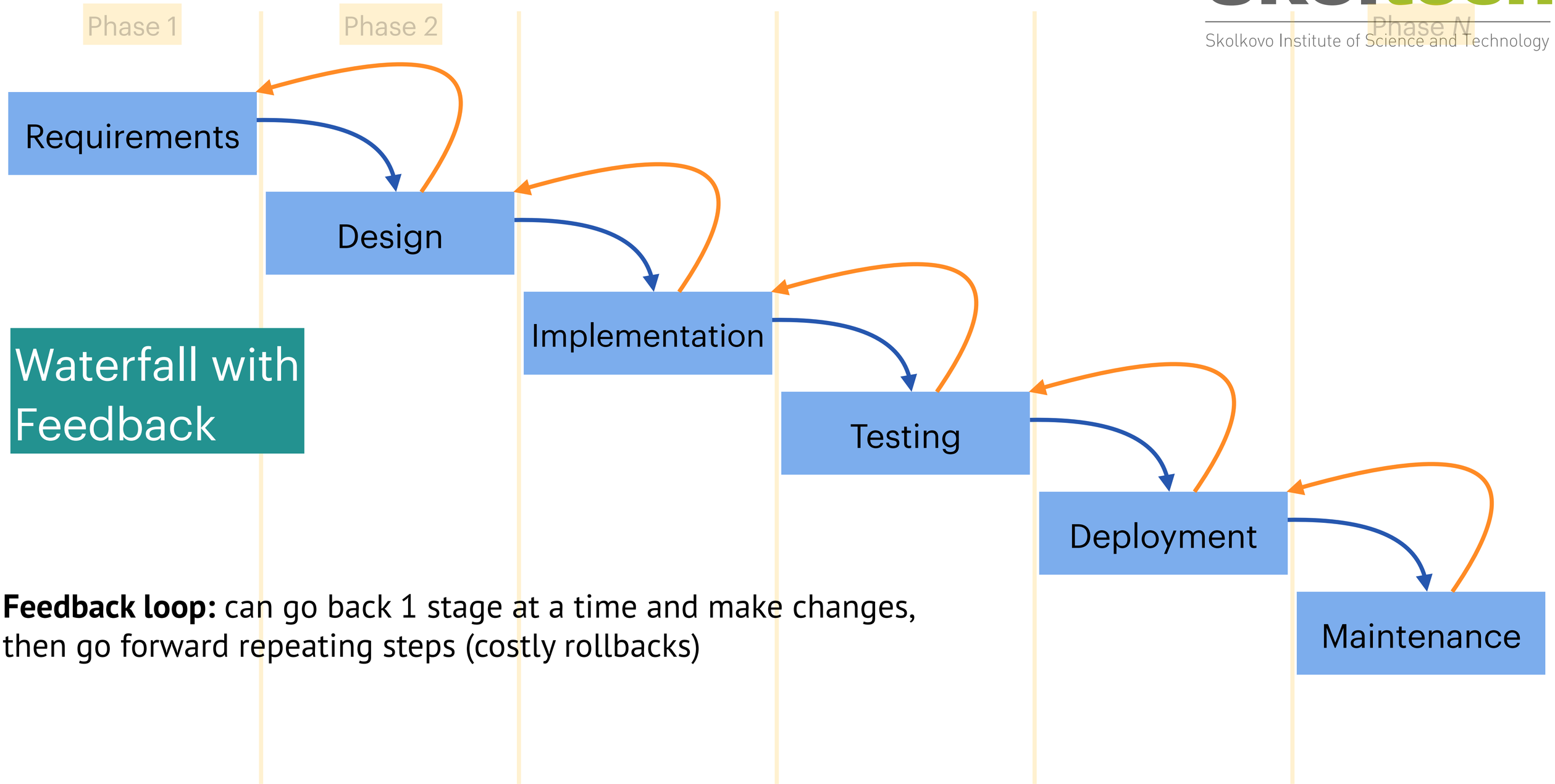
2.1. Waterfall

- **Waterfall** [works reasonably well when]:
  - Requirements are **known** very well, include **no unresolved high-risk** items, and **won't change**
  - Team has experience building something similar
  - Transition requirements -> product
- Pros:
  - Very **predictive** model (requirements known upfront)
  - Very efficient process (simple and robust)
- Cons:
  - Not flexible
  - No early release / value during development process



Feedback loop: can go back 1 stage at a time and make changes, then go forward repeating steps (costly rollbacks)

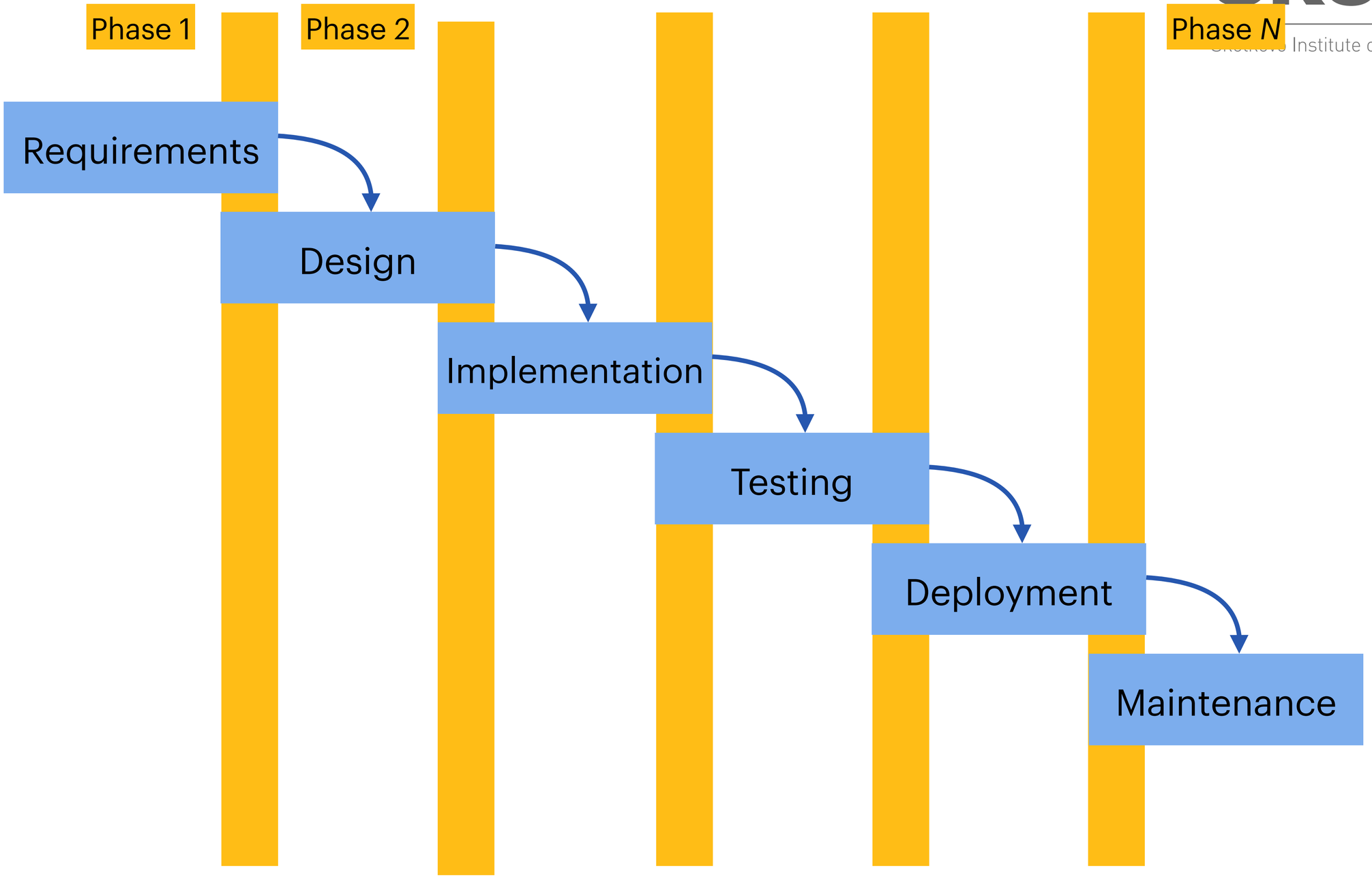
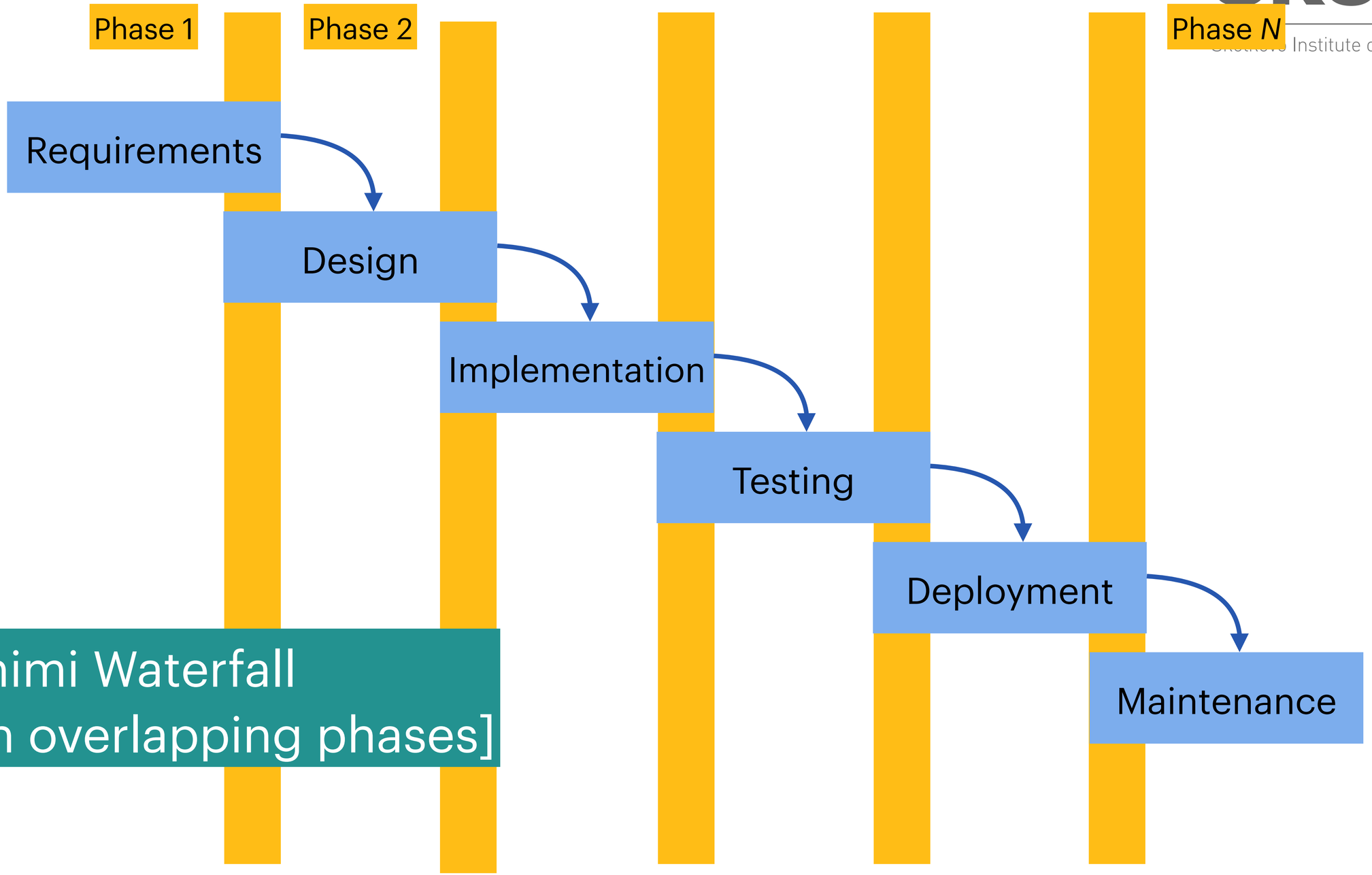

