Verification and Validation

Objectives

- To introduce software verification and validation and to discuss the distinction between them
- To describe the program inspection process and its role in V & V
- To explain static analysis as a verification technique

Topics covered

- Verification and validation planning
- Software inspections
- Automated static analysis

Verification vs validation

- Verification:
  "Are we building the product right".
  - The software should conform to its specification.
- Validation:
  "Are we building the right product".
  - The software should do what the user really wants.

The V & V process

- Is a whole life-cycle process - V & V must be applied at each stage in the software process.
- Has two principal objectives
  - The discovery of defects in a system;
  - The assessment of whether or not the system is useful and useable in an operational situation.

V & V goals

- Verification and validation should establish confidence that the software is fit for purpose.
- This does NOT mean completely free of defects.
- Rather, it must be good enough for its intended use and the type of use will determine the degree of confidence that is needed.

V & V confidence

- Depends on system's purpose, user expectations and marketing environment
  - Software function
    - The level of confidence depends on how critical the software is to an organisation.
  - User expectations
    - Users may have low expectations of certain kinds of software.
  - Marketing environment
    - Getting a product to market early may be more important than finding defects in the program.

IV & V: Independent Validation and Verification

- Can be done by another internal team or external (other company)

developer

Understands the system

but, will test "gently"

and, is driven by "delivery"

independent tester

Must learn about the system,

but, will attempt to break it

and, is driven by quality

Static and dynamic verification

- Software inspections. Concerned with analysis of the static system representation to discover problems (static verification)
  - May be supplement by tool-based document and code analysis
- Software testing. Concerned with exercising and observing product behaviour (dynamic verification)
  - The system is executed with test data and its operational behaviour is observed

Program testing

- Can reveal the presence of errors NOT their absence.
- The only validation technique for non-functional requirements is the software has to be executed to see how it behaves.
- Should be used in conjunction with static verification to provide full V&V coverage.

Types of testing

- Defect testing
  - Tests designed to discover system defects.
  - A successful defect test is one which reveals the presence of defects in a system.
  - Covered in next lecture
- Validation testing
  - Intended to show that the software meets its requirements.
  - A successful test is one that shows that a requirements has been properly implemented.

Testing and debugging

- Defect testing and debugging are distinct processes.
- Verification and validation is concerned with establishing the existence of defects in a program.
- Debugging is concerned with locating and repairing these errors.
- Debugging involves formulating a hypothesis about program behaviour then testing these hypotheses to find the system error.

