The Final Lecture

or

"Coming up for air!"

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30 May 2016

University of Queensland

But first…

Some house keeping

Calendar at a glance

Week	Dates	Lecture	Reviews	Demos	Assessment submissions
1	28/2 – 3/3	Introduction			
2	6/3 – 10/3	Principles of Mechatronic Systems design			Problem analysis
3	13/3 – 17/3	Professional Engineering Topics			
4	20/3 – 24/3	Introduction to Practical PCB Design	Progress review 1		
5	27/3 – 31/4	Your soldering is (probably) terrible			
6	3/4 – 7/4				
7	10/4 – 14/4		Progress seminar	25% demo	
Break	17/4 – 21/4				
8	24/4 – 28/4				
9	1/5 – 5/5			50% demo	
10	8/5 – 12/5		Progress review		
11	15/5 – 19/5			75% demo	Preliminary report
12	22/5 – 26/5				
13	29/5 – 2/6	Closing lecture		Final testing	Final report and reflection

You are here

Lab matters

- Almost at the end!
  - Projects submitted!
  - Toolboxes handed in!
  - Lab cleaned up!

Hopefully, everyone has survived the ordeal.

If not, please let me know after class.

FAQ Roundup

- **How is the final demo different from the incremental demos?**
  - Aside from the mark cap? No different - just the same.

- **Will it ever end?**
  - Yes, on Friday. Then you are free.

Final report

- Due on Friday
  - *Really, really soon now!*
- Your report must have:
  - Max 5 + 1 pages of explanation/writing
  - Bibliography/math/sims/figures/budgets/etc. in the appendices
  - Analytics
  - Incorporate comments from preliminary report

Final report

- Do not exceed 6 pages of written content
  - Go nuts with the appendices for bibliography/math/sims/figures/budgets etc.
  - There is no such thing as too many pictures
  - Don't try to sneak written content into the appendices – *seriously?* We won't read them.

Exception: you may include a short personal reflection in the appendices, if you wish.

Final report

Remember:

- The preliminary report comments are a guide only, and **NOT** a foolproof sure-fire guaranteed way to get 100% on the final.
- You are expected to make changes and improvements that reflect your continued development, changes and improvements made since week 11

Final report

- Hand in via the assignment slot, in hard copy by 23:59 pm Friday.

- I’m still happy to sit down with you and go through your preliminary report comments!
  - This is a free, complimentary service, and all part of our value-added customer service commitment!

Final demo schedule

- Tuesday 30st
  - 14:00-14:30 Setup
  - 14:30-15:00 Team 5
  - 15:00-15:30 Team 2
  - 15:30-16:00 Team 14
- Thursday 1st
  - 11:30-12:00 Setup
  - 12:00-12:30 Team 13
  - 12:30-13:00 Team 9
  - 13:00-13:30 Team 16
  - 13:30-14:00 Team 12
  - 14:00-14:30 Team 4
  - 14:30-15:00 Team 3
- Wednesday 31st
  - 13:30-14:00 Setup
  - 14:00-14:30 Team 15
  - 14:30-15:00 Team 1
  - 15:00-15:30 Team 11
  - 15:30-16:00 Team 6
  - 16:00-16:30 Team 8
  - 16:30-17:00 Team 17
  - 17:00-17:30 Team 10
  - 17:30-18:00 Team 7

Marking schema

- Product demo is 60 per cent of class grade
- This is subdivided into:
  - Build quality – 10 marks
  - Basic functionality – 25 marks
  - Recovered items – 30 marks
  - Recovered hull sections – 35 marks
  - Bonus object recovery – 10 marks

Totally possible to get 110 marks out of 100.

Functionality and scoring

Basic Functionality	**25/25 Points**
Return images of the sea floor to surface	10
Locate the wreck of *Sir Nils Olav*	10
Return image of sail markings to surface	5

Recovered items	**30/30 Points**
Torpedo	2 each
ICBM	2 each
Reactor module	4 each
Code cipher machine	2 each

Recovered hull sections	**35/35 Points**
One separate section	10
Two separate sections	15
Three separate sections	20
Two joined sections	25
Two joined sections, one separate section	30
Entire submarine intact	35

Bonus Functionality	**10/10 Points**
Recover other sunken object	3 or 4

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

Structure of the final demo

1. Meet at tank 10 mins before slot time
2. Setup and config during 5 min changeover
3. Commence 25 minutes of ~~terror~~ testing
4. Build quality assessment during changeover
5. Fill out PAF and return to tutor
6. Commiserate/celebrate at Red Room

Build quality

- Marks are given for the quality of fabrication
  - Neat and tidy assembly
  - Smooth operation of moving parts
  - Clean design and professional finish
- Worth 10 per cent of project mark
  - Be able to locate code, drawings, etc when asked!
- This will be assessed after your demo
  - Try to keep your hardware in one piece

Build quality

Grade Band	Electrical (35)		Mechanical (35)		Software (20)		Finish(10)	
Excellent (85-100%)	Clearly designed and well thought-out optimised construction, high-quality of manufacture and defect-free. Professional-quality work	35 33	Clearly designed and well thought-out optimised construction, high-quality of manufacture and defect-free. Professional-quality work	35 33	Tight well-structured code, useful comments, easy to read and understand without explanation	20 18	Beautiful construction, intuitive and pleasurable to use	10 9
Very Good (75-85%)	Neatly laid out and ordered, orderly sensible circuit routing and layout, high-quality assembly with few defects	29	Solid construction with no excess or deficit of material, tightly-toleranced components, rock-solid assembly, good materials selection	29		16		8
Good (65-75%)	Solid design and construction, few soldering or assembly defects, indications of methodical layout design	25	Clear indication of design and care in construction, well-fitting parts, and robust assembly, few design or fabrication problems	25	Comprehendible, organised and methodical, easy to follow with minimal effort, could be maintained without help	14	Straightforward to use, sensible interface, clean and appealing, everything in its place	7
Satisfactory (50-65%)	Obtuse layout, some suboptimal design elements, construction problems or defects but serviceable	21 17	Chunky or weak in parts, but not fragile or bloated, inappropriate materials, rough fits, unrefined but serviceable	21 17	Structured and understandable with effort, unhelpful variable names or functions, difficult to make sense of without explanation	12 10	Unhelpful markings, unintuitive interface, poor attention to detail, unattractive	6 5
Poor (25-50%)	Shoddy design/construction, low-quality soldering with a high rate of defects, unlikely to be reliable	13 9 5	Rickety, rough and cobbled together; poorly fitting and shoddily assembled, unlikely to be reliable	13 9 5	Chaotic and incomprehensible, impossible to modify or maintain, even if it works	8 6 5	Frustrating, ugly and unusable	4 3
Very Poor (0-25%)	No attempt made	0	No attempt made	0	No attempt made	0	No attempt made	0

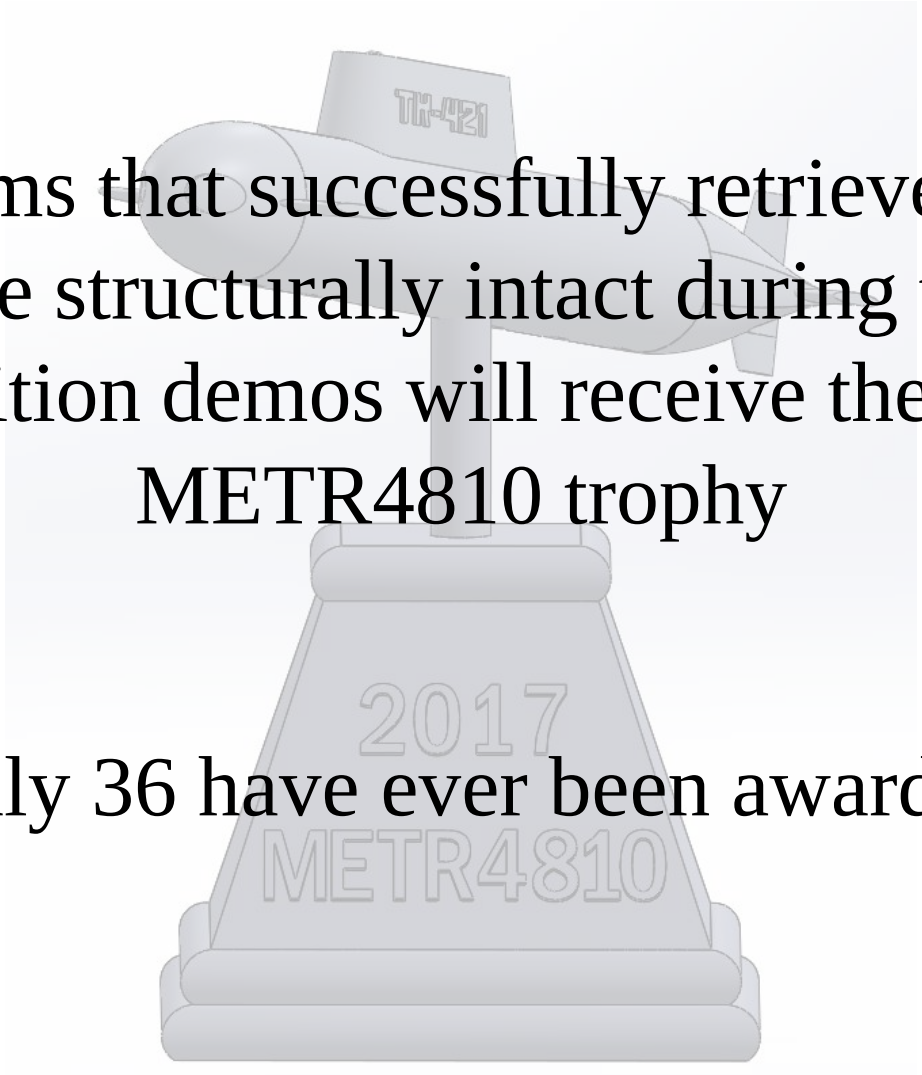
Exhibition demo

- Groups that recover at least one hull section, may be invited to present their work at an exhibition on Friday

- The exhibition is for glory, not marks
  - No points will be awarded, no matter how good or badly you do

But also...

