17: Testing

Project proposals

Graded on completion (everyone got a 6/6)

Everyone got comments – some ask for changes to be made before the milestone report/demo, so **please read them**

General comments

- Make sure there is some complexity (whole project shouldn't just link an input to an output – what kind of control can you introduce?)
- Check for compatibility with Arduino (SAMD architecture for libraries, 3.3V for parts)

Watchdog timers

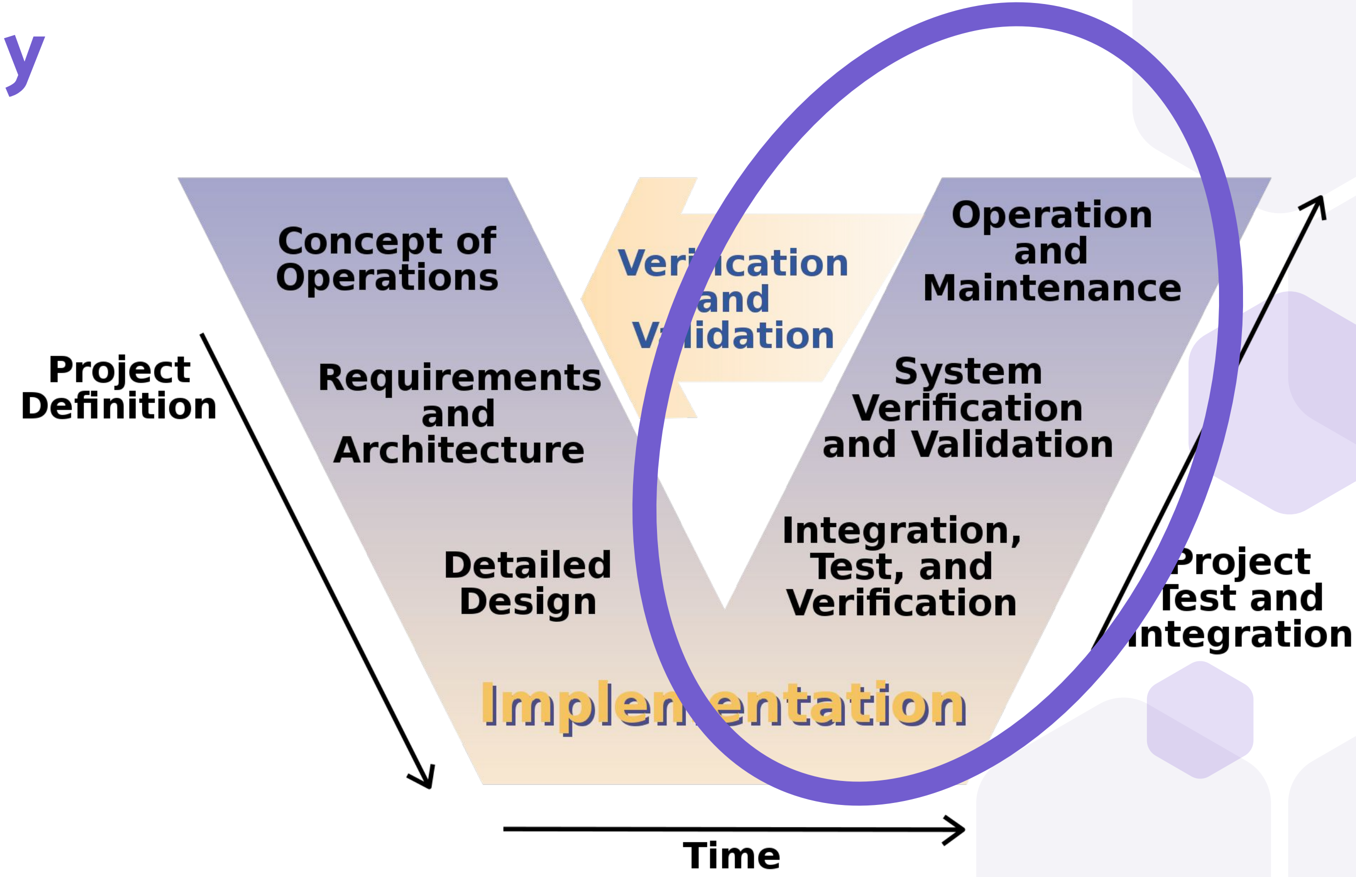
- Watchdogs are meant to detect system hangs
  - Pet them in specific places in the code
  - Successful pet = code still running = no watchdog reset
  - WDTs should not be used as regular timers!
- *Actively* detecting a failure (such as malformed input) and acting upon that failure should not be handled by a watchdog
- Also think about what it means for the system to reset: is resetting safe behavior for your system?
  - Consider using early warning interrupt to warn user instead

