TEAM LEBOB

FLL Team KOI34 - Perth, Western Australia

Four identified problems

Talking to working archaeologists and subsea engineers, we pinned down four specific failure modes that the standard industrial gripper forces onto fragile recovery work.

High risk of breakage. Industrial grippers apply force with no feedback channel back to the pilot. Thin pottery, coral, bone fragments, and delicate shapes could crack if they're held too tightly.

Poor grip on odd shapes. Flat metal jaws can't adapt to curved, tapered, or uneven artefacts. Items slip out, or can't be lifted at all. The grippers in service today were designed for cylindrical T-bar handles on industrial tools, not for amphorae, bones, or coral.

Limited awareness for pilots. ROV operators can't feel how much force the arm is applying, especially in low visibility water where the camera feed is the only signal. That leads to unforeseen accidents.

Cost and time pressures. Getting archaeology equipment to site costs millions of dollars. A broken gripper or a missing tool means days of delay while they get a replacement. These failures slow missions down, push costs up, and can permanently destroy cultural heritage that has waited centuries to be recovered.

4 innovations

Each innovation answers a specific way the standard industrial gripper fails fragile recovery work. We built every one, and a working expert reviewed every one.

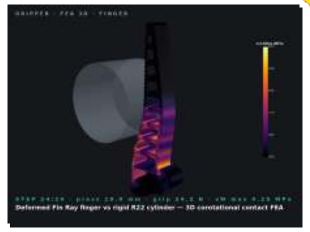
1. Soft-contact fingers — Compliant Fin Ray TPU fingers wrap and spread grip force over ~10× the area of a rigid jaw. → kills BREAKAGE
2. Pressure sensing — Pel-pad force readout + auto-stop, with an ambient-pressure sensor that stays honest at depth. → kills BLIND PILOTING
3. Rotating platform — Pads self-align to the artefact's angle, growing true contact area and forgiving ROV aim. → kills POOR GRIP ON ODD SHAPES
4. Modular printed kit — ~AUD 100 in filament. Carry spares, swap a broken module in the field, even print on deck. → kills COST & TIME

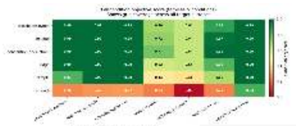
Italics = professional

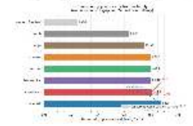
WE ARE COOKED

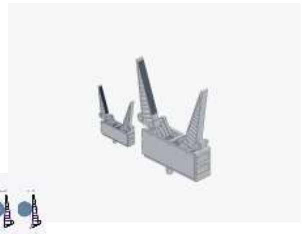
STORYBOARD

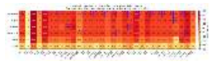
- **Lebob wants to go fishing for artefacts**
  - He spends all his money on Bobel's special arm
  - He has $500 left :(
- **Industrial Grippers are bad**
  - Lebob uses industrial gripper, but it breaks :(
  - He is now broke
  - *Explain the 4 problems*
- **Sees softsense ad**
  - Investigates the product because hes skeptical (too cheap)
- **Eblob (business tycoon) explains stuff to him as well as Obleb (the engineer)**
  - **• 5–60 m+ — depths where new WA wrecks sit, beyond safe diving**
  - **• ~5% — of global ROV use is scientific; the rest is industrial**
  - *Explain the 4 pillars of the inno*
    - *Adaptive soft contact finger (FEA images)*
    - *Embedded Pressure Sensing*
    - *Rotating Finger Platform (assembly picture)*
    - *Cheap, Kit based, and modular (actuator lineup)*
      - Include some random serious photos for literally no reason (for lols)
  - *Outward splay 20deg to fit bigger items*
  - Obell and Eblob are lazy, did not want to keep designing, building, and testing. Obelb used python to run FEA simulations to fully iterate on laptop (show 70+ comparison)
  - They also simulated grip with FEA (heatmap and bar graph, winning texture picture), tested different grip designs
  - Eblob used minimal electronics, motor is also pressure sensor
  - Eblob lazy, did not want to buy new parts, decided to make everything printable. (assembly gif) front cover just clips on.
  - Finger is scalable, minimal changes in mechanics
  - Obel calls his friends, gets feedback:
    - We shared SoftSense with working subsea experts and acted on what they told us.
    - • Tim MacDonald — "Make it a cheap printable kit; time is the cost." → We dropped the metal frame for a modular 3D-printed body.
    - • David Howard — "Ambient pressure will fool your sensor." → We added a body sensor that cancels ambient pressure in code.
    - • Patrick Morrison — "Foam compresses with depth." → Oil-fill / encoder / differential-sensor options on the 1:1 roadmap.
  - Designed to mount on common place manipulator arms.
    - 7 parametric adapters for
    - • Subsea standard D-handle, manipulator arms like the reach series, cobot flanges, and three BlueROV2 mounts
- ITERATION:
  - Our first concept got better because we put it in front of experts. The biggest design pivot came from a single phone call.
  - **• Regionals — CTD-4000:** A four-finger claw — EPE-foam pads, pressure sensors with auto-stop, a rotating platform — on a titanium / anodised-aluminium frame.
  - **• Expert call — Tim MacDonald:** Drop the metal. Make it a cheap, printable kit anyone can manufacture and carry spares of. Time is the real cost.
  - **• Nationals → Korea — SoftSense:** Re-engineered as a flooded, 3D-printed, modular gripper with compliant Fin Ray fingers — backed by a full FEA + texture + motor study.