The METR4810 Trophy



Teams that successfully retrieve the submarine structurally intact during the 100% or exhibition demos will receive the coveted METR4810 trophy

Only 36 have ever been awarded

And now…

The tables are turned

SECaTs

- SECats opened last week and will be open until the end of semester
  - You should have gotten an email about it
  - Why not take this opportunity to use your laptop/mobile device to complete it *now*?

But while you're doing that…

SECaTs

- In this class, I have been evaluating you.
  - Now is your chance to evaluate me.
- I have been asking you to show me methodical engineering design.

You should expect no less of me!

SECaTs

So, in fairness, I would like to present…

METR4810

An (Abridged) Design Case-Study

The full version would probably be boring.

The process

1. Specification
2. Research
3. Analysis
4. Implementation
5. Validation

Specification

What is it I’m supposed to be doing, anyway?

Design Specification

Codified in the "learning objectives":

1. TEAMWORK

1.1 Be an effective team player.

1.2 Understand your responsibilities in a team situation.

2. DESIGN

2.2 Design an electromechanical and software based product.

2.3 Identify and break down personal and technical problems in product design.

2.4 Implement a complete design cycle.

2.6 Choose appropriate design strategies.

3. PROJECT

3.2 Apply project management skills.

3.4 Produce, implement and devise product plans.

3.5 Deliver a product on-budget and on-time.

4. COMMUNICATION

4.2 Use ICTs for information retrieval and dissemination.

4.4 Write formal reports

4.6 Chair and attend formal meetings.

4.7 Verbally present your design ideas

The underlying goals

Read between the lines:

Get students to experience doing a real **engineering design** project…

… on a **challenging problem**…

… that requires **teamwork** to be successful…

… leading to real world **social dynamics**.

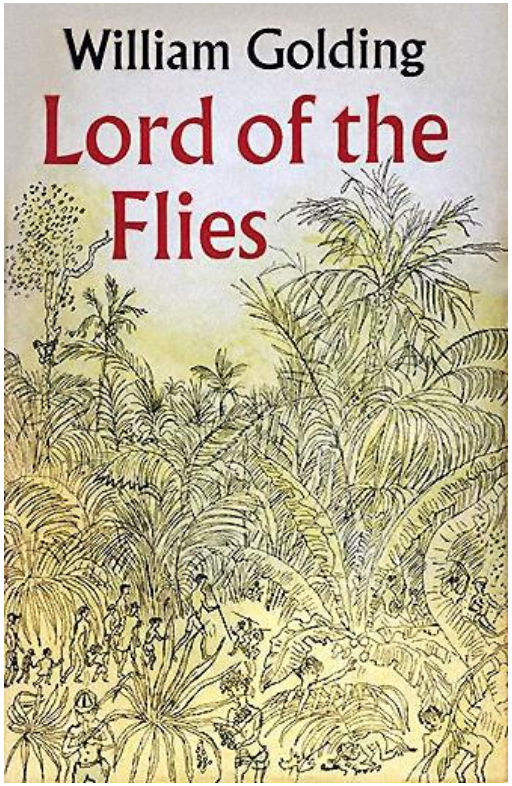
Why is this hard?

Challenging problems?

Social dynamics?

Team work??

<u>This is a recipe for disaster!</u>



And that's before I actually try to teach design!

Research and analysis

Lessons and insights from previous classes

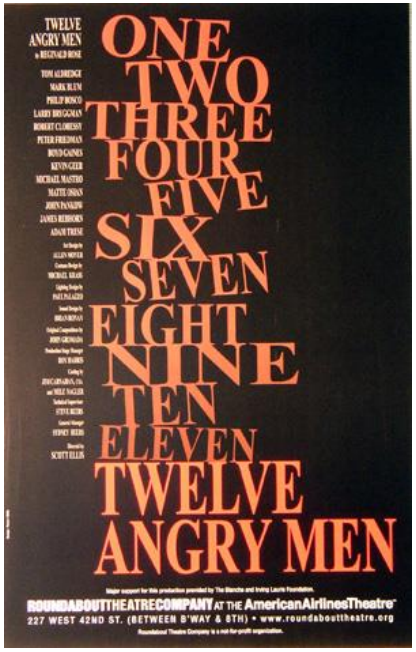
Prior experience

Lessons from METR team projects past:

1. Students are overly familiar with classic projects – Robocup, Micromouse, etc…

2. Friend-based teams can go *catastrophically* wrong ☹

3. PAFs can be unfair and brutal
   – "12 Angry Men syndrome"



Prior experience

5. Product-based courses exhibit boolean failure modes
   – Small errors on the last day are lethal
6. Students rigidly follow design methods and suggested schedules to their detriment
7. Students *never* get started early enough
   – Even when you tell them to!

Translate into design constraints

- Project must be awesome
  - Easy to be motivated by intrinsic drivers
  - ie. for the joy of engineering, not just marks!
- The project must be properly scaled
  - Suitable to teams of four students with mechatronics backgrounds
  - Tough task, but not impossible (with teamwork!)
- The class structure must reward hard work
  - Don’t reward slackers; identify problems early

The idea

Why not a submarine recovery project?

- Special case of a “closed box” problem
  - Limited visibility
  - Relies on preassembled systems
  - Well-controlled scope
  - Special difficulties: water-proofing, teleoperation

The idea

Big focus on practical elements

- Underwater environment – design challenge
- Dark, gloomy water – vision challenge
- Grasping objects – manipulation challenge
- Shoebox size – tough size constraints

Lots of good disparate problems to tackle!

Comparative analysis

There are many other candidate projects, but I won't discuss them here, as they will likely be used for future years and are **TOP SECRET**

So… yeah… sub recovery!

Meeting the spec’

Why submarine salvage?

- No reuse of previous project work
- Four clear, independent mechatronics tasks
  - Control, gripper, winch, propulsion
- Naturally motivated analysis and integration
- More focus on design, less on fabrication
  - Less to build, but plenty to analyse
  - Lower time burden and better learning value

Implementation

Key design subsystems:

1. Sensible assessment
2. Make it challenging
3. Make it fun

Sensible assessment

Assessments as a *de facto* project plan

- Design analysis to get you thinking early
- Regular freeform milestones every 2 weeks
- Big milestone in the middle
- Early preliminary report submission to get you working on report *before* crisis point

Sensible assessment

- Reports differentiate students
  - Allows good students to survive bad groups
  - Safety net options – designed to reduce angst
- Multiple chances for most assessments
  - No single assessment is ‘sudden death’
  - Recover marks from bad luck failings

Making it challenging

- Multiple competing objectives
  - Must use the synthesis step to find a solution
  - Duct-tape approach will not succeed
- Obvious approaches inferior to carefully reasoned approaches – rewards thinking
- Add challenges to test specific design skills
  - Good motion control vs simple robustness
  - Light-weight solution vs sophistication

Making it fun

- Just what makes something ‘fun’ is ineffable
  - But years of game design experience help!
- Sense of humour and consistent style
  - Little bit quirky, little bit silly, very polished
  - A little bit of theatre!
  - ‘Look and feel’ modelled on MIT Mystery Hunt

My team didn’t win – we are not surprised!

Making it fun

Several key design features that elicit ‘fun’

- Well-defined objectives
  - You know what to do; clear project spec’
  - Collaborative puzzle-solving
- Multiple possible solutions – huge variety!
- Difficult but obviously achievable
  - Not futile; tangible reward for time put in
  - Early pay-off for effort (eg. keeping hull intact)

Results

How it went down

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

The good, the bad, and fun details

I did some things well,

other things not so well

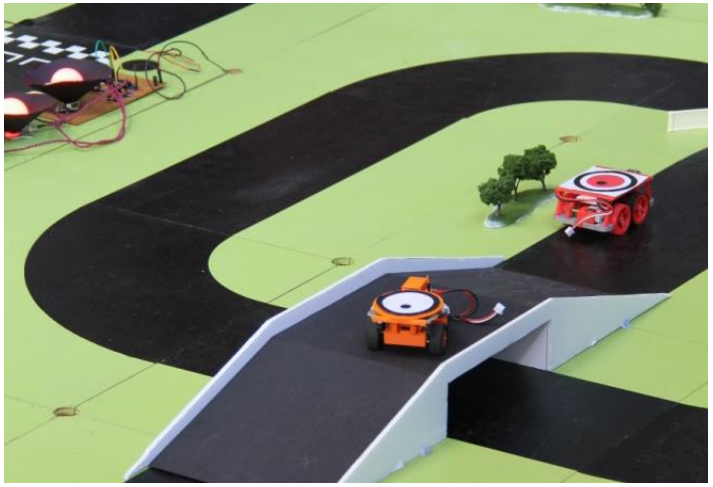
Previous years' feedback

Main strong points:

- Intellectually stimulating
- Learned a lot in the course
- Incremental PAFs = *good*

Main weak points:

- Availability of apparatus
- Limited access to apparatus



This year

Several experimental changes:

- Very difficult design problem ✓
- Very strict lab rules in force ✓
- Tutor only apparatus access ✗
- Post-Q&A coffee sessions ✗
- Very high analysis standards ?

