
ASTRO


5 SECONDS TO
MARS

5 Seconds to Mars

or

"Touchdown on the Red Planet"

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23 February 2021

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

Notes about online etiquette

- Use the ‘raise hand’ tool to ask a question
- Keep your mic muted if not called upon to speak
  - Keep background noise to a minimum if you can
- The sessions are recorded
  - If you don’t want your questions or responses to be recorded, please email your questions directly, after the session.

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

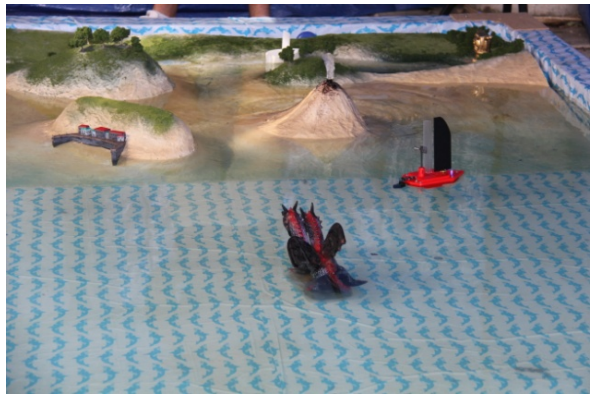
- Taking the safeties off
  - Real challenge, no hand-holding
- Unconstrained design, broad horizons
  - Very few limitations or constraints
- Focus on communication, design process, teamwork

