
MACHINETRON
DEFENDERS OF THE WORK CELL

MACHINETRON

or

"Submachines, *Assemble*!"

Pauline Pounds

25 February 2019

University of Queensland

METR4810

- **What**: Mechatronics team project course
- **When**: Starting now, going until week 13
- **Where**: Hawken 50-c404 (mostly)
- **Who**: Cast of thousands
- **How**: Lots of work
- **Why**: Get experience developing complex mechatronic and robotic systems... and

because it's awesome

New year, new me

- Those of you who have taken this class before might notice a few changes from last year…
  - These are hopefully for the better!

- I appreciate your understanding and support

Specific class objectives

- Explore the trade-offs involved in complex mechatronic/robotic systems
- Gain experience in multi-variable analytical design synthesis
- Exercise practical cyber-electromechanical integration and trouble-shooting techniques
- Build interpersonal skills working in teams

A quick note on objectives

Your objective: 7/7 grade

My objective: 5/5 SECaT

Shared priorities:

- Meet course objectives
- Reduce unnecessary work
- Have fun!

What this class is

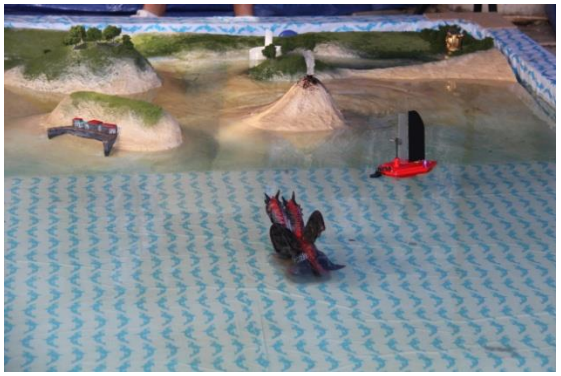
- Taking the safeties off
  - Real challenge, no hand-holding
- Unconstrained design, broad horizons
  - Very few limitations or constraints
- Focus on communication, design process, teamwork

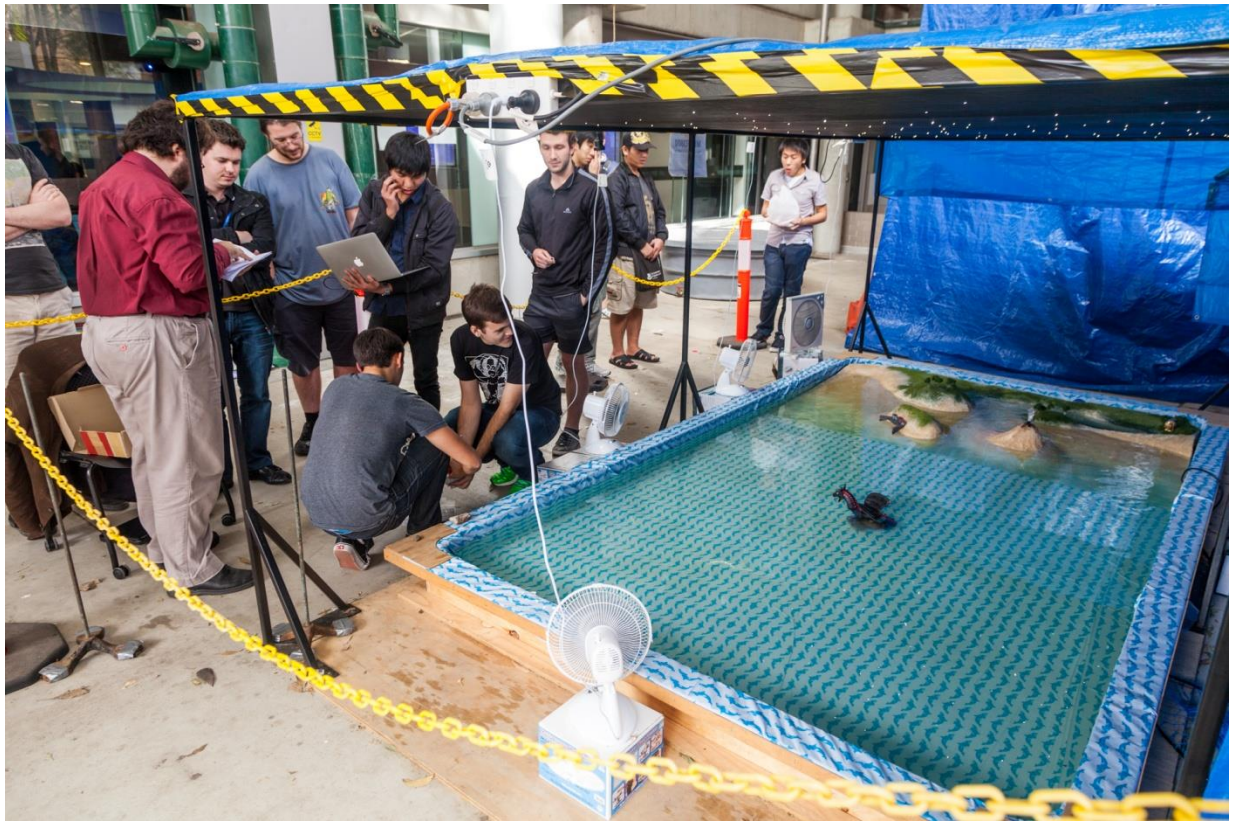
What this class is not

- Not about the project (not really)
  - It's about how you go about solving it
- Not teaching you technical engineering
  - You already know how to do math, etc.
- Not giving you one single, clear path
  - It's scary out there, and much is unknown