What I think I did well

- Kept it real
  - Treated you like Men and Women
- Cared about the stuff that matters
  - No stupid nit-picking about stuff
  - Told you what to *really* expect from industry!
- Gave a lot of support
  - Regular tutor and coordinator lab presence
  - Ran the testing tank, even in our own time

"Let that which does not matter truly slide" – Tyler Durden

What I think I did well

- Useful experiences, fair grades
  - Toy problem, real analysis; no busywork
  - Focus on professional practice in industry
- Made time for students
  - Made myself available in the lab
  - Lots of one-on-one feedback
- Project well-organised, well-balanced
  - Very achievable task, but plenty of complexity

What I think can be improved

Things I *can't* change:

- Miserable clash with thesis, CSSE3010
- Accidental injury of workshop staff ☹
- Had to be a disciplinarian about cleanliness

Things I *can* change:

- Easier student access to testing apparatus
- Better management of machined parts fab

What you liked

- Incremental demos – well used!
- Apparatus and submarine worked very well
  - Delays notwithstanding
- Multimodal lectures (optional attendance)
- Sense of humour (?)

What you didn't like

- People left hanging by Doug taking leave right when machined parts were being done
- Standards were high and feedback frank
  - Maybe too harsh?
- The design problem was especially difficult

Outcome

- This year has run pretty smoothly, all things considered... with only a few small bumps
- Everyone seems pretty much on the ball
  - Most teams seem to have pulled it together

High hopes for testing day!

• • •

And now for something completely different

Behind the scenes

The making of METR4810 2017

Theme

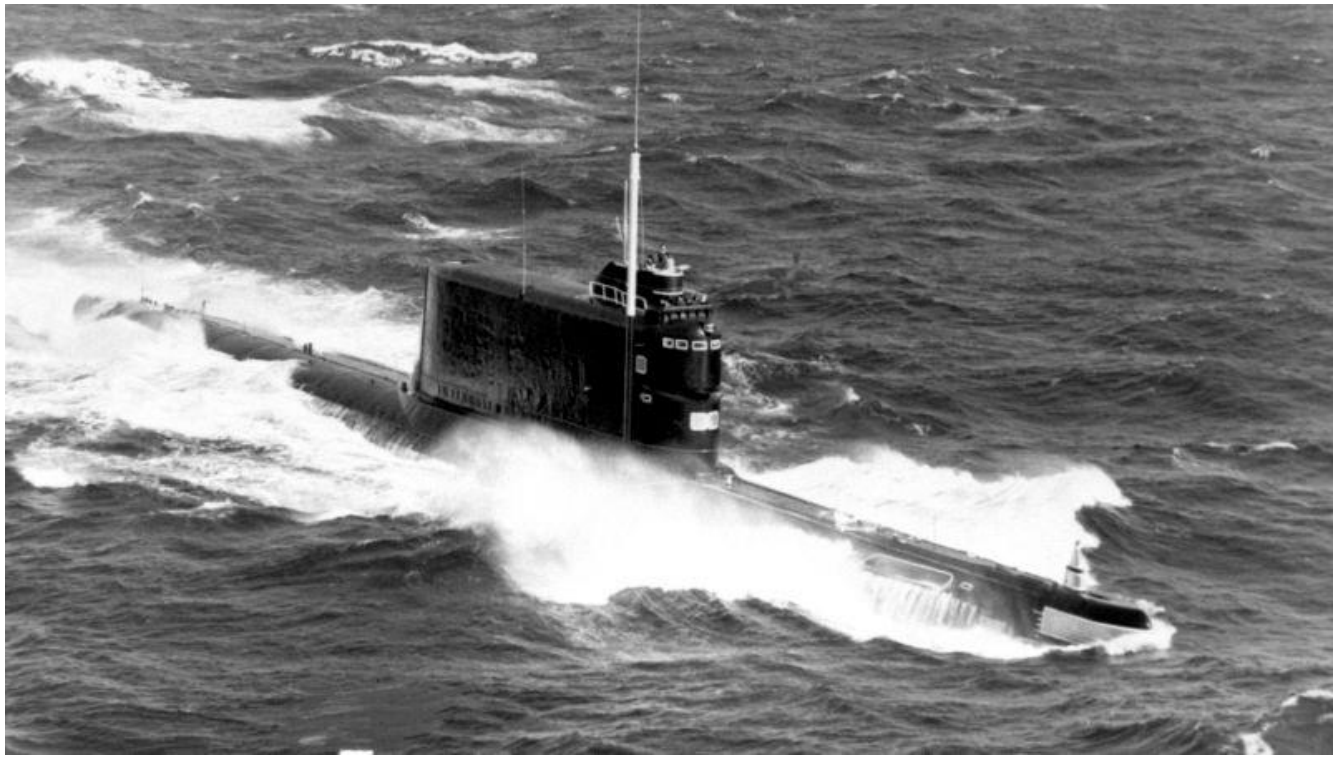
This year's theme was one I had in mind from the very beginning of running this course

Only now, after several successful years under our belt, do we have the chutzpah to actually attempt a project as insane as this!

Note to self: Do not run a water project for at least another 4 years

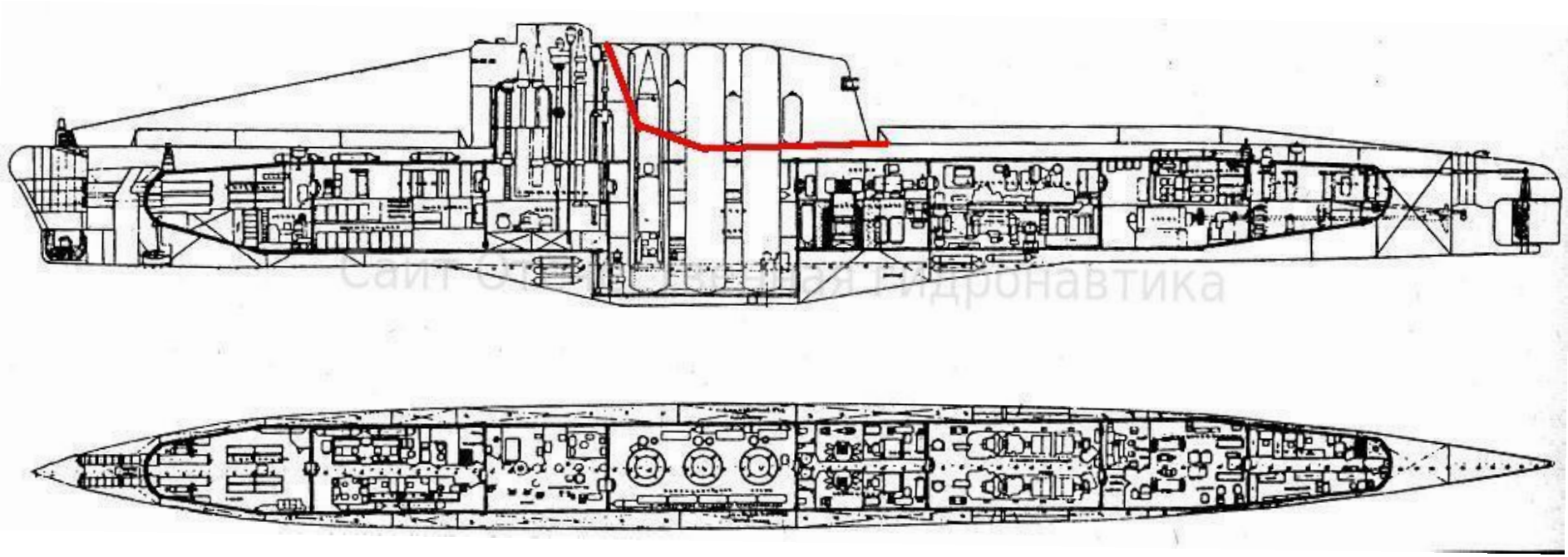
Theme

- Inspired by the 1974 CIA mission to recover the K-129: “Project Azorian”



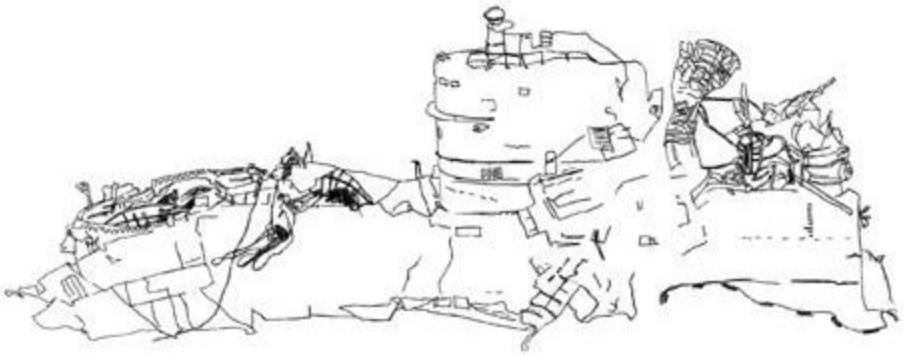
K-129

- Nuclear missile sub, launched in 1960
- Lost on patrol in February 1968



The wreck of K-129

- Located to within approximately 5 nm by hydrophone triangulation of the implosion
- Found at 4900 m by USS Halibut in Aug 1968
  - Amazingly after only 3 weeks of searching!!