Interrupts

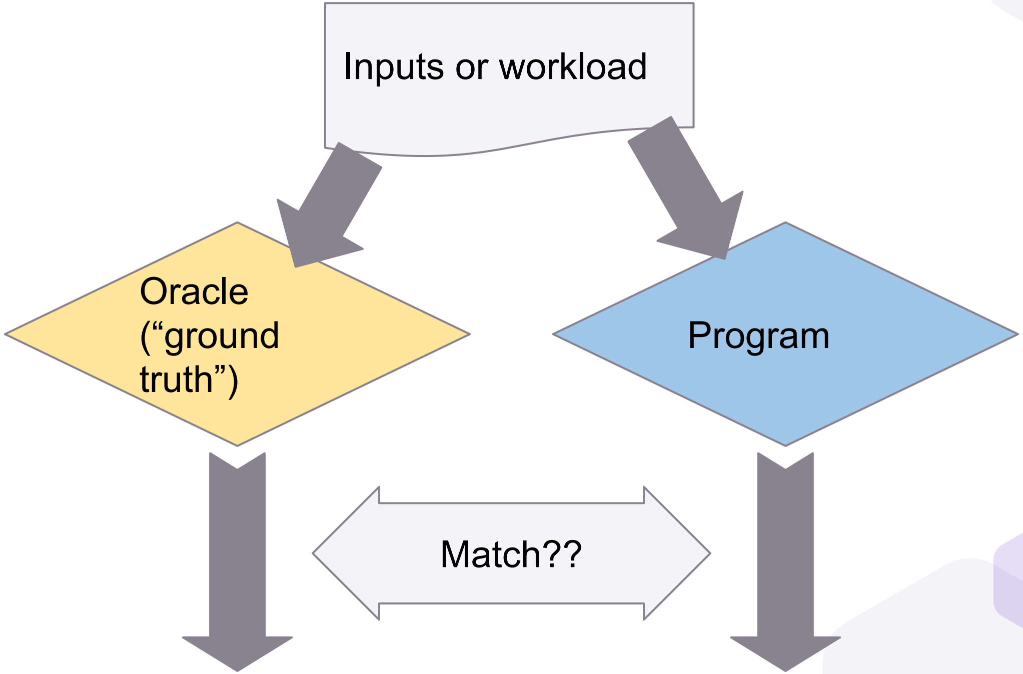
Read the datasheet to find out how your components work

- Be sure to say what is *triggering* the interrupt, not just the result
- Some of the proposed “interrupt” ideas could only be accomplished with polling
  - Does it make sense to interrupt on an analog signal (or a “change” in something that’s not a digital electrical signal?)
  - MKR1000 WiFi/Serial API does not expose an interrupt for communication (have to poll)