The Ghost of Projects Past

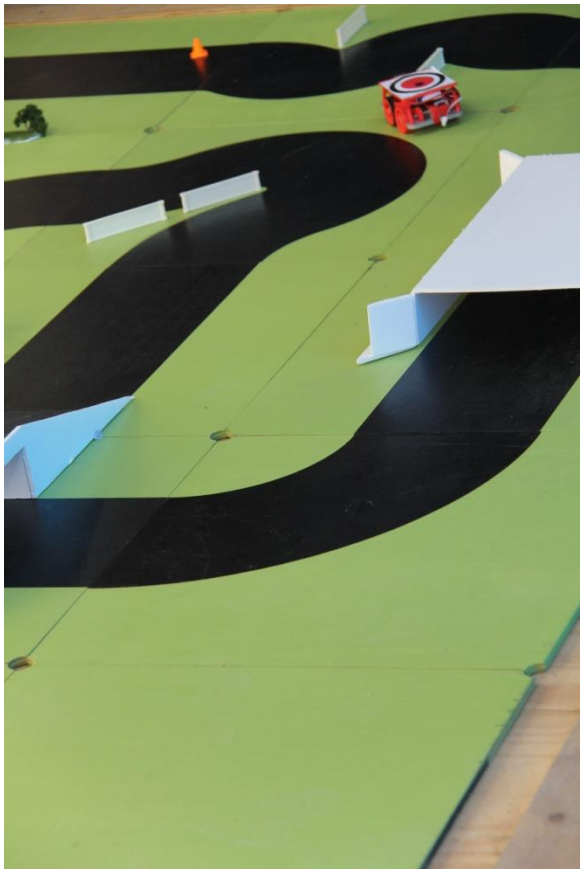
2013: Autonomous sailing and navigation





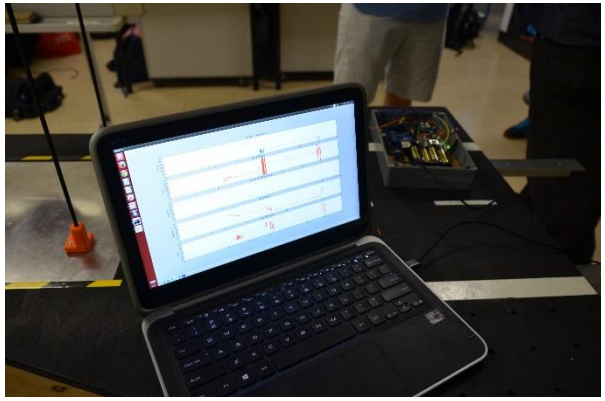
The Ghost of Projects Past

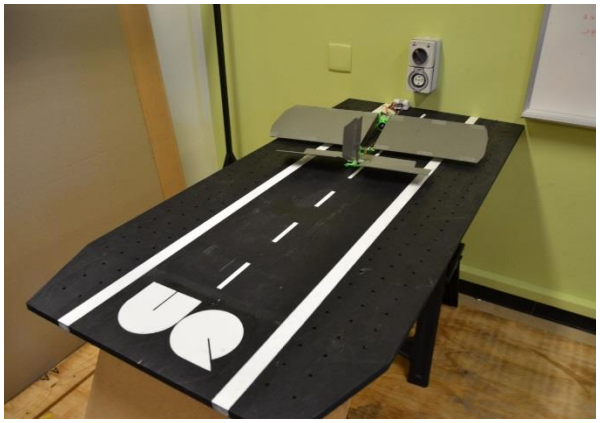
2014: Autonomous race car challenge



The Ghost of Projects Past

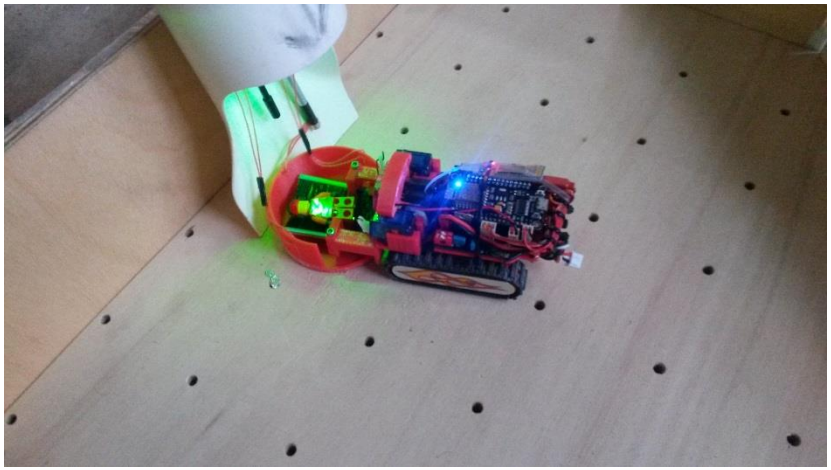
2015: Autonomous Carrier Operations