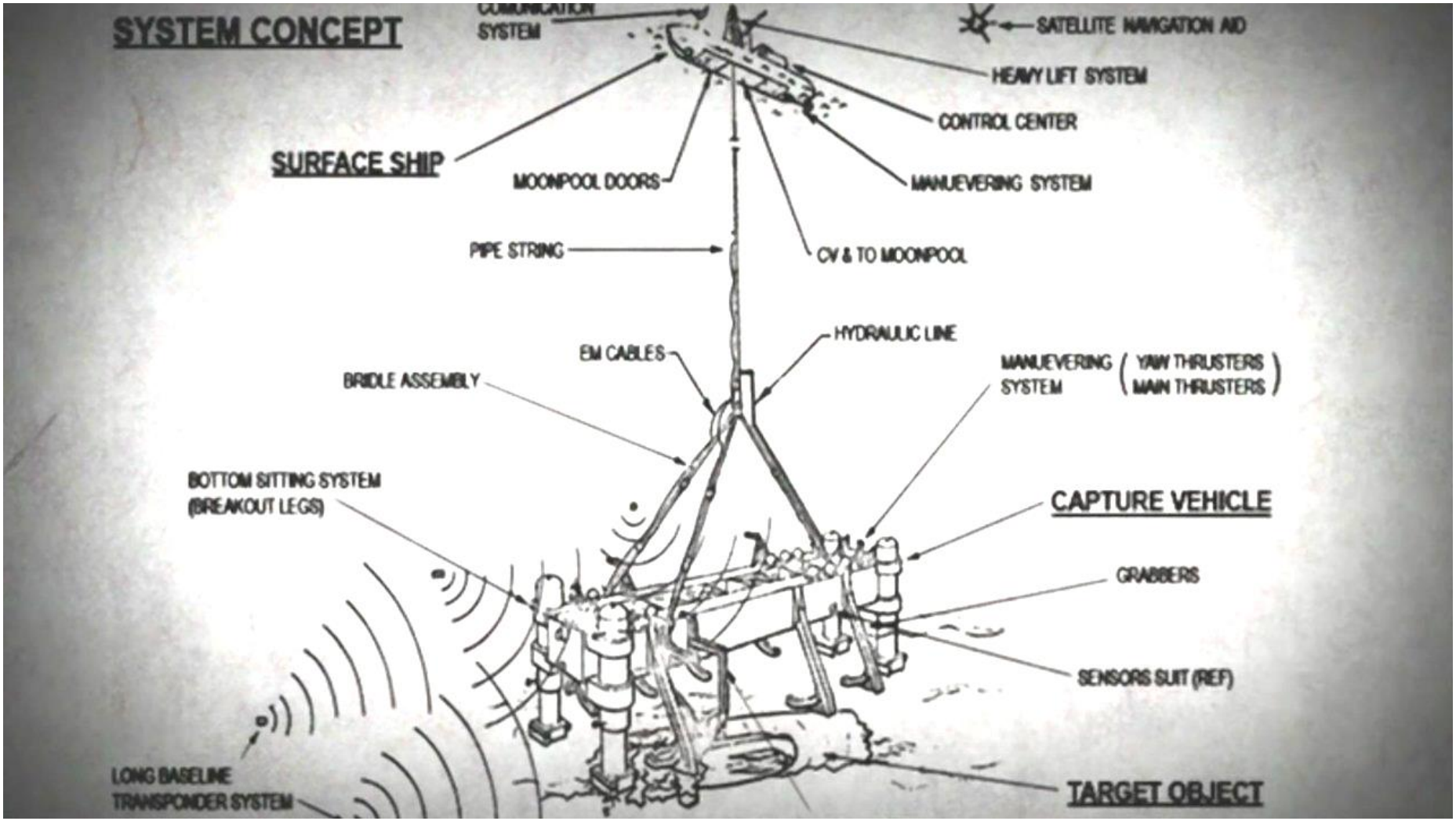


Project AZORIAN

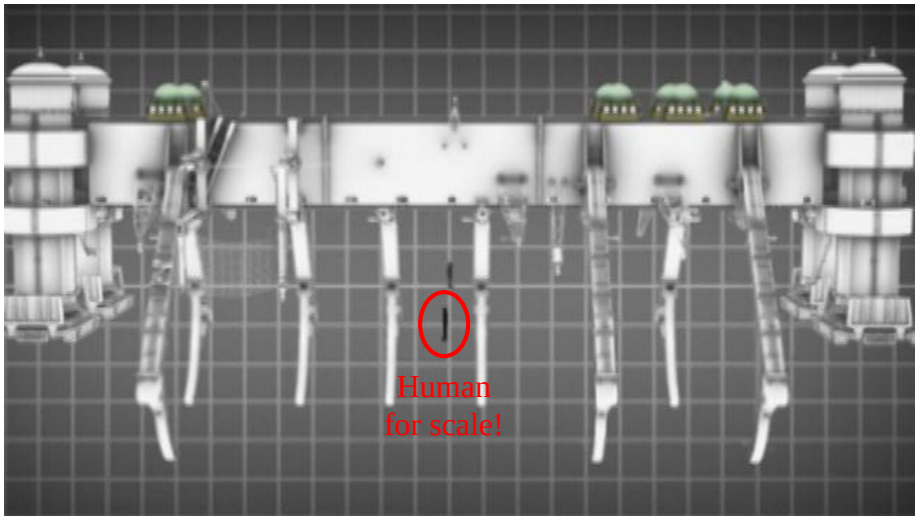
- Salvage K-192 from under Soviet noses?
- Elaborate cover story of Howard Hughes and underwater manganese nodule mining

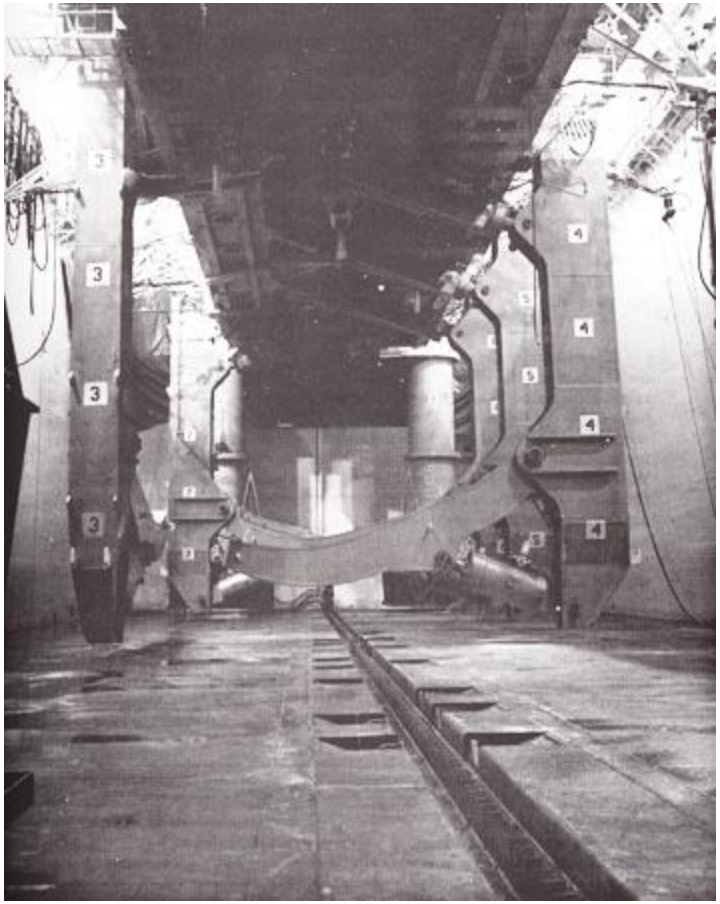
Glomar Explorer

Recovery concept



‘Clementine’ capture vehicle





Specially developed by Lockheed

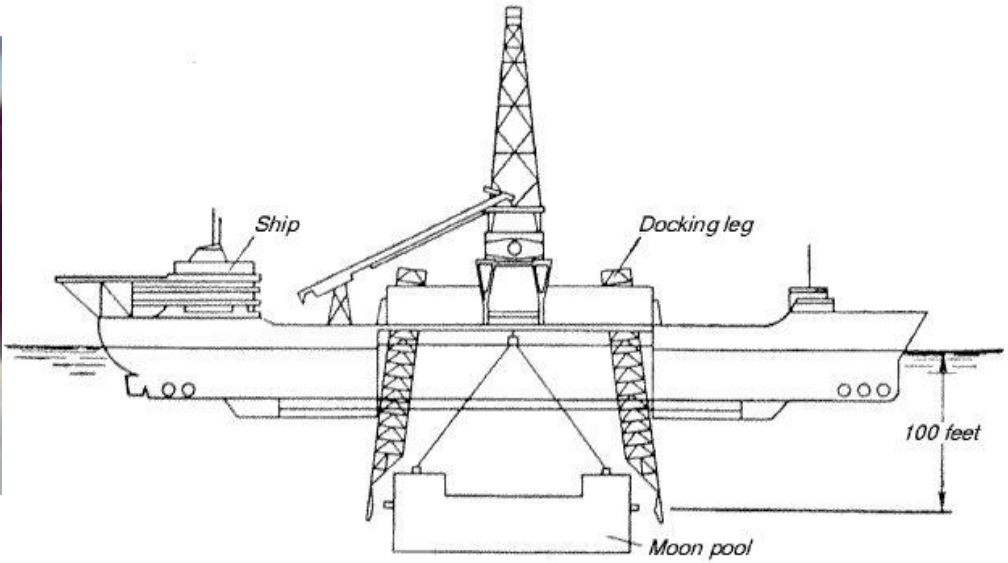
Hughes mining barge

- Clementine was assembled in drydock and installed underwater for absolute secrecy
  - Hughs Mining Barge submerged to allow the Glomar Explorer to pluck it from above