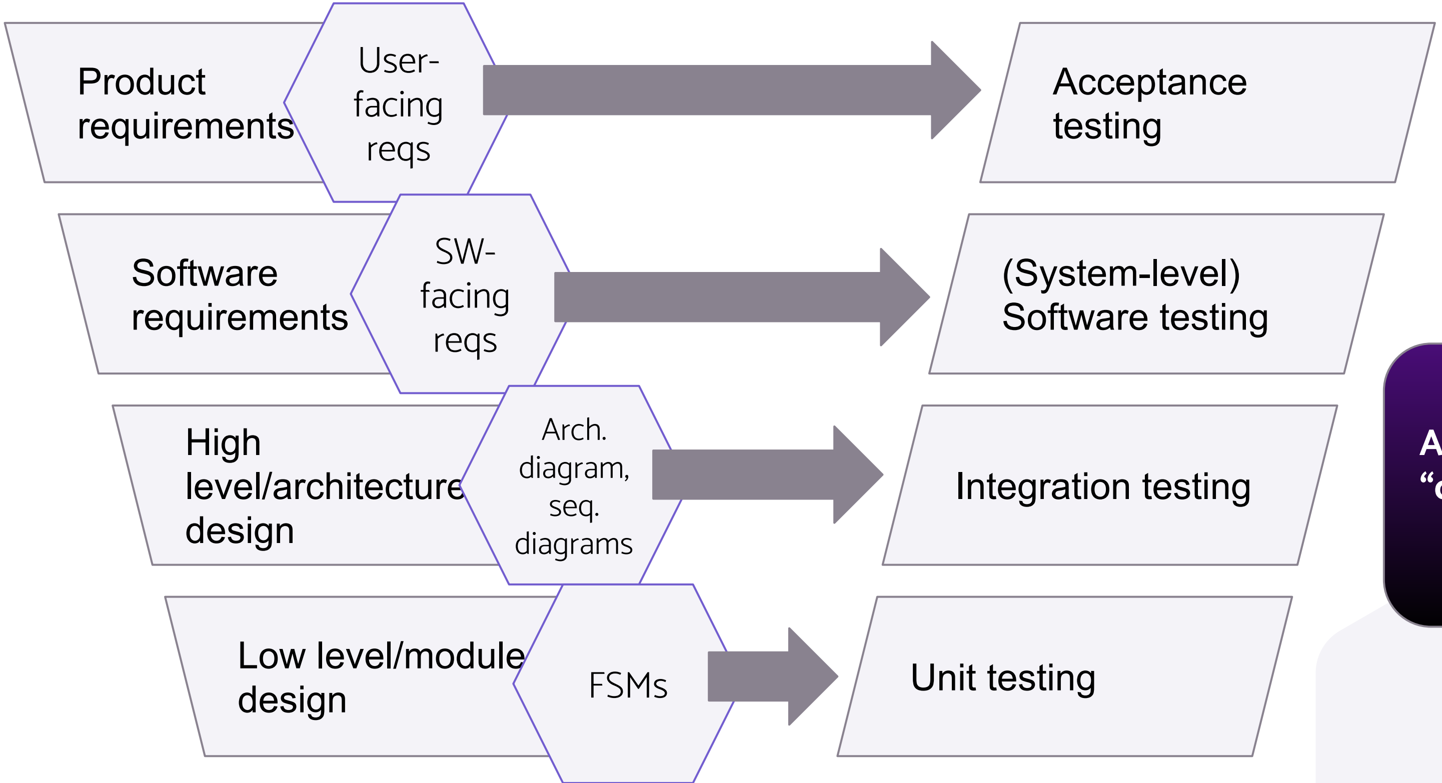
Today


Concept of Operations
Requirements and Architecture
Detailed Design
Verification and Validation
Operation and Maintenance
System Verification and Validation
Integration, Test, and Verification
Implementation
Project Definition
Project Test and Integration
Time

What is testing?