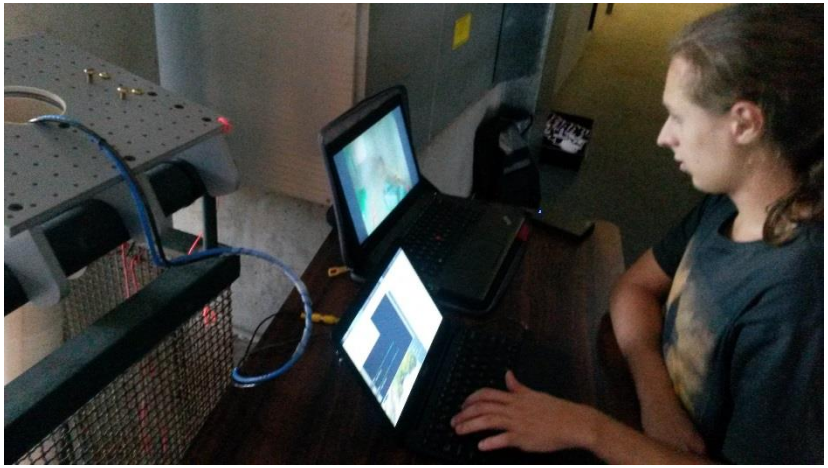




The Ghost of Projects Past

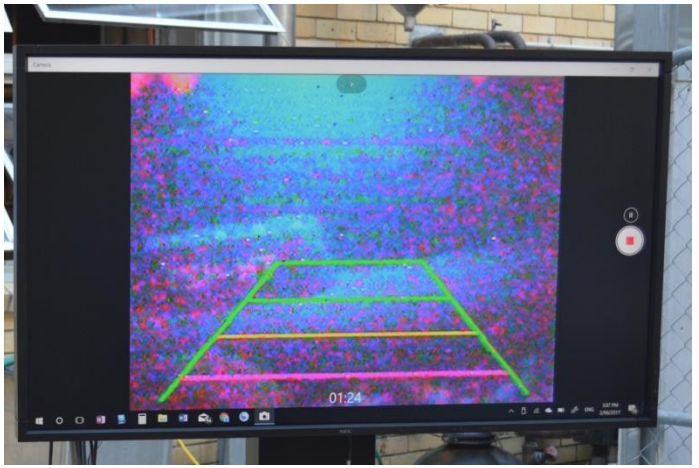
2016: Subterranean Mine Rescue

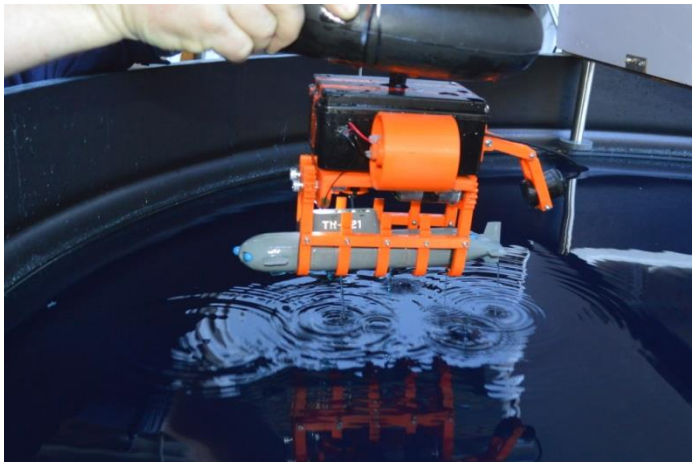




The Ghost of Projects Past

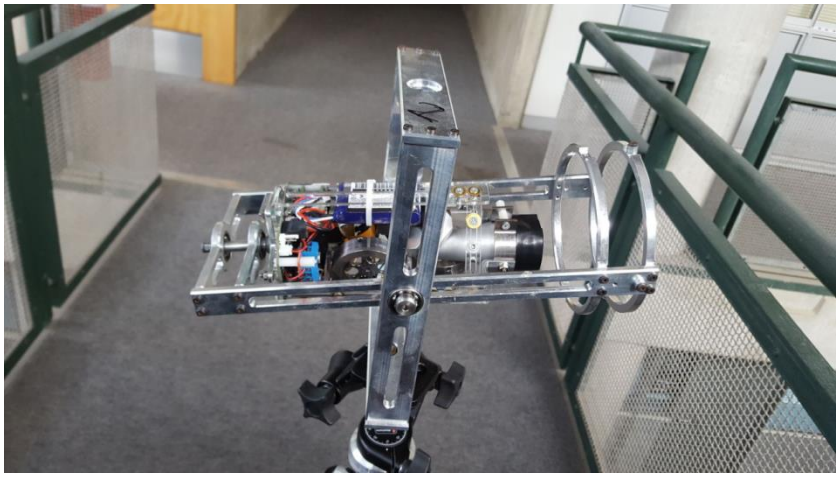
2017: Sunken Submarine Recovery

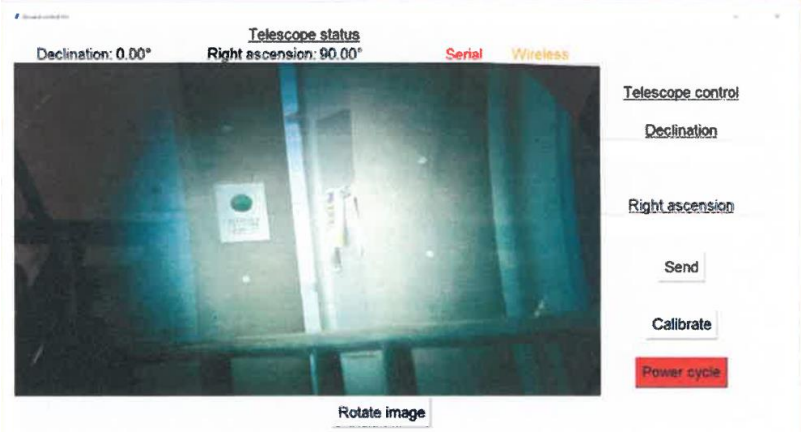




Ghost of Projects Past