Hughes Mining Barge

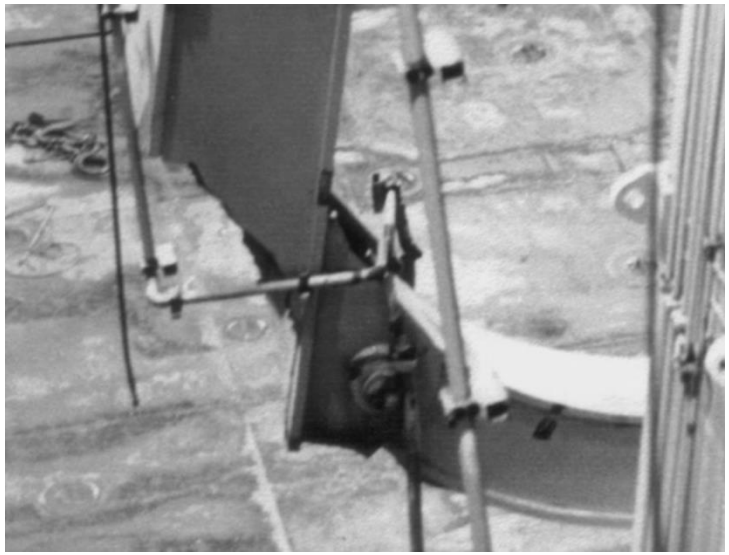
Position control

- Pipe tether to control descent
- Omni-directional thrusters for lateral motion
- Capture arms for precise recovery
- Whole assembly is gimbaled on bearings!



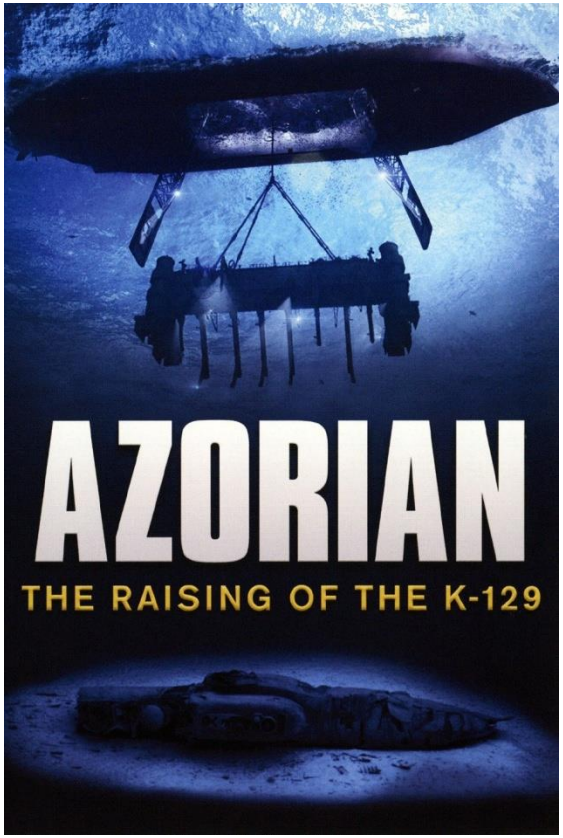
Partially successful

- Broke support legs during grasping
  - Maraging steel is brittle in cold Atlantic water
- Only captured the front of the bow
  - Included two nuclear torpedoes and other intel



Awesome documentary

- Check out the excellent PBS documentary "Azorian:The Raising of the K-129"



Who is Sir Nils Olav?

- The mascot (and Colonel-in-chief) of the Norwegian King's Guard
  - Given as a gift to Edinburgh Zoo, he is given a promotion every time the King's Guard visits
  - Third penguin to hold the title – Nils Olav III

Theatrical introduction

- A splashy introduction gets students engaged
  - My way of saying “This is gonna be awesome!”

2013 : Showed up in my full academic regalia
  - Very popular, great result!

2014 : 3 minute Power Point animated intro
  - Surprisingly negative feedback (?)

2015: Aviator glasses and flight jacket, address to recruits
  - No one under 30 remembers TOPGUN

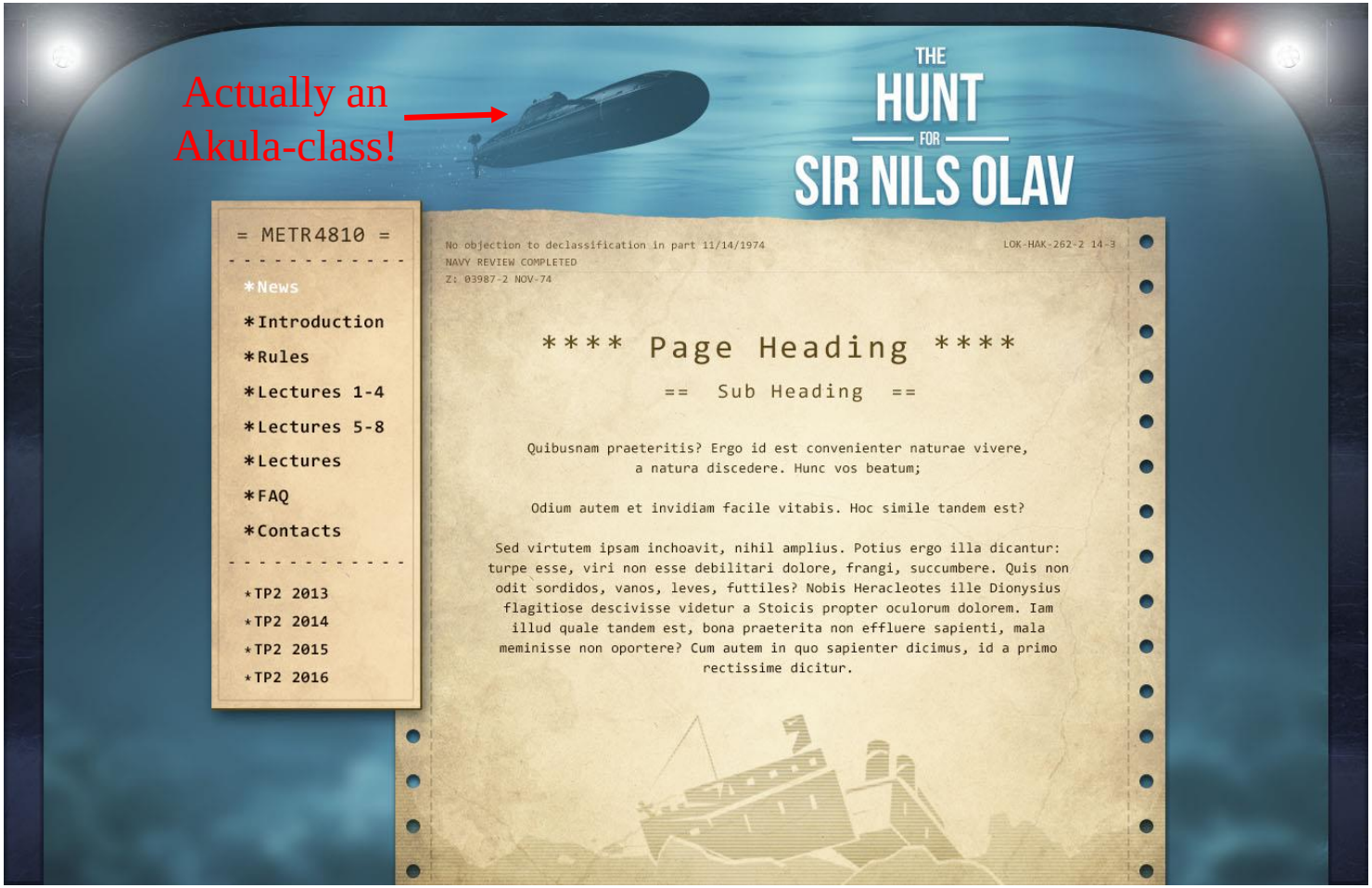
2016: Had to be overseas and prerecorded the entire lecture ☹
  - I was more sad than the students, I think

Website theme

- Each year, I hire an artist to help give the class a sexy, slick theme
  - This was inspired by my most favouritest film, the Hunt for Red October
- Vague idea that the ocean got deeper as you scrolled down the lecture list
  - And got deeper as the semester progressed…
  - A metaphor for METR4810?