The debugging process

Debugging Techniques

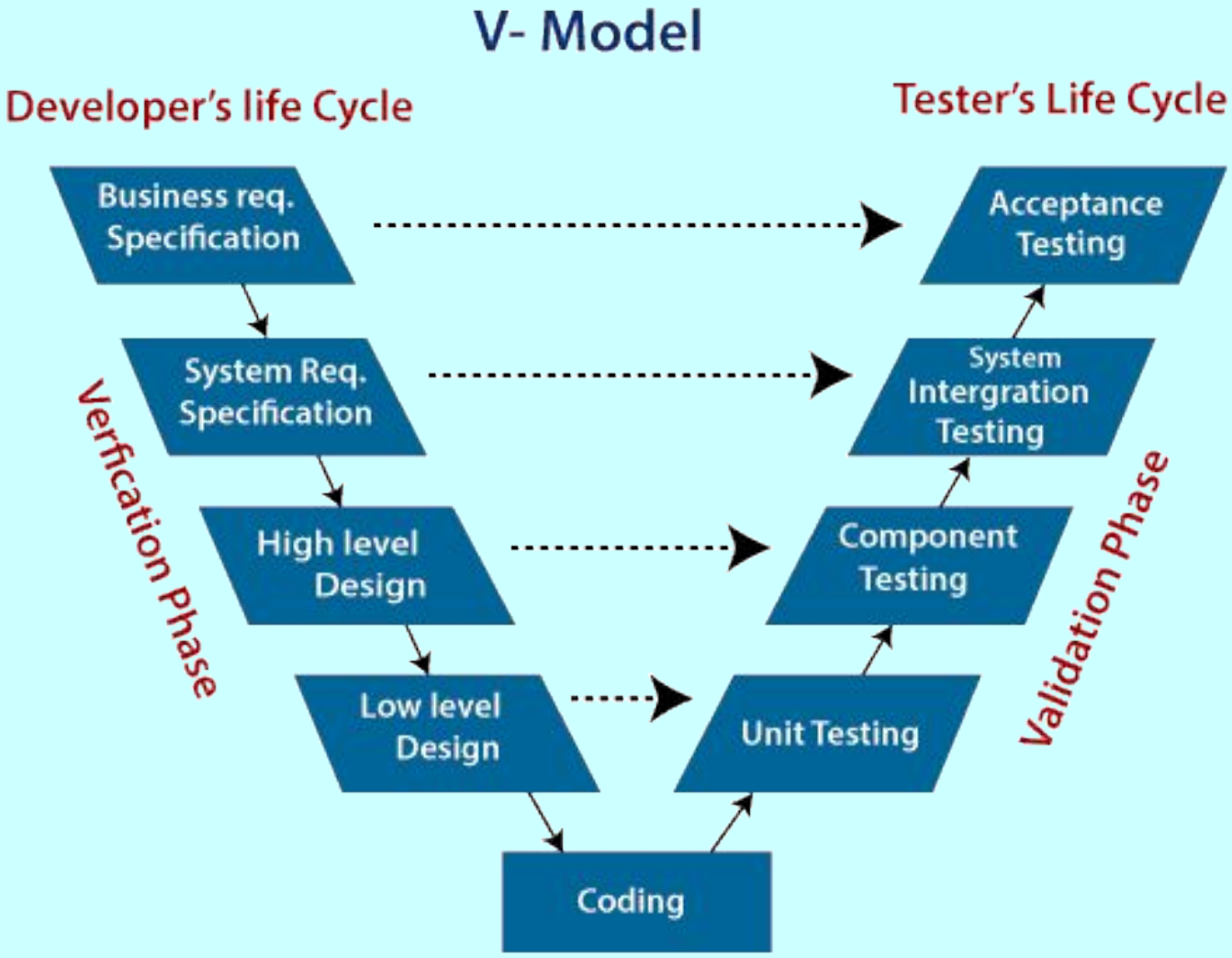
- brute force
- backtracking
- Cause elimination

When all else fails, ask for help!

V & V planning

- Careful planning is required to get the most out of testing and inspection processes.
- Planning should start early in the development process.
- The plan should identify the balance between static verification and testing.
- Test planning is about defining standards for the testing process rather than describing product tests.