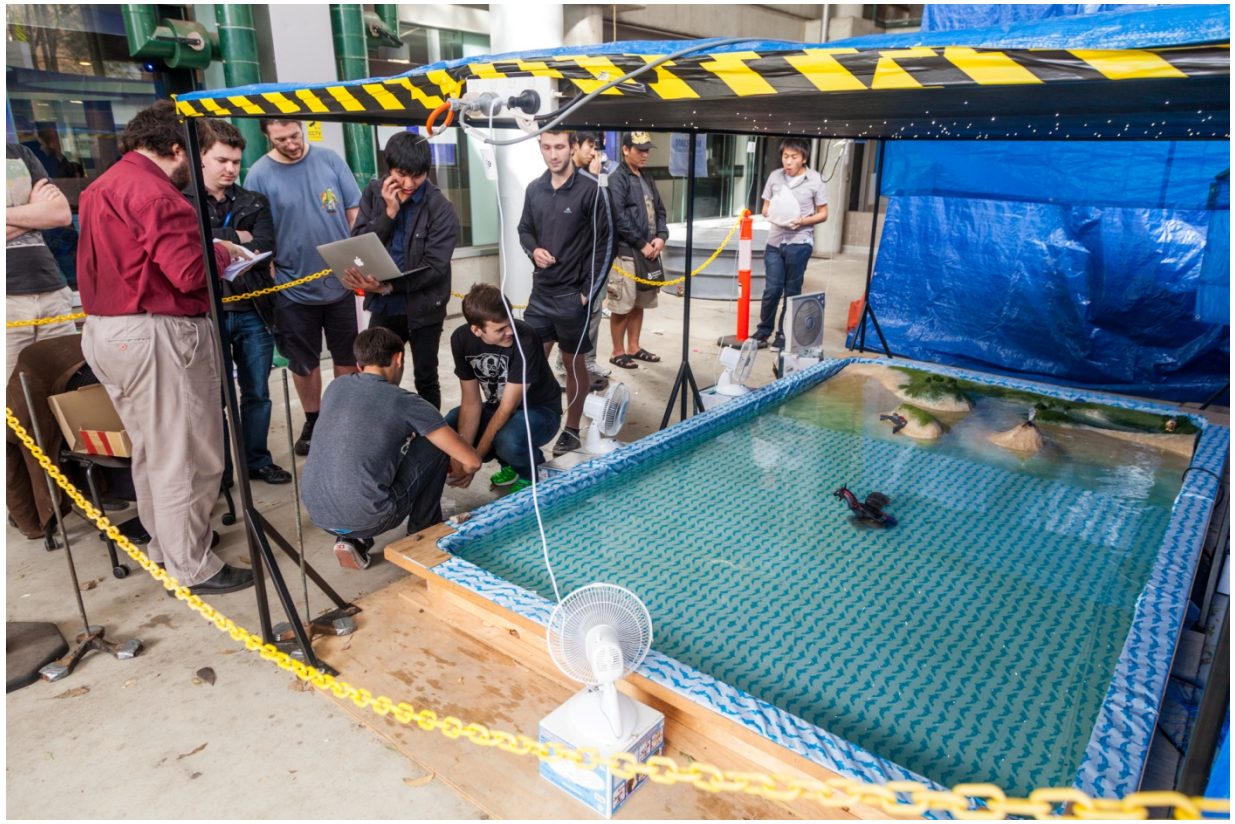
What this class is not

- 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

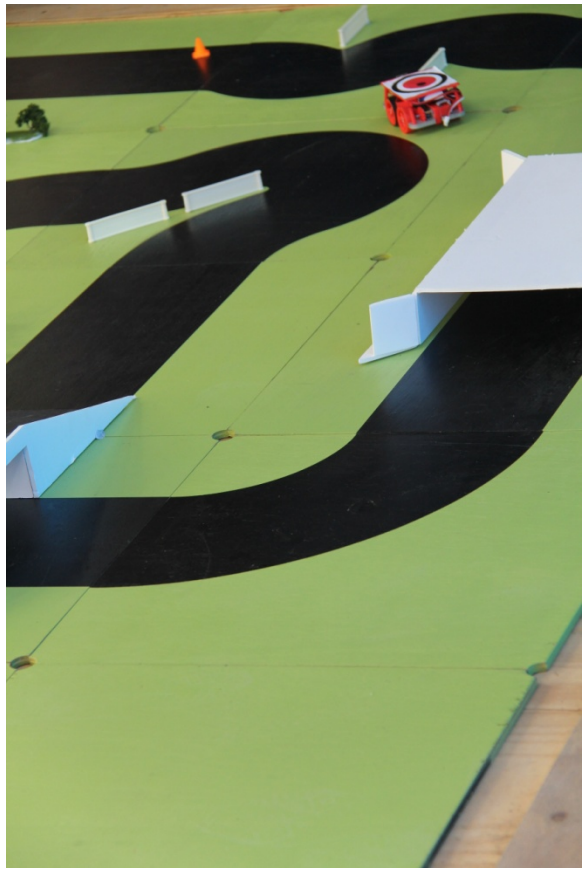
2013: Autonomous Sailing and Navigation





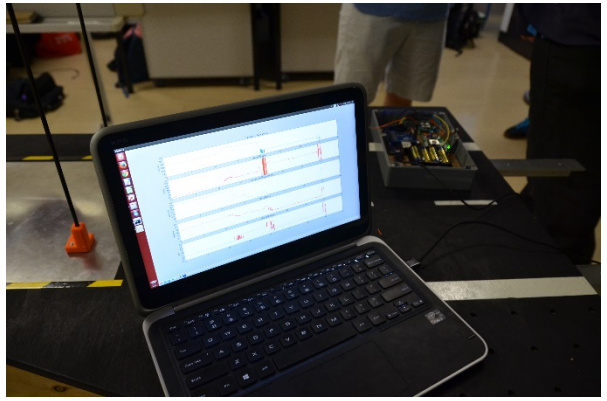
The Ghost of Projects Past

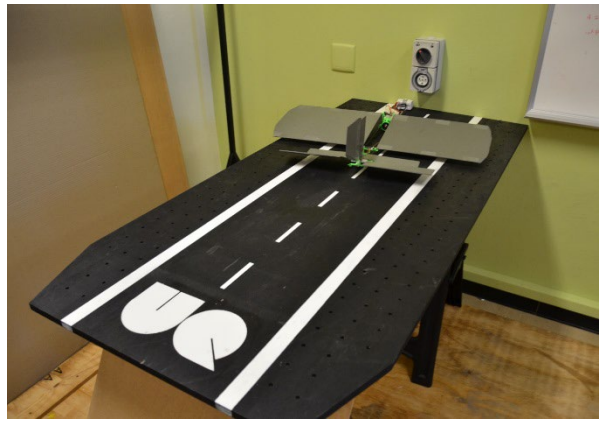
2014: Autonomous Race Cars



The Ghost of Projects Past

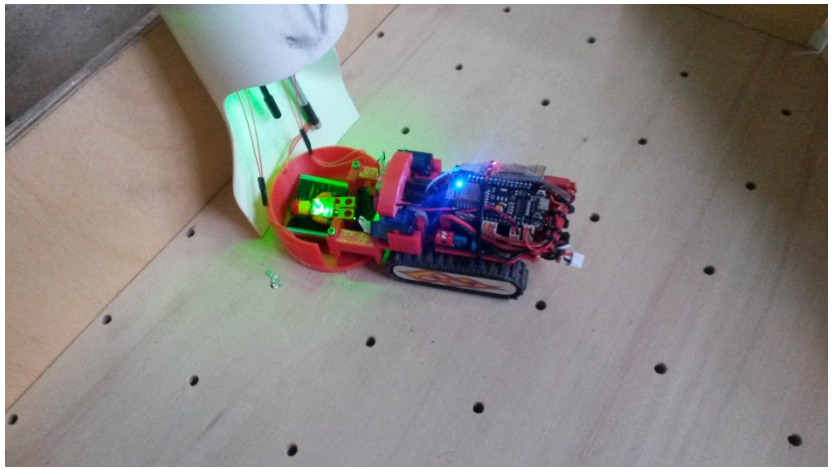
2015: Autonomous Carrier Operations





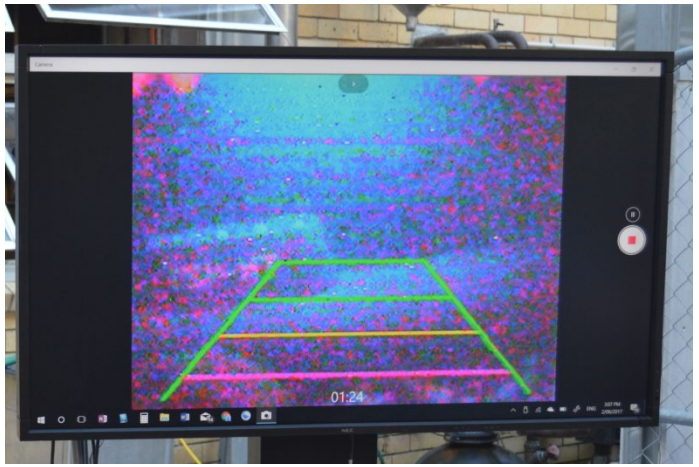
The Ghost of Projects Past

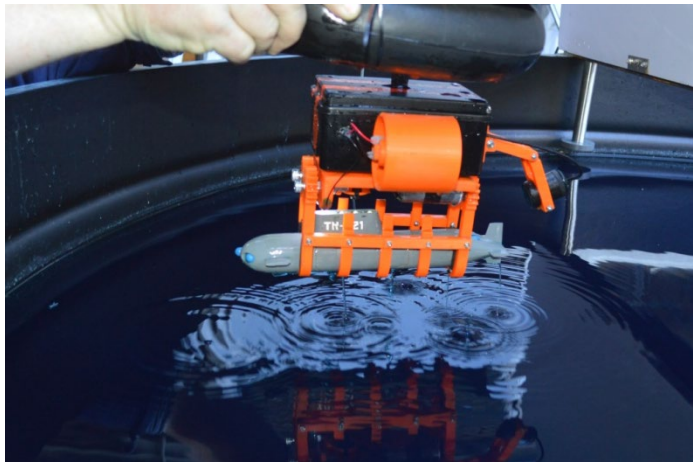