Phase 1
Phase 2
Phase N
Requirements
Design
Implementation
Testing
Deployment
Maintenance

Image Credit: Wikimedia



Sashimi Waterfall [with overlapping phases]

§2. Waterfall models

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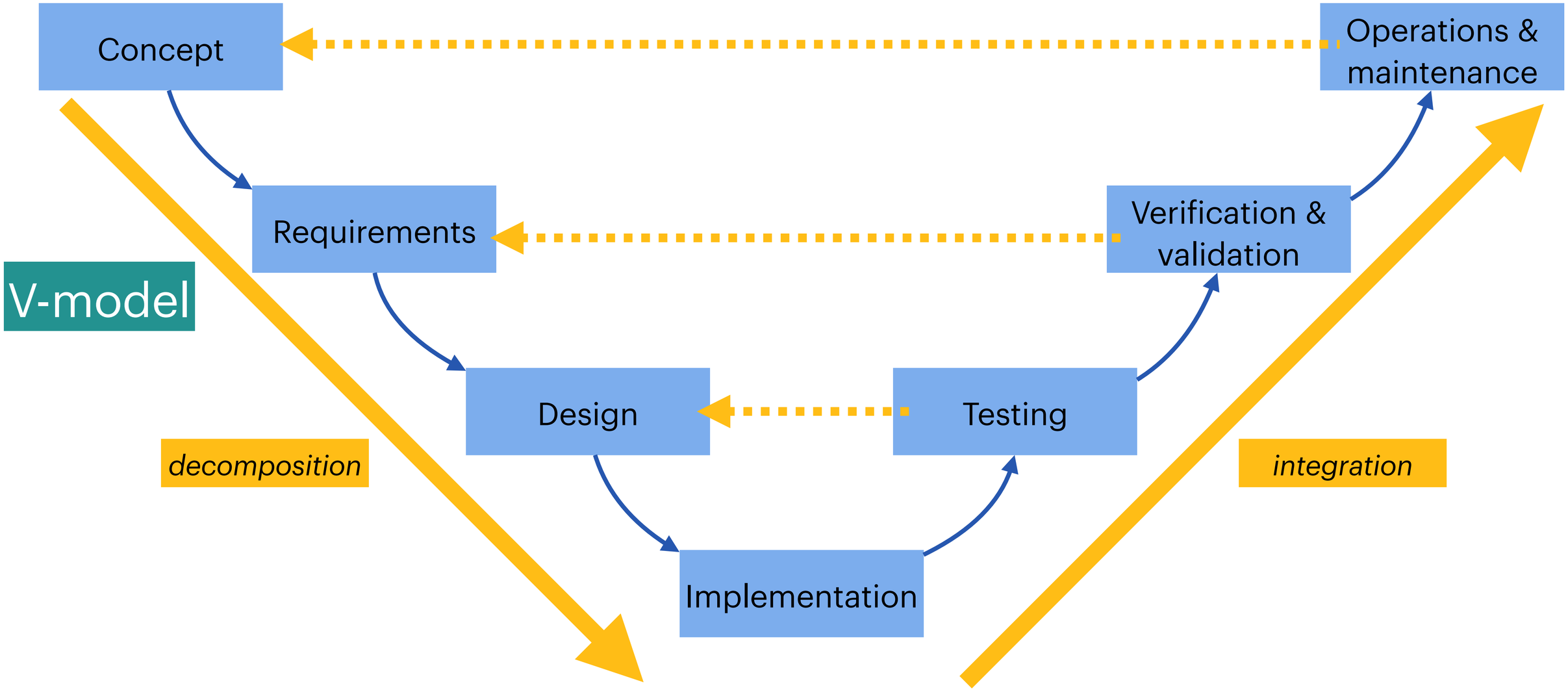
2.1. Sashimi

- **Sashimi** [works reasonably well when]:
  - Allow **overlap** between different phases during the lifecycle
    - Design starts before the requirements are fully finished
    - Architects start working on the completed subset of requirements, not waiting for the other parts
- Pros:
  - Mostly **predictive** model (requirements known upfront)
  - Shorten development time
  - People with different skills can start doing work simultaneously
- Cons:
  - May result in rework in later phases when previous phases get complete


Concept
Operations & maintenance
Requirements
Verification & validation
V-model
Design
Testing
decomposition
integration
Implementation