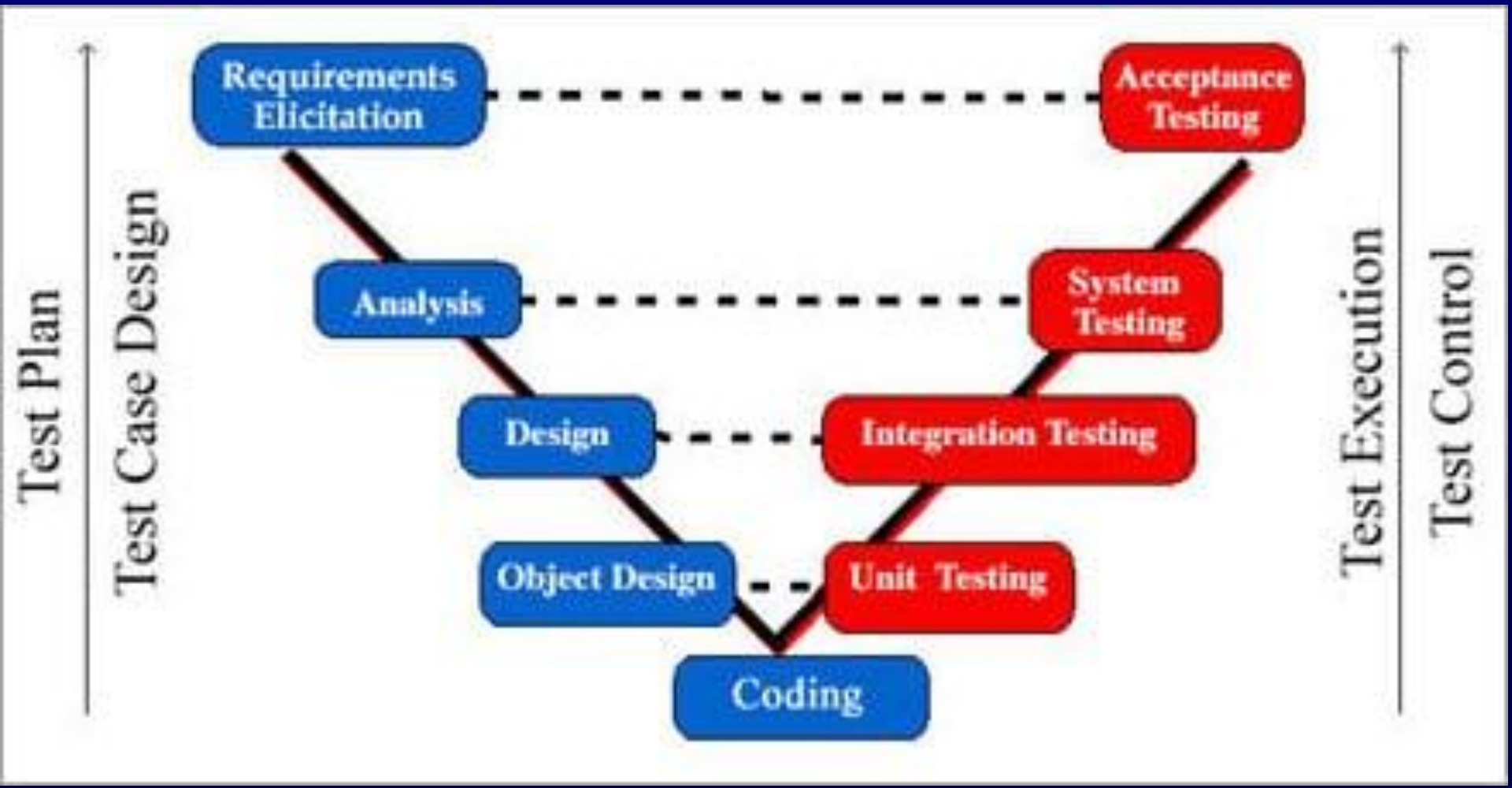
The V-model of development



The structure of a software test plan

- The testing process.
- Requirements traceability.
- Tested items.
- Testing schedule.
- Test recording procedures.
- Hardware and software requirements.
- Constraints.

The software test plan



Software inspections

- These involve people examining the source representation with the aim of discovering anomalies and defects.
- Inspections do not require execution of a system so may be used before implementation.
- They may be applied to any representation of the system (requirements, design,configuration data, test data, etc.).
- They have been shown to be an effective technique for discovering program errors.

Inspection success

- Many different defects may be discovered in a single inspection. In testing, one defect may mask another so several executions are required.
- Reuse and programming patterns are common so reviewers are likely to have seen the types of error that commonly arise.

Inspections and testing

- Inspections and testing are complementary and not opposing verification techniques.
- Both should be used during the V & V process.
- Inspections can check conformance with a specification but not conformance with the customer's real requirements.
- Inspections cannot check non-functional characteristics such as performance, usability, etc.