2016: Subterranean Mine Rescue



The Ghost of Projects Past

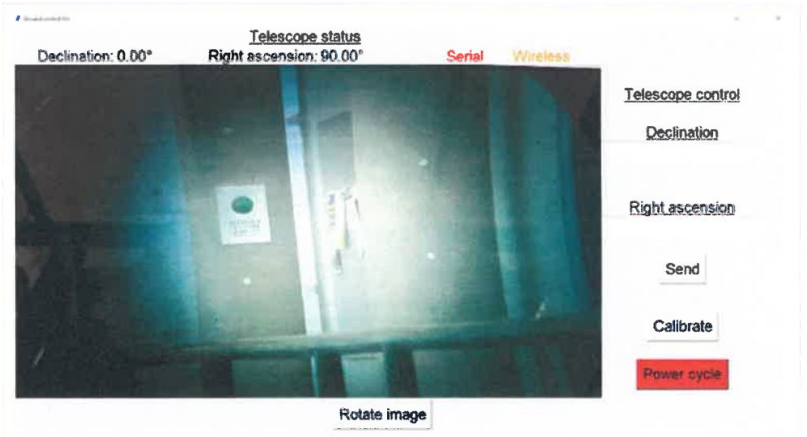
2017: Sunken Submarine Recovery





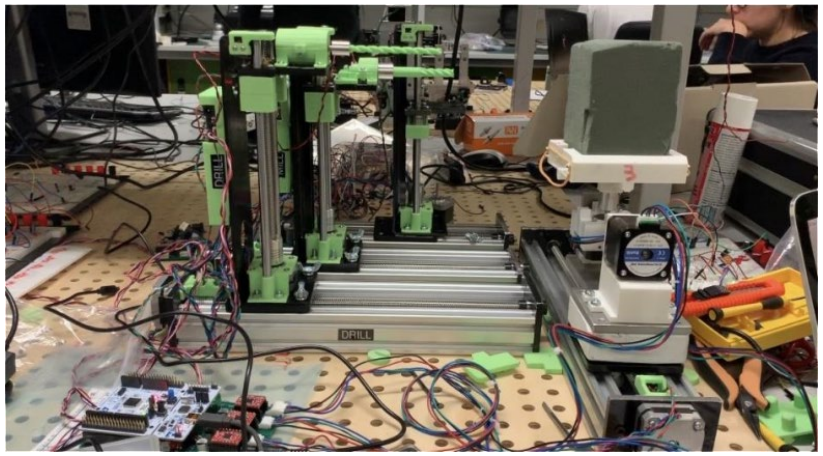
The Ghost of Projects Past

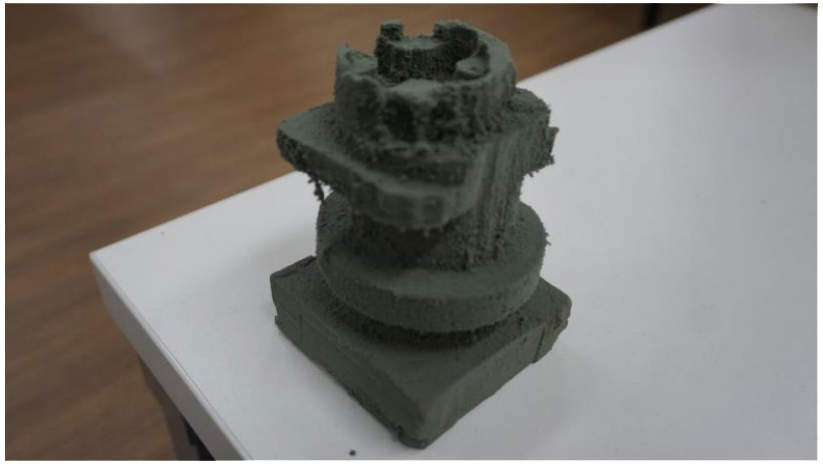
2018: Space Telescopes Searching for Exoplanets

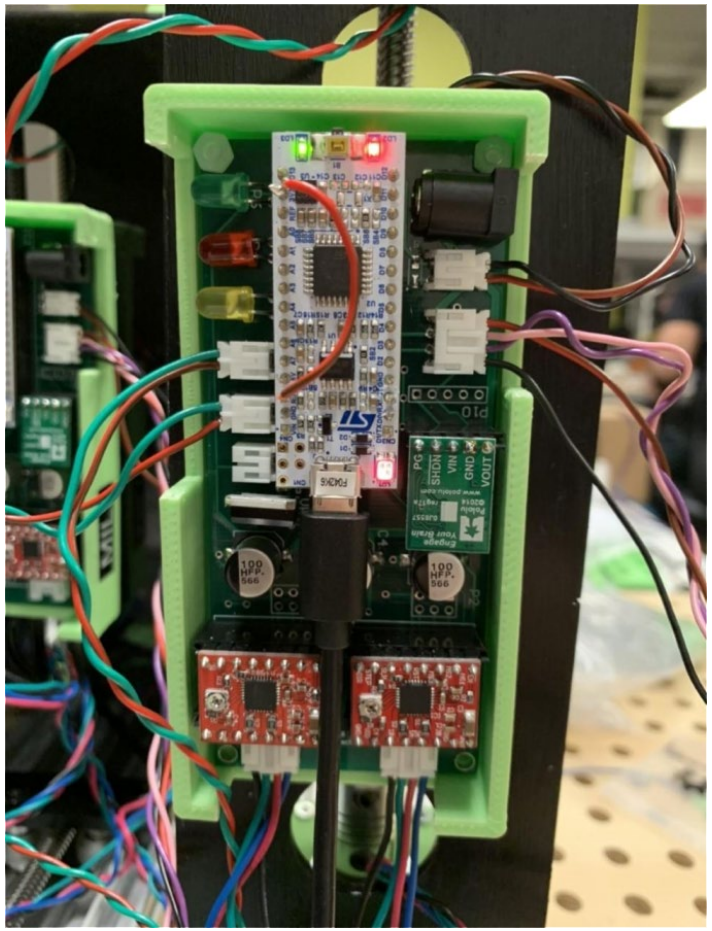


The Ghost of Projects Past

- 2019: Automatic Machining

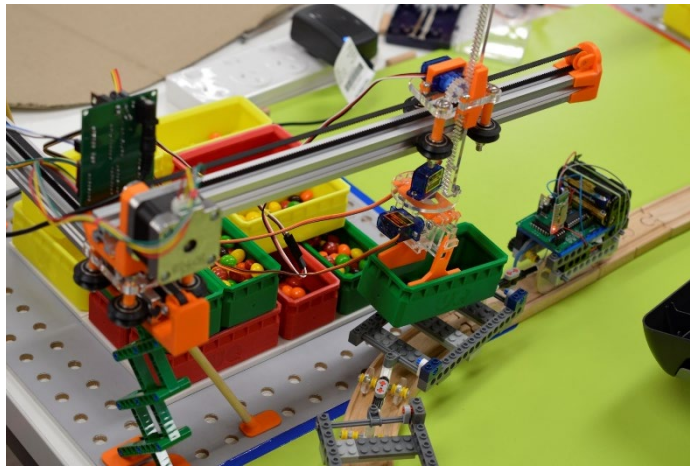
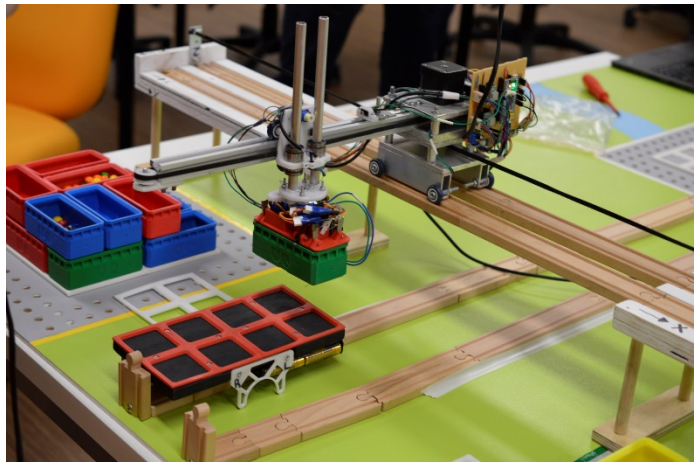
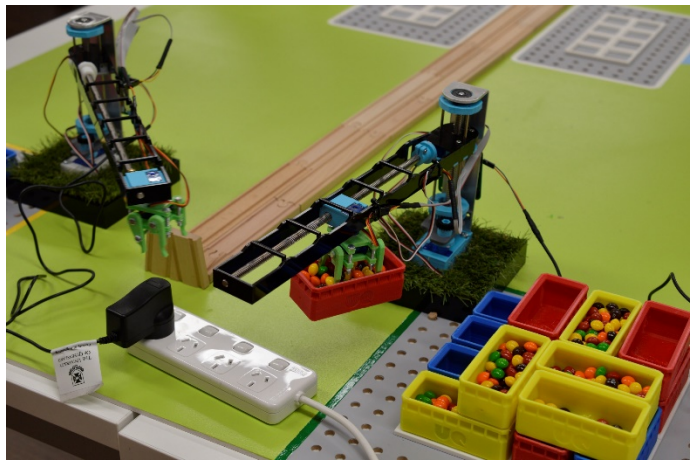
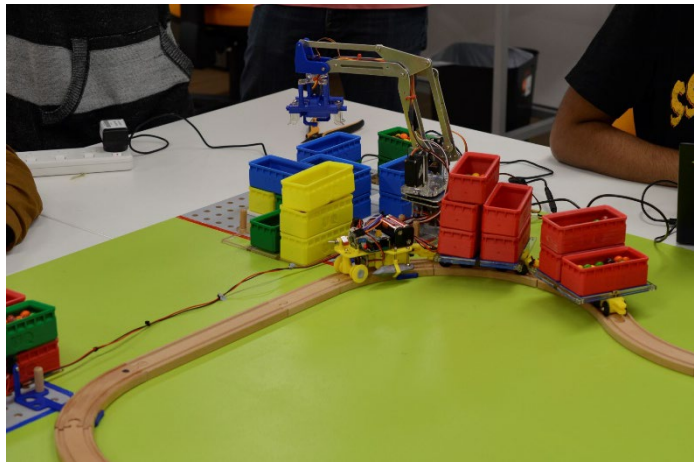