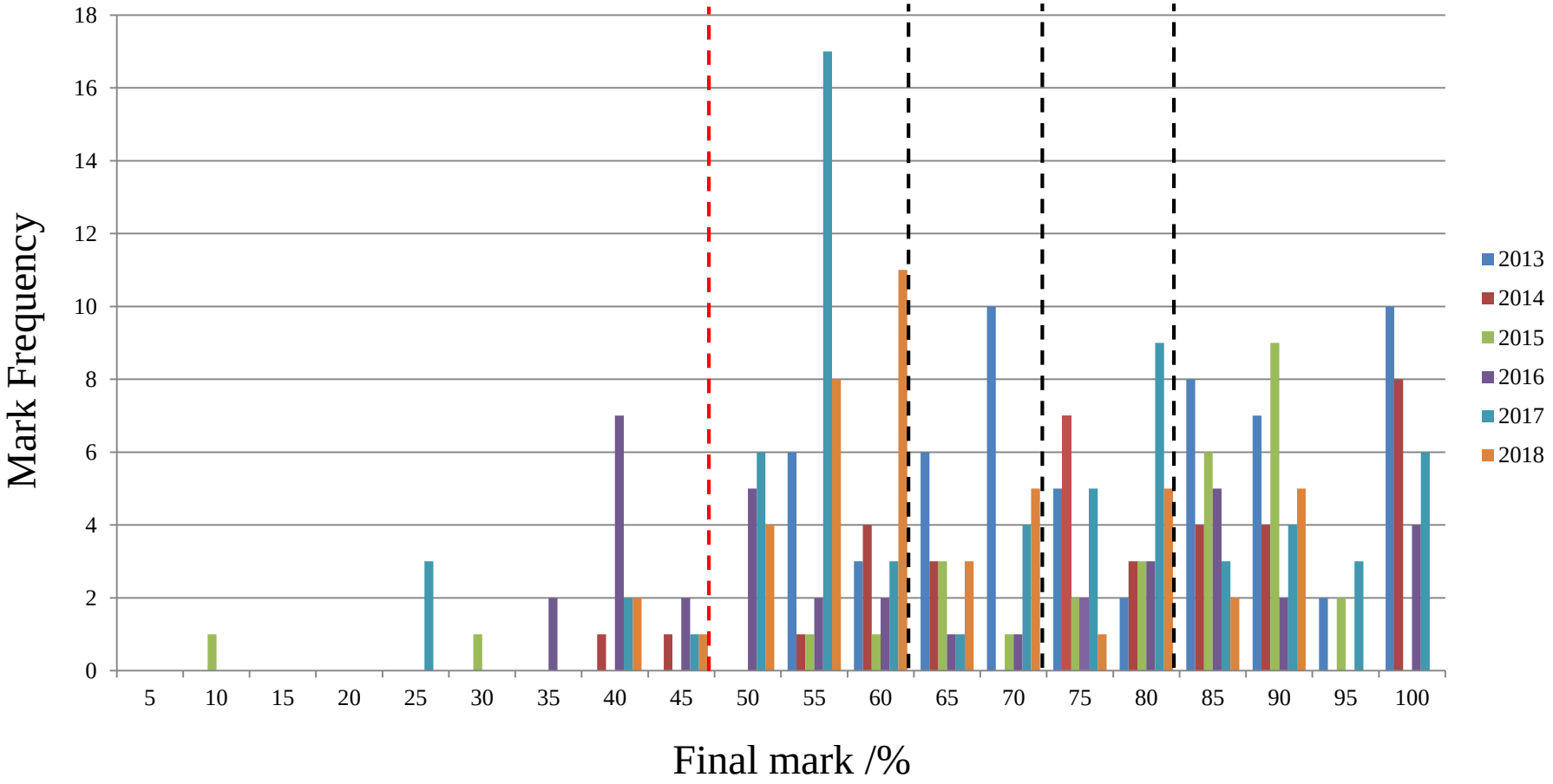
2018: Exoplanet Space Telescopes





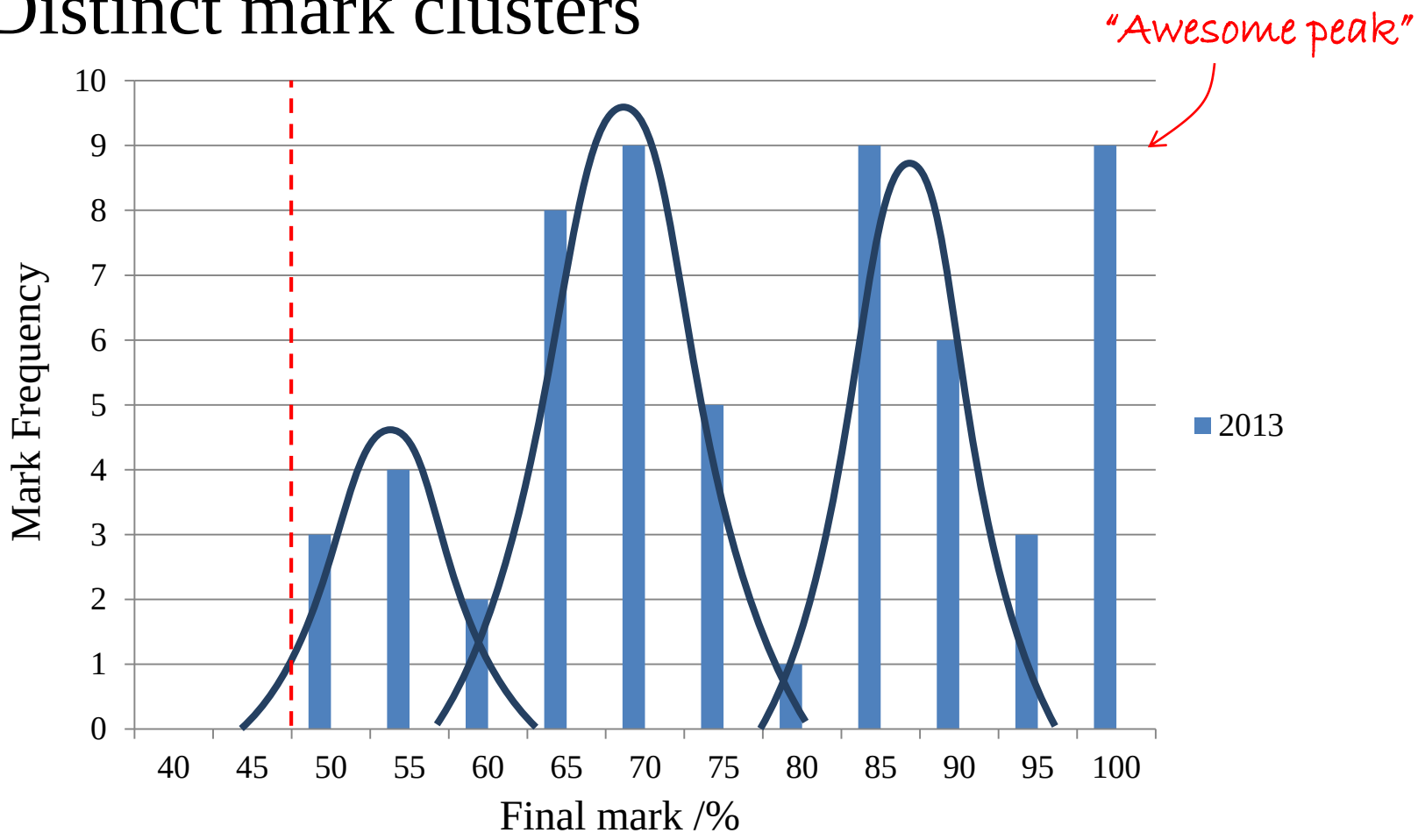
Assessment results

- Atypical mark spread: not a real bell curve



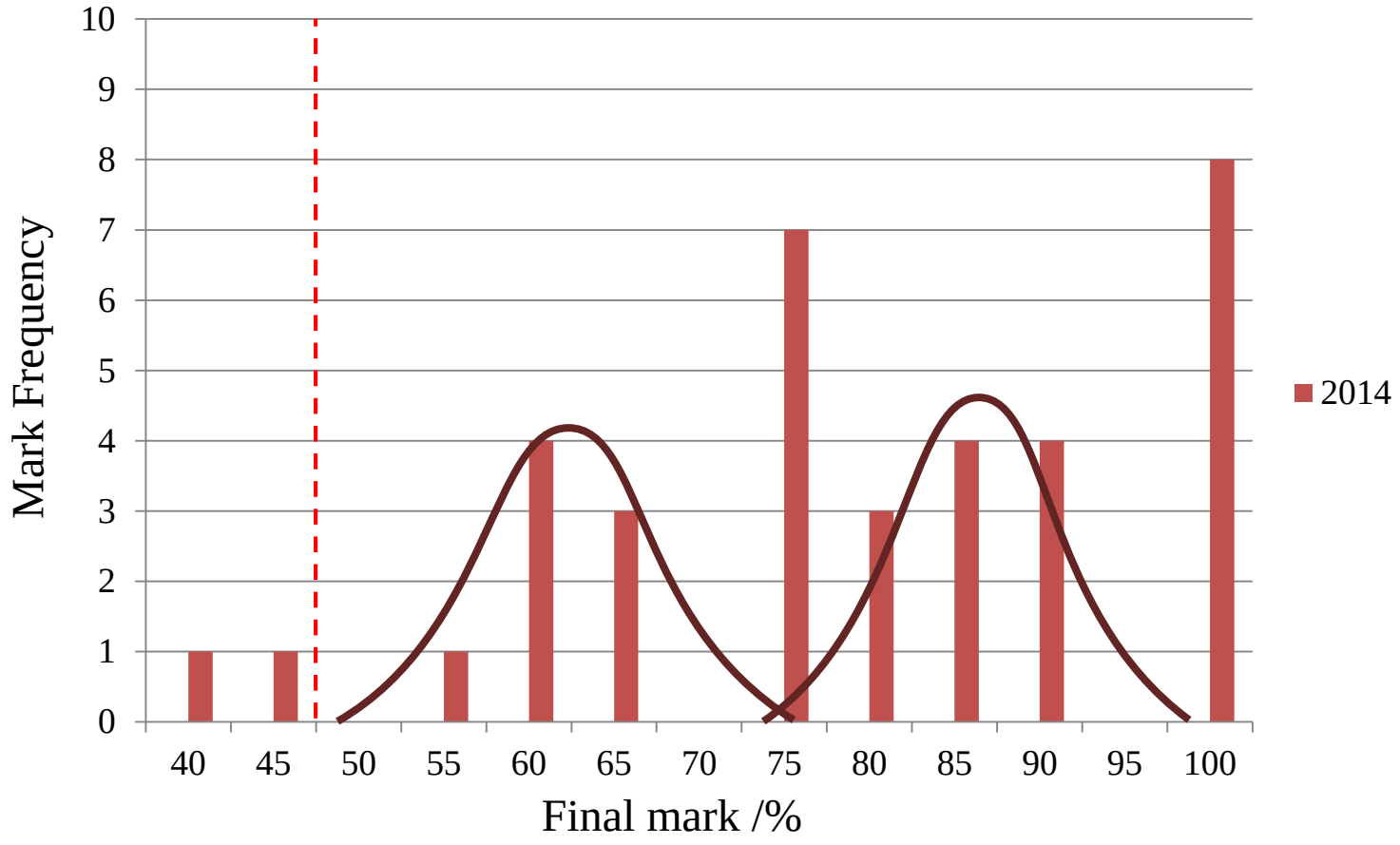
Assessment results

- Distinct mark clusters



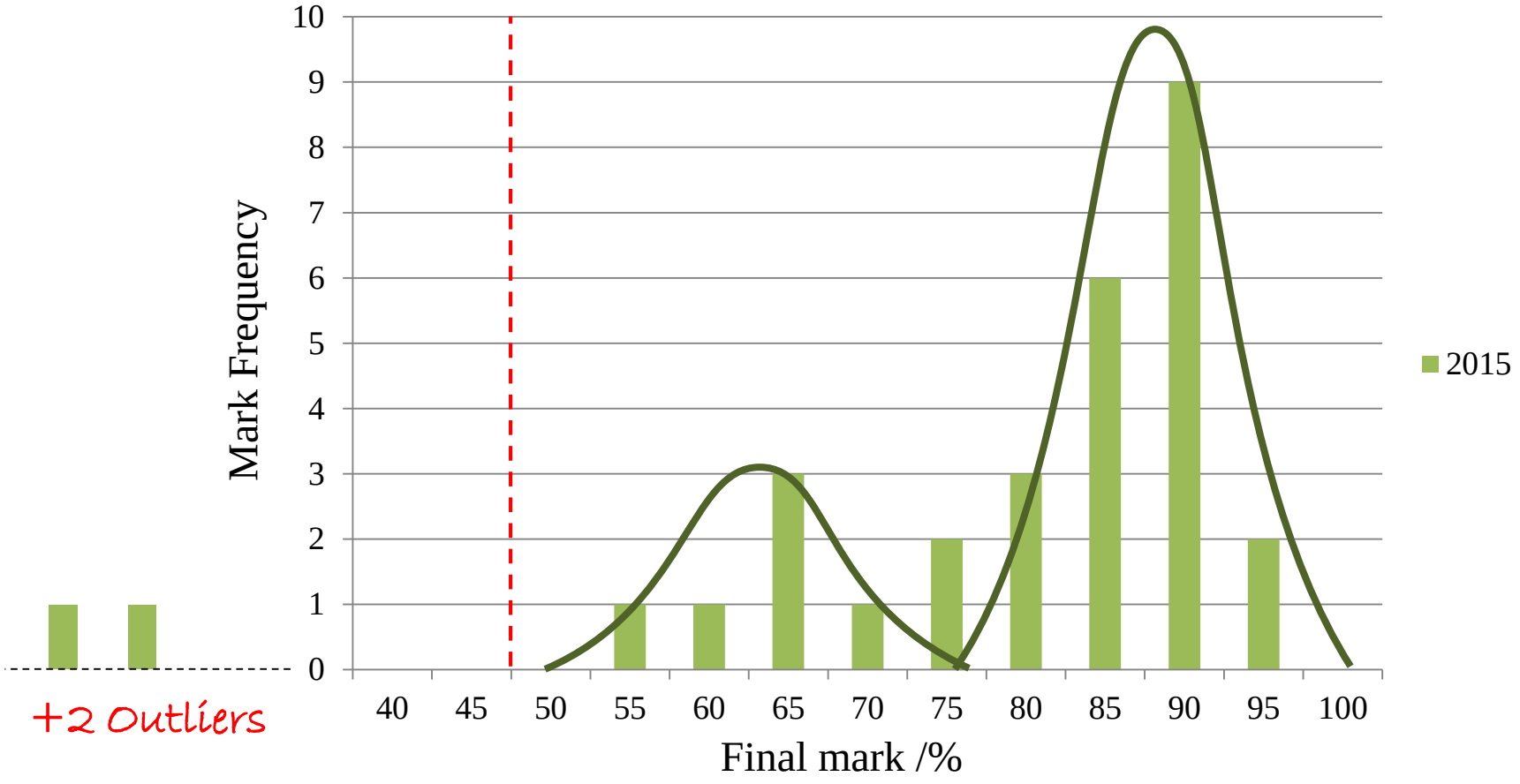
Assessment results

- Mark clusters move over time:



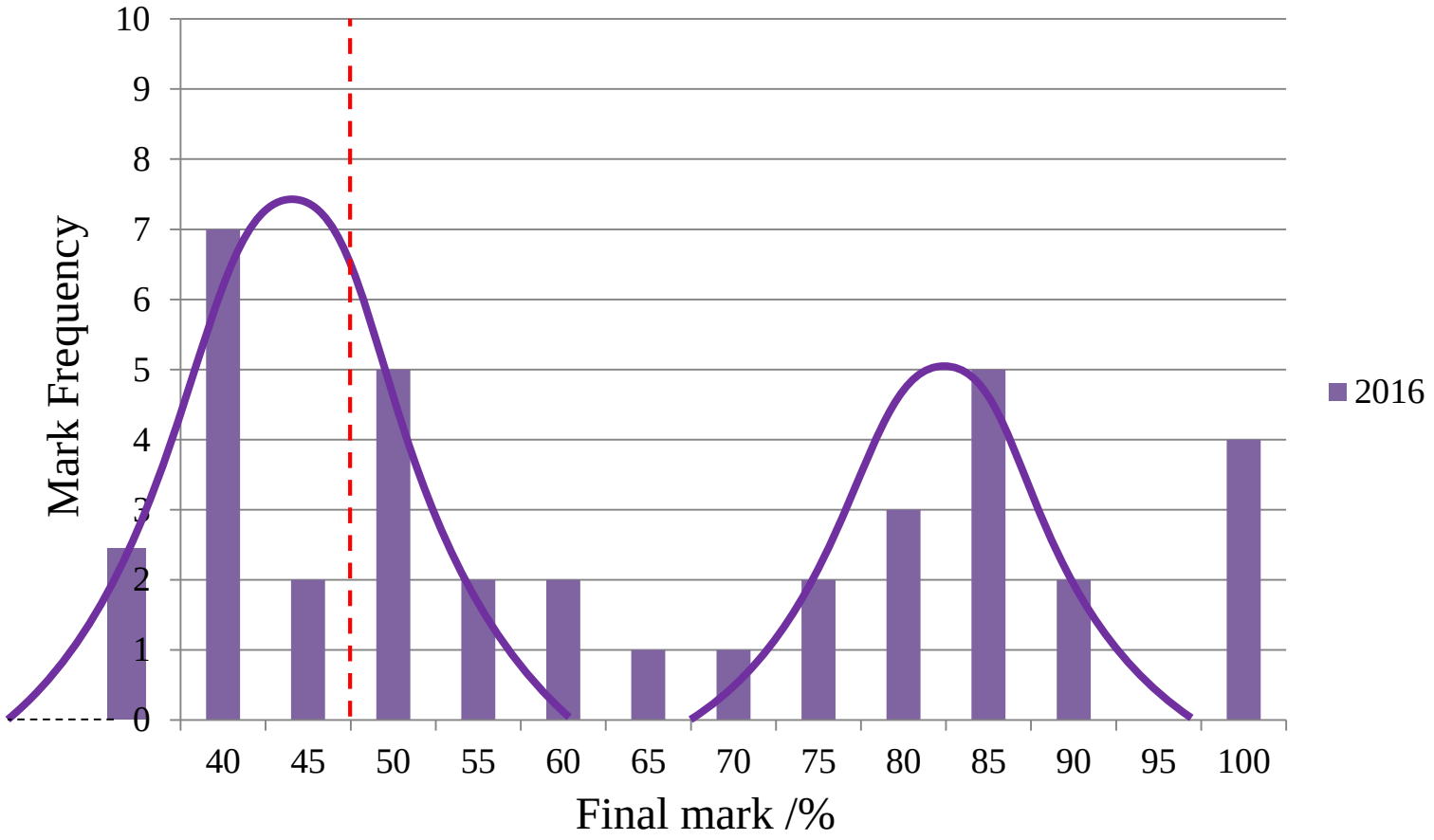
Assessment results

- Increasing performance, but more failures



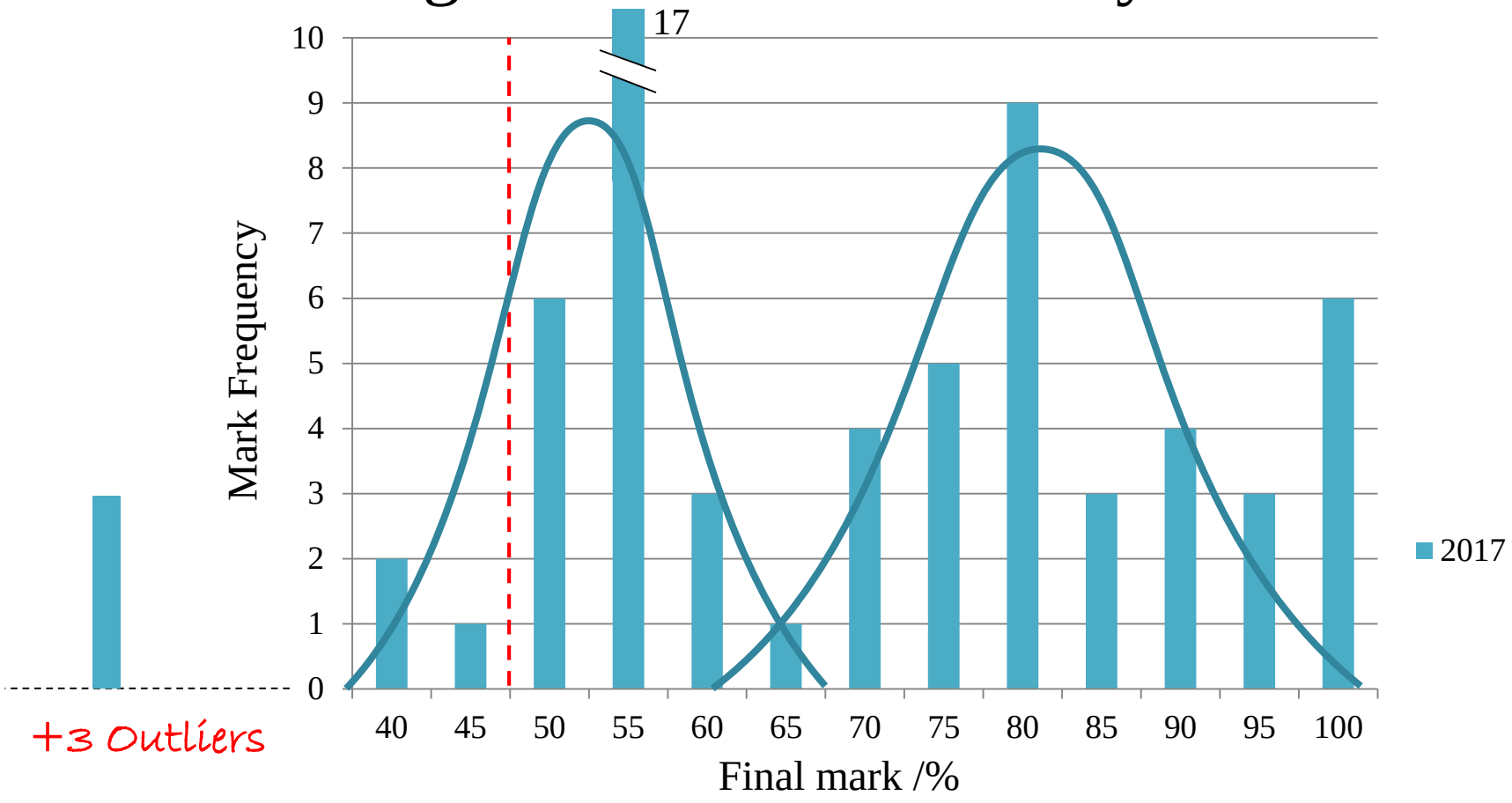
Assessment results

- Strong successes but higher failure rate, still



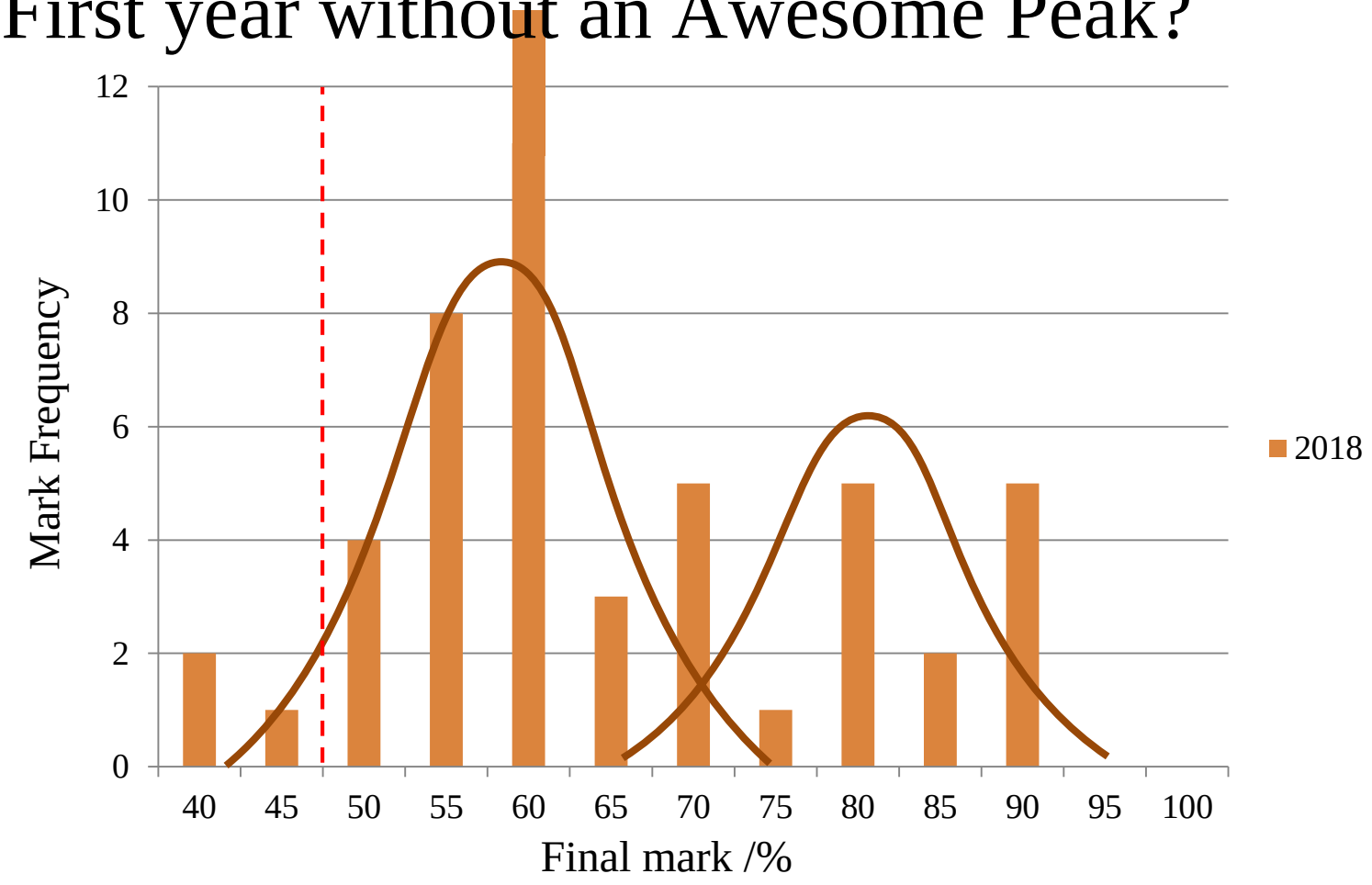
Assessment results

- Marking criteria saved so many butts!



Assessment results

- First year without an Awesome Peak?



Assessment results

- Or, put another way:

	Percentage of class					
	≤3	**4**	**5**	**6**	**7**	**Avg**
2013	**0**	25	24	**19**	**32**	5.58
2014	**6**	14	8	**28**	**44**	5.90
2015	**7**	16	10	**30**	**37**	5.66
2016	**29**	24	5	**21**	**21**	4.52
2017	**18**	31	13	**18**	**19**	4.94
2018	**4**	57	13	**15**	**11**	4.72

Typical student outcomes

Student tend to fall into two broad groups:

The **Gets-its** and the **Don’t-Gets-its**

- The Gets-its work as a team, deconstruct the task rationally, try to understand the real problem, and implement a solution well
- The Don’t-Gets-its... don’t

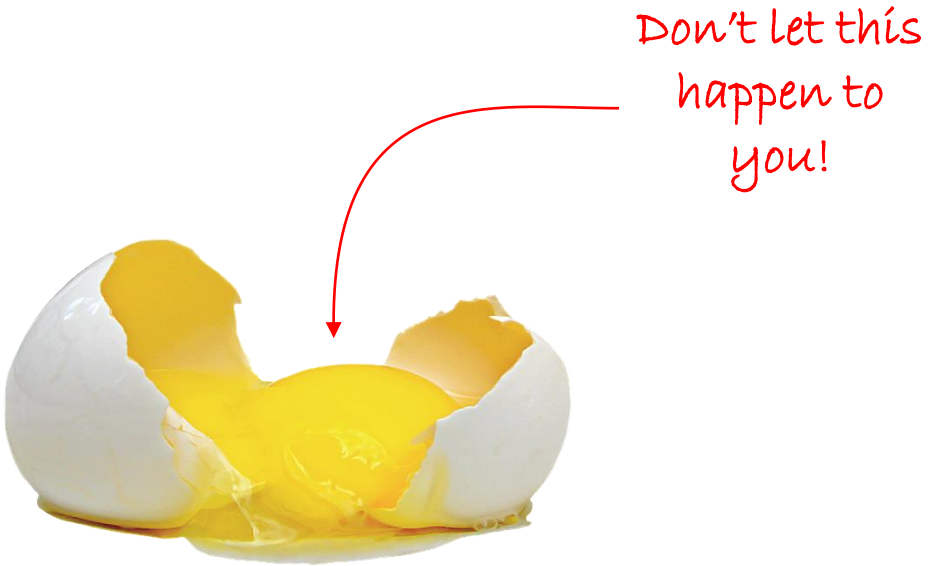
Sins of the forbearers

- 2013: Mortal ability, immortal ambition.
- 2014: You cannot 3D print a passing grade
- 2015: Balsa, electrical tape, hot glue and paperclips – *zero engineering analysis*.
- 2016: “Testing? What testing?”
- 2017: Assumed maximum hand-in volume limitation wouldn’t be enforced – it was.
- 2018: “But, but… I did *my* bit!!”

Welcome back, frequent fliers

This course breaks eggs

- You are probably going to find this course technically or socially challenging (or both!)
  - This is intentional



How to pass this course

- Work as a team
- Get started early
- Deconstruct the task logically
- Understand the *real* problem
- Implement a solution well

How to fail this course

- Don’t contribute to your team
- Do it all at the last minute
- Don’t play nice with others
- Fixate on your pet approach
- Do lazy, effortless hacking