§2. Waterfall models

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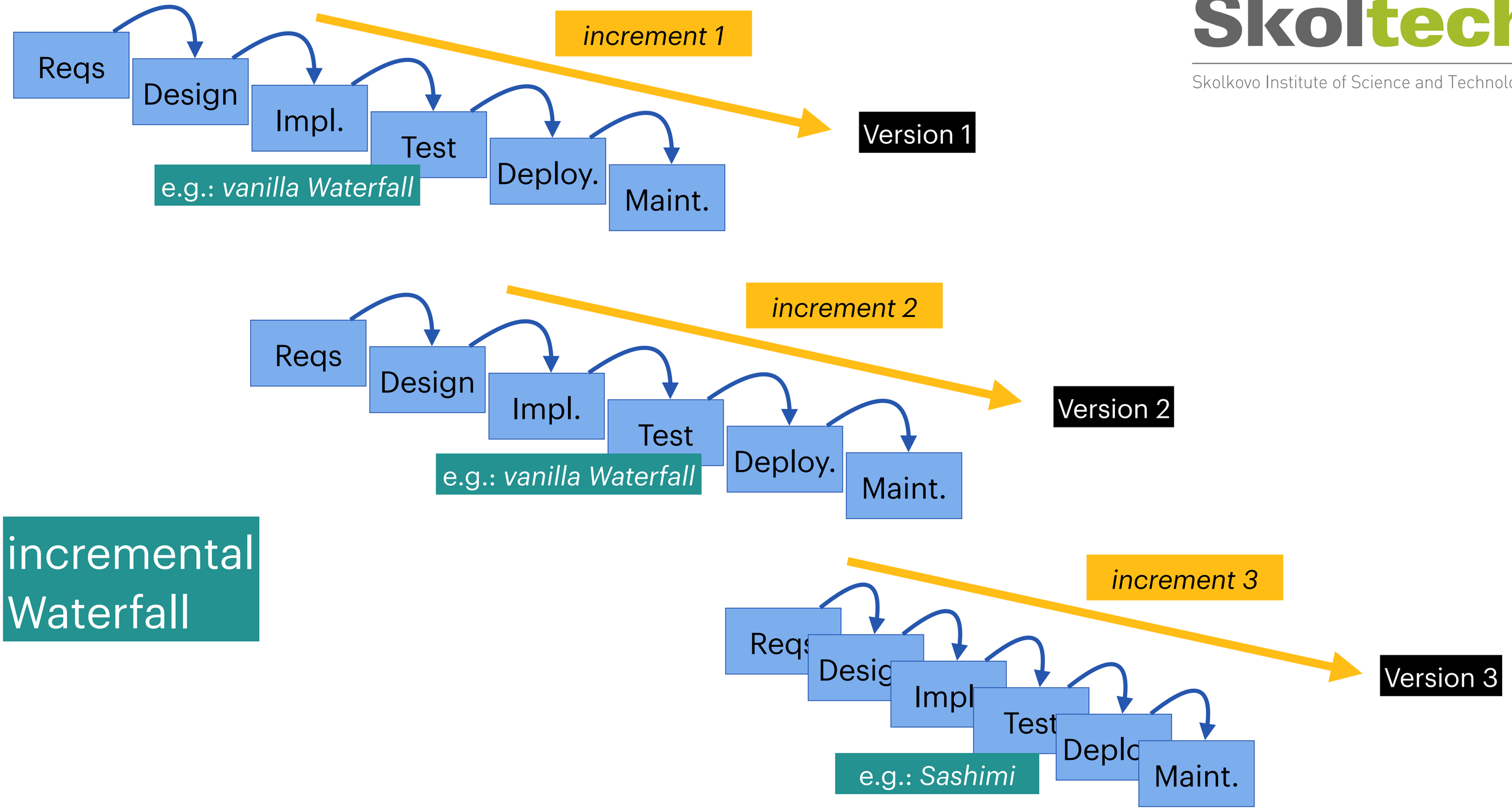
2.1. V-model

- **V-model** [works reasonably well when]:
  - Address shortage of time for testing by cascading the validation of software on multiple levels
  - Emphasize validation earlier in the process
- Pros:
  - Mostly **predictive** model
  - Early detection on potential problems
- Cons:
  - May result in rework in later phases when previous phases get complete

Incremental Waterfall

incremental Waterfall



§2. Waterfall models

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2.2. Incremental Waterfall models

- **Incremental Waterfall:**
  - Build an **increment** (all waterfall steps apply), then switch to another one
  - Increments may overlap
  - Can use different models during each increment
- Pros:
  - Deliver value early
  - Get feedback early
- Cons
  - Don’t know about some of the requirements early in the phase
- If your organisation may benefit from getting partial work early, use it

§3. Iterative models

Why iterative software development?

Image Credit: pikist

good predictive design

Image Credit: pinterest

bad predictive design

§3. Iterative models

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Why iterative software development?

- **Predictive models:**
  - Ill-suited to handle unexpected change
  - Don’t handle fuzzy requirements well
  - Spend a lot of effort at the beginning figuring out exactly what they will do
- **Iterative models:**
  - Build the application incrementally, **start with the smallest reasonably useful program**
  - Add more features in a series of increments
  - Increments cheaper (smaller amount of work), including cheaper to cancel
  - Handle fuzzy requirements by building the known parts now, figuring the rest later

The spiral model

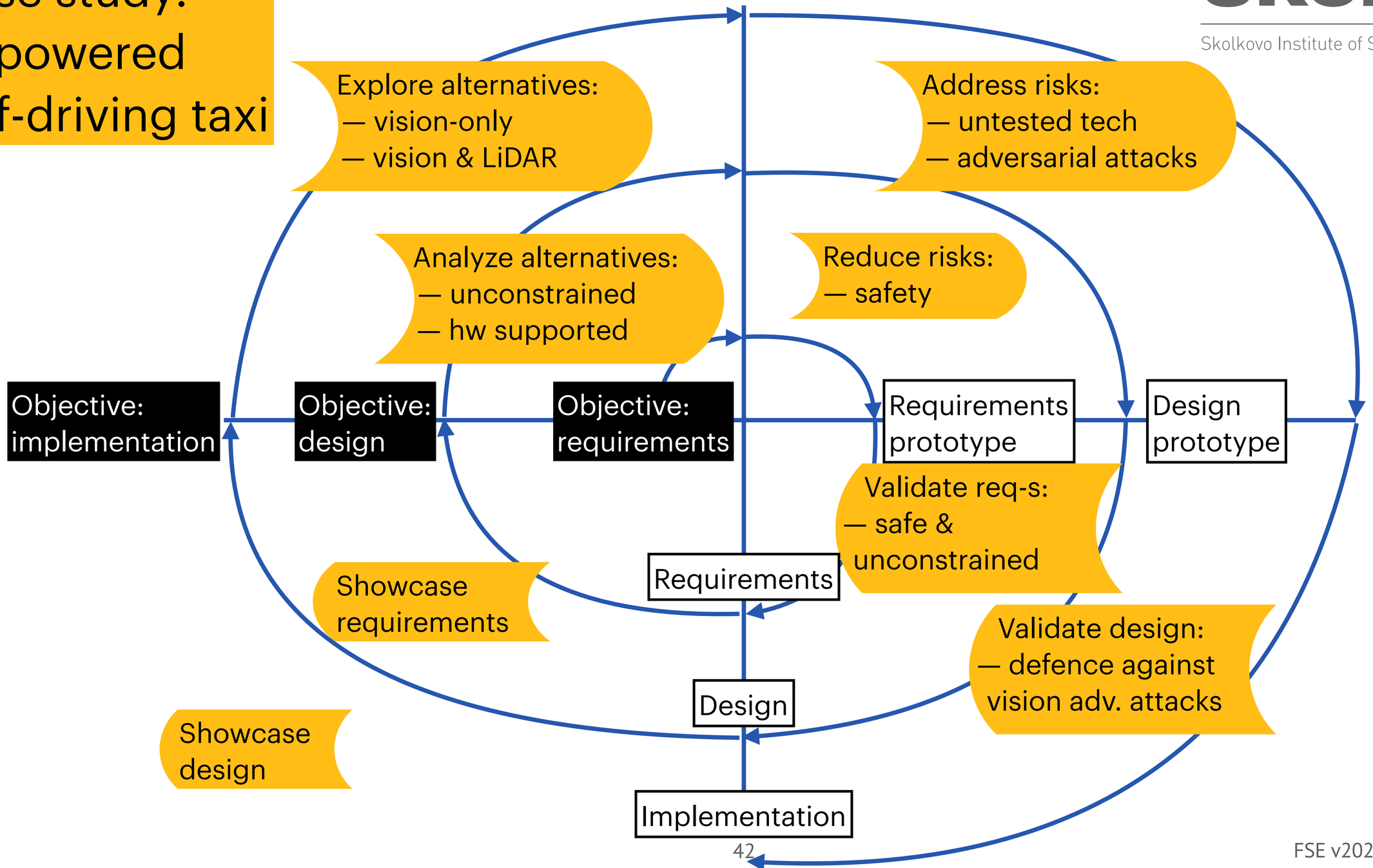
Phase 1:
Set objectives, alternatives and constraints on them

Phase 2:
Risk analysis and resolution; build prototype

Phase 4:
Evaluate progress, demonstrate solution, prove correctness

Phase 3:
Evaluate solution using the prototype; discover problems

Case study: AI-powered self-driving taxi



§3. Iterative models

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3.1. The spiral model

- **Risk-driven** cyclic approach: do only as much as needed to lower the risk at a particular stage
- **Process generator:** use other models within
- Determine objectives ⟶ identify and resolve risks ⟶ develop and test ⟶ planning for next iteration
- Milestones:
  - Life cycle objectives (LCO): consensus on technical and management approach
  - Life cycle architecture (LCA): project's approach can satisfy goals + eliminated risks
  - Initial operational capability (IOC): sufficient preparation of the software and all participants for release

§3. Iterative models

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3.1. The spiral model

+ Supports go/no-go decisions
+ Risk focused
+ Easy to accommodate change
+ Iterative: cost and effort estimates become more accurate over time
− Complicated, not always worth the effort
− Costs more
− Need stakeholder engagement and skills for project review
− Risk analysis costs much time: costly for small projects

- **Use:** very large high risk projects

The Unified Process

§3. Iterative models

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3.2. Unified process

- Iterative and incremental
- Inception ⟶ Elaboration ⟶ Construction ⟶ Transition
- Gray area: share of effort into process step at each phase