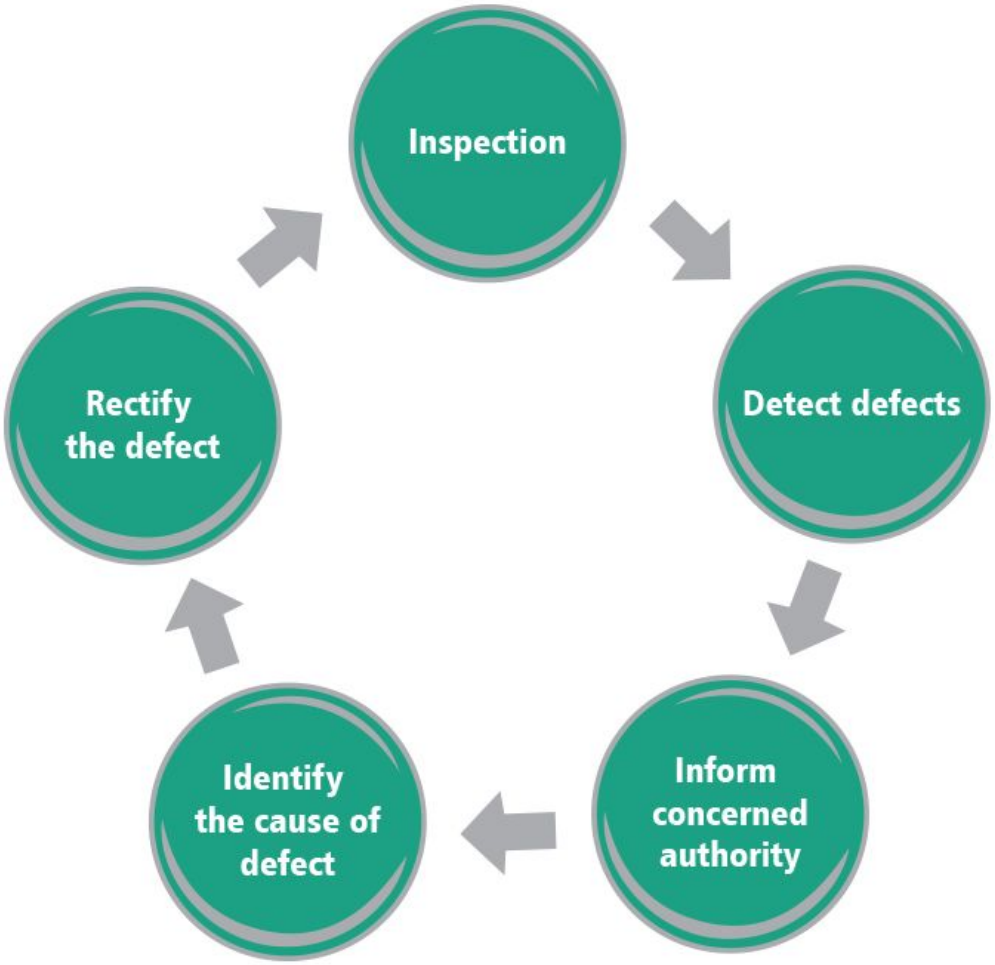
Program inspections

- Formalised approach to document reviews
- Intended explicitly for defect detection (not correction).
- Defects may be logical errors, anomalies in the code that might indicate an erroneous condition (e.g. an uninitialised variable) or non-compliance with standards.

Inspection pre-conditions

- A precise specification must be available.
- Team members must be familiar with the organisation standards.
- Syntactically correct code or other system representations must be available.
- An error checklist should be prepared.
- Management must accept that inspection will increase costs early in the software process.
- Management should not use inspections for staff appraisal ie finding out who makes mistakes.