Enough about other people…

Now it’s your turn

PART 1

The Project

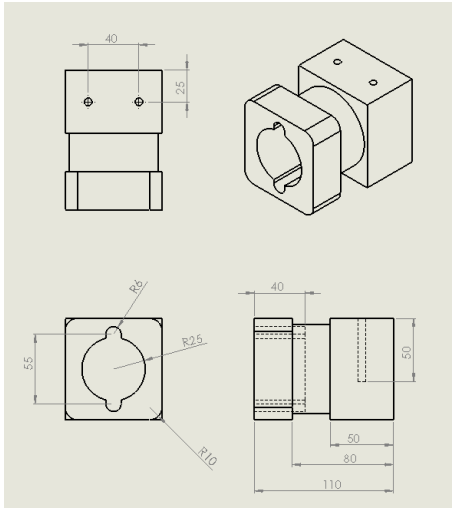
The task

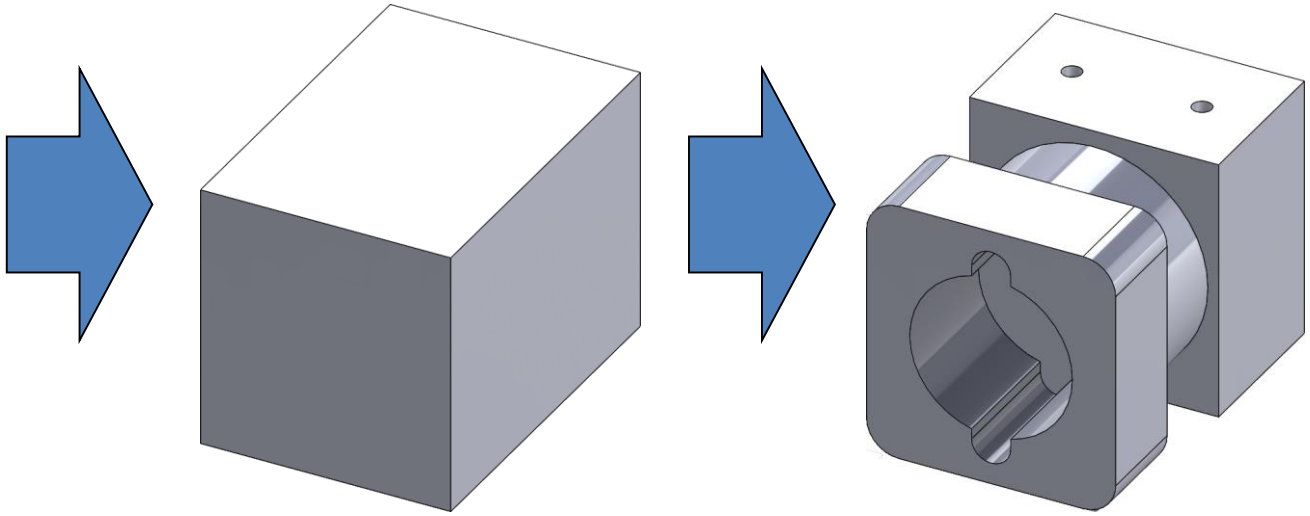
Build a fully-automated (miniature) work cell consisting of a mill, a lathe, a drill and a work-piece handler to cut florist foam blocks into specified shapes.

The task

- You will be given 3D STL files and 2D PDF drawings of target parts
- All four machines will be necessary to complete each part
- Incremental versions can be made without the drill and lathe, so 3-person teams aren't totally screwed… (it's ok, *relax*)

An example

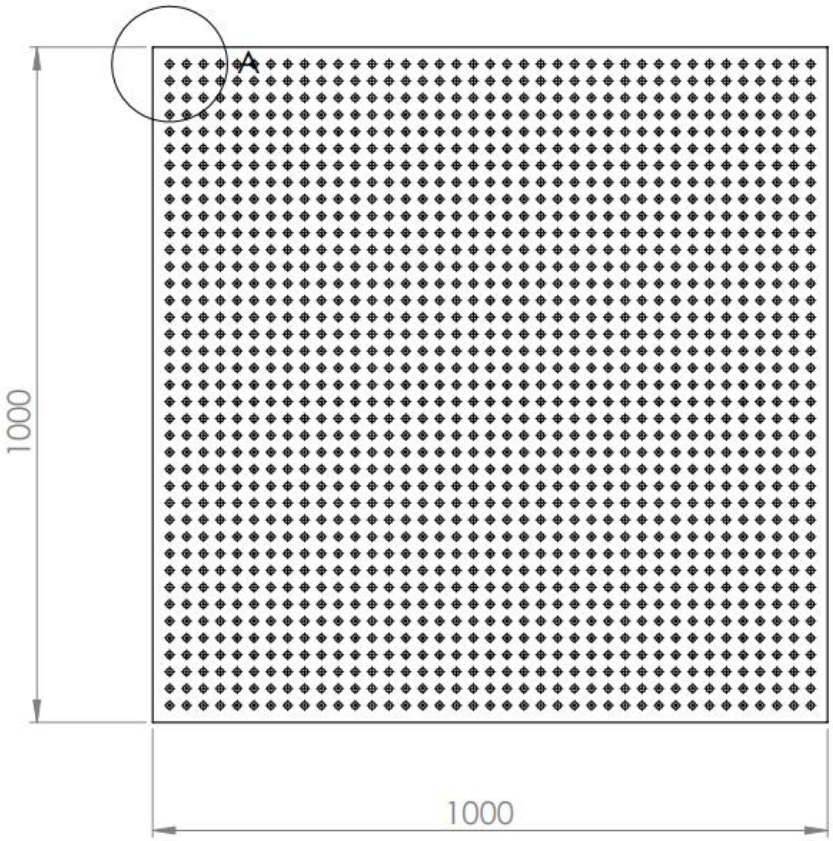


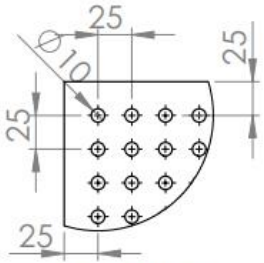


Planning Fixturing Cutting

Apparatus

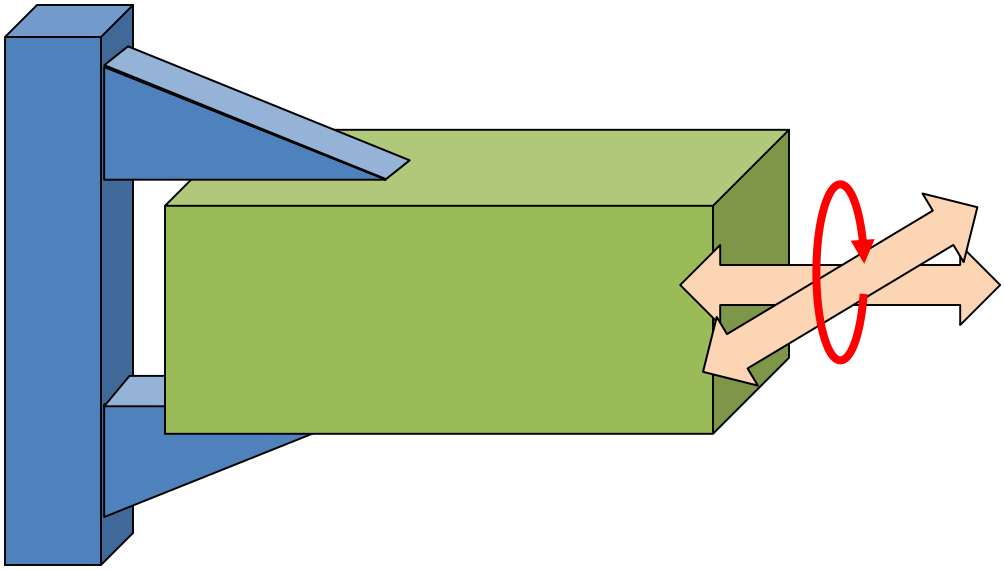
- Really simple – a big base plate





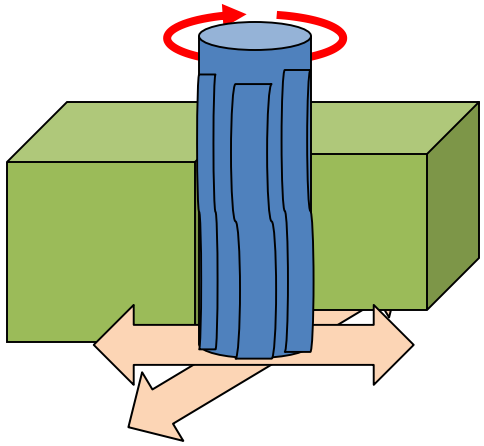
Handler

- A moveable fixture for constraining the motion of the work piece.
- Three actuators



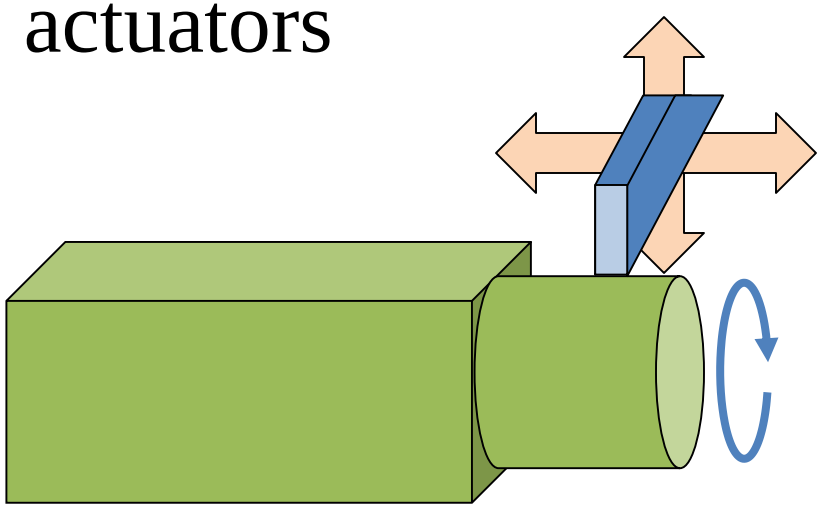
Mill

- Square end-mill cutter – cuts from the sides
  - 10 mm diameter, 30 mm long
- Two actuators, plus tool spindle



