Software life cycle, high assurance & types

Stages in software development

Requirements

Specification

Design

Implementation

Validation

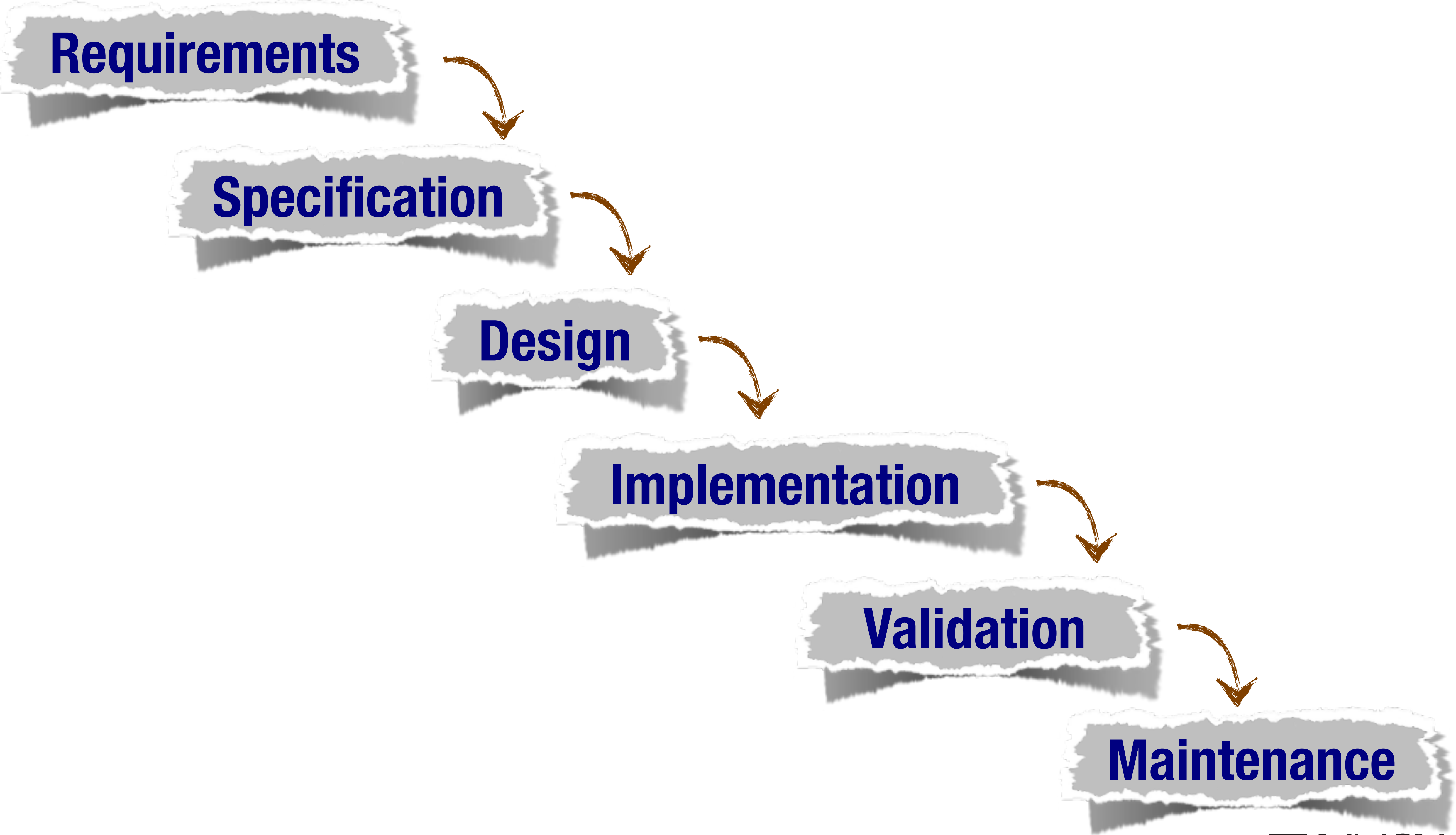
Maintenance

Photo by BloodLight - http://flic.kr/p/5A38zp

Photo by denn - http://flic.kr/p/bhu2C

Waterfall model versus agile methods