The inspection process



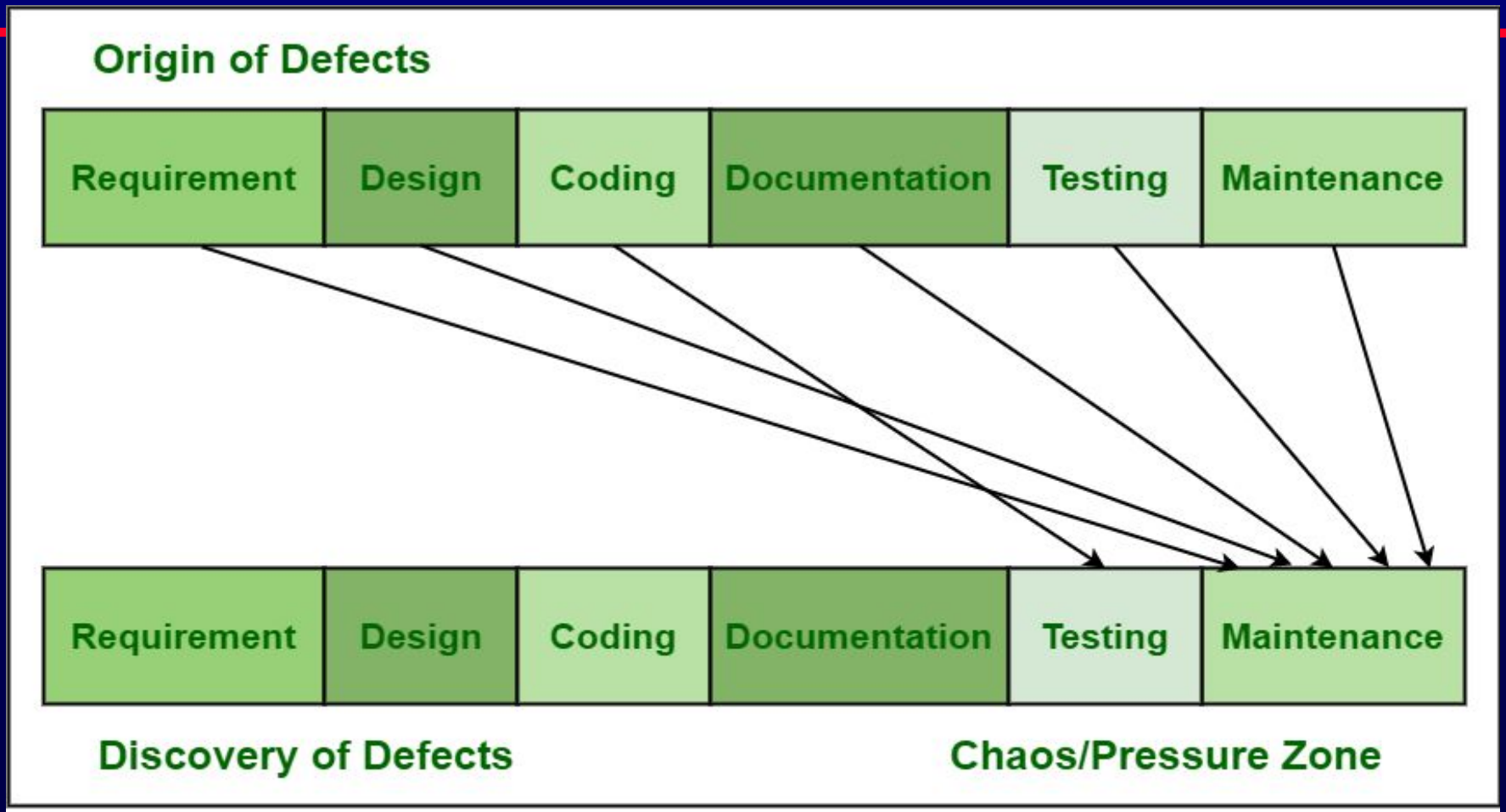
Inspection procedure

- System overview presented to inspection team.
- Code and associated documents are distributed to inspection team in advance.
- Inspection takes place and discovered errors are noted.
- Modifications are made to repair discovered errors.
- Re-inspection may or may not be required.