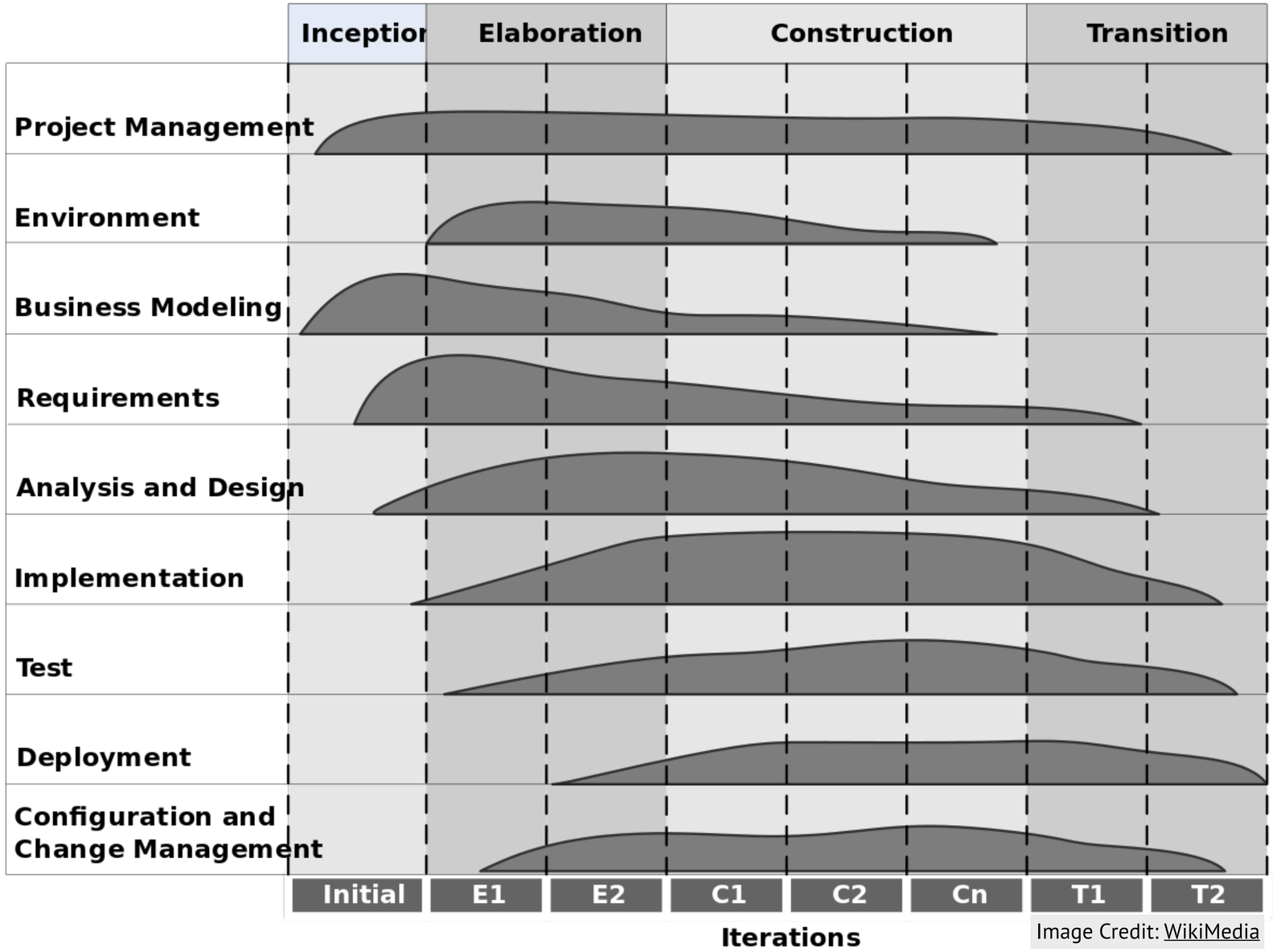

Image Credit: WikiMedia

§3. Iterative models

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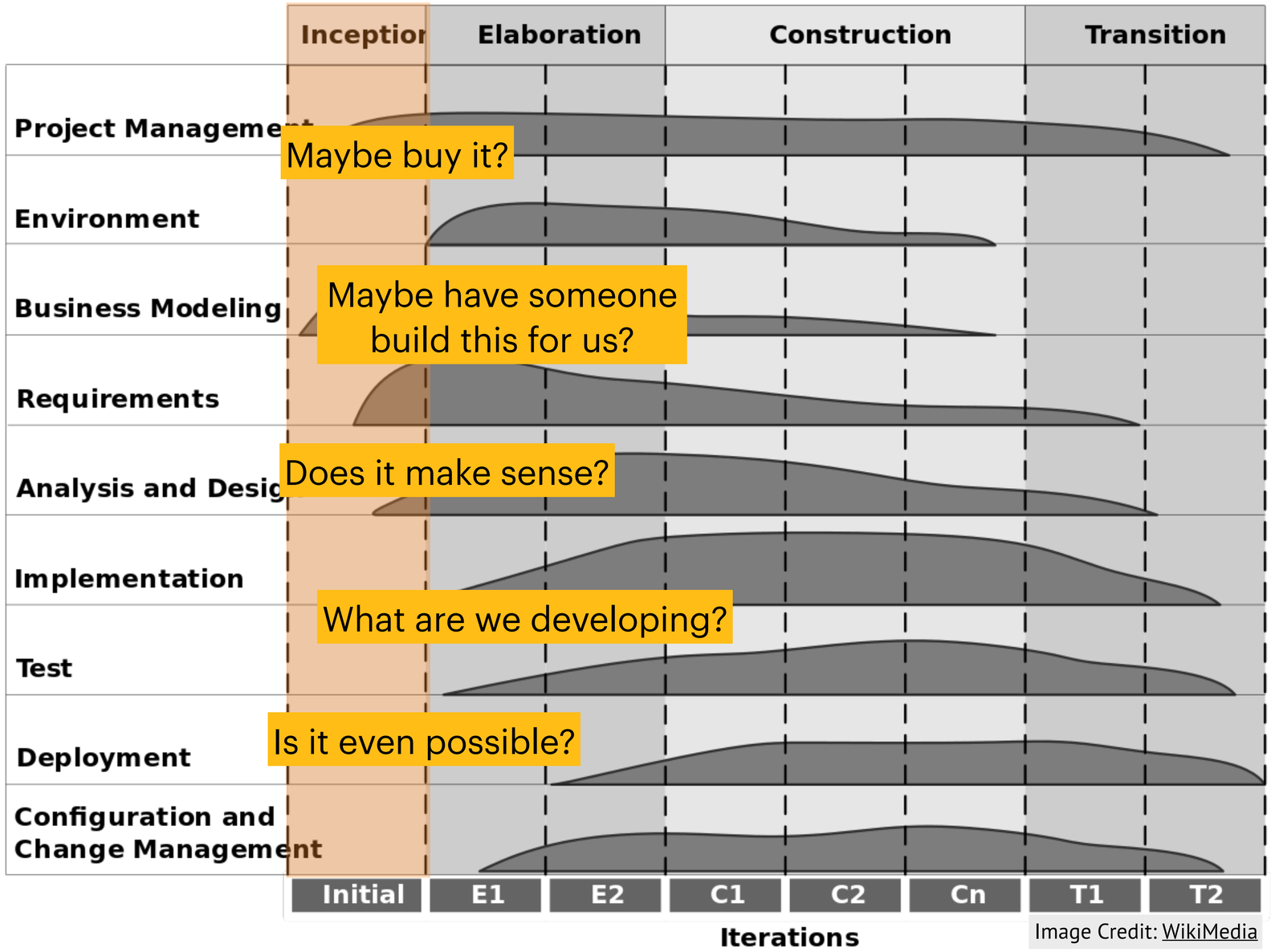
3.2. Unified process

- **Inception:**
  - The shortest phase
  - Focus on business cases, scope and requirements
  - Feasibility study
  - Build vs. buy
  - Preliminary schedule and cost
  - Milestone: lifecycle objective (LCO)



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§3. Iterative models

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3.2. Unified process

- **Elaboration:**
  - Capture requirements
  - Address known risks
  - Validate architecture
  - Build core components of the system to demonstrate that it will work
  - Milestone: lifecycle architecture (LCA)