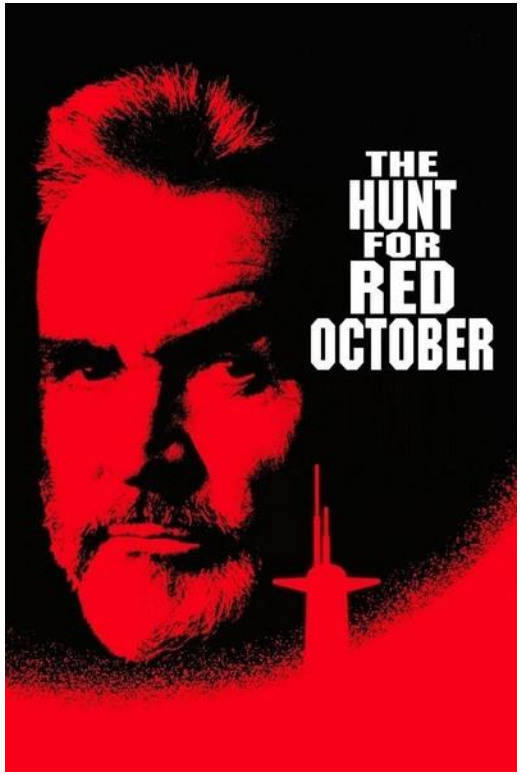
Website theme

- Several different concepts explored

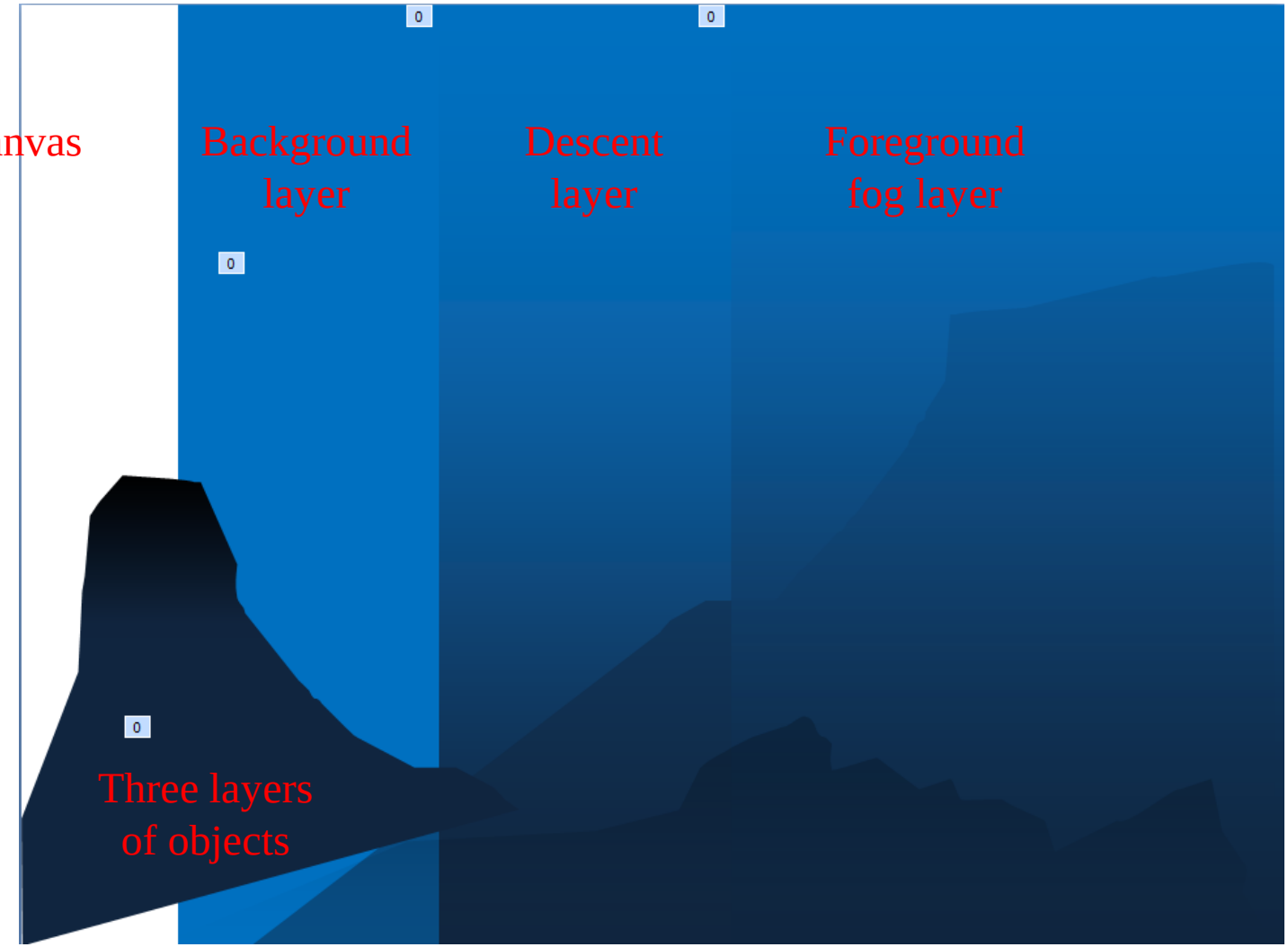


Introductory animatic

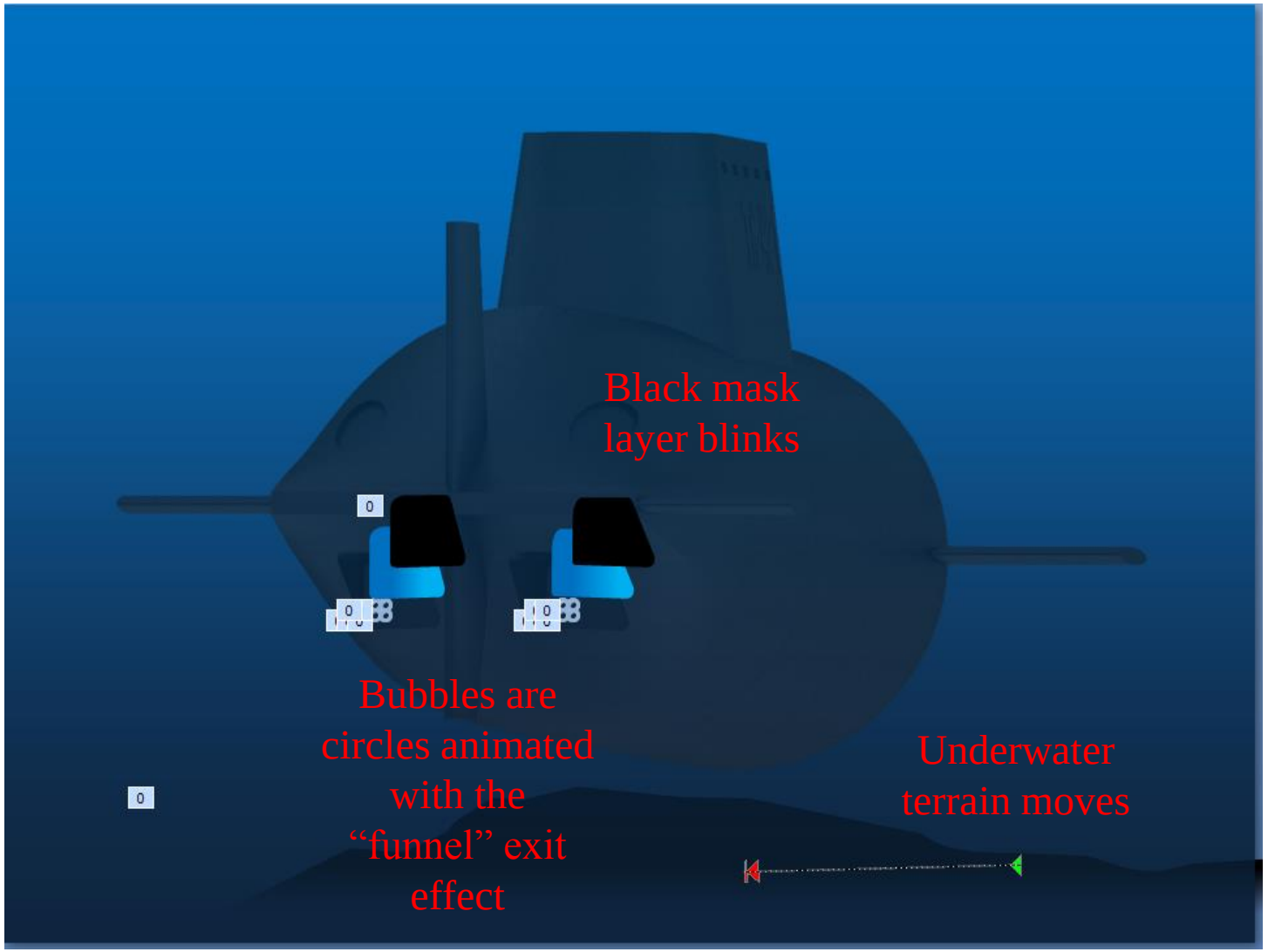
- Rendered entirely in Microsoft Powerpoint
  - This year's was the most sophisticated yet!
  - Separate 317 animations, excluding transitions