Inspection checklists

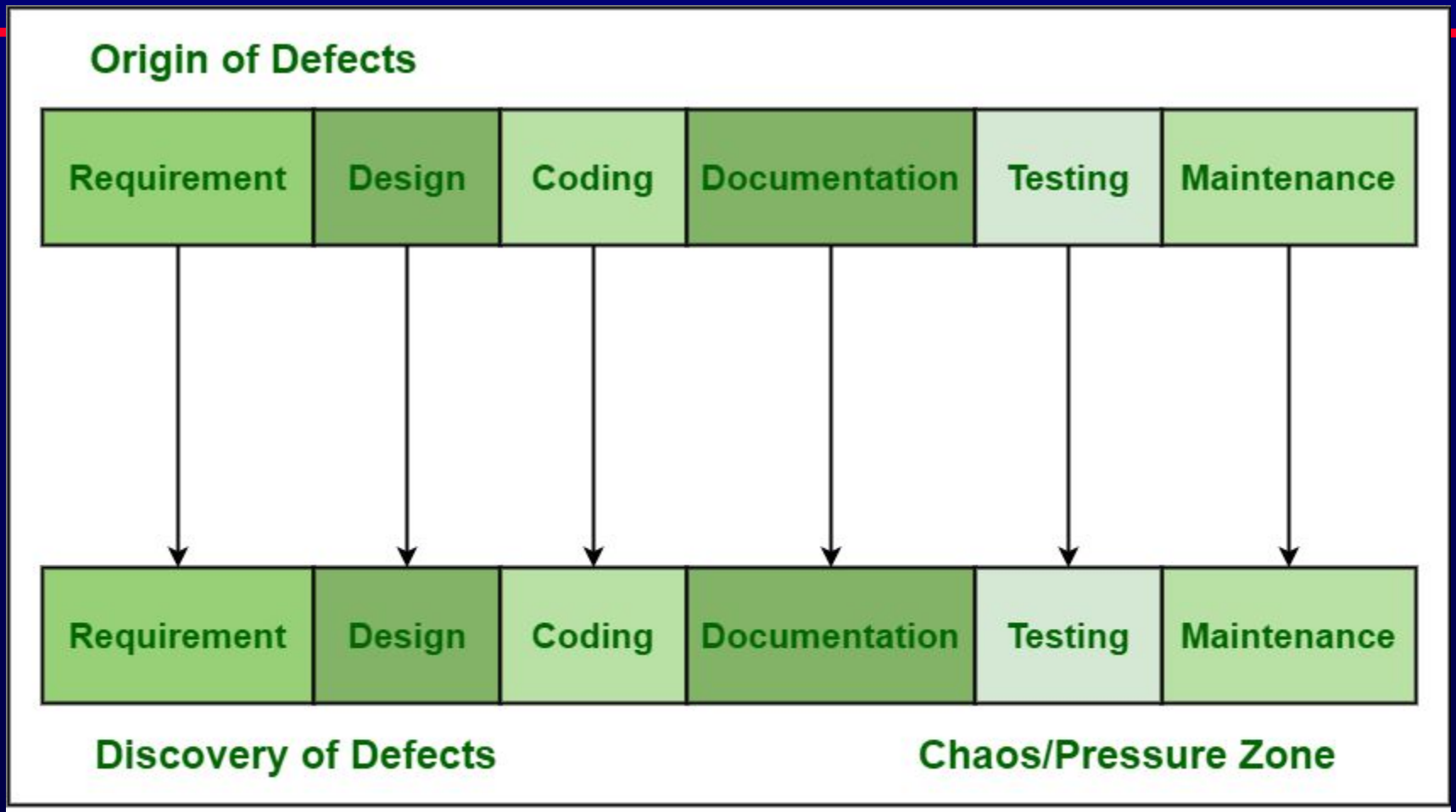
- Checklist of common errors should be used to drive the inspection.
- Error checklists are programming language dependent and reflect the characteristic errors that are likely to arise in the language.
- In general, the 'weaker' the type checking, the larger the checklist.
- Examples: Initialisation, Constant naming, loop termination, array bounds, etc.