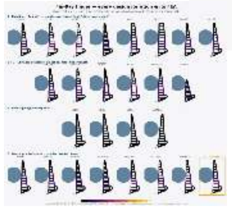












Innovation Project

Team #	Team Name	Judging Room

Instructions
Teamsshouldcommunicate to the judges their achievement in each of the following criteria.
This rubric should be filled out according to the Innovation Project presentation.

Judges are **required** to tick one box on each separate row to indicate the level the team has achieved. If the team **EXCEEDS**, a short comment in the exceeds column is required.

BEGINNING 1	DEVELOPING 2	ACCOMPLISHED 3	How hastheteamexceeded?
IDENTIFY – Team had a clearly defined problem that was well researched.			
Unclear definition of the problem	Partially clear definition of the problem	Clear definition of the problem	
Minimal evidence of research	Partial evidence of research from one or more sources	Clear,detailedresearchfroma variety of sources	
DESIGN – Team worked together while creating a project plan and developing their ideas.			
Minimal evidence of an effective project plan	Partial evidence of an effective project plan	Clear evidence of an effective project plan	
Minimal evidence that development process involved all team members	Partial evidence that development process involved all team members	Clear evidence that development process involved all team members	
CREATE – Team developed an original idea or built on an existing one with a prototype model/drawing to represent their solution.			
Minimal explanation of innovation in solution	Simpleexplanationof innovation in solution	Detailedexplanationof innovation in solution	
Unclear model/drawing that represents the solution	Simple model/drawing that represents the solution	Detailed model/drawing that represents the solution	
ITERATE – Team shared their ideas with others, collected feedback, and included improvements to their solution.			
Minimal sharing of their solution with others	Solution shared with at least one person/group	Solution shared with multiple people/groups	
Minimal evidence of improvements based on feedback	Partial evidence of improvementsbasedon feedback	Clear evidence of improvementsbasedon feedback	
COMMUNICATE – Team shared an effective presentation of their solution, its impact on others, and celebrated their team's progress.			
Unclear explanation of the solution and its potential impact on others	Partially clear explanation of solution and its potential impact on others	Clear explanation of solution and its potential impact on others	
Presentation shows minimal pride or enthusiasm for their work	Presentation shows partial pride or enthusiasm for their work	Presentation clearly shows pride or enthusiasm for their work	

Criteria on this page with this style of check box count dually toward Innovation Project and Core Values awards rankings