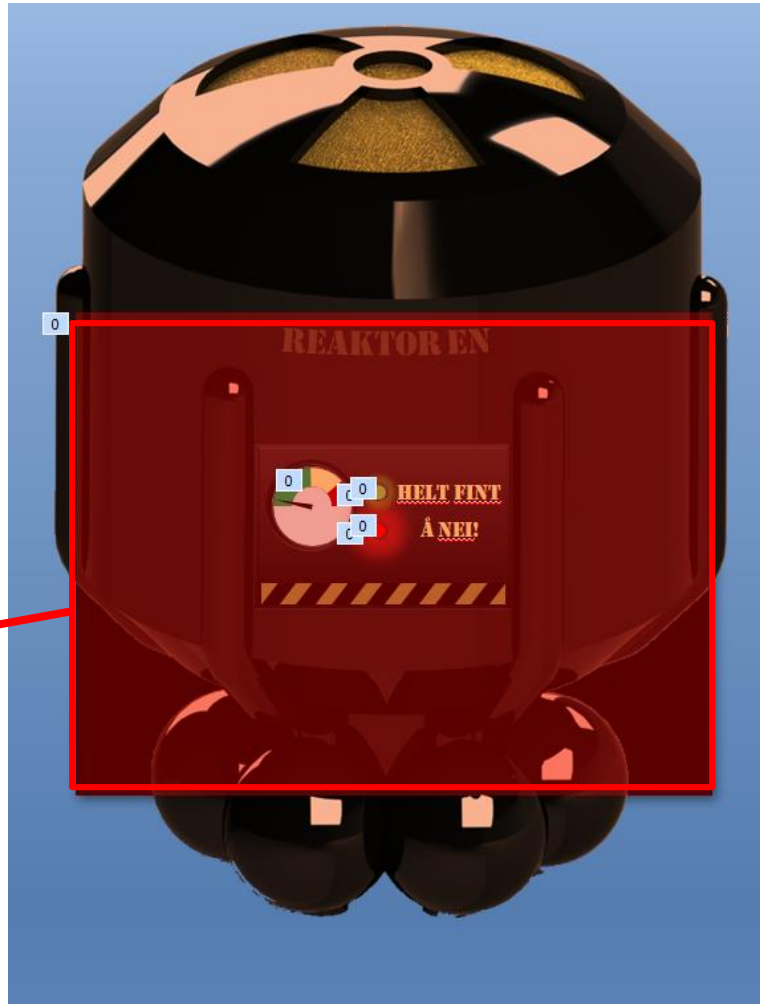
Introductory animatic



Introductory animatic



Introductory animatic

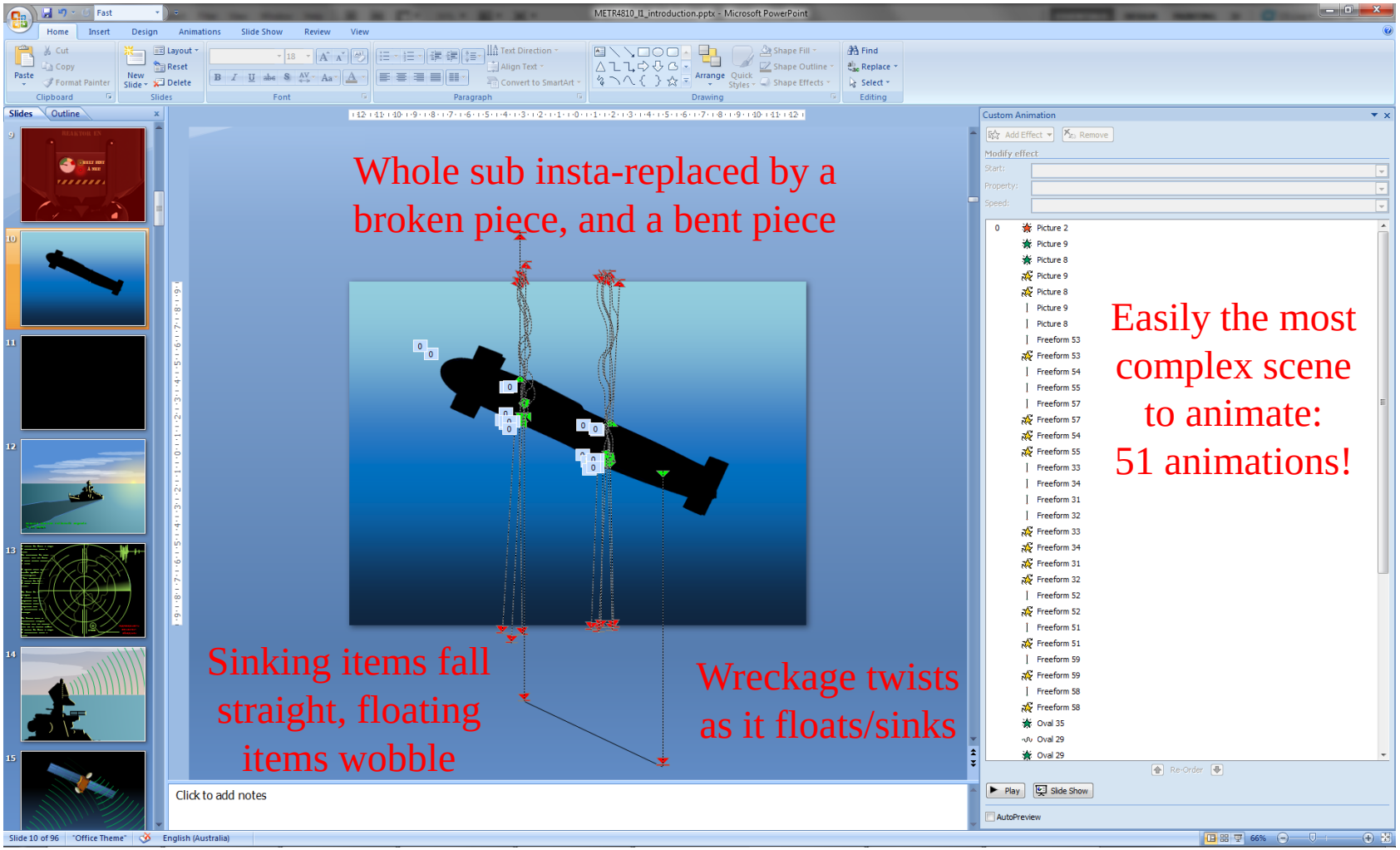


You only get to see this much of the screen

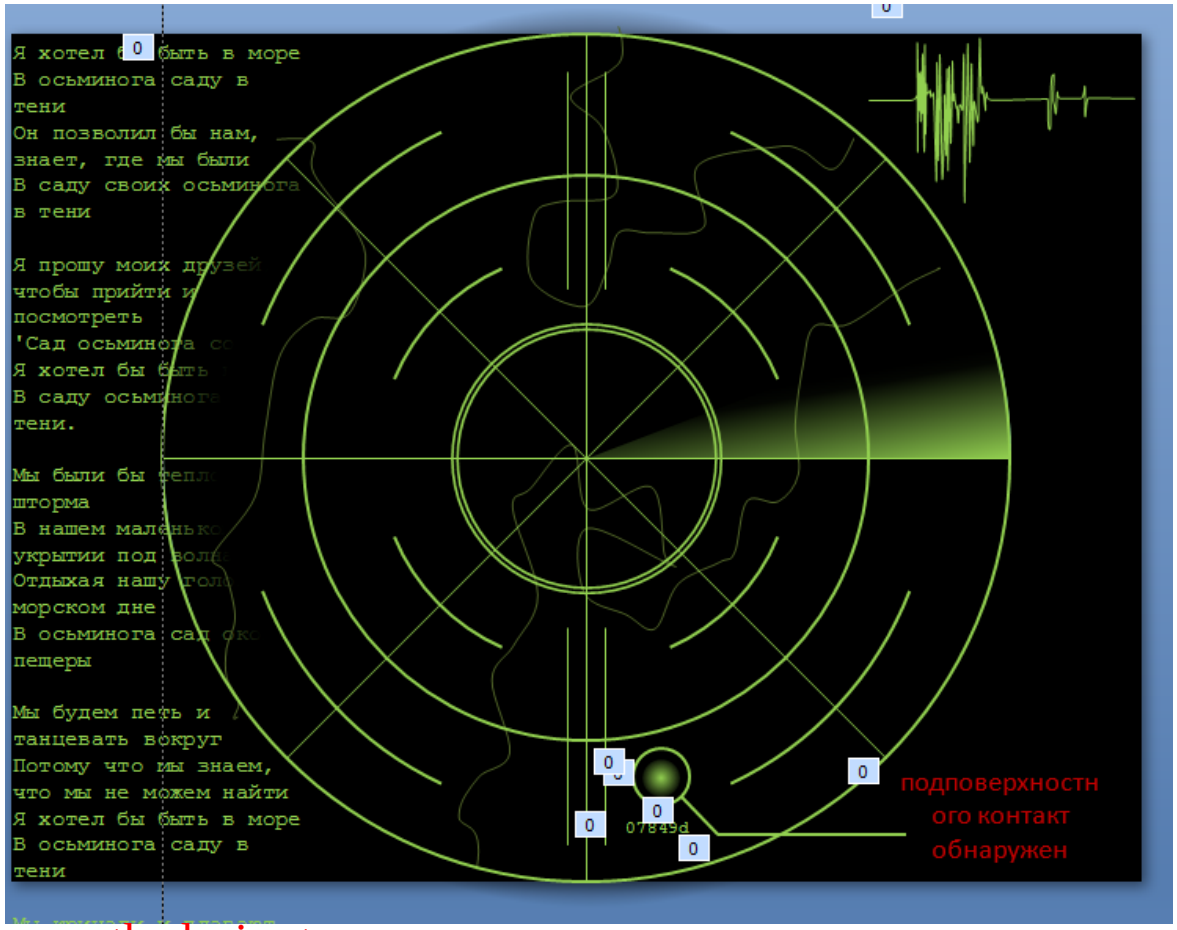
The whole SNO reactor was modeled and rendered in Solidworks

Text is actually Norweigian for "All ok" and "OH NO!"