Inspection checks 1



Defect Discovery when Inspections are not Performed

Inspection checks 2



Defect Discovery when Inspections are not Performed

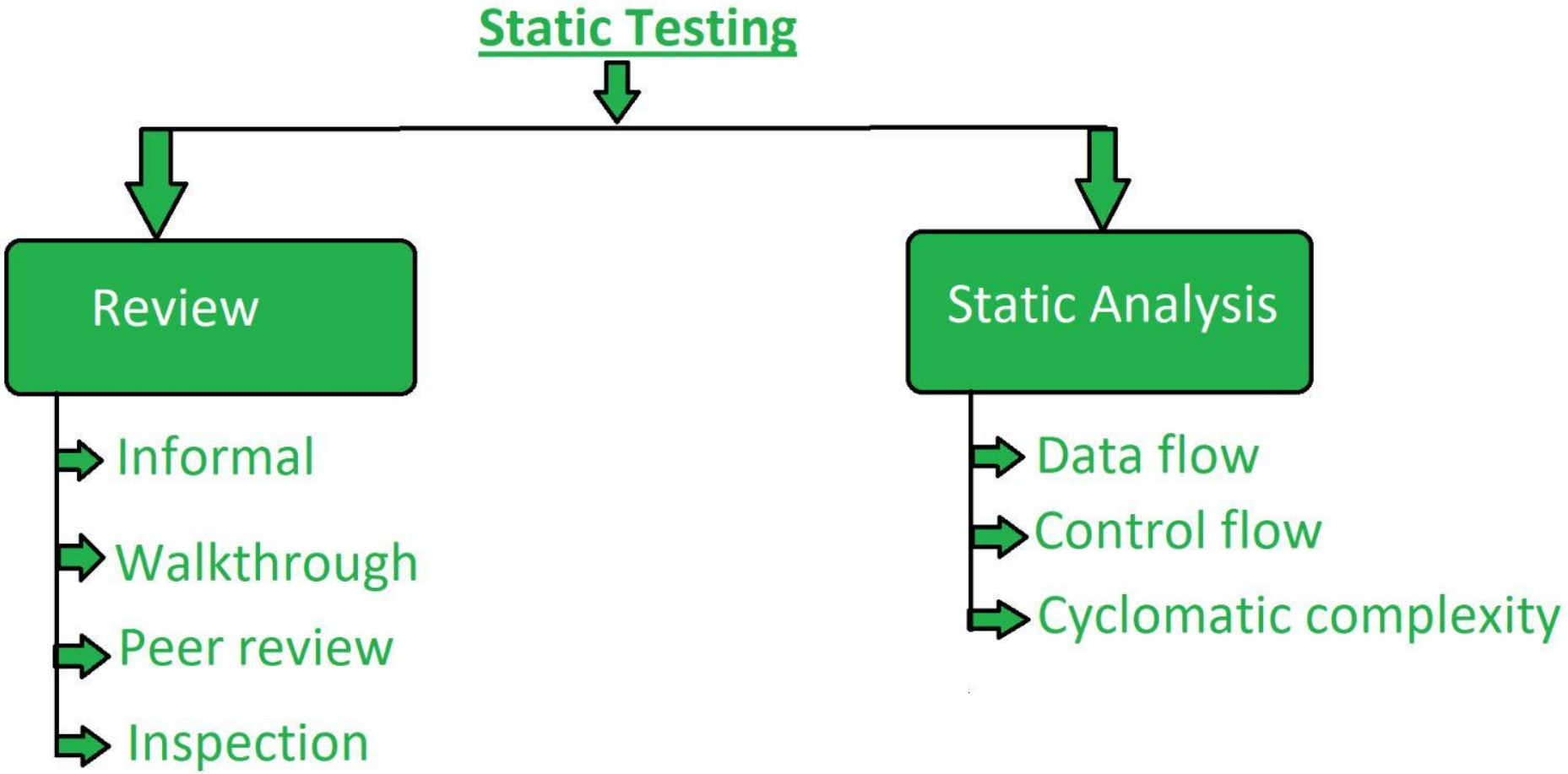
Inspection rate

- 500 statements/hour during overview.
- 125 source statement/hour during individual preparation.
- 90-125 statements/hour can be inspected.
- Inspection is therefore an expensive process.
- Inspecting 500 lines costs about 40 man/hours effort - about £2800 at UK rates.

Automated static analysis

- Static analysers are software tools for source text processing.
- They parse the program text and try to discover potentially erroneous conditions and bring these to the attention of the V & V team.
- They are very effective as an aid to inspections - they are a supplement to but not a replacement for inspections.