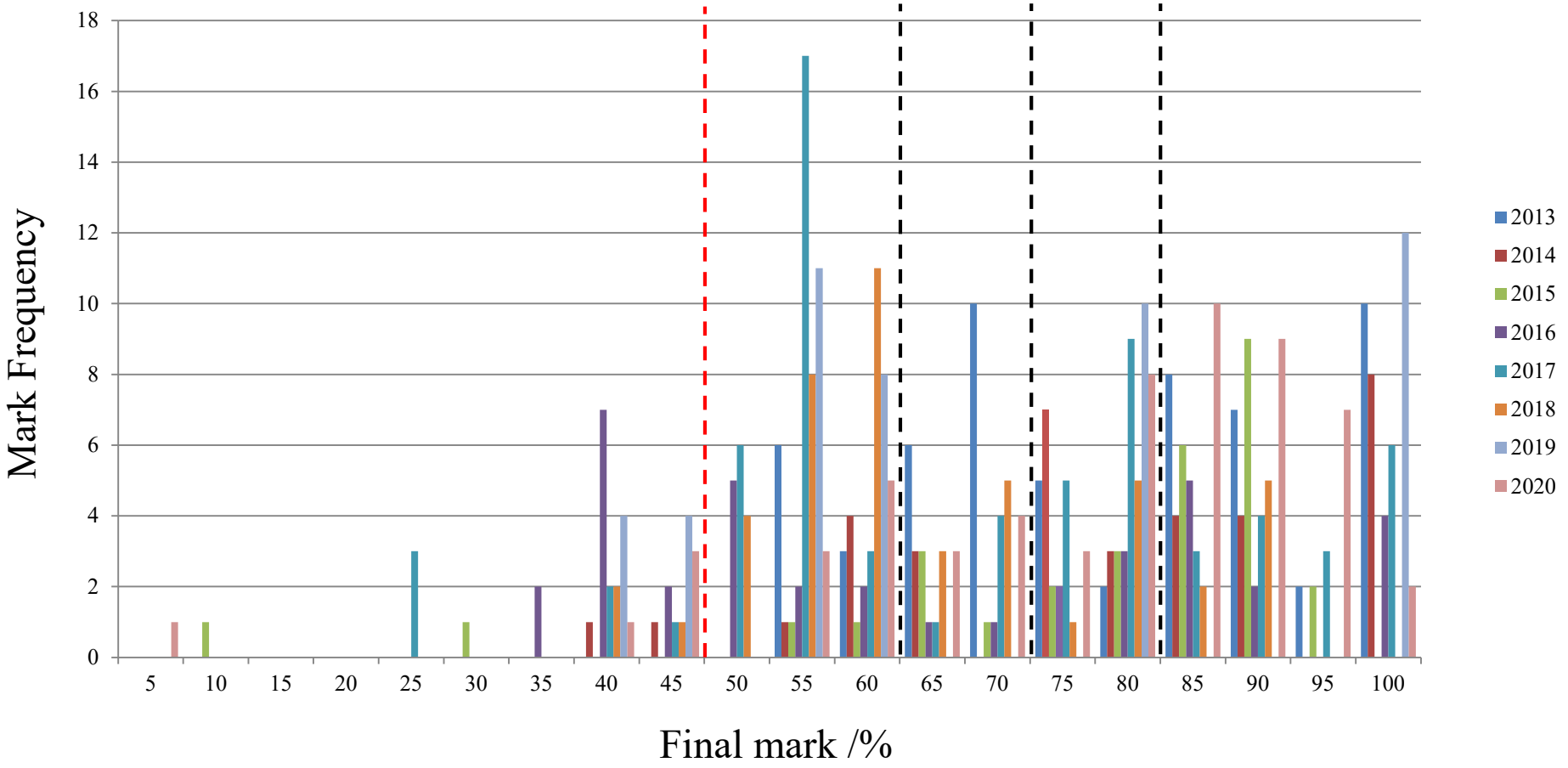
The Ghost of Projects Past

- 2020: Cargo Container Logistics Network

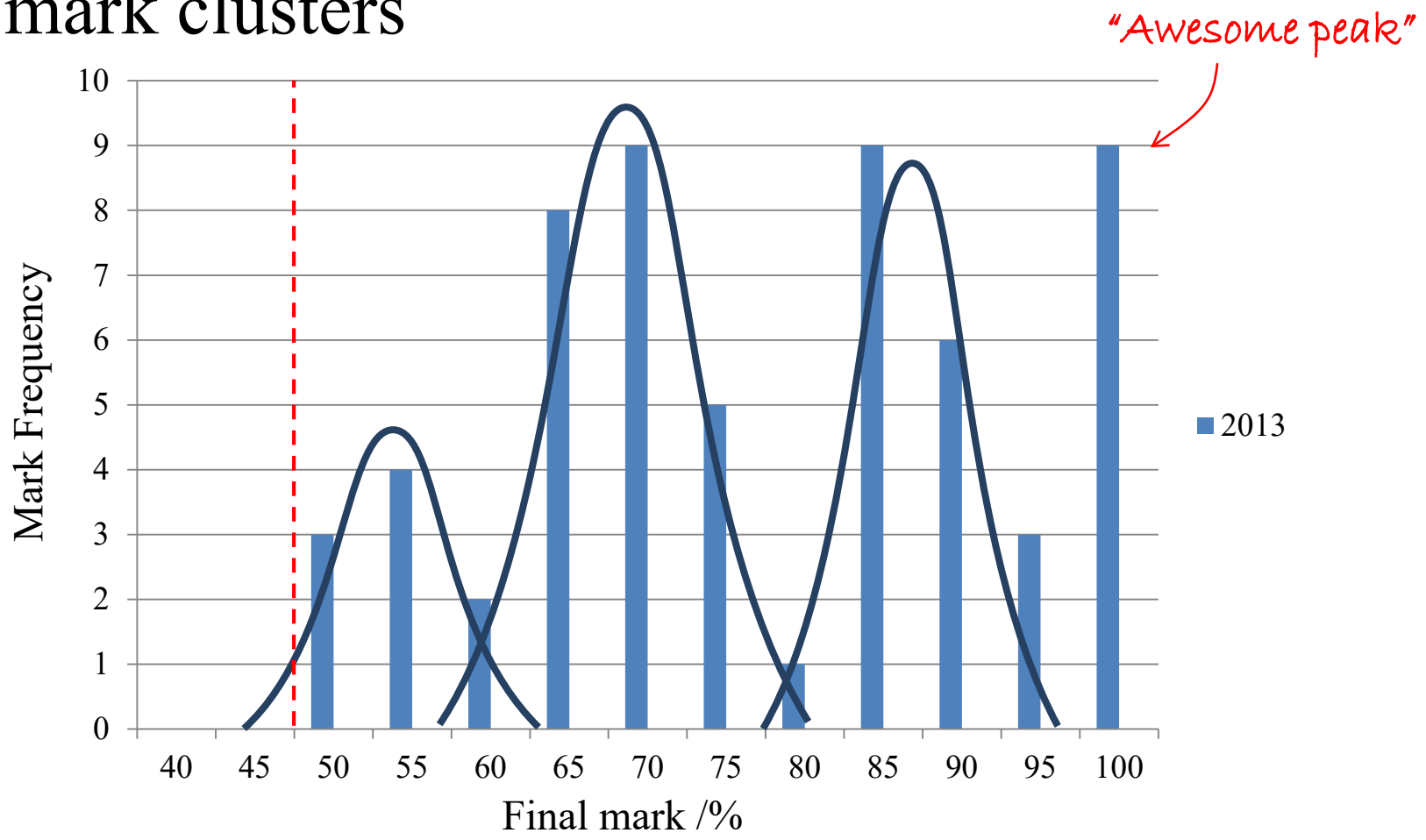
Assessment results

- Atypical mark spread: not a real bell curve



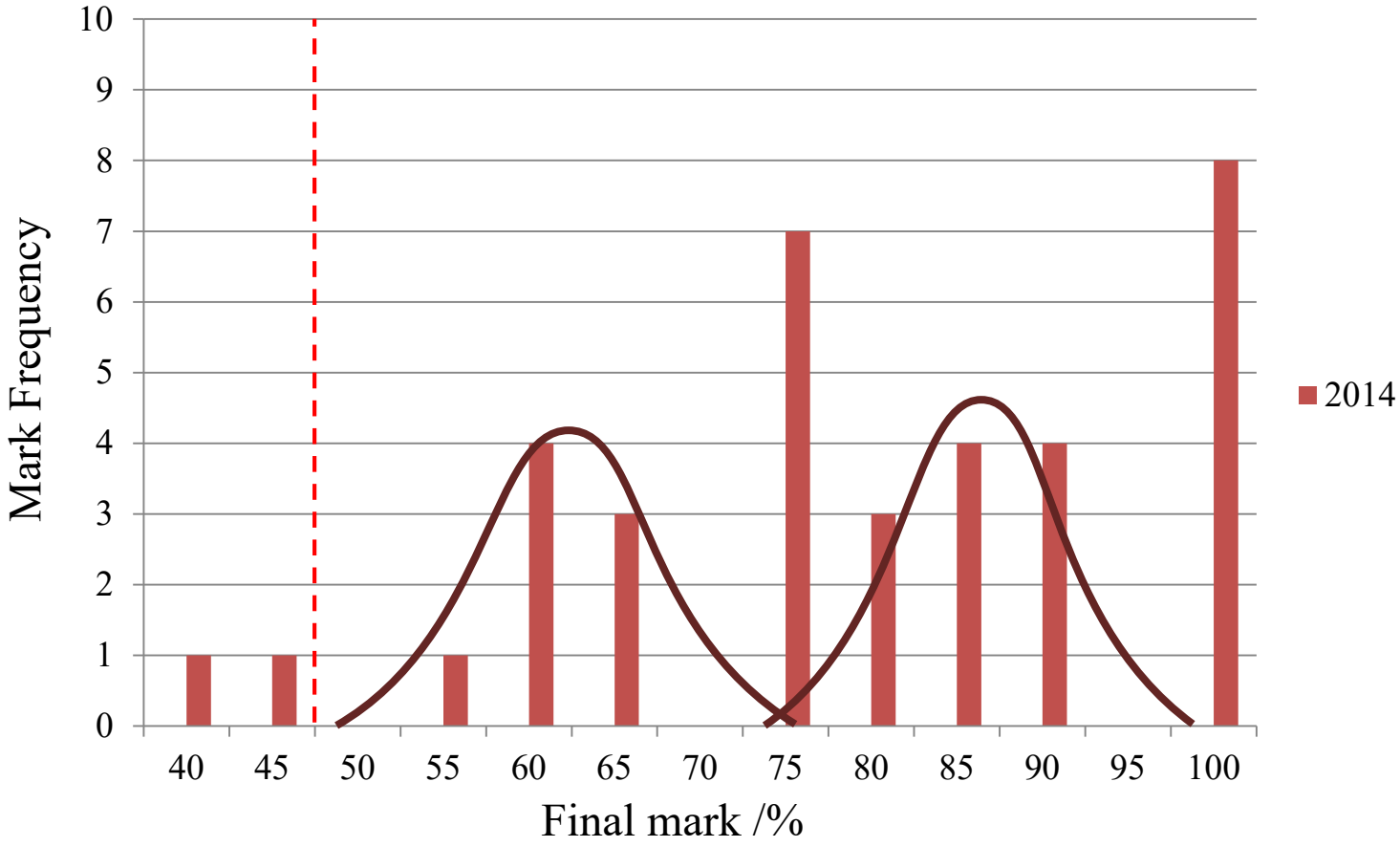
2013 assessment results

- Distinct mark clusters



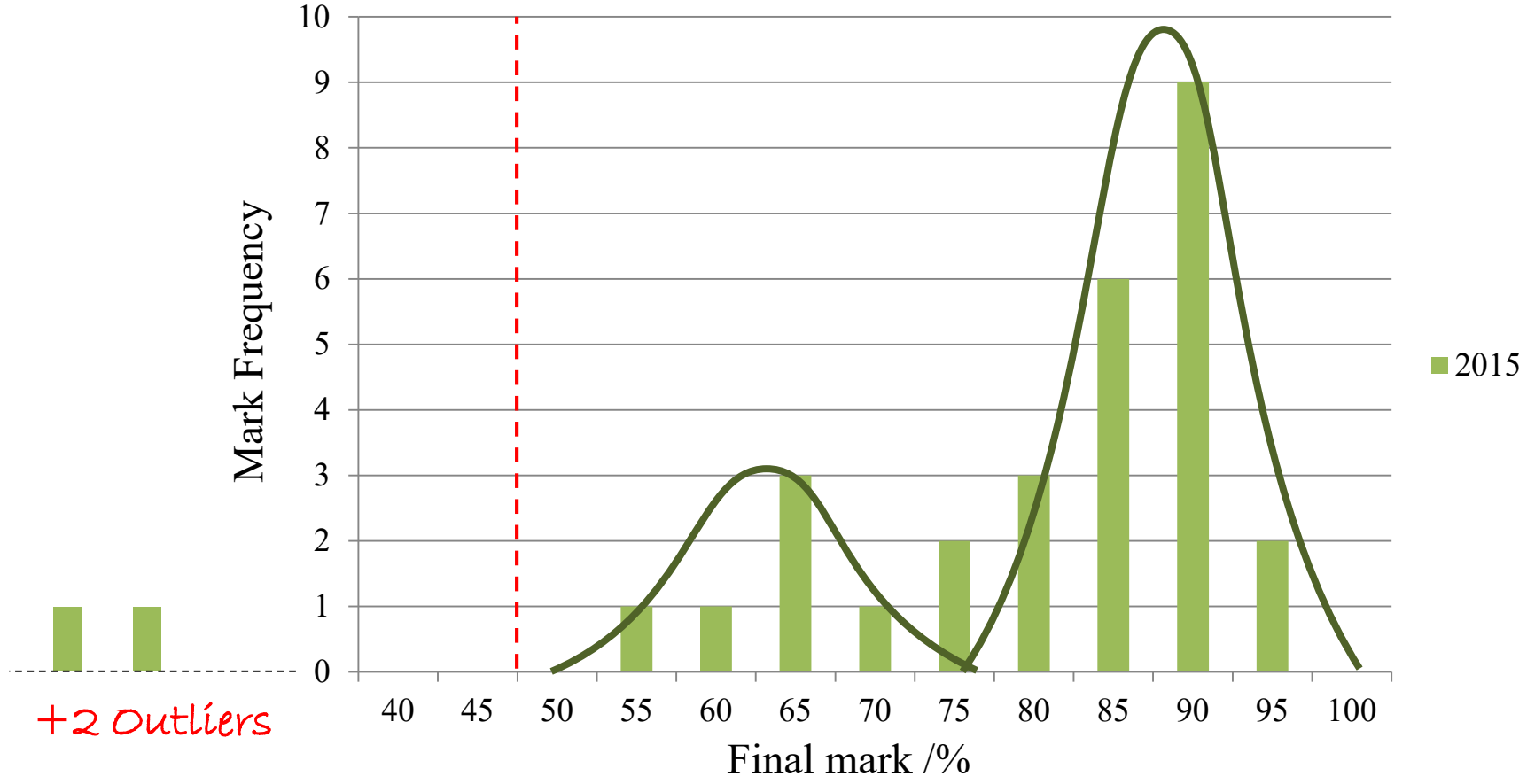
2014 assessment results

- Mark clusters move over time:



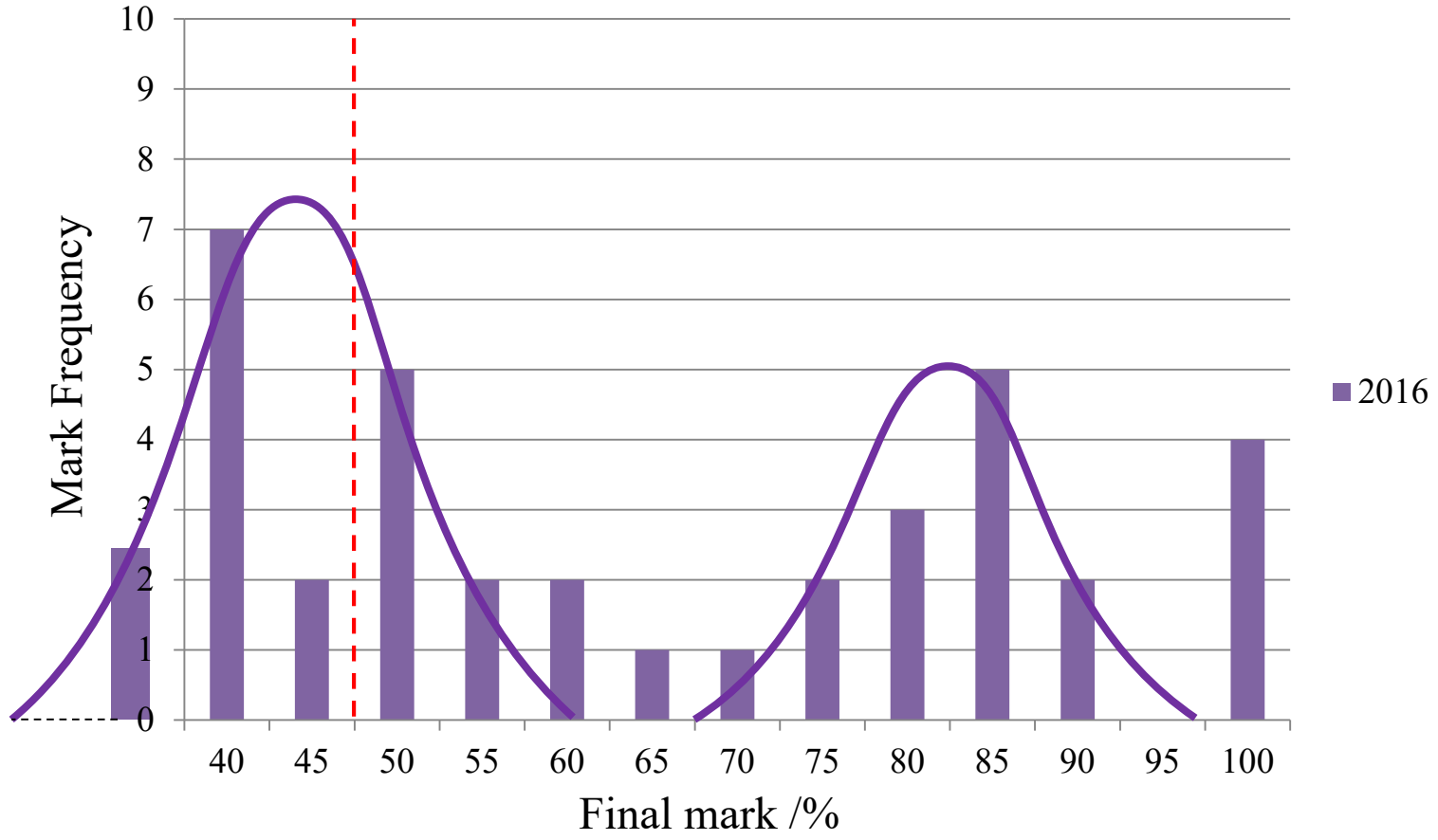
2015 assessment results

- Increasing performance, but more failures



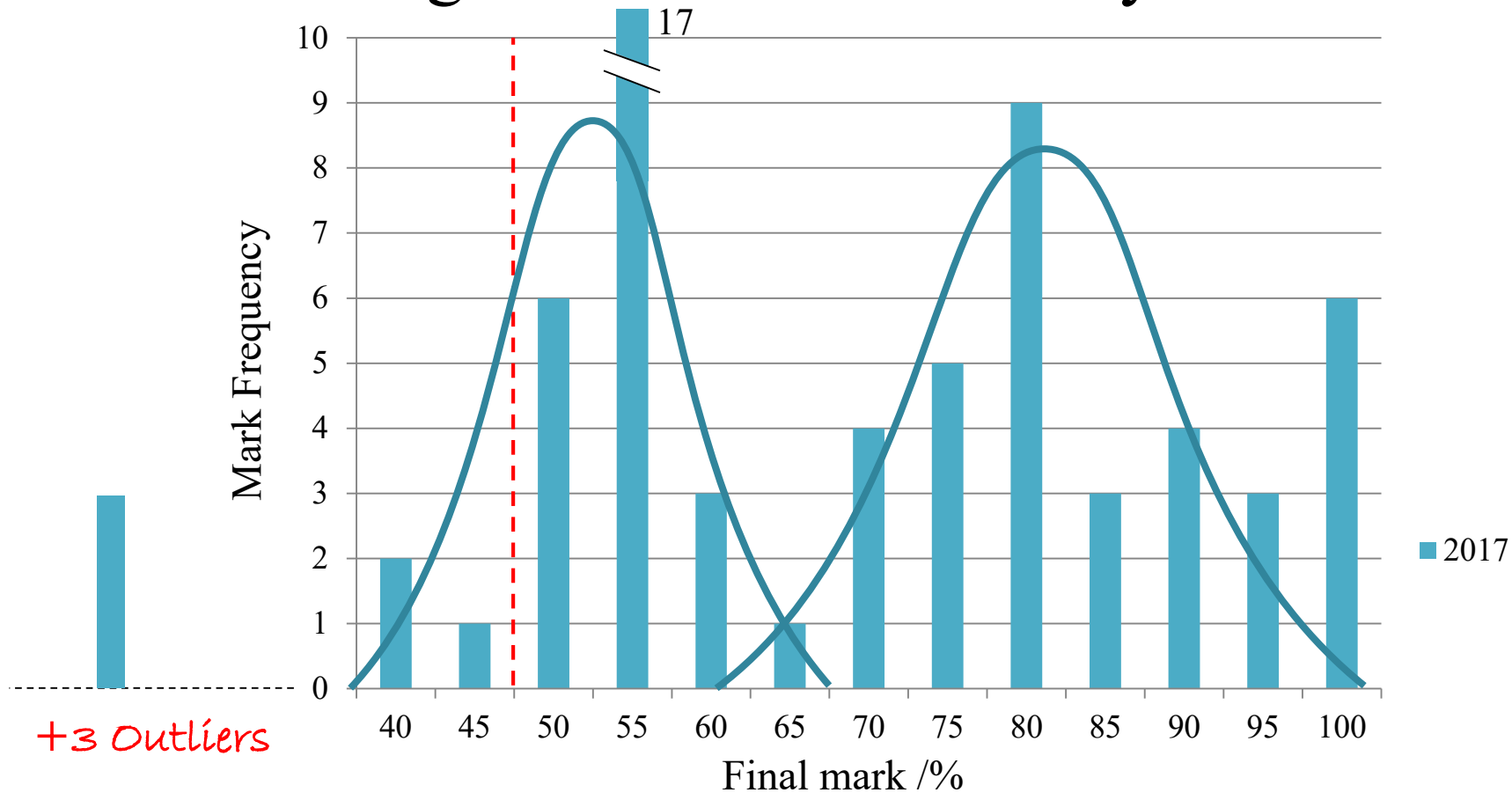
2016 assessment results

- Strong successes but higher failure rate, still



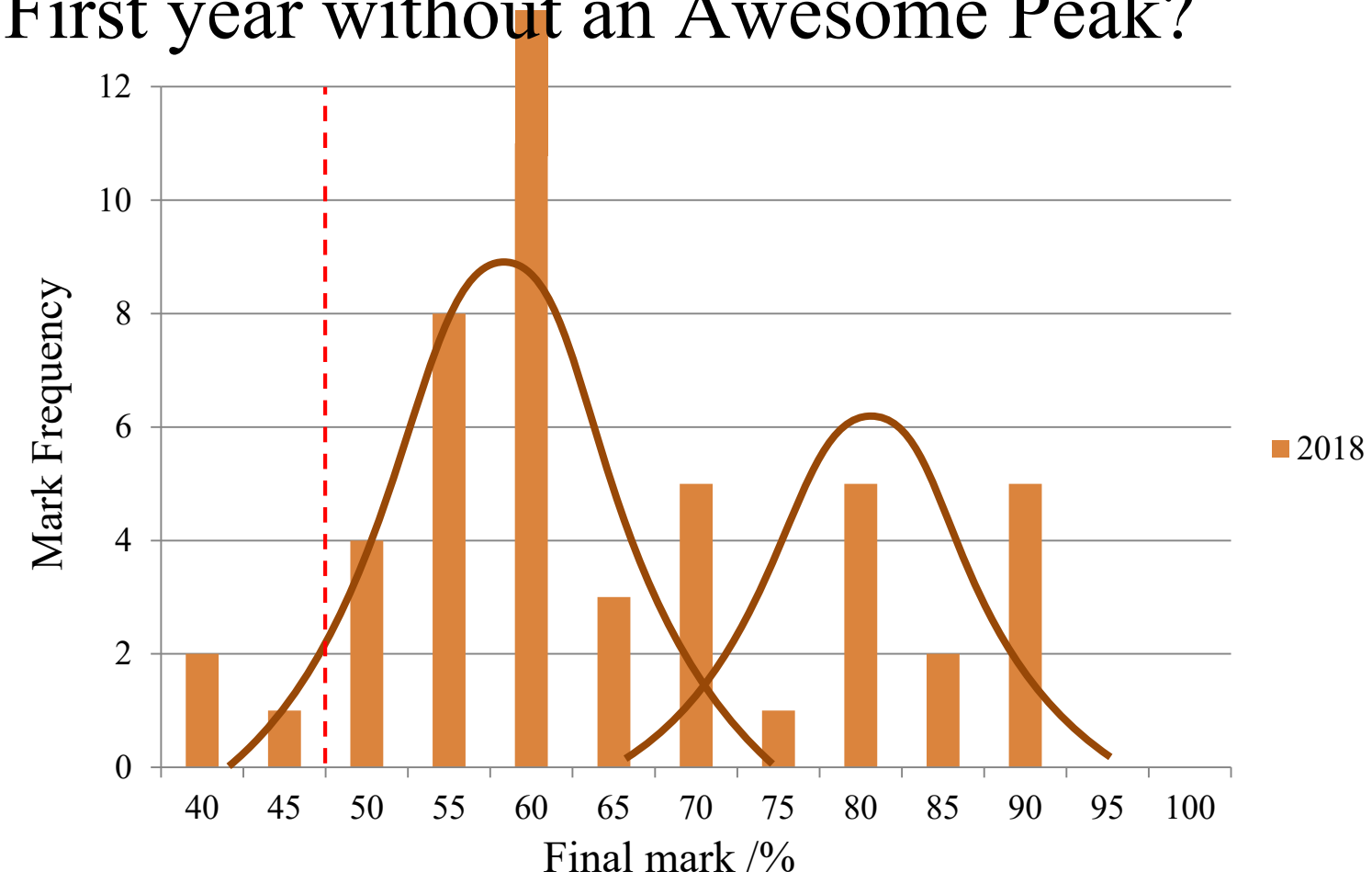
2017 assessment results

- Marking criteria saved so many butts!