Waterfall model



Requirements

Specification

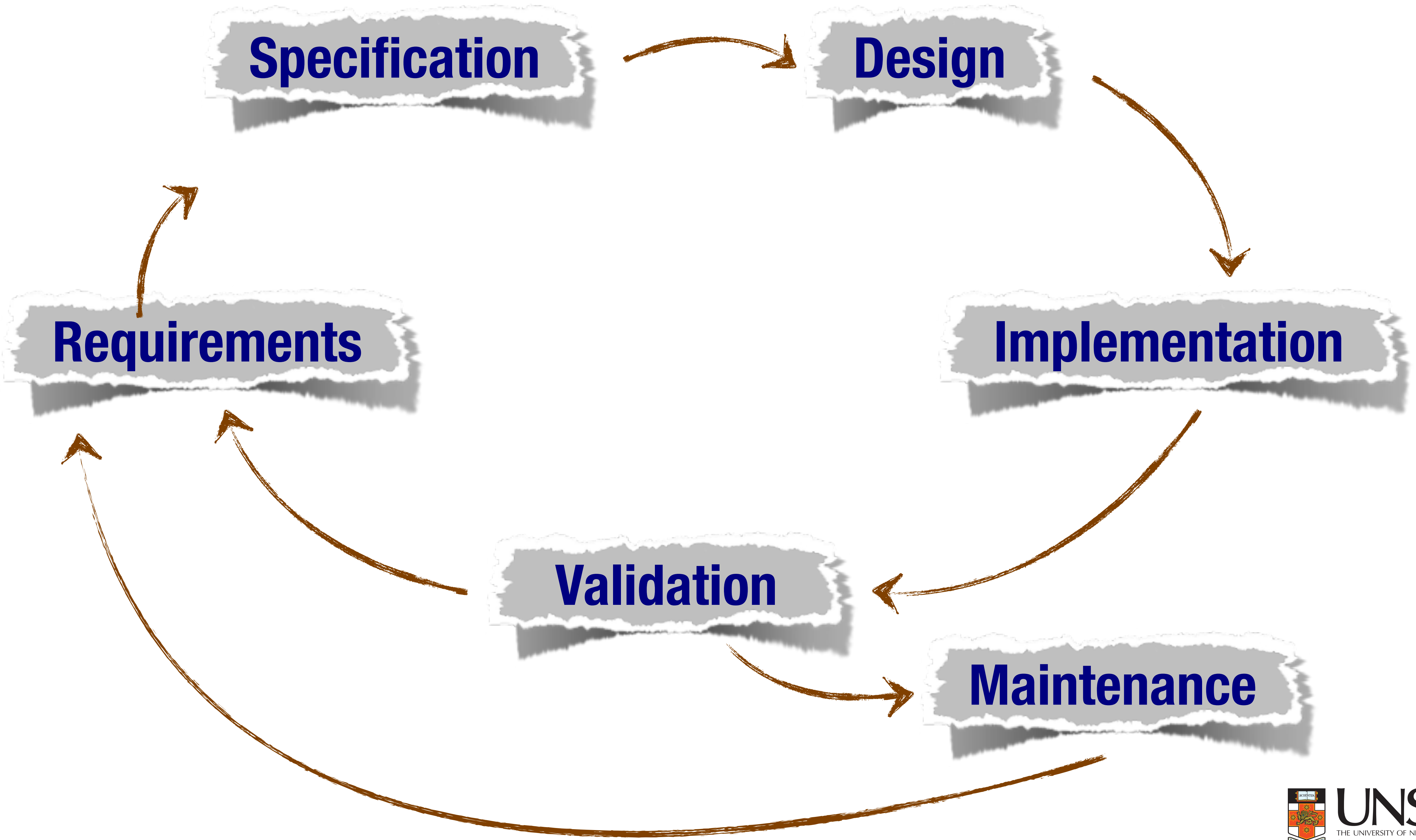
Design

Implementation

Validation

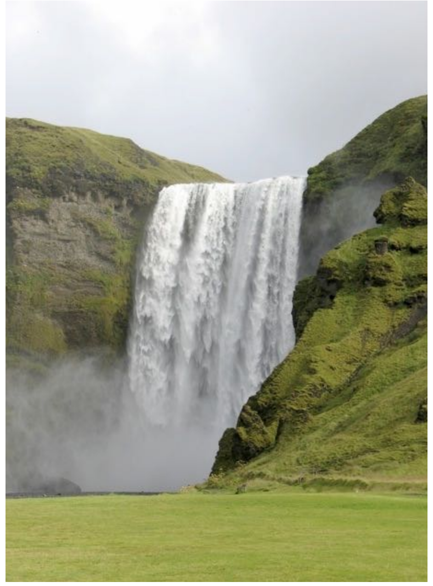
Maintenance

Agile methods



Different projects require different methods

- Implementing an AES (Advanced Encryption Standard) component
    - Requirements and specification is not going to change significantly
    - Predictability and correctness are paramount

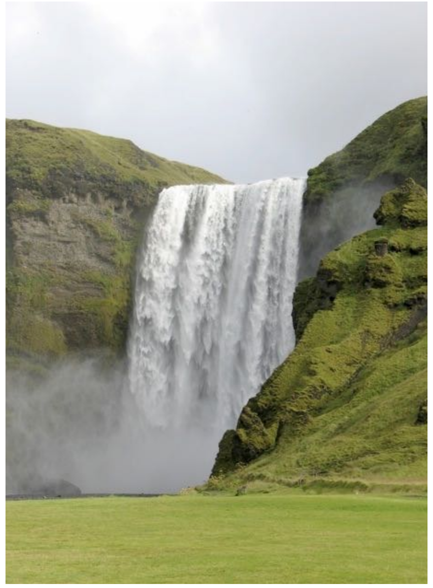


- Implementing a social media website
    - Requirements are initially very vague
    - Web users are well accustomed to half-baked features and a little downtime