Static analysis checks



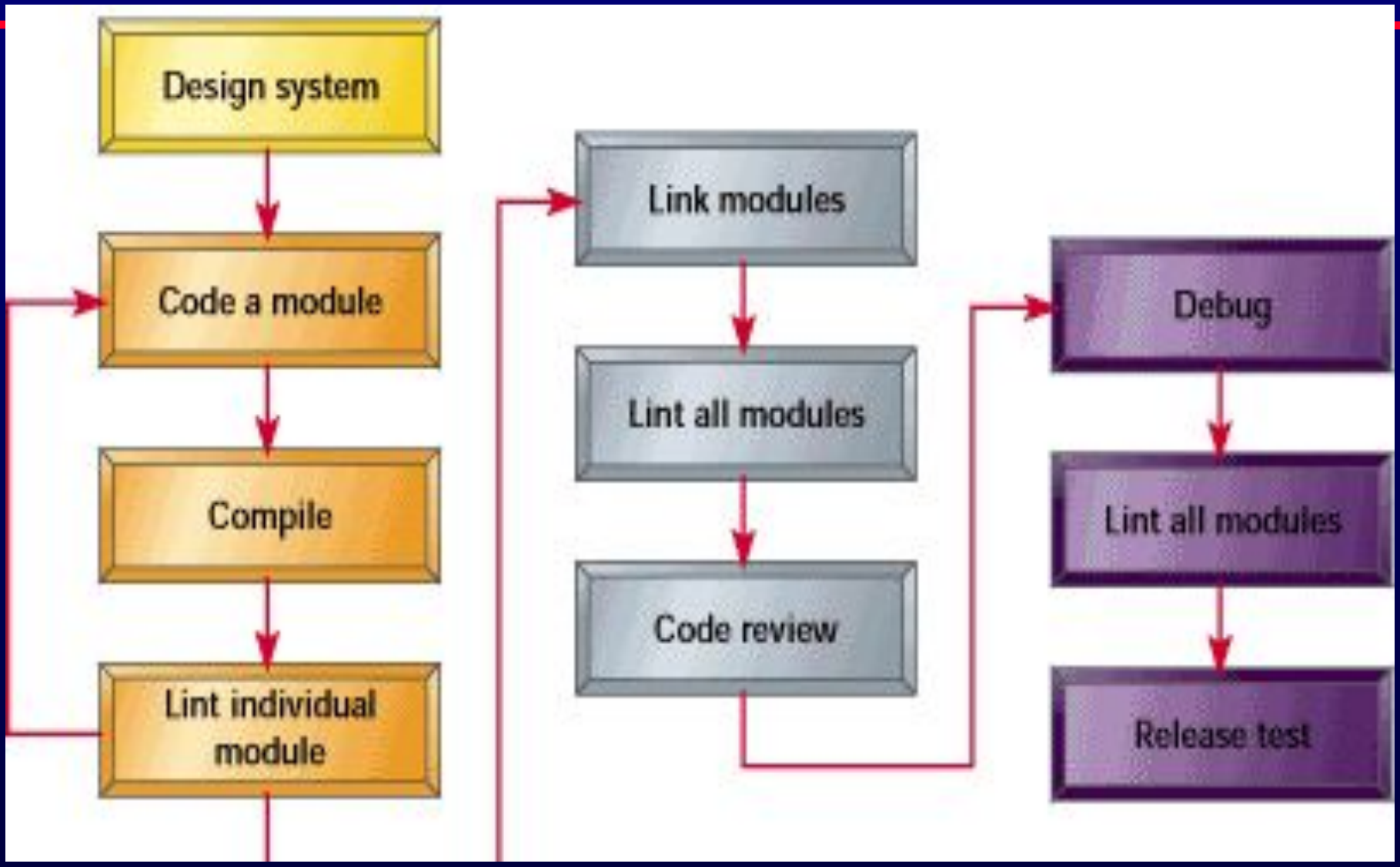
Stages of static analysis

- Control flow analysis. Checks for loops with multiple exit or entry points, finds unreachable code, etc.
- Data use analysis. Detects uninitialised variables, variables written twice without an intervening assignment, variables which are declared but never used, etc.

Stages of static analysis

- Information flow analysis. Identifies the dependencies of output variables. Does not detect anomalies itself but highlights information for code inspection or review
- Path analysis. Identifies paths through the program and sets out the statements executed in that path. Again, potentially useful in the review process
- Both these stages generate vast amounts of information. They must be used with care.

LINT static analysis



Static Analysis Tools

- FindBugs - Finds MANY categories of bugs
- Checkstyle - coding standard violations
- PMD - Maybe a lot more, but seems to be mainly unused variables it seems, also cut-n-paste code.
- Jamit - Java Access Modifier Inference Tool - find tighter access modifiers

Verification and formal methods

- Formal methods can be used when a mathematical specification of the system is produced.
- They are the ultimate static verification technique.
- They involve detailed mathematical analysis of the specification and may develop formal arguments that a program conforms to its mathematical specification.

Arguments for formal methods

- Producing a mathematical specification requires a detailed analysis of the requirements and this is likely to uncover errors.
- They can detect implementation errors before testing when the program is analyzed alongside the specification.

Arguments against formal methods

- Require specialized notations that cannot be understood by domain experts.
- Very expensive to develop a specification and even more expensive to show that a program meets that specification.
- It may be possible to reach the same level of confidence in a program more cheaply using other V & V techniques.
- Formal specification using a state transition model.
- Incremental development where the customer prioritises increments.
- Structured programming - limited control and abstraction constructs are used in the program.
- Static verification using rigorous inspections.
- Statistical testing of the system.

Key points

- Verification and validation are not the same thing. Verification shows conformance with specification; validation shows that the program meets the customer's needs.
- Test plans should be drawn up to guide the testing process.
- Static verification techniques involve examination and analysis of the program for error detection.

Key points

- Program inspections are very effective in discovering errors.
- Program code in inspections is systematically checked by a small team to locate software faults.
- Static analysis tools can discover program anomalies which may be an indication of faults in the code.