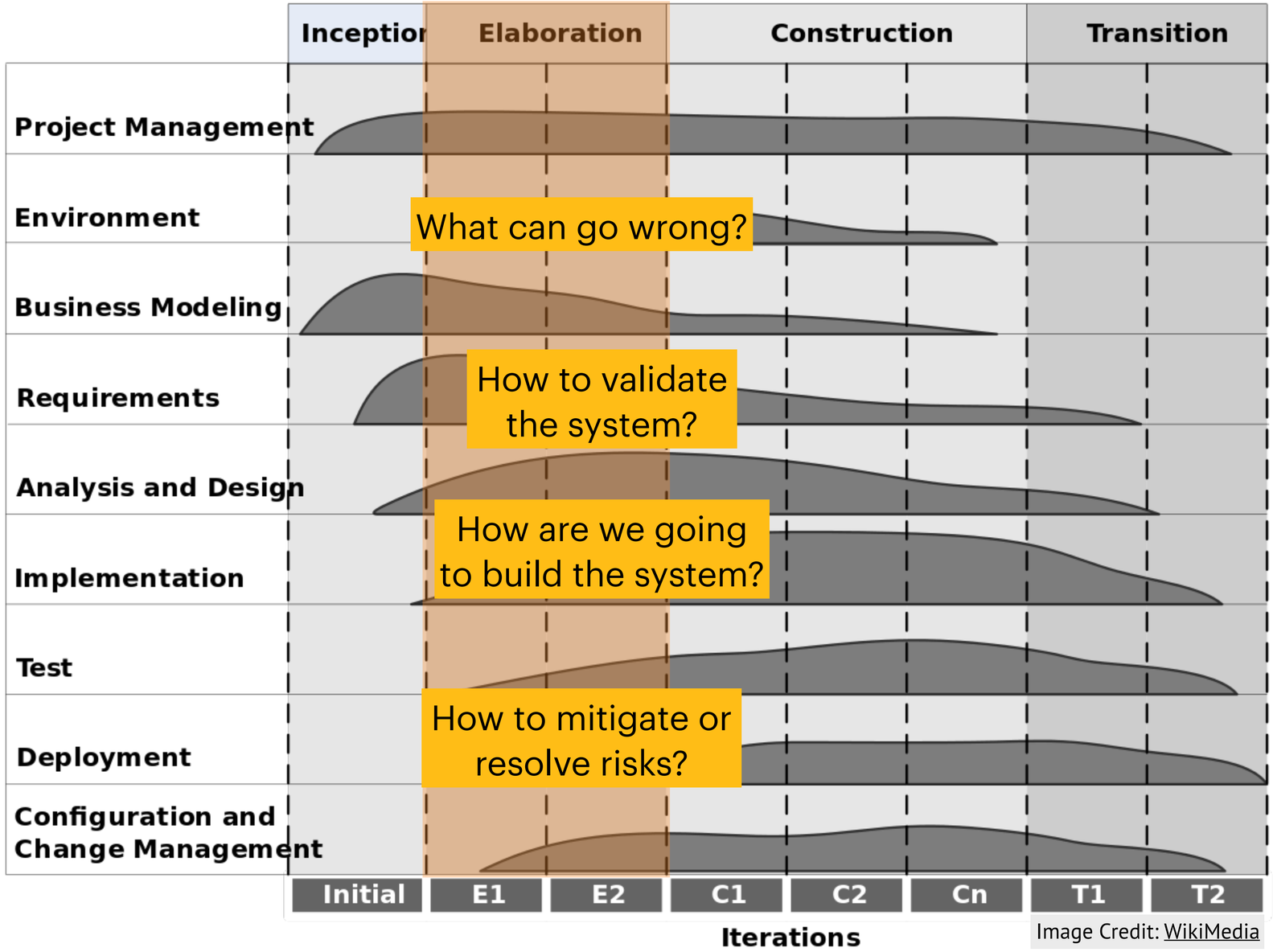

Image Credit: WikiMedia

§3. Iterative models

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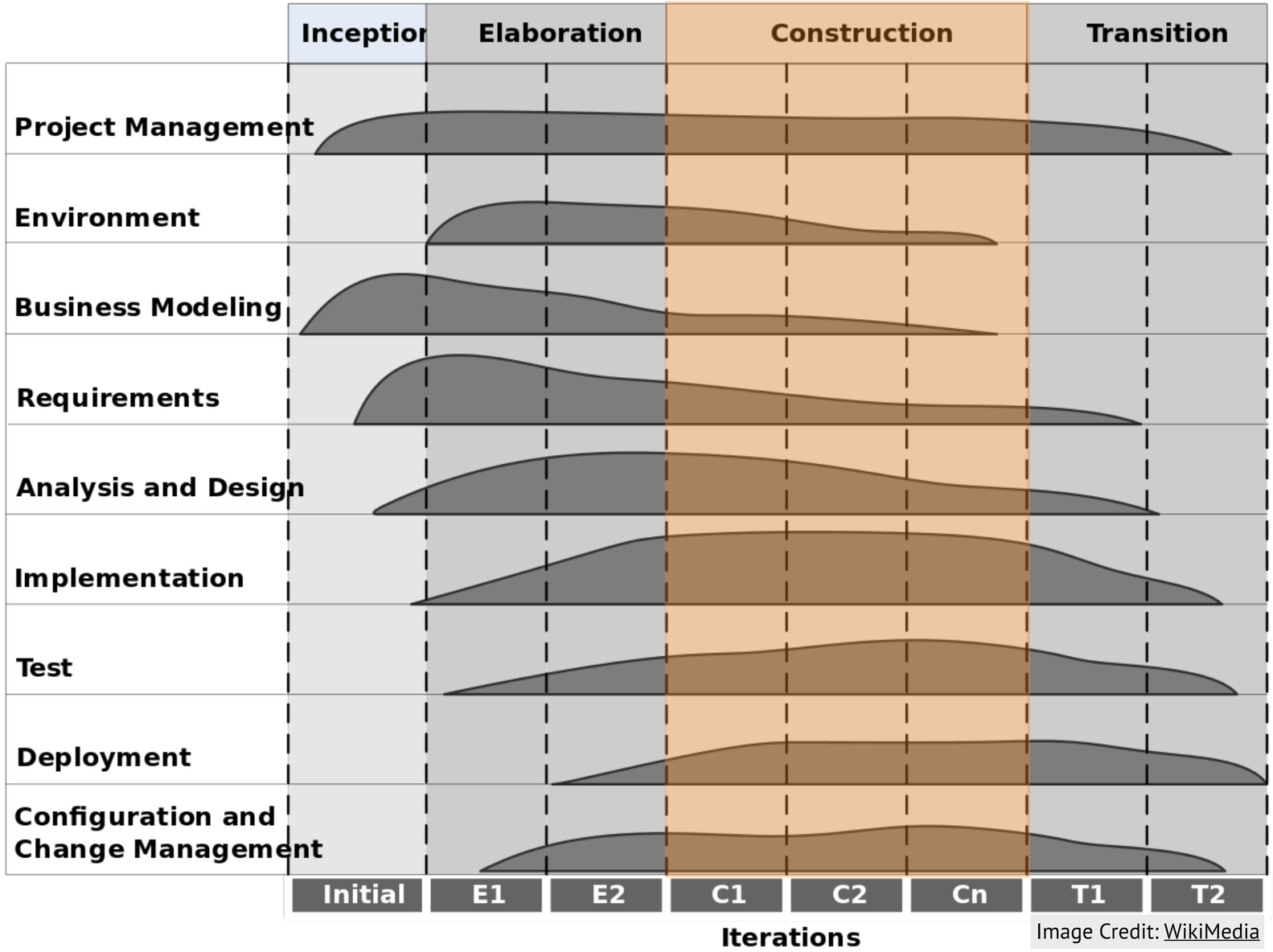
3.2. Unified process

- **Construction:**
  - The largest phase
  - Build software
  - Many iterations ⟶ each time release the software
  - Iterative and incremental
  - Milestone: initial operation capability (IOC)



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§3. Iterative models

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3.2. Unified process

- **Transition:**
  - Deployment
  - Get feedback from users
  - Refine software based on feedback