Introductory animatic



Introductory animatic



These are the lyrics to "Yellow Submarine" and "Octopuss's Garden"

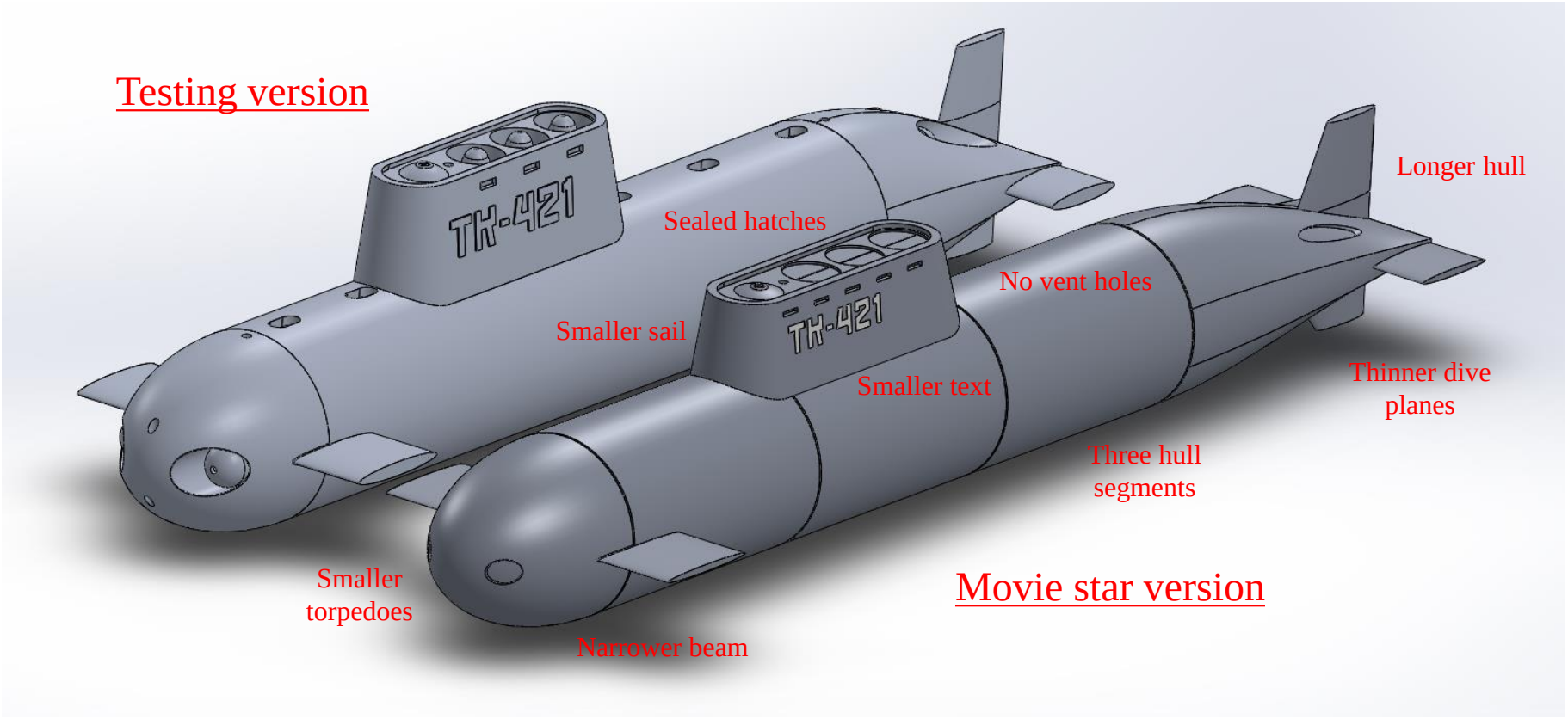
"Underwater contact detected"

Introductory animatic

- Background music was synchronised to the animation –lights supposed to turn on in sync to the drumbeat… only sort of worked

Introductory animatic

- The *SNO* that that appears in the intro is *slightly* different from the testing version:



Introductory animatic

- In total, the introductory animatic probably took about 30 hours work
  - Probably didn't help your learning, but was fun!
- The background music is a remix of the Hymn for Red October (used by permission)
  - I listened to *so much* awful Soviet-era music trying to find the right mood
  - Russians just love brass bands… seriously

Cutting room floor

Considered much more brutal challenges:

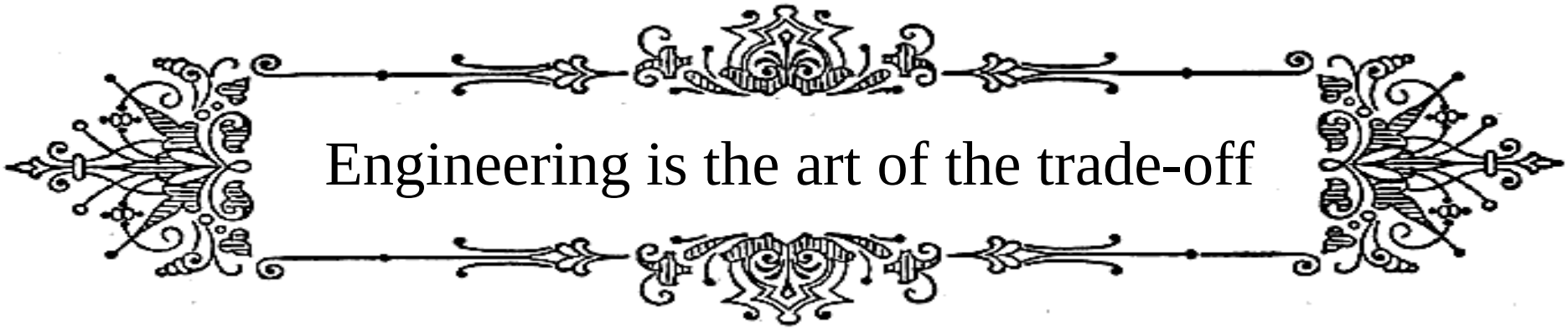
- Had to be fully autonomous
  - Far, far too difficult (!)
- Rescuing trapped sailors (a la *Kursk*)
  - Rejected as “too depressing”
- Some sort of undersea menace: “The Kraken”
  - Very popular with the tutors
  - Questionable educational value

Final thoughts

This class was never actually
about salvaging sunken submarines

This class was about starting along the path from being a *student* to being an ***engineer***.

The most important truth in your degree



Take-home points

- Think about things analytically, first
- It's rarely possible to optimise any one thing without regard for other subsystems
- You need to get along with your fellow engineers if you want to succeed

Conclusion

Have to wait until demo day!

Cast of Thousands

Dozens of people helped make this a success, but a few deserve particular recognition:

The *simply amazing* workshop guys:

Keith Lane and **Grant Tayles**

The *always helpful* **Doug Malcolm**

And now…

Vote 1 Paul in 2017

Fun fact: If we don't get higher than 3.5 on Q8, we don't get paid!

Supporting Cast

Paul Pounds as Captain
Will Deer as First Mate
Edwin Davis as Political Officer
Iain Rudge as KGB Mole
Prof. Steve Wilson as Acting Course Coordinator
Dr. Michael Kearny as Backup Lecturer
Peter Bleakley as Lab Director 1
Doug Malcolm as Lab Director 2
Dr. Surya Singh as Penguin

Hymn to Red October (Rock Cover) Juanjo Tristán

Camera and Cinematography

Camera 1	Dr. Surya Singh
Camera 2	Michael Eastwood
Key grip	Iain Rudge
Gaffer	William Deer
Best Boy	Edwin Davis

Casting

Prof. Stephen Viller

Set Decoration

Keith Lane
Ian Daniels
Greg Tayles

Stunts

Stunt Coordinator	Paul Pounds
Stunts performed by	Paul Pounds
Safety Manager	Jeanelle Scown
Safety Supervisor	Harry Penkeyman
Electrical Safety	Dennis Bill
Site Officer	Martin Bull

Penguin Wrangler

Dr. Surya Singh

Technical Support Group Manager

Richard Newport

Workshop Unit 1

Keith Lane
Ian Daniels
Greg Tayles

Workshop Unit 2

Peter Bleakley
Dejan Subaric
Doug Malcolm

Makeup and Hair

Styling and grooming	Paul Pounds
Cosmetics	Paul Pounds
Assistant to Dr. Pounds	Surya Singh

Production Management

Prof. Michael Bruenig
Dr. Stephen Viller
Prof. Steve Wilson
Dr. Surya Singh

Assistant Director

Prof. Steve Wilson

CGI and Artwork

Paul Pounds
Chris McKenna
Michael Eastwood

Props and Practical Effects

Paul Pounds
Keith Lane
Ian Daniels
Greg Tayles
Michael Eastwood

Finance and Administration Unit

Prof. Stephen Viller
Dr. Surya Singh
Richard Newport

Location and Facilities

Doug Malcolm
Prof. Stephen Viller

Public Relations and Marketing

Izaeel Koh
Casey Fung

Web Design

Hotpot Creative
Chris McKenna
Paul Pounds

Web Administration

Dr. Hanna Kurniawatti

Transportation

Michael Eastwood

No students or penguins were harmed in the teaching of this class

Special thanks to
Keith Lane
Doug Malcolm
Michael Eastwood

And all the students who made this class fun and enjoyable!

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