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LEBOB

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— *INNOVATIONS* —

Artefacts

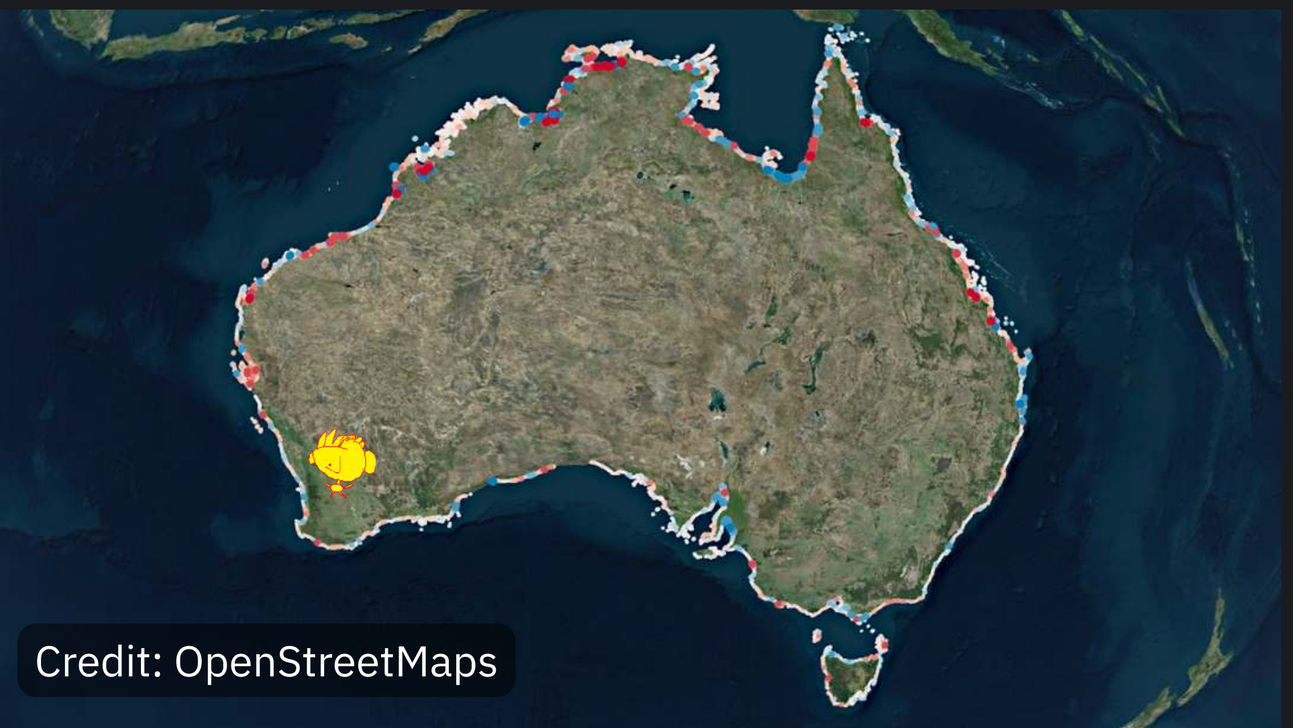
Coastline: 12000+ km.

Shipwreck found: 1650+.

First found: Batavia

- Lost 1629.
- Dutch trading ship.

Credit: Malis



Credit: OpenStreetMaps

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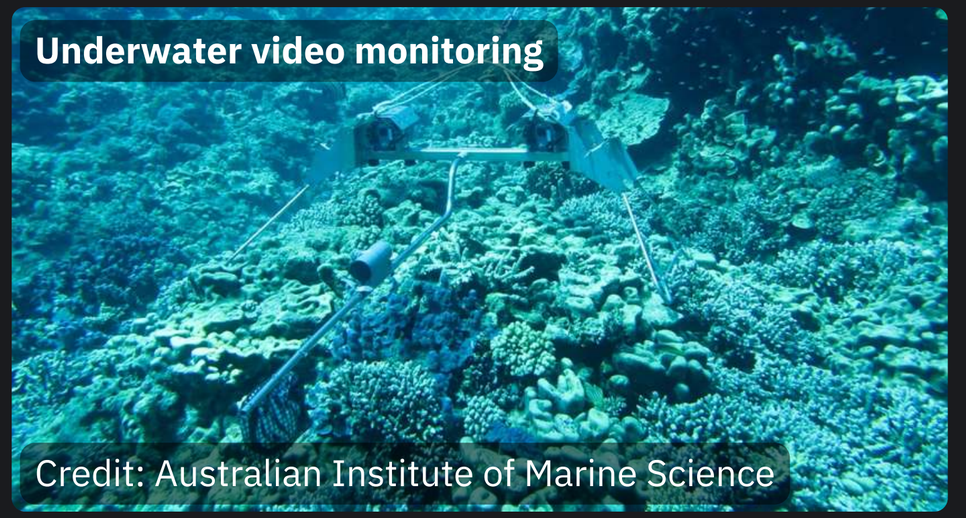
Underwater Museum

