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Verification Cases: Characterizing the Completeness Degree of Incomplete Verification

Towards Using Formal Verification for Low Criticality Functions

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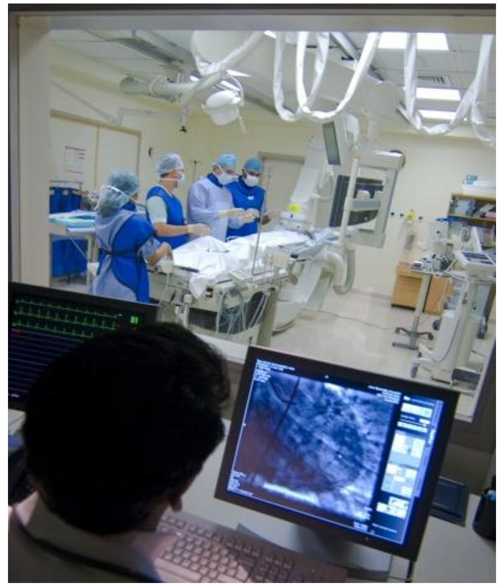
Our Business Domains



State of Practice

Structural test coverage recommendations for different SIL levels (IEC 61508)

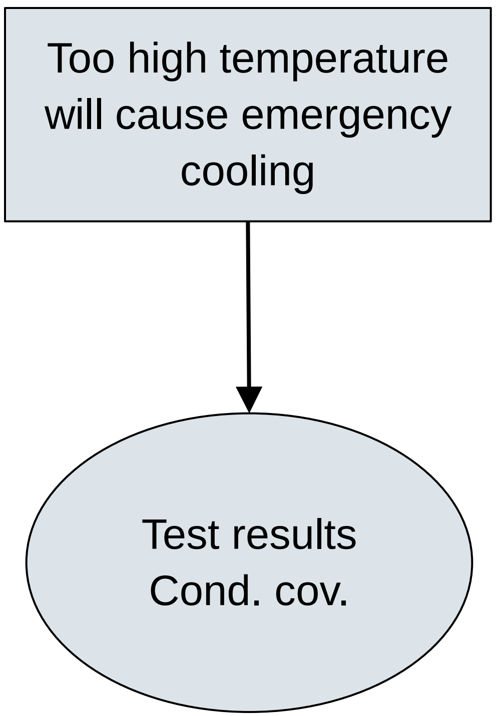
	Technique/Measure *	Ref	SIL 1	SIL 2	SIL 3	SIL 4
7a	Structural test coverage (entry points) 100 % **	C.5.8	HR	HR	HR	HR
7b	Structural test coverage (statements) 100 %**	C.5.8	R	HR	HR	HR
7c	Structural test coverage (branches) 100 %**	C.5.8	R	R	HR	HR
7d	Structural test coverage (conditions, MC/DC) 100 %**	C.5.8	R	R	R	HR

State of Practice (2)

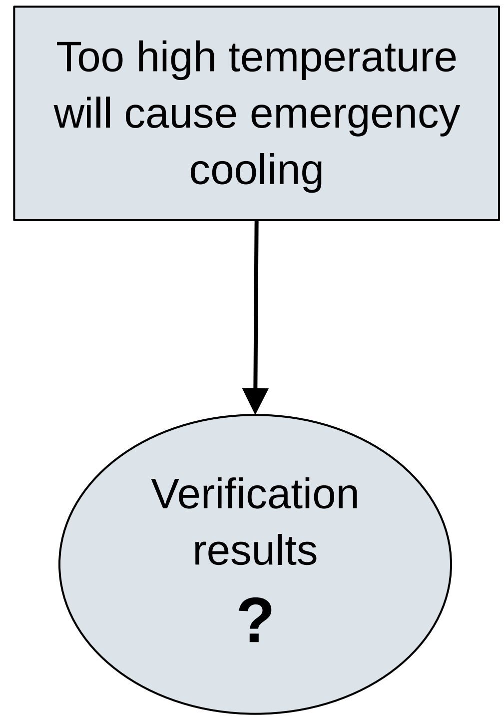
Formal verification is used only when explicitly required by safety standards (i.e. not at all for SIL1-3 functions)

… even if scalable C-level model checkers are available,
… results as good as „branch coverage testing“ are easy to achieve

Evidence in Assurance Cases



Tests results as evidence



Verification results as evidence

Why is Formal Verification not (really) Used?

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We need means to characterize the completeness degree of incomplete verification

… in order to qualify the evidence which is used in an assurance case

Verification Cases

Complement Unit Testing with Verification for Functions at Lower Criticality Levels

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Causes of Incompleteness

- Tooling limitations
  - Boundness of model checkers

- Simplification assumptions to speed-up the verification
  - Restrictions on the data environment
  - Simplifying models of libraries
  - Bounding the unwinding of certain loops
  - Stubbing parts of the system
  - Bounding the number of threads
  - …

Example

The system must prevent overheating. […] The cooling system can be started manually or automatically. […] The min. and max. temperatures of coolant are entered by the operator

```
uint16 min
uint16 max
boolean coolingStarted;

cooling_cmd coolingCommand(uint16 crtTemp) {
  return
```

	crtTemp < min	crtTemp in [min..max[	crtTemp > max
coolingStarted	stop cooling	start cooling	emergency cooling
!coolingStarted	no cooling	no cooling	emergency cooling

```
} coolingCommand (function)
```

```
  exported testcase coolingTest1 {
    min = 20;
    max = 50;
    coolingStarted = true;
    assert(0) coolingCommand(25) == start_cooling;

    coolingStarted = false;
    assert(1) coolingCommand(25) == no_cooling;
  } coolingTest1(test case)
```

Example

The system must prevent overheating. […] The cooling system can be started manually or automatically. […] The min. and max. temperatures of coolant are entered by the operator

```
uint16 min
uint16 max
boolean coolingStarted;

cooling_cmd coolingCommand(uint16 crtTemp) {
  return
} coolingCommand (function)
```

	crtTemp < min	crtTemp in [min..max[	crtTemp > max
coolingStarted	stop cooling	start cooling	emergency cooling
!coolingStarted	no cooling	no cooling	emergency cooling

```
verification_case coolingVerification for :coolingCommand {
  initial state: {
    data env: min : uint8 -> min (uint16) {   };
    data env: max : uint8 -> max (uint16) { max > min; };
  }

  verification step {
    data env: myTemp : uint8 -> crtTemp (uint16) {   };
    data env: myCoolingStarted : boolean -> coolingStarted (boolean) {   };
    cooling_cmd cmd = coolingCommand(myTemp);
    assert(myTemp > max → cmd == emergency_cooling);
  }
} coolingVerification (function)
```

Verification Cases vs. Test Cases