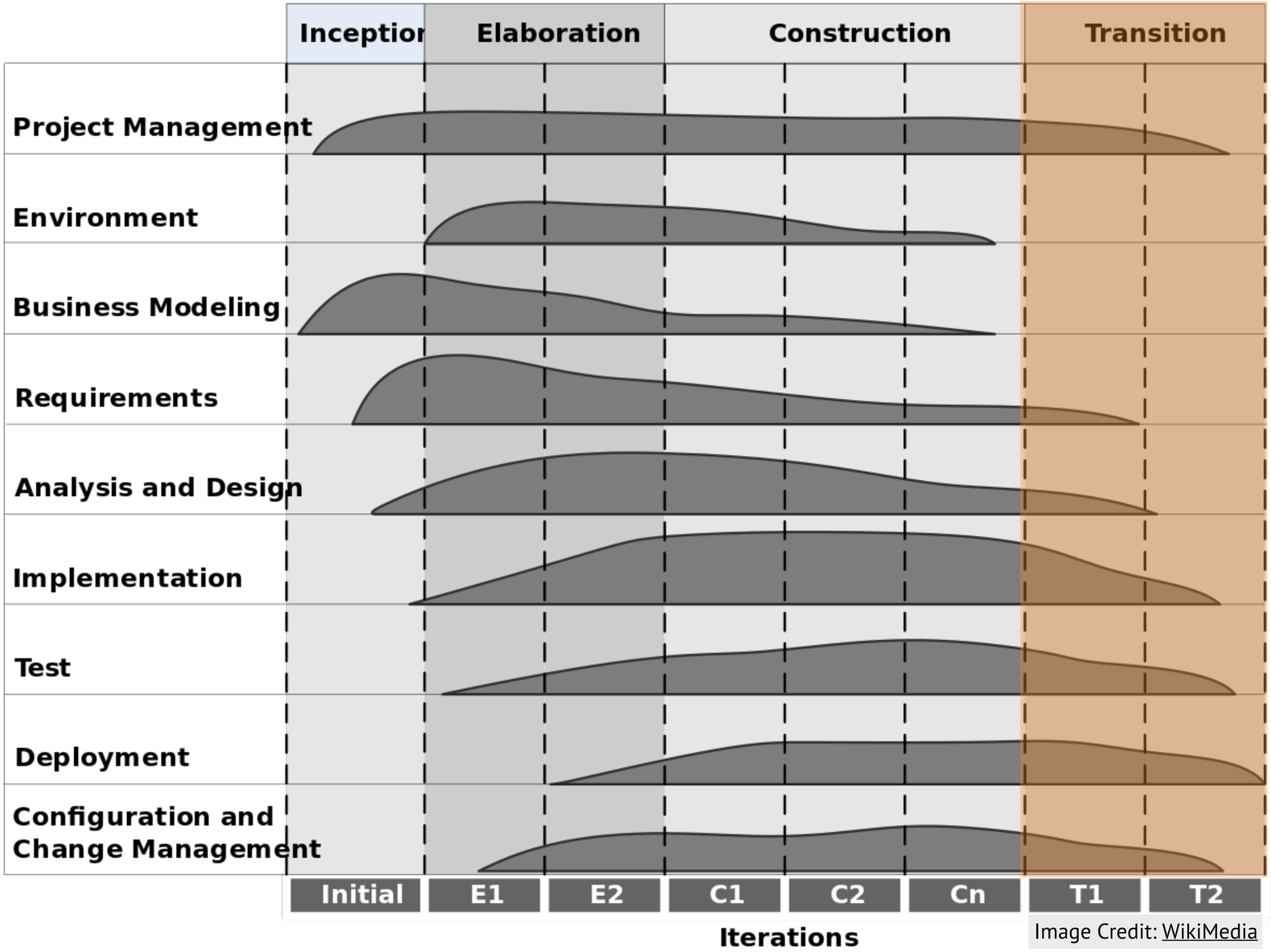

Image Credit: WikiMedia

§3. Iterative models

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3.2. Unified process

- **A framework, not a process:** can use any model during any phase
- Any step requires **all phases** in process, but emphasis may be on different steps
- Architecture-centric, use-case-centric
- Focus on risk mitigation
- **Pros:**
  - Quality and reuse by thinking about architecture ahead of time
  - Risk mitigation: more chances for success
  - Flexibly incorporates other s/w development models
- **Cons:** complicated, needs more resources, too heavy for small projects
- **Use:** bigger and riskier projects, not all requirements known early, desire to deliver value earlier

§4. Agile models

Why Agile?

Image Credit: kickvick.com

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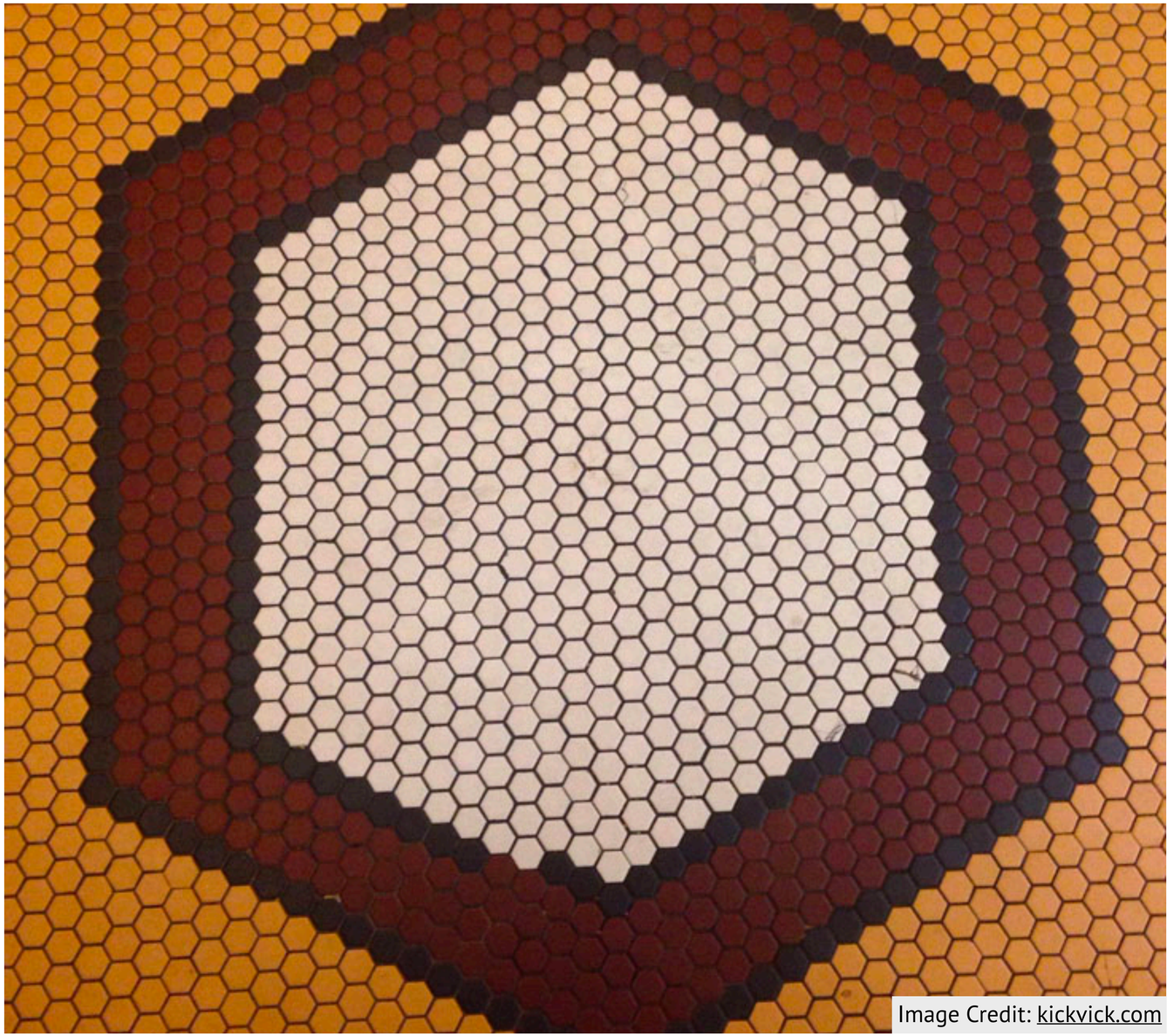

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Image Credit: The Fortune Teller (1617), WikiMedia

Image Credit: "Blind monks examining an elephant" by Itcho Hanabusa (1888), WikiMedia

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The Agile manifesto

§4. Agile models

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4.2. Agile manifesto: values and principles

- Individuals and interactions over processes and tools ⟶ informal chats are better
- Working software over comprehensive docs
- Customer collaboration over contract negotiation ⟶ understand user needs
- Responding to change over following a plan ⟶ make adjustments as situation changes