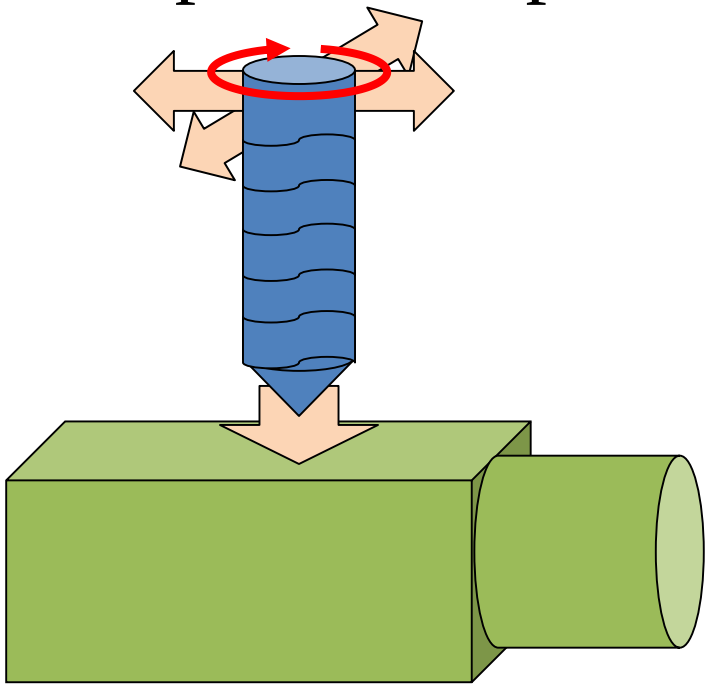
Lathe

- Rectangular, non-rotating cutting tool
  - 3 mm wide, 20 mm deep
- Three actuators



Drill

- Taper point drill – plunge cuts
  - 6 mm diameter, 60 mm long
- Two actuators, plus tool spindle



Lead developers

- Each team member shall be ‘lead developer’ for one of the four submachines
  - If your team has less than four, then you can omit Drill (if three) or Drill and Lathe (if two).
- The lead developer is responsible for guide the progress of his or her subsystem
- This does NOT mean you do not help your team mates: “lead”, not “only”

Other things

- No ATmega 168/2560/324/328/32U4 microprocessors
- Only 2 actuators per subsystem, *including* tool spindles (except where noted)
- Each subsystem must be demonstrable in isolation or using stubs

Full details on restrictions and constraints are in the task specification document

Key points

- Fully autonomous
  - Feed it your instructions and then no intervention after pressing “GO”
  - Big benefits to automatic tool path generation
- This task is intended to be *challenging*
  - Focus on getting readily achievable points first
  - Don’t underestimate the effects of variability
  - Consider limitations on testing availability

Submitting parts to the workshop

- You must have at least on machined part per team – ie. milled, lathed, water-jet cut
  - Your job will be costed in magical “workshop bucks” charged at $30 per hour, or quarter-fraction thereof.
- Submit jobs via EAIT Faculty Workshops job request form, as “coursework”:

  https://student.eait.uq.edu.au/workshops/jobrequest.wphp
  - Submissions open in week 6, and close end of week 10
  - if your part isn’t in by then, you’re on your own

Scoring

- Performance will be measured with a point system for demonstrated functionality
- Points will be awarded during scheduled demonstration sessions in week 13
  - 30 minute total time for set up and test
  - Last 5 minutes reserved for pack-down/marking

See rules and description document for full details

Functionality and scoring

Build quality	**10/10 Points**

Submachine Basic Functionality x4	**10/10 Points**
Submachine demonstrates motion on each axis and spindle.	2
Activation of the GO button produces movement of the machine	3
Submachine successfully cuts a trajectory	5

Protip: Passing the class pretty much requires you to be able to do this

Assembled MACHINETRON Functionality	**30/30 Points**
A rough, but recognisable version of the target piece is produced	10
A quality version of the target piece is produced, accurate to <1 mm	15
A precise version of the target piece is produced, accurate to <0.5 mm	5

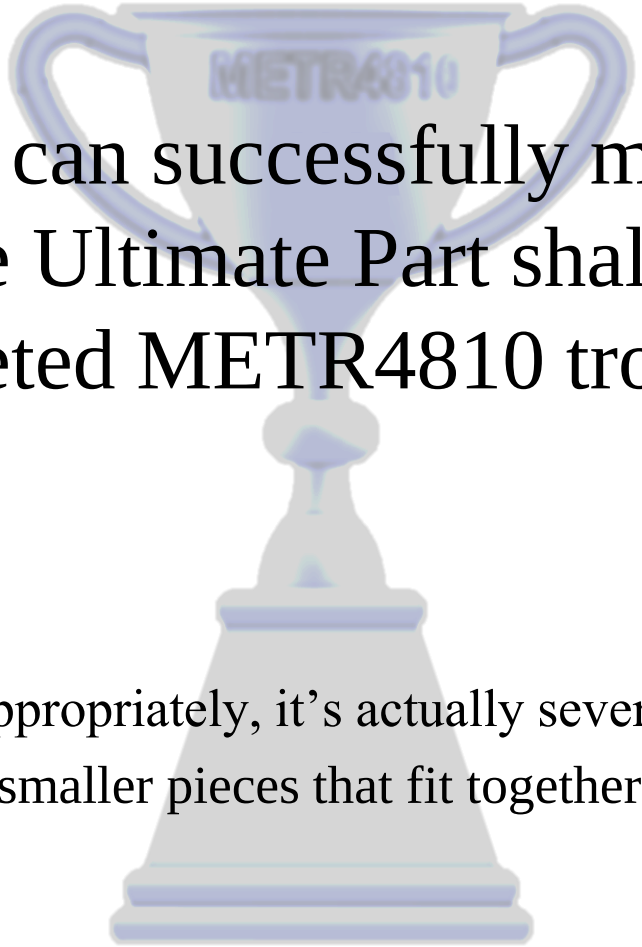
Advanced Functionality	**20/20 Points**
Each additional copy of the target piece produced	1 per unit
Each additional type of target piece produced	2 per target

Bonus Functionality	**10/10 Points**
Path planning and cutting fully autonomous	5
Cut the Ultimate Shape	5

The low energy solution

- There is often a simple, elegant low-energy solution to an engineering challenge
  - There is no ‘right’ way to solve any problem
  - Some people spend much energy on a complex solution, only to get frustrated when someone else finds a much simpler way
  - The simpler way is **more correct**; if you are struggling with your approach, maybe you need to rethink your assumptions?

The trophy



Teams that can successfully machine and complete the Ultimate Part shall receive the coveted METR4810 trophy

Appropriately, it's actually several smaller pieces that fit together

PART 2

Assessment

My philosophy

- Engineering is the highest, purest and most noble pursuit of the human experience
  - All else is artifice or drudgery
- You are training to be engineers, and this is a chance to actually practice engineering
- You are not your grade*
- There will be second chances

~~* They make me assign you a grade~~

Qualitative assessment

I have *finally* managed to convinced UQ to let me use qualitative assessment

Qualitative assessment

That is, I set your grade directly based on holistic observation of your demonstrated achievement viz. the course objectives

Qualitative assessment

Ranked by competence, not numerical scoring:

Very competent ✓✓

Competent ✓

Not yet competent ✗

Qualitative assessment

- The University of Queensland trusts me
  - 6 years teaching this course
  - Tenured, recently appointed to Assc. Professor
  - Never had a disputed grade changed

- Focus on learning, not stupid numbers
  - No haggling, no “mark anxiety”
  - Just do the work and do it well.

Qualitative assessment

This is almost CERTAINLY in your favour

Qualitative assessment

- This is not an adversarial process
  - My mission is to help you learn the material and be the best engineer you can be.
  - Reflects professional performance review
- I *want* you to pass and do well
  - Seriously, I'm on your side here.
  - Just give me the excuse I need to pass you! ☺

What to expect

- Expect to learn new things on your own
  - You need will need to know *more* than just what you've been taught at university thus far
- Expect to apply real effort
  - This course **actively** punishes freeloaders
- Expect to be involved
  - Lots of peer assessment; PAFs can be ***vicious***
- Expect change
  - The specifications will change (intentionally)

A common theme

- Present analysis to justify design decisions
  - Motor torque/power calculations
  - Chassis structural load simulations
  - Clearance and tolerance of components
  - Microcontroller control cycle overhead
  - Decision matrices... and such!

If you can’t back up it up with numbers, you‘re really just **guessing**

Deliverables

- Problem analysis – V/C/N
- Progress Review 1 – pass/fail†
- Progress Seminar* – V/C/N
- Progress Review 2 – pass/fail†
- Preliminary Report – pass/fail†
- Final Product Demo* – V/C/N, with score
- Final Project Report – V/C/N

There is no magic formula from V/C/N to final grade

* Team assessment with peer and tutor weightings

† More on this later

Problem analysis

Due 8th March– V/C/N (2 pages max)

- Break down the design problem, determine its scope, requirements and constraints.
- Describe the key underlying engineering design challenges – what makes this hard?
- Present a candidate solution, and explain how your approach addresses the problem.
  - Analysis is golden.

Progress Reviews 1 and 2

Due 18th – 22th March and 6th – 10th May

- Tutor-mediated meetings
- Demonstrate your progress in the preceding period with tangible **evidence** of your contributions – eg. prototypes, code, etc
- Pass/fail based on quality of work and relative progress towards the goal

EXPECT NO MERCY.

Statement of roles

- At Progress Review 1, your team will be required to present a statement of lead developer roles signed by the whole team.
- You will be expected to account for your responsibilities at subsequent reviews
- *Remember:* You shouldn’t/don’t have to be the only monkey working on that system, and you should help others!

Progress Seminar

Due 10th – 14th April (team assessment) V/C/N

- Provide a 10 minute seminar outlining progress towards developing a solution to the problem.
  - Focus on the progress, not the approach
  - Each student presents for roughly equal time
- Assessed by course coordinator and tutors

Preliminary Report

Due 17th May

- Describes the methodical analytical approach to solving your subtask, how it relates to the other subsystems within the project and the analytical process that was used in developing the solution.
- Show the formal, disciplined, quantitative engineering process followed, demonstrating the feasibility of the approach taken.