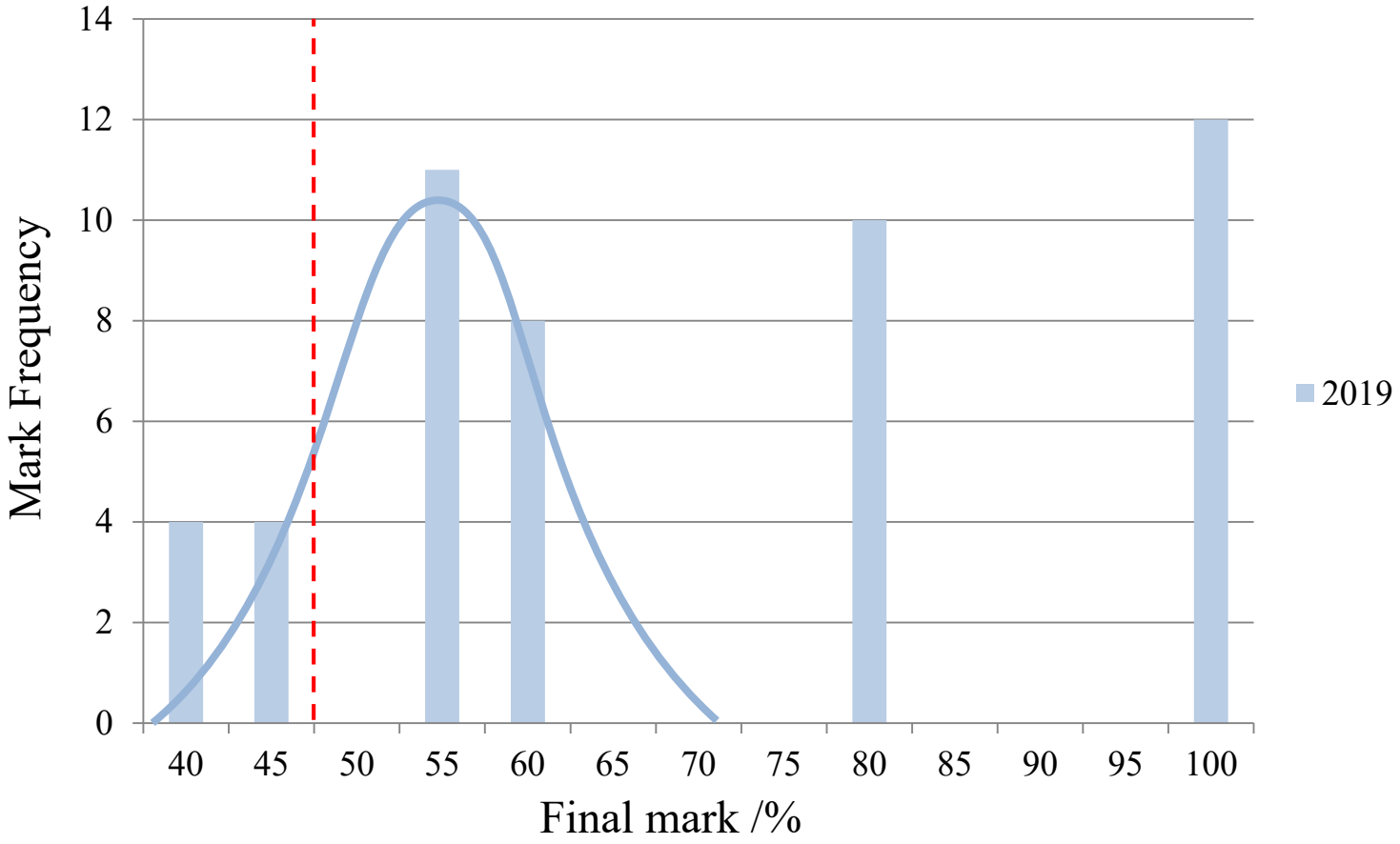
2018 assessment results

- First year without an Awesome Peak?



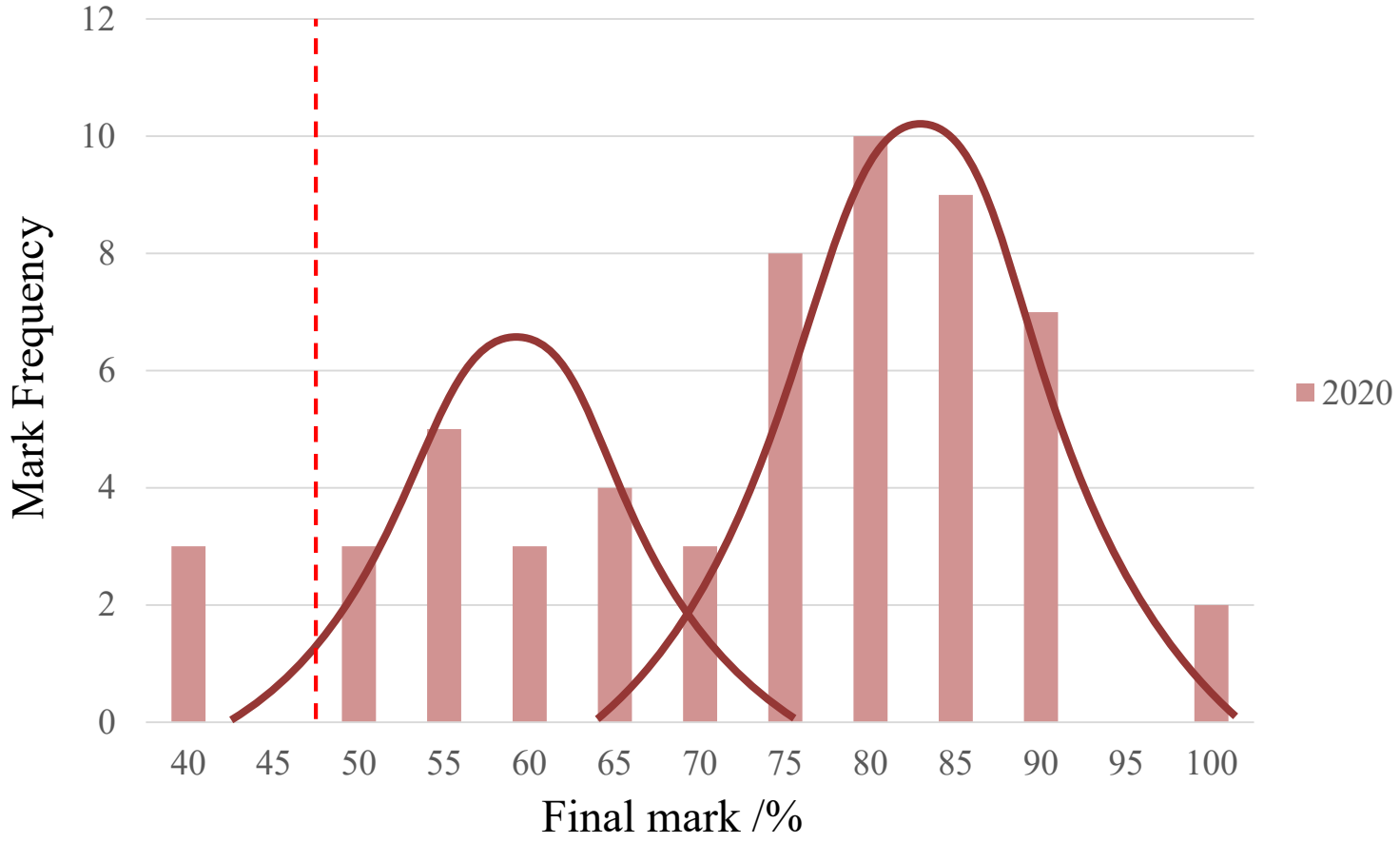
2019 assessment results

- Qualitative assessment; mixed results?



2020 assessment results

- Back to quantitative assessment; mixed results?



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**
2019	**16**	23	16	**20**	**25**	**5.06**
2020	**8**	19	12	**31**	**31**	**5.12**

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

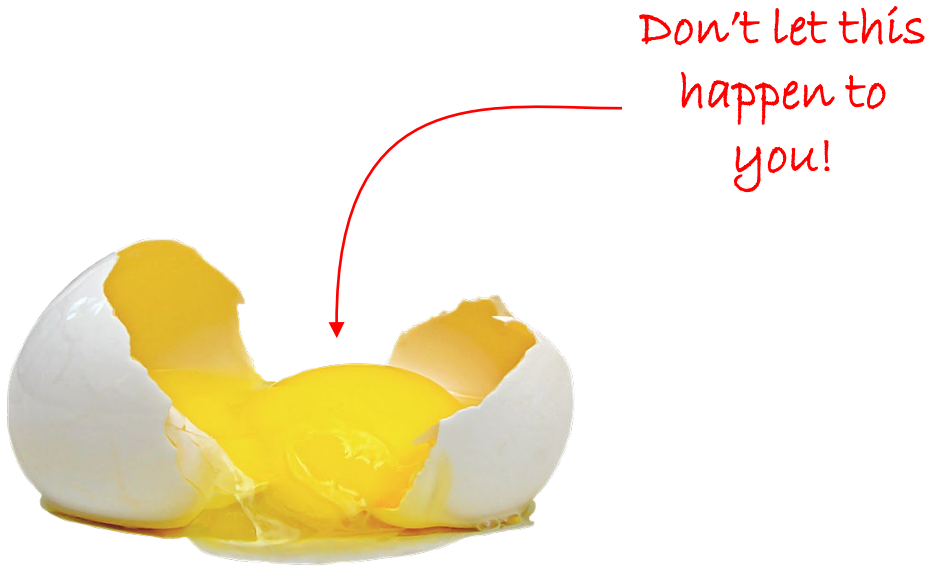
Sins of the forbearers

- 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!!”
- 2019: “Meh, I’ll get around to it.”
- 2020: *~COVID haze~*

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


ANY QUESTIONS?