YouTube video:
The Agile Manifesto - 4 Agile Values Explained

§4. Agile models

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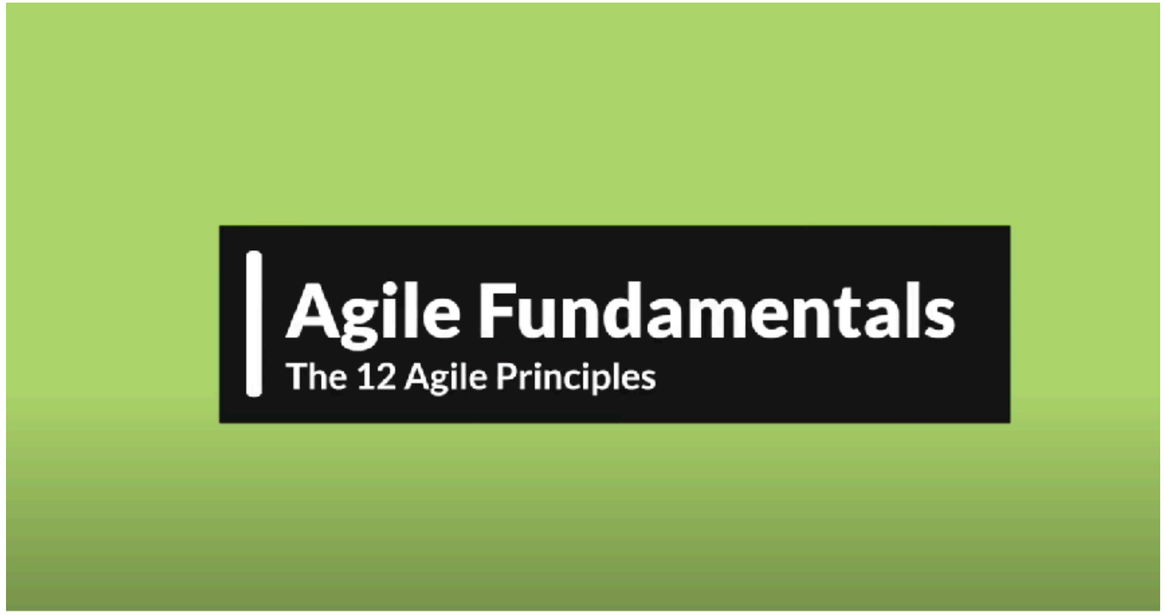
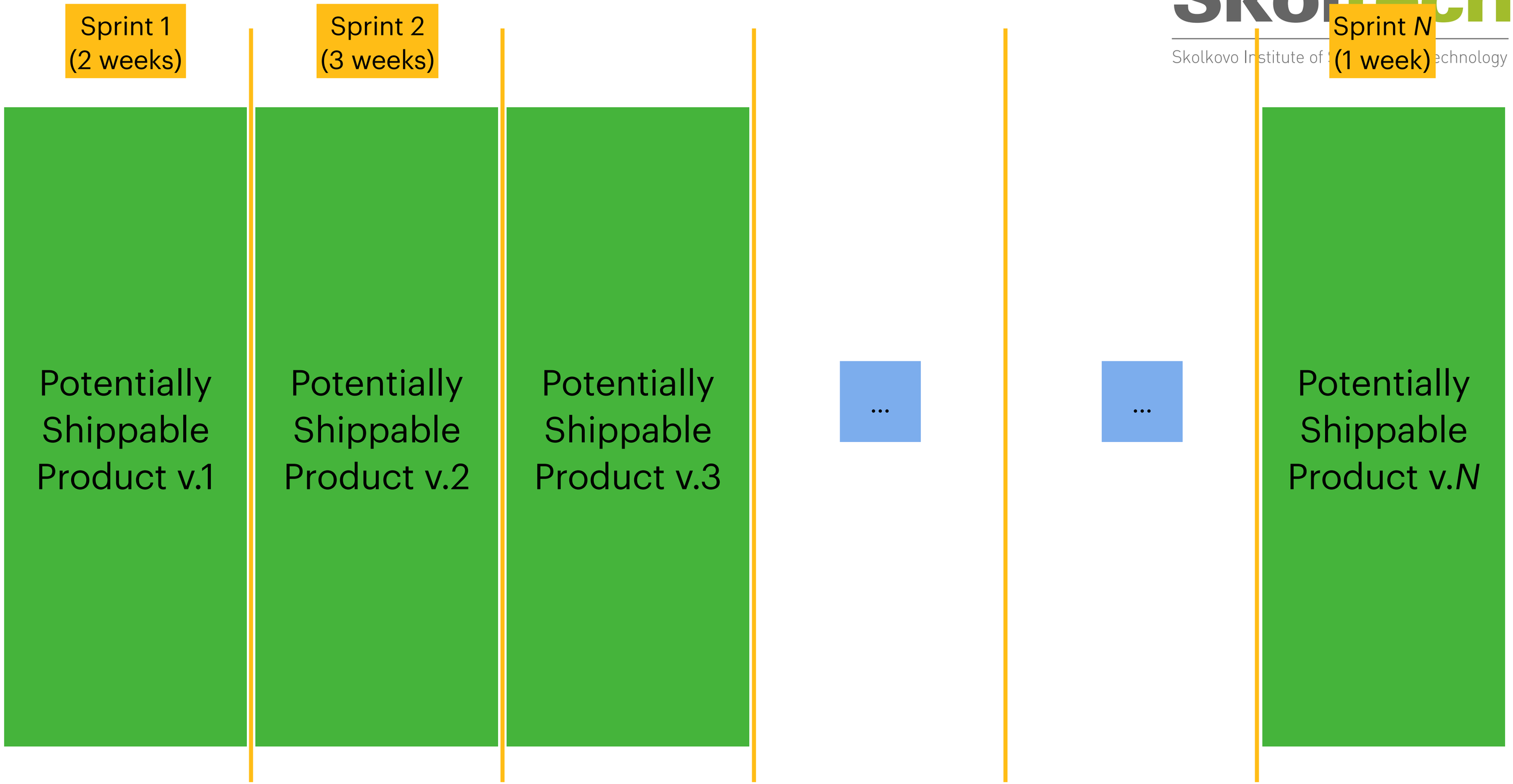
4.2. Agile manifesto: values and principles

- Focus in customer values
- Embrace change
- Preference towards a shorter time scale
- People with different skills work together
- Motivate individuals
- Face-to-face communication
- Working software is the first priority
- Maintain a constant pace indefinitely
- Pay attention to your design ⟶ make changes easily
- Simplicity ⟶ maximize amount of work not done
- Self-organisation in teams
- Reflect on how to become more effective



YouTube video:
Agile Fundamentals: The 12 Agile Principles

Agile frameworks: Scrum


Sprint 1
(2 weeks)
Sprint 2
(3 weeks)
Sprint *N*
(1 week)
Potentially Shippable Product v.1
Potentially Shippable Product v.2
Potentially Shippable Product v.3
...
...
Potentially Shippable Product v.*N*

§4. Agile models

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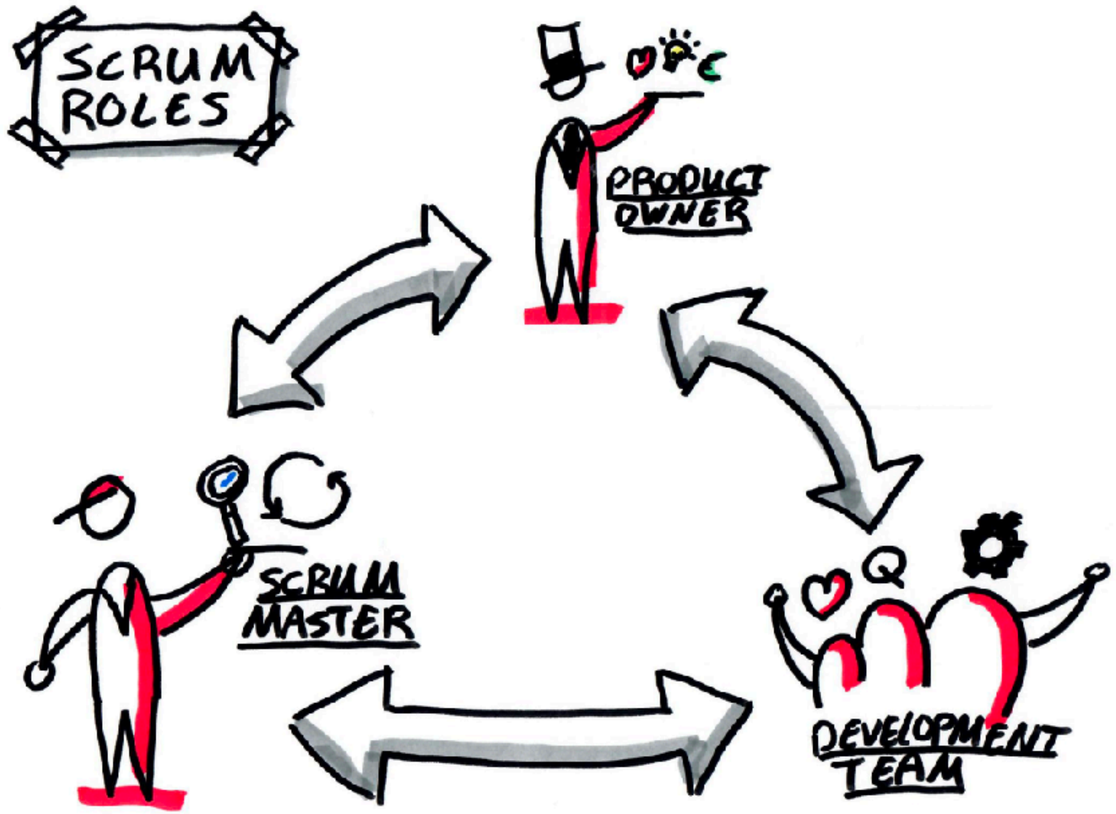
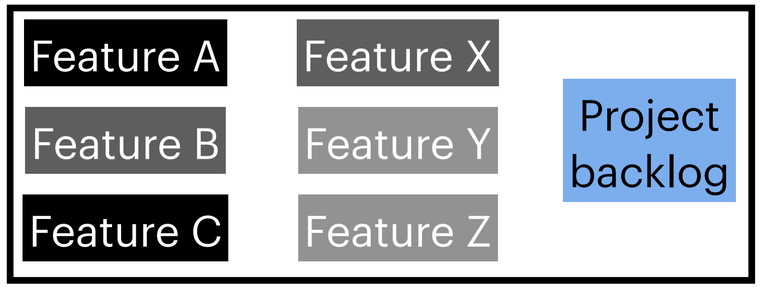
4.3. Scrum Agile framework

- Roles:
  - Product Owner: defines what needs to be done
  - Scrum Master: facilitates meetings
  - Team: builds software