Credit: WA Shipwreck Museum

Credit: WorldHistoryPics.com via Picryl.com

Underwater shipwreck's engine

Credit: Dwi sumaiyyah makmur



Underwater video monitoring

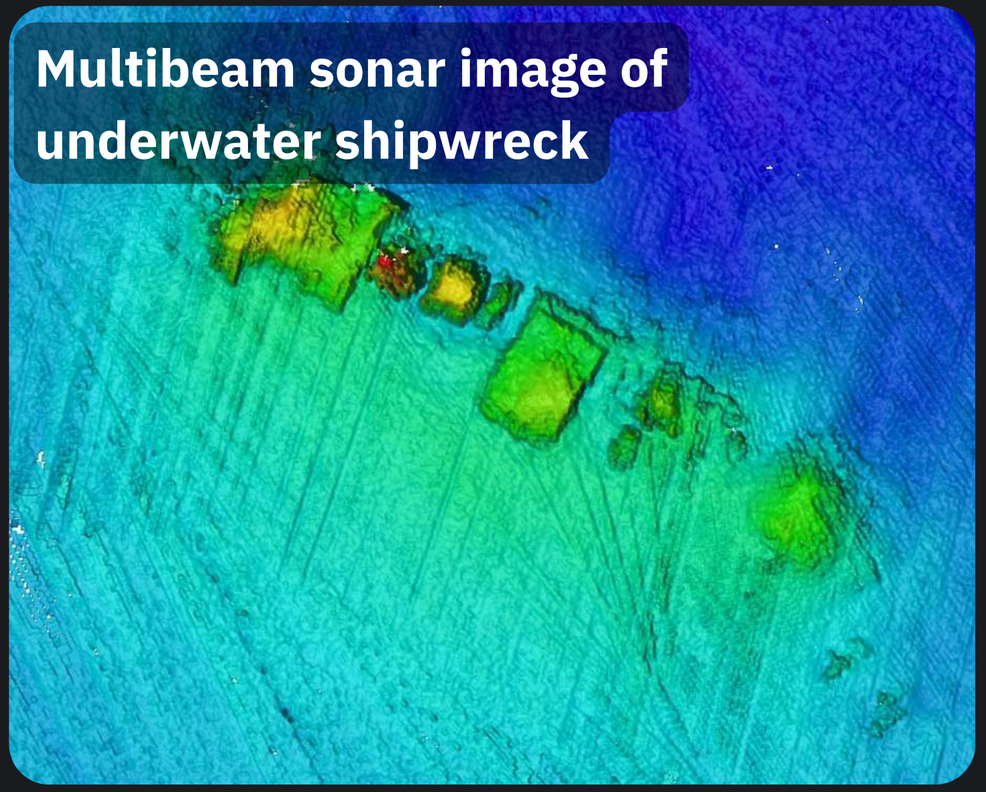
Credit: Australian Institute of Marine Science

Human history: Trade and transportation.

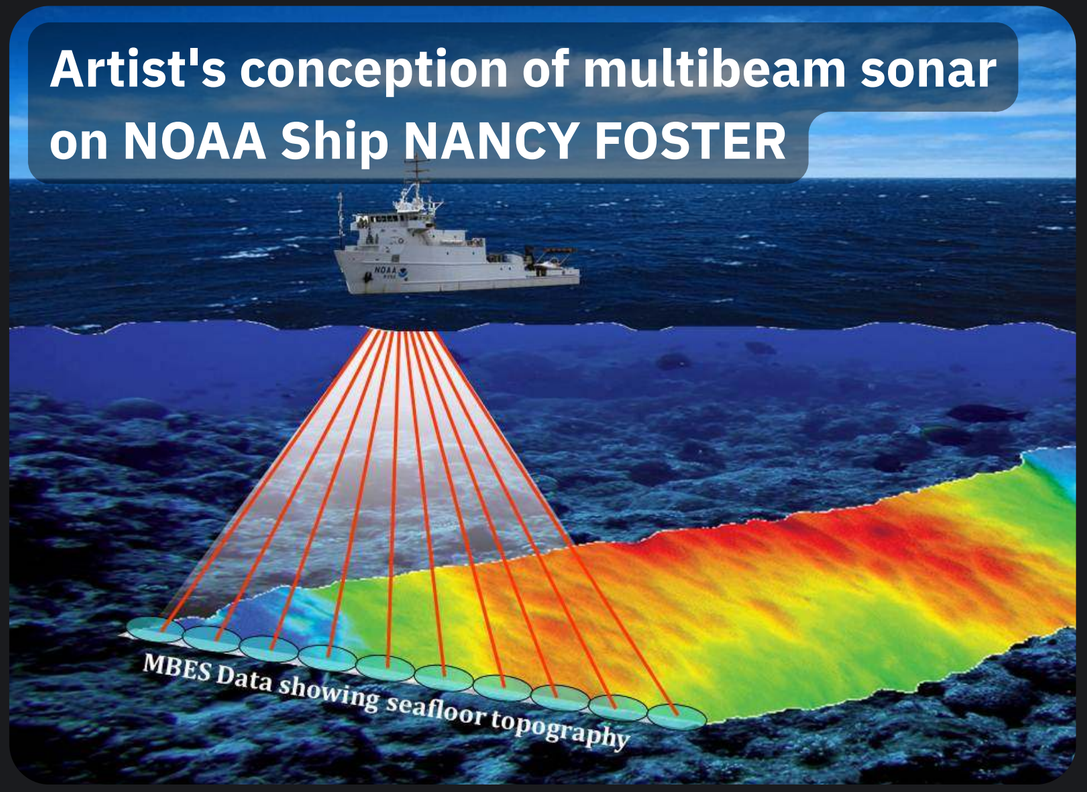
Countless artefacts.

Irreplacable, loss of culture.

Recent Developments



Credit: Wessex Archaeology



Credit: NOS/NCCOS/CCMA