V model: artifacts guide testing



Product requirements

User-facing reqs

Acceptance testing

Software requirements

SW-facing reqs

(System-level) Software testing

High level/architecture design

Arch. diagram, seq. diagrams

Integration testing

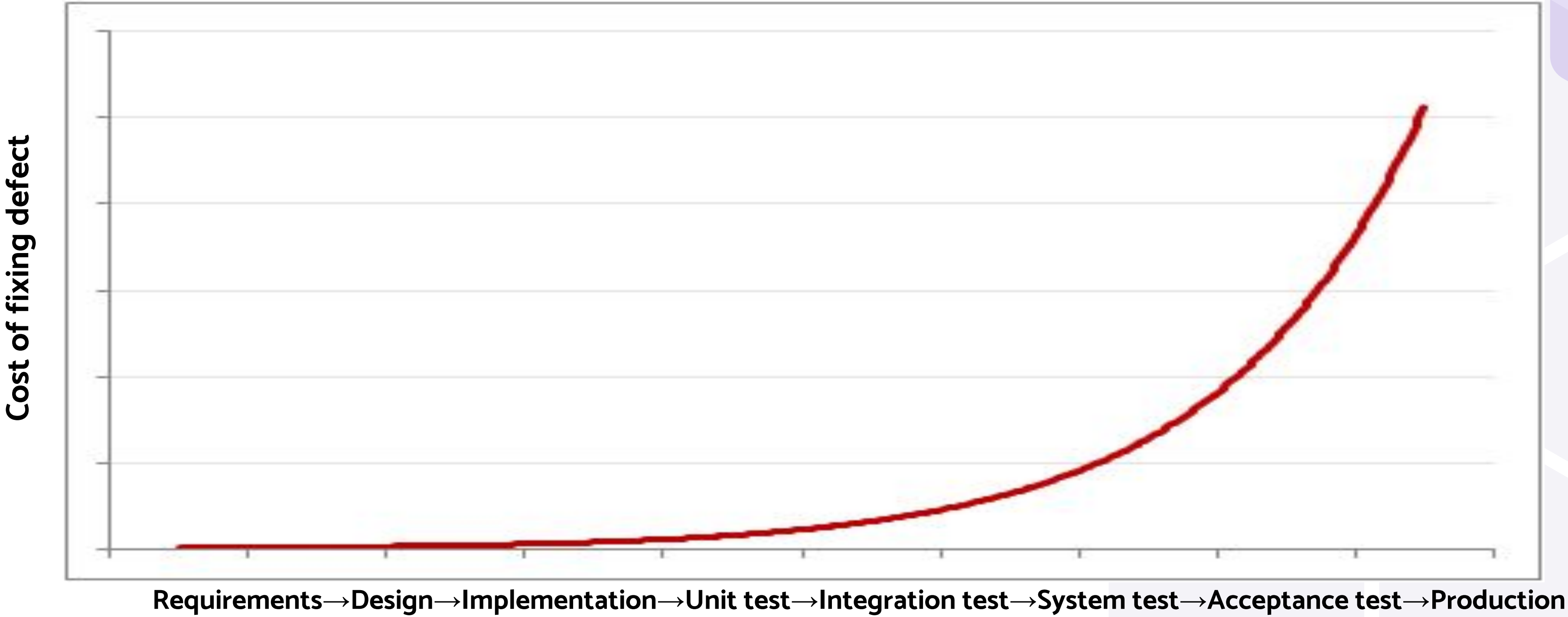
Low level/module design

FSMs

Unit testing

At each level: testing asks, “does the implementation match the design?”

Why not just system/acceptance testing?



Unit testing

Check correctness of a module

One unit test = test a single function/method/path

Cannot test even single function calls exhaustively - consider f(int x, int y, int z)

Best place to test edge case values

Both structural and functional testing

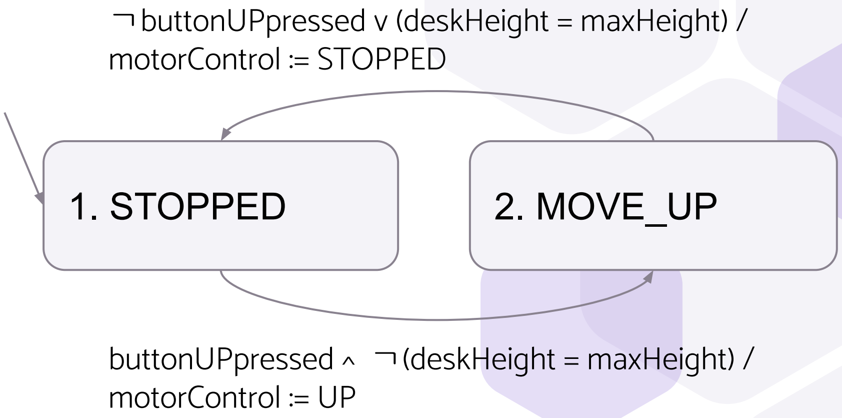
Functional vs. structural testing

Functional	Structural
“Black box” testing	“White box” testing
No underlying knowledge of code	Knowledge of structure of code - guides testing
Example goal: exercise every requirement for module, or every transition in FSM	Example: exercise every line of code in function call

What are the tradeoffs between black box and white box testing?

How to unit test an implementation based on FSM?

```
state updateFSM(state currentState, bool buttonUPpressed, …)
{
  state nextState = currentState;
    switch(currentState) {
      case STOPPED:
        // transition 1-2
        if (buttonUPpressed && (deskHeight != maxHeight)) {
          nextState = MOVE_UP;
          setMotorControl(UP);
        }
        break;
      case MOVE_UP:
        // transition 2-1
        if (!buttonUPpressed || (deskHeight == maxHeight) {
          nextState = STOPPED;
          setMotorControl(STOPPED);
        }
        break;
      default:
        error(“invalid state!”);
    }
  return nextState;
```