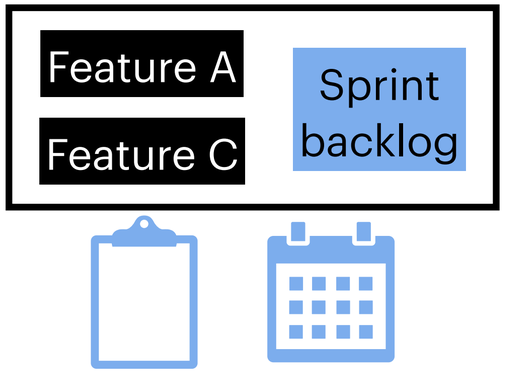
Scrum Sprint pipeline

1. Sprint planning

2. Sprint execution

3. Sprint review

4. Sprint reflection



Daily standup

Show product

Improve processes

§4. Agile models

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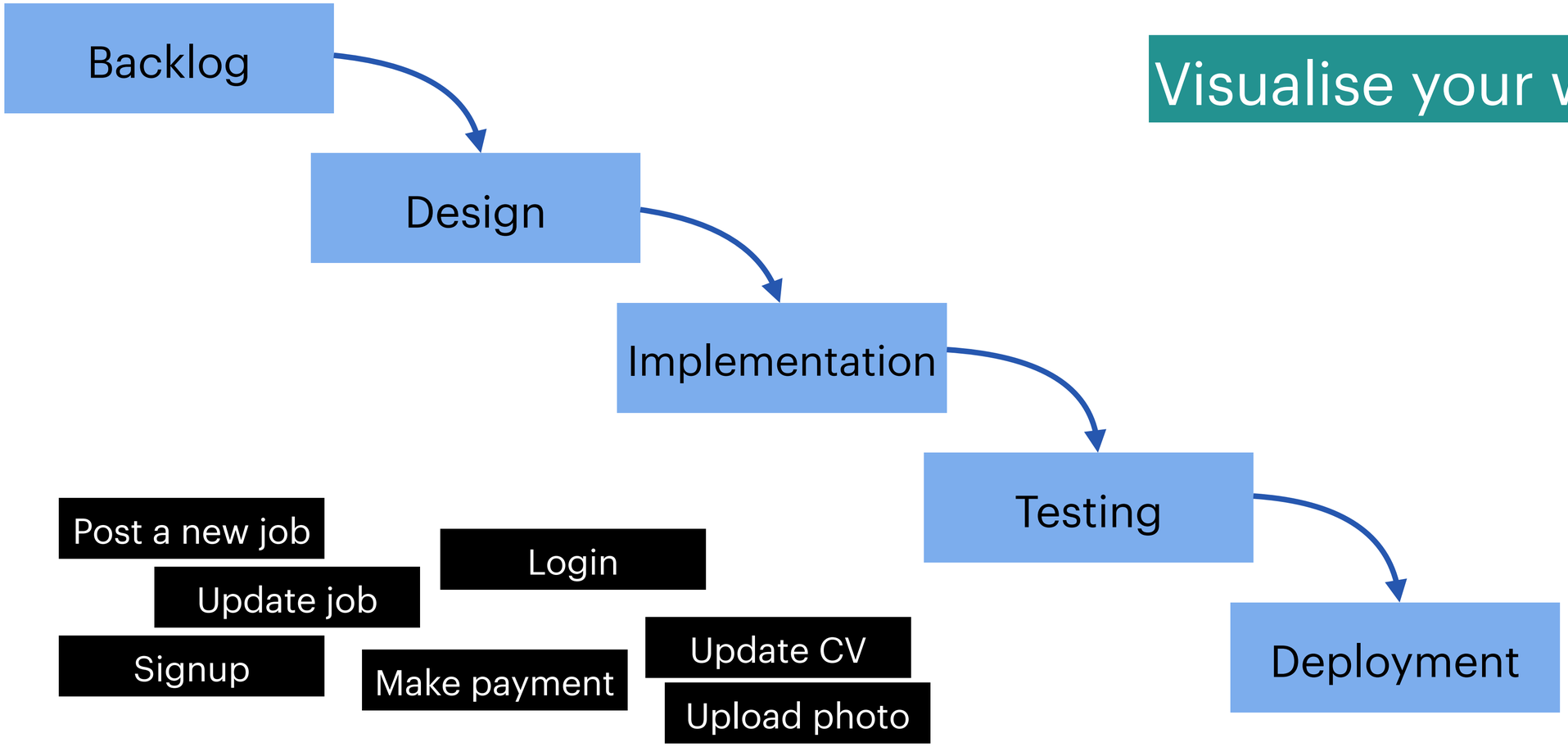
4.3. Scrum Agile framework

- Agile principles:
  - Build iteratively ⟶ address changes
  - Lots of meetings ⟶ collaboration
  - Continuous improvement with retrospectives
  - …

Agile frameworks: Kanban

Visualise your workflow



Visualise your workflow

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Backlog	Design	Implementation	Testing	Deployment

- Post a new job
- Update job
- Login
- Signup
- Make payment
- Update CV
- Upload photo

Visualise your workflow

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Backlog	Design	Implementation	Testing	Deployment
Login	Post a new job			
Signup	Update job			
Make payment				
Update CV				
Upload photo				

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Limit work in progress

Backlog	Design 4	Implementa 2	Testing 2	Deployment
				Post a new job
			Update job	
			Login	
			Signup	
			Make payment	
		Update CV		
	Upload photo			

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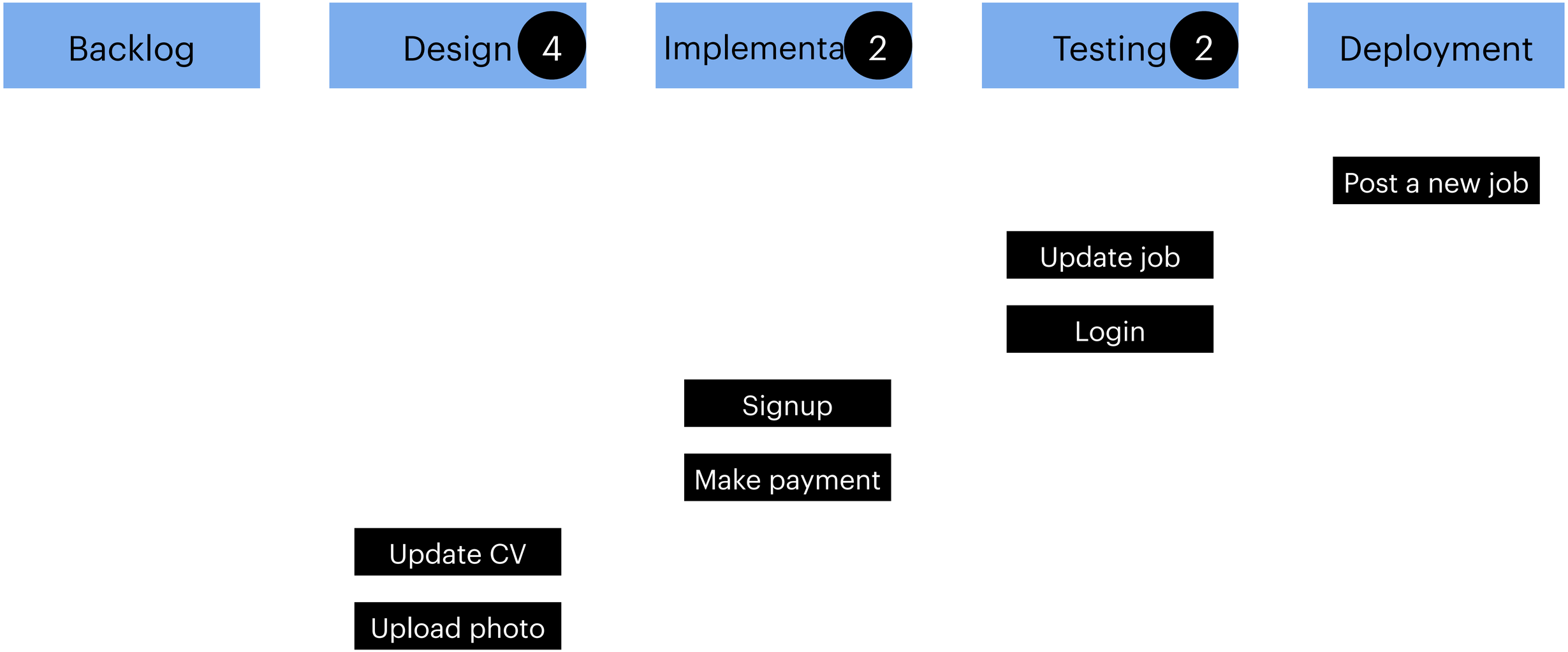
Manage the flow

Backlog	Design 4	Implementa 2	Testing 2	Deployment
				Post a new job
			Update job	
			Login	
		Signup		
		Make payment		
	Update CV			
	Upload photo			

Make process policies explicit



§4. Agile models

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4.4. Kanban Agile framework

- Agile principles:
  - Visualise your workflow ⟶ Simplicity
  - Limit work in progress ⟶ Maintain a constant pace indefinitely
  - Manage the flow ⟶ Maintain a constant pace indefinitely
  - Make process policies explicit ⟶ Self-organisation in teams / Motivate individuals / Face-to-face communication

§4. Agile models

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- **Pros** from adaptive nature of software development
  - Detect process problems early
  - Validate user needs early
  - Detect integration issues early
  - People and interaction ⟶ detect translation issues quickly
- **Cons** from iterative development
  - Constant changes ⟶ lack of control and unpredictability
  - People need to be more involved ⟶ spent more time on the system
- **Use:** when the requirements may change or the technology is unknown

References

1. Stephens, R. (2015). Beginning software engineering. John Wiley & Sons.
2. Cockburn, A. (2006). Agile software development: the cooperative game. Pearson Education.
3. *Coursera course:* Software Development Lifecycle. University of Minnesota