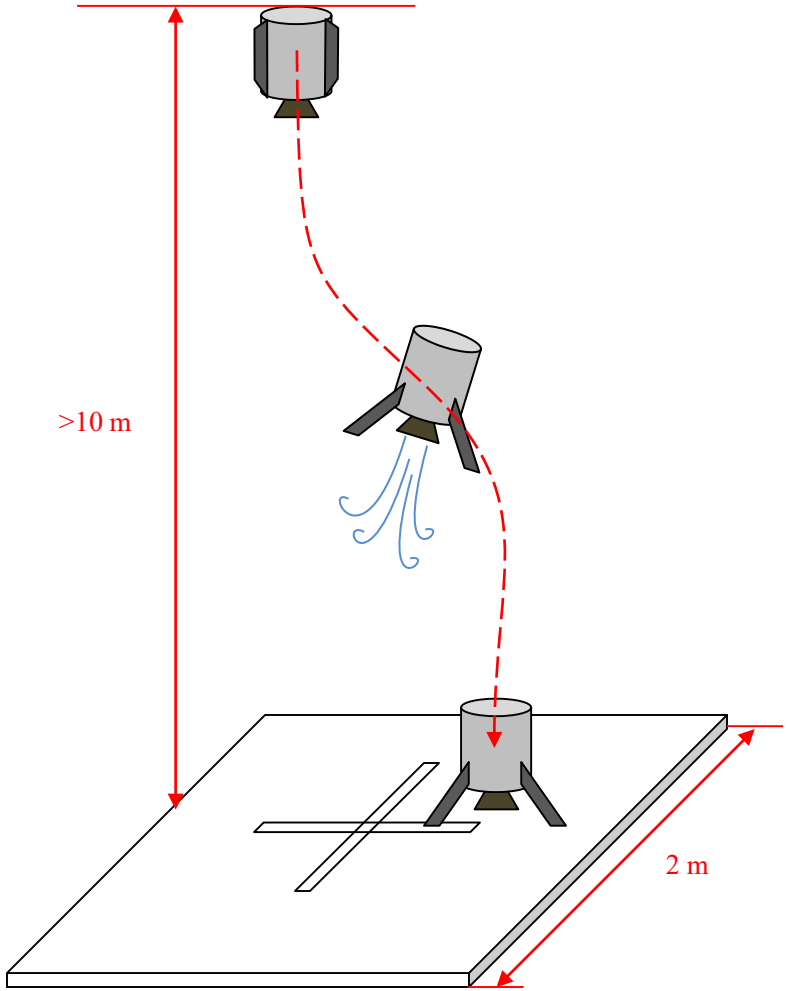
Enough about other people…

Now it’s your turn

PART 1

The Project

The task



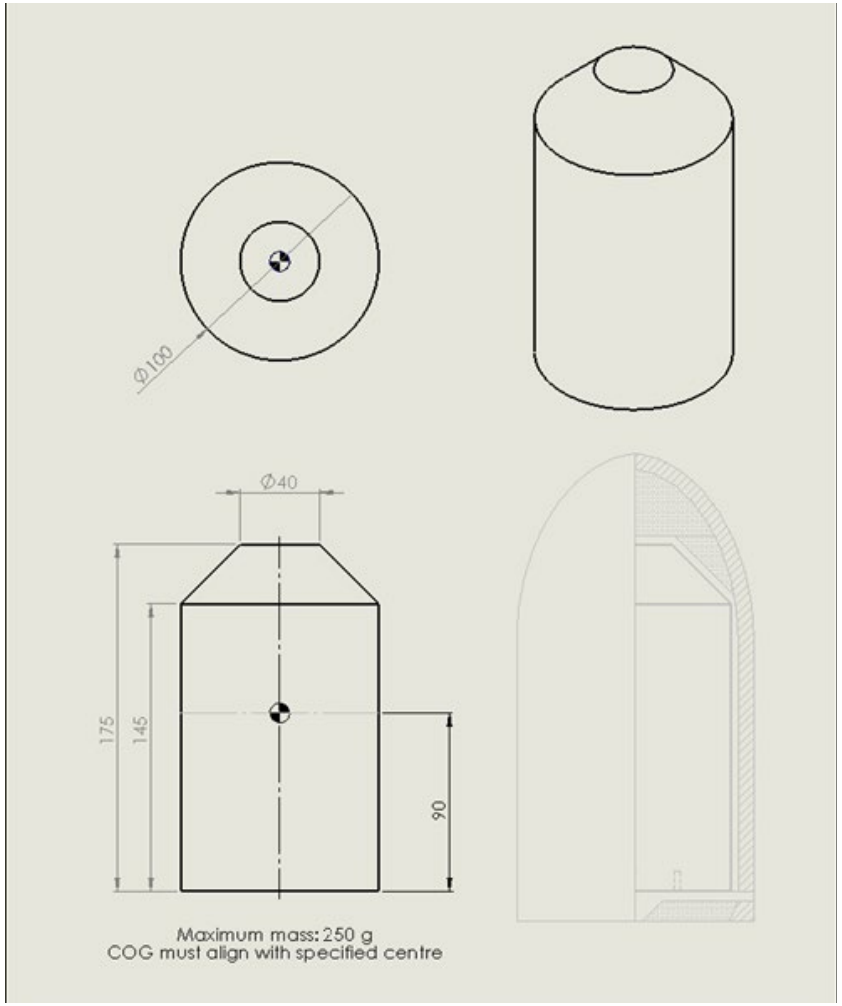
Build a miniature spacecraft lander to descend from >10 m onto a flat 2x2 m target platform under powered descent.

The spacecraft must employ a ducted fan for deceleration, though other braking systems may be incorporated.

Performance will be judged on landing precision and minimising acceleration.

The task

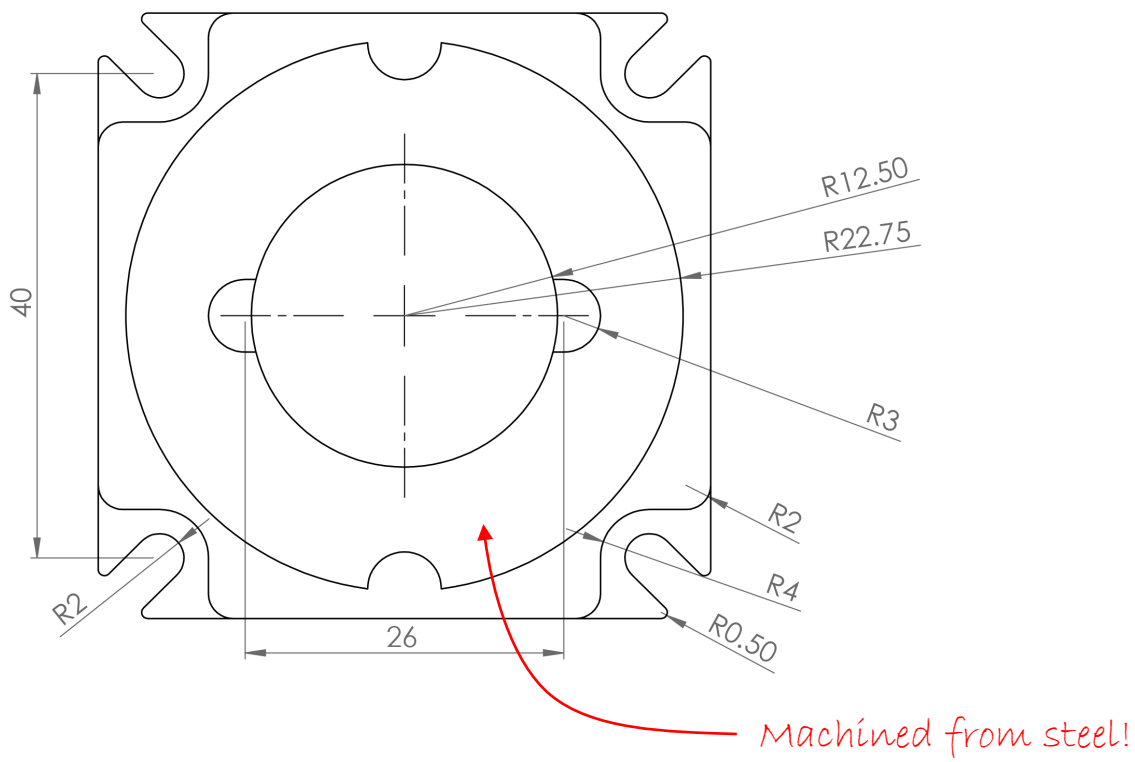
- **Max 250 g weight limit**: this is a CASA legal requirement and shall be *strictly adhered to*.
- The spacecraft must fit within the payload size limits
  - Pieces will be removed with side cutters until it fits within the limits.
- Must be self-contained
  - No ground wires, cables, etc.

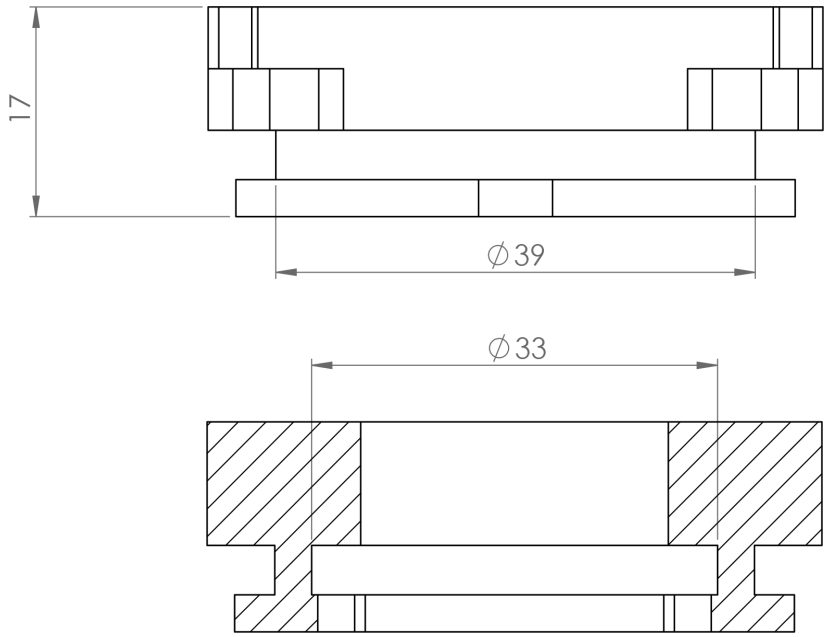


*still in talks with CASA for broader flight exemptions

The task

- The spacecraft starts attached to a ‘service module docking adaptor’, from which it must release itself to start descent.





The task

- Your spacecraft must have an “abort mode” that can be remote-activated to stop the ducted fan and immediately deploy any other descent or arrest systems.

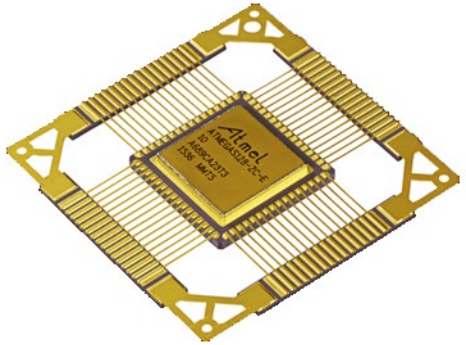
- You must be able to demonstrate that it works on the ground prior to testing
  - Good idea to make it something that is quick and simple to reset

Flight controller

- Your team shall designate a ‘flight controller’, who shall remotely activate spacecraft’s deployment, descent and abort routines, and receive and plot sensor telemetry from the spacecraft.
- If your team includes an External student, the External student *must* take on this role. There will be at most one External student per team.