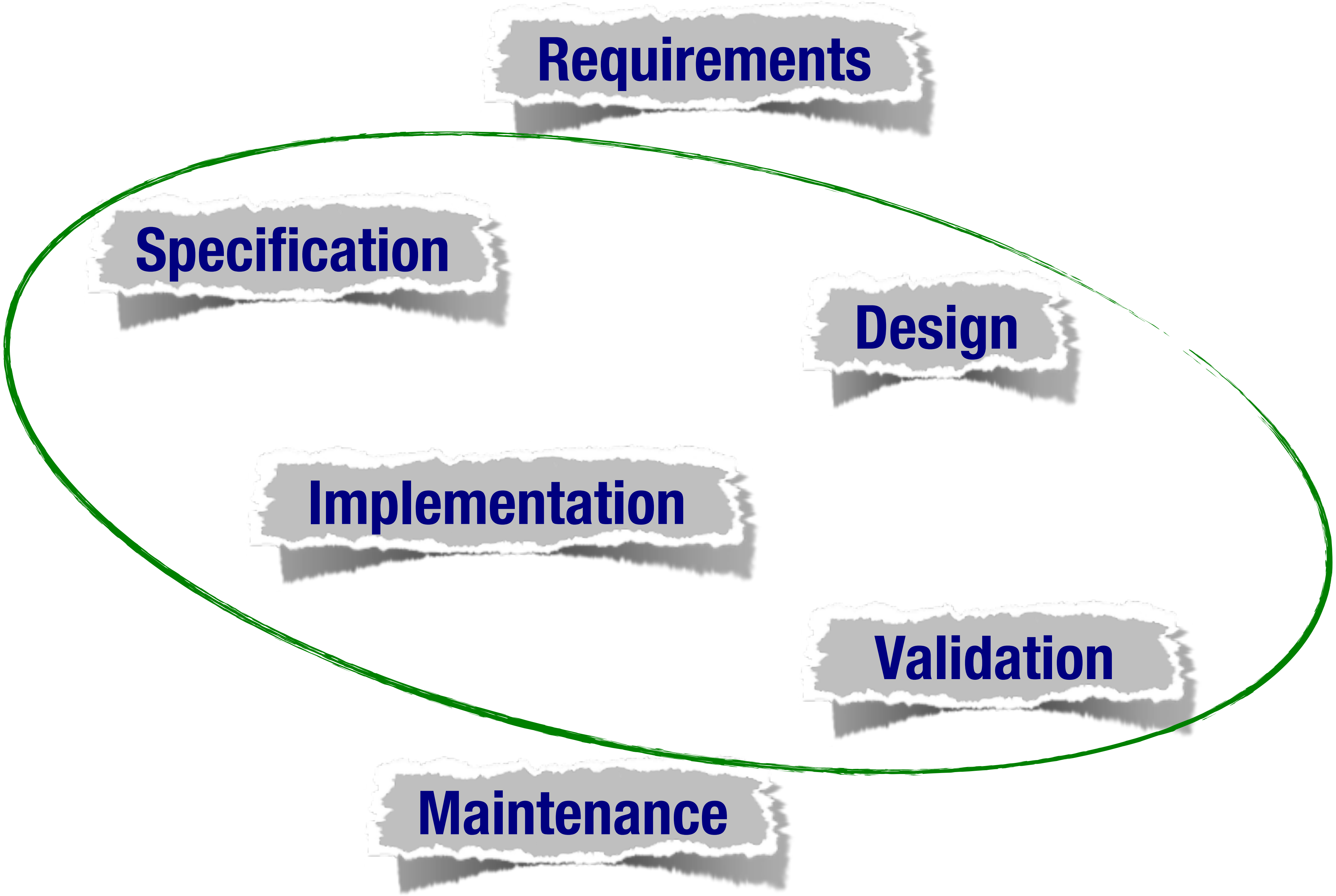
Again, we need to be flexible

- We need to be able to trade quality for reduced effort

- We need to be able to trade predictability for agility



The scope of this course



Logical program properties

- Our tool of choice for specifications
- They are flexible
    1. They can directly be used for testing
    2. They can directly be used for formal verification
- They are fundamentally connected to types

Type-driven development

- We will use types for all four stages of software development

1. Specification — types can encode arbitrary properties

2. Design — types structure code

3. Implementation — types guide and sometimes imply implementations

4. Validation — types can be automatically checked

Types provide flexibility

- Singleton types are perfectly precise

$$n : SInt(n)$$

- Bit-size types track an important implementation constraint

$$n : BInt(w)$$

- Types as we know them

$$n : Int$$

- Dynamic types

$$n : Dynamic$$

By making types more precise...

- We refine the specification
- The type checker requires us to justify our implementation in more detail

We gain quality, but also have to spend more effort

By making types less precise...

- We simplify experimentation
- We will have to perform more testing, or accept defects

We avoid fixing too many details of the specification

Lambda calculus in a nutshell

Haskell

- A practical, strongly-typed functional programming language
  - Widely used in research, industry & education
  - Mature, highly optimising compiler with interactive environment
  - Over thousands of open-source libraries and tools
- Named after the logician Haskell B. Curry

http://haskell.org/

Why Haskell?

- Functional languages are based on the lambda calculus
  - Semantics of programs is fairly precisely defined
  - This simplifies formal reasoning about these programs
- Functional languages can dramatically increase productivity
  - Factor of four has been cited for Erlang versus C++
- Haskell has a very sophisticated type system
- Haskell has controlled effects