¬buttonUPpressed v (deskHeight = maxHeight) /
motorControl := STOPPED
1. STOPPED
2. MOVE_UP
buttonUPpressed ^ ¬(deskHeight = maxHeight) /
motorControl := UP

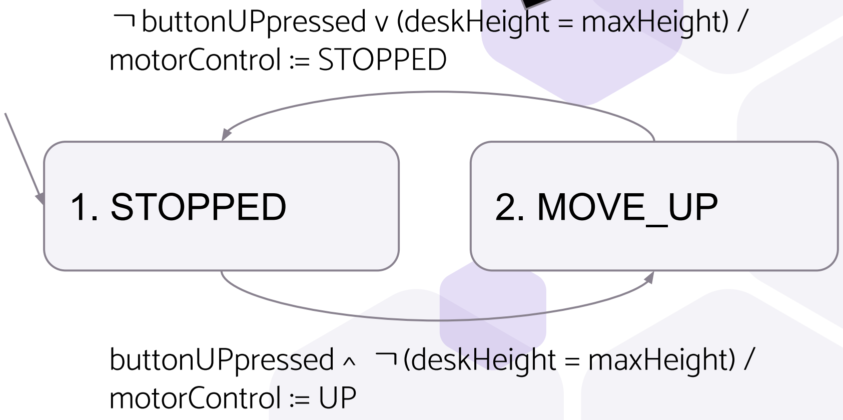
Want to test updateFSM’s implementation as-is (without making changes to it)

Test for transition 1-2

Test: transition correctly taken based on inputs, variables/outputs set correctly

```
endState = updateFSM(STOPPED, true, 35)
assert(endState == MOVE_UP)
assert(motor is moving up)
```

Test should be independent of any other sequence of transitions!


¬buttonUPpressed v (deskHeight = maxHeight) / motorControl := STOPPED
1. STOPPED
2. MOVE_UP
buttonUPpressed ^ ¬(deskHeight = maxHeight) / motorControl := UP

guided by FSM/spec (to test that code matches FSM): ***black-box testing***

Mock out functions

```
// #define TESTING // uncomment to test

#ifndef TESTING // means TESTING is not defined

void setMotorControl(MotorEnum me) { ...normal operation … }

#else

MotorEnum motorState;

void setMotorControl(MotorEnum me) { motorState = me;}

#endif
```

Updated test of FSM transition 1-2

```
endState = updateFSM(STOPPED, true, 35)
assert(endState == MOVE_UP)
assert(motorState == UP)
```

Edge case/unexpected inputs

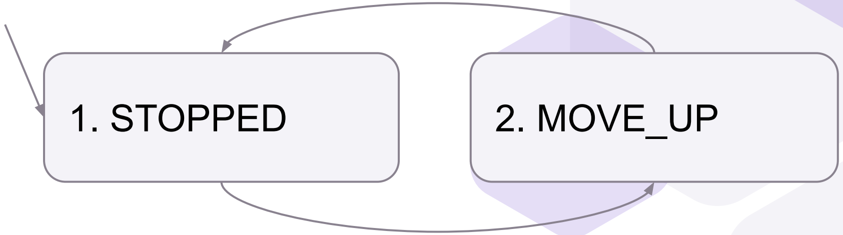
What should this do?

```
updateFSM(STOPPED, true, 5000)

updateFSM(STOPPED, true, -2)
```

What about this?

```
updateFSM(DONT_MOVE, true, 40)
```



¬ buttonUPpressed v (deskHeight = maxHeight) /
motorControl := STOPPED

1. STOPPED

2. MOVE_UP

buttonUPpressed ^ ¬ (deskHeight = maxHeight) /
motorControl := UP

Structural testing

```
int some_fun(int x, int y, int z) {
     if (x == 3 && y < 0 ) {
      // do something;
     } else {
       // do something else
     }

     q = x + z;

     if (q < y) {
       if (x == z) {
         // do another thing
       }
       // do a fourth thing
     }
}
```

What should guide your selection of test inputs for this function, if you know the underlying code?

Coverage (a preview)

Notion of how completely a piece of code has been tested with a particular set of tests, with respect to a specific metric

Examples:

- What % of requirements have been tested?
- What % of lines of code have been tested?

100% coverage does **not** mean 100% tested, but it’s a start to assess testing thoroughness

Unit testing summary

Cheaper to catch defects here than at any other stage of testing

Perform structural (white-box) or functional (black-box) testing on modules/components/functions