Space-rated microcontrollers

- The space environment requires a space-rated supervisory microcontroller
  - Doesn't have to be an *actual* rad-hardened micro; just show that it comes in a space-rated version
  - All key subsystems must be able to be power-cycled by the space-rated microcontroller



Other things

- $400 budget
- At-home 3D printing is explicitly allowed
- Consider producing multiple functioning hardware systems, *just-in-case*

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

Key points

- Multiple different systems to be developed in parallel – don't short-change any part
  - Each subsystem is harder than it looks!
- This task is intended to be *challenging*
  - Focus on getting readily achievable points first
  - Get a functional proof-of-concept pathway early


ANY QUESTIONS?

Lead developers

- Each team member shall be ‘lead developer’ for one key project subsystem
  - It’s up to you how to divide up the projects into subsystems, but they must each be equal loads
- The lead developer is responsible for making key decisions, monitoring progress and ensuring success of the subsystem
- You will be expected to account for your area of responsibility at progress reviews.

Statement of roles

- At the first progress review, your team must present a statement of lead developer roles signed by the whole team.

- *Remember:* You shouldn't and don't have to be the only monkey working on that system (and you should also be helping others)!

Submitting parts to the workshop

- You must have at least one machined part per team – ie. milled, lathed, EDM'd or 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

Printing parts in the makerspace

- 3D printing can be done at home or by the makerspace
  - There are no 3D printers in the lab
- ~~You will be given a 500 g quota that will be accounted against for all parts printed.~~
  - ~~Only parts printed by the makerspace may be submitted for final assessment. Home printed parts are ineligible.~~
  - Home printed parts are ok.
- Nominate *one* student to submit print files to the makerspace

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**

Basic Functionality	**40/40 Points**
The thruster activates on command	10
The arrest system deploys	10
The onboard sensors read meaningful data	10
Telemetry data is received and plotted by ground control	10

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

Landing Precision	**30/30 Points**
Spacecraft lands upright	4
Spacecraft lands on landing pad	8
Spacecraft lands within 0.66 m of target	4
Spacecraft lands within 0.33 m of target	6
Spacecraft lands on target	8

Landing Acceleration	**20/20 Points**
Spacecraft does not exceed 16 G	2
Spacecraft does not exceed 8 G	4
Spacecraft does not exceed 4 G	6
Spacecraft does not exceed 2 G	8

Bonus Functionality	**10/10 Points**
Upright, centred, <2 G landing	10

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 achieve the bonus functionality shall receive the coveted METR4810 trophy

Only 17 teams have won trophies since 2013


ANY QUESTIONS?

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

On qualitative assessment

Question: do students need fine-grained numerical feedback to stay motivated, or was the cohort quality different?

On qualitative assessment

- In 2019, I experimented with qualitative assessment
  - IE. I set your grade based on holistic observation of your demonstrated achievement
- Result: grades were on par with previous results, but student engagement was noticeably reduced
  - The first and (so far) only year that no team completed 100% of the task and no trophies were awarded
- In 2020, I returned to quantitative assessment: back to business as usual

On qualitative assessment

- Thus, A/B testing indicates numerical grades are necessary for student success and achievement
  - Sad but true ☹
- Personally, I engineer for the sheer joy of it, but I realise I'm not a sensible, ordinary, everyday sort of person
  - Perhaps this course can change how you feel about engineering?

What to expect from this course

- 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**


ANY QUESTIONS?

Deliverables

- Problem analysis – 10%
- Progress Review 1 – pass/fail†
- Progress Seminar* – 10%
- Progress Review 2 – pass/fail†
- Preliminary Report – pass/fail†
- Final Product Demo* – 60%
- Final Project Report – 20%

* Team assessment with peer and tutor weightings

† More on this later

All non-project written deliverables to be submitted via Turnitin

Problem analysis

Due 5th March– 10% (2 pages max)

- Break down the design problem, determine its scope, key 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 15th – 19th March and 4th – 7th May

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

EXPECT NO MERCY.

Progress Seminar

Due 5th – 8th April (team assessment) – 10%

- 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 an expert panel of hand-picked highly-trained, fully-equipped elite tutors and/or course coordinator

Preliminary Report

Due 14th May – pass/fail*

- 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.

*See “In case of COVID-19” back-up plan

Final Product Demo

Due 24th – 28th May (team assessment) – 60%*

- The Main Event – show your system works!
- Marks 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*.

*See "In case of COVID-19" back-up plan

Final Report

Due 28st May – 20%*

- 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!

 *See “In case of COVID-19” back-up plan

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 mark is less than what was scored in an incremental demo, you will be awarded the incremental demo mark.

Incremental demos

- Scored just like the final demo, but the marks 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: 5% each
  - Preliminary report: 10%
- These deductions are *cumulative*
  - If you were to fail all of them, your maximum achievable grade for the course would be 80%
  - … but realistically you'd probably be struggling to pass.

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 mark 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%

Tutor assessment

- TAFs work just like PAFs, except the score is provided by the tutors
- Tutors pay attention to who is working and usefully contributing throughout the year
  - Being present and effective in the lab is a great way of convincing them you're a contributor
  - This is evidence based: we take notes.

The TAF also works as a sort of safety valve for hard-luck students

Calendar at a glance

You are here

Teams assigned here

Week	Dates	Lecture	Reviews	Demos	Assessment submissions
1	22/2 – 26/2	Introduction			
2	1/3 – 5/3	Principles of Mechatronic Systems design			Problem analysis
3	8/3 – 12/3	Previous years deconstruction case studies			
4	15/3 – 19/3	Professional Engineering Topics	Progress review 1		
5	22/3 – 26/3	PCB design tips			
6	29/3 – 2/4*	Your soldering is (probably) terrible			
Break	5/4* – 9/4				
7	12/4 – 16/4	Introduction to firmware design	Progress seminar	25% demo	
8	19/4 – 23/4	No lecture!			
9	26/4 – 30/4	Q and A sessions		50% demo	
10	3/5* – 7/5	Q and A sessions	Progress review		
11	10/5 – 14/5	Q and A sessions		75% demo	Preliminary report
12	17/5 – 21/5	Q and A sessions			
13	24/5 – 28/5	Closing lecture		Final testing	Final report and reflection

Pauline on junket! Yay!

Break! (Try to work?) ☺

Madness Week


ANY QUESTIONS?

In case of COVID-19…

In case of COVID-19…

Tentative response plan (subject to change):

- <2 weeks lockdown: Keep calm, carry on.
  - No change to expected assessment schedule, meetings moved online as required – don't worry, we are sensible and fair.
- 3-4 weeks lockdown: Extended design phase
  - Teams may elect to reduce final demo marks to 30%, with marks reallocated to final report (so, 50% final report).
- >4 weeks lockdown: Paper-only design
  - No hardware submission – final demo marks to be reassigned the preliminary report (20%, no longer P/F) and final report (60%).

In case of COVID-19…

- If lockdowns prevent in-person testing of your project, it will be assessed by the course coordinator and tutors in accordance with the best functionality that can be demonstrated via remote operation.

Pro tip: Make your system fully remote-operable and easy to set up by ~~complete idiots~~ the tutors and academics!

(These are proposed measures only; actual execution may vary depending on circumstances)


ANY QUESTIONS?

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: https://metr4810.uqcloud.net/

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 thrice 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

Further 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 are more nicely-groomed and 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 and don't think you're cool

Some suggested topics

- Digital control
- Electromechanical devices
- Radio communications
- Principles of aerodynamics
- Sensor-fusion and filtering
- 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 ~~small~~ ~~high~~ frightening number of students this year – 79 enrollments!
  - It's going to be *packed*...
  - Good idea to work from home if you can.
- Consequence: share and keep it tidy
  - Compact lockers for project work
  - Shared space and resources
  - Get started early; consider how you can work most effectively in the final two crunch weeks


ANY QUESTIONS?


<eyeofsauron>
Hey, about that lab . . .

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** 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

- The induction session requires you to sign-up via uRite:
  https://student.eait.uq.edu.au/urite/index.wphp?act=show&schedule=264
  - The session will be held on March 3rd, during the practical slot
  - Also when you'll get your toolboxes!

- If you can't attend that session, you will have to organise a separate session with Jonathan Read.

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/myspace/whatsapp/tictoc/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

And now a word from our sponsor…

A valuable message about safety…

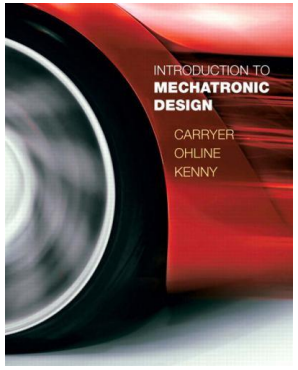
And now a word from our sponsor…

Thank you for your attention

(We're trying these out, tells us what you think!)

Resources

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



(recommended but not required)

Knowledgeable people

- Course Coordinator and Professtrix:
  - Pauline Pounds
- Tutors:
  - Will
  - Ben
  - Stewart
  - Henry
  - John
- Technical Staff
  - Patrick Morris
  - Jason Herriot
  - Malcolm Marker
  - Jonathan Read
- Emergency Auxiliary Temporary Back-Up Replacement Stand-in Teaching Faculty
  - Dr. Tyson Phillips
  - Dr. Phil Terrill

Contact info

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

- Rules questions
- Technical issues
- Ordering
- Assessments
- Group problems
- Enrolment
- Disenfranchisement 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 47-310 or Nanos

When: 11ish to 5ish – by appointment (or drop in)

What: Coffee or coke (either kind)

How: pauline.pounds@uq.edu.au

Plz preface class-related messages with [METR4810] in the subject line, kthxbye

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 3rd March
  - Toolbox handouts
  - Room 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: It took SpaceX 19 launches to successfully land an orbital rocket stage.

Questions?

?