Final Product Demo

Due week 13 (team assessment) –V/C/N, score

- The Main Event – show your system works!
- Points awarded for functionality, achievements and build quality.
- Hand in everything needed to make your system work, including documentation and printouts of design schematics.

Above all: Convince me you can *engineer*.

Final Report

Due 31st May – V/C/N

- Identical to the preliminary report, but incorporating corrections and reflecting any changes from the final two weeks.
- Preliminary report will be returned with comments so that you have an opportunity to revise your work and improve upon it,

Just like in real life!

Incremental demos

- Spontaneous night-before failure of hardware systems is **brutal** and **unfair***.

  Just like real life!

- If your system is sort-of working early, you can have it tested in an incremental demo.
  - If the final demo points are less than what was scored in an incremental demo, you will be awarded the incremental demo points.

Incremental demos

- Scored just like the final demo, but the points are capped according to time left in semester
  - Week 7: 25%
  - Week 9: 50%
  - Week 11: 75%
- Incremental demos are by appointment only*

* Do not attempt a demo with an obviously non-functional system or you may forfeit future incremental demo privileges

Pass/fail penalties

- Subpar (or absent) pass/fail submissions incur a deduction from your final grade
  - Project reviews: minor deduction
  - Preliminary report: major deduction
- These deductions are *cumulative*
  - If you were to fail all of them, your maximum achievable grade for the course would be a 6

PAF and TAF

- A substantial fraction of assessment is peer-moderated; others are tutor-moderated
  - Regularly adjusts results by up to **2 grades**
- It's vital your team recognises your efforts
  - A bitter or frustrated team means a low PAF!
- Ultimately, peer and tutor weighting is mediated by the course coordinator

Peer assessment

- At progress reviews, progress seminar and final demo, you will fill out PAFs
- Your demo points will be weighted by all of the PAFs through the semester:
  - Progress review 1: 10%
  - Progress seminar: 20%
  - Progress review 2: 30%
  - Final demo: 40%

Calendar at a glance

You are here

Teams assigned here

Week	Dates	Lecture	Reviews	Demos	Assessment submissions
1	25/2 – 1/3	Introduction			
2	4/3 – 8/3	Principles of Mechatronic Systems design			Problem analysis
3	11/3 – 15/3	Previous years deconstruction case studies			
4	18/3 – 22/3	Professional Engineering Topics	Progress review 1		
5	25/3 – 29/3	PCB design tips			
6	1/4 – 5/4	Your soldering is (probably) terrible			
7	8/4 – 12/4	Introduction to firmware design	Progress seminar	25% demo	
8	15/4 – 19/4	Q and A sessions			
Break	22/4 – 26/4				
9	29/4 – 3/5	Q and A sessions		50% demo	
10	6/5 – 10/5	No lecture	Progress review		
11	13/5 – 17/5	Q and A sessions		75% demo	Preliminary report
12	20/5 – 24/5	Monday lecture!!			
13	27/5 – 31/5	Closing lecture		Final testing	Final report and reflection

Break! Try to work ☺

Madness Week (Pauline on junket)

PART 3

Class Organisation

Blackboard and splashy website

- This class has a Blackboard page and a "splashy" outwards-facing website
  - If the two ever differ (which they won't), the Blackboard page is considered authoritative

Blackboard: learn.uq.edu.au/

Splashy: robotics.itee.uq.edu.au/~metr4810/

Weekly schedule

- Lectures – 2 hours once per week
  - Professional topics and Q&A sessions
- Practicals – 2 hours twice per week
  - Tutors available in lab (but 24/7 access)
- "Contact" – 2 hours twice per week
  - Time set aside for meetings, demos, etc.

Your team should meet and interact continuously outside of class – *at least* once per week

Class clashes

I am aware of some clashes with other classes

- Most notably METR4900
  - This will ruin your life – plan accordingly
- Any others I've missed?

All lecture content will be online

Major announcements go out via Blackboard

… but you'll hear it first in class, by design

Lectures

- Boring, useless lectures help *nobody*
- I will endeavour to provide lectures that are educational, useful and (sort of) entertaining
- Lectures will be student-driven: you tell me what you want to learn about and I'll teach it

Lectures

- Lecture 1: Introduction to the project
- Lecture 2: Principles of mechatronics system design
- Lecture 3: Previous years deconstruction case study
- Lecture 4: Professional engineering topics
- Lecture 5: PCB design tips
- Lecture 6: Your soldering is terrible (probably)
- Lecture 7: Introduction to firmware design

Topics may be nominated by emailing me, and then voted for on a doodle poll

Lectures

- No, you don't *have* to attend lectures, but if you don't you're really missing out
  - Protip: Students who attend lectures historically do better than those who don't!
- Lectures are the first and most immediate way of hearing about what's happening and getting your questions answered
  - Note: recordings aren't interactive

Some suggested topics

- Principles of machine tool design
- Digital control
- Electromechanical devices
- Computer vision
- Sensor-fusion and filtering
- Localisation
- Schopenhauer and philosophical pessimism

Teams

- Teams will each consist of four people
  - Except for when they don't
- Teams will each be assigned a tool kit
  - Complete kit must be returned ***or else***
- Work together! Contact sessions are set aside for team meetings and collaboration

Teams

- You will have to work with people you hate*

  Just like in real life!

- You may email me and request one person with whom you do not want to work
  - Exclusion requests must be in by Friday
- Otherwise, teams will be allocated by *magic*
  - Teams will be assigned in week 2

*If you don't hate them now, you will by the time you're done

Laboratory space

- A fair number of students this year
  - Not terrible, but some possible crowding
  - 13 teams, 12 workstations…
- Consequence: share and keep it tidy
  - New (smaller) lockers for project work
  - Shared space and resources
  - Get started early; consider how you can work most effectively in the final two crunch weeks

<eyeofsauron>

Laboratory space

- The laboratories are governed by the UQ risk management policy
- To work in the lab:
  - You **MUST** have completed the induction
  - You **MUST** have read the lab risk assessment
  - You **MUST** wear appropriate footwear
  - You **MUST** abide by all safety requirements
- If you do not follow the guidelines you will be barred from the lab

Laboratory space

- Just in case you forgot:
  - No eating/drinking in the lab
  - No sleeping in the lab
  - No non-METR4810 students in the lab
  - The lab is not for facebook/tindr/grindr/gaming/ socialising/having a life etc.
  - I am held personally responsible for the safety and condition of the lab and I get ***very*** grumpy.

So don’t say you weren’t told.

Laboratory space

- Every year, I go out of my way to find ~~people~~ violators to make an example of
  - Don't let this happen to you!

Proposed lab management policy

Laboratory space

- Keep the lab clean and orderly
- Cleanliness "warning light" system in effect
  - Status noted on Blackboard/class website

Green: Full speed ahead

Yellow: Clean up needed

Red: *Danger, Will Robinson!**

Black: "*Uh oh.*"**

*Lab will go to limited hours until cleaned.

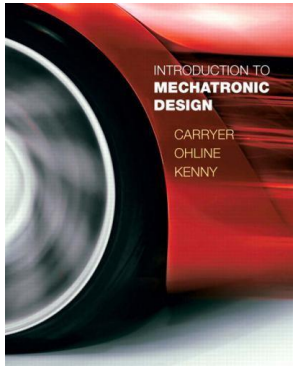
**Lab will be locked until further notice.

</eyeofsauron>

Keeping the lab tidy makes for a nicer place to work and makes it easier to get stuff done

Resources

- Website
  - Everything will be posted on the Blackboard class website: (learn.uq.edu.au)
  - Better-looking class website will mirror course materials: (robotics.itee.uq.edu.au/~metr4810)
- Textbook
  - "Introduction to Mechatronic Design" by Carryer, Ohline and Kenny



(recommended but not required)

Knowledgeable people

- Course Coordinator and Professtrix:
  - Pauline Pounds
- Technical Staff
  - Peter Bleakley
  - Jason Herriot
- Tutors:
  - TBD
- Emergency Auxiliary Temporary Back-Up Replacement Stand-in Teaching Faculty
  - Dr. Phil Terrill
  - Prof. Stephen Wilson

Contact info

If anything is bothering you, bring it up *early*

- Rules questions
- Technical issues
- Ordering
- Assessments
- Group problems
- Enrolment
- Disenfranchisment with the sociopolitical gestalt

➢ Serious? Email first to arrange a meeting

➢ No? Just stop on by! (but email is good too)

On that topic…

- I often get comments in the SECaTs about things that *could* have been addressed during the semester if I'd been told about it earlier
- Don't wait until you're angry in week 13
  - Tell me about it as soon as it comes up so I can explain it/solve it/fix it/find it/sort it right away
- I'm always happy to help! ☺

Contact info

Who: Me!

Why: Questions, issues, concerns, ennui!

Where: GPS 78-529 or Wordsmiths

When: 10ish to 4ish – by appointment (or drop in)

What: Coffee or coke (either kind)

How: pauline.pounds@uq.edu.au

What happens next?

- Send me group exclusion requests
  - Email me ASAP!
  - Groups will be posted next week
- Attend the afternoon practical session in Hawken c404 Wednesday 6th March
  - Toolbox handouts
  - Room induction, 3D printer induction

And start thinking about solutions!

Tune-in next time for…

Principles of Mechatronic Systems Design

or

"Striking a Balance is Making Everybody Equally Unhappy"

Fun fact: Voltron was based on a Japanese series called "*Beast King GoLion*".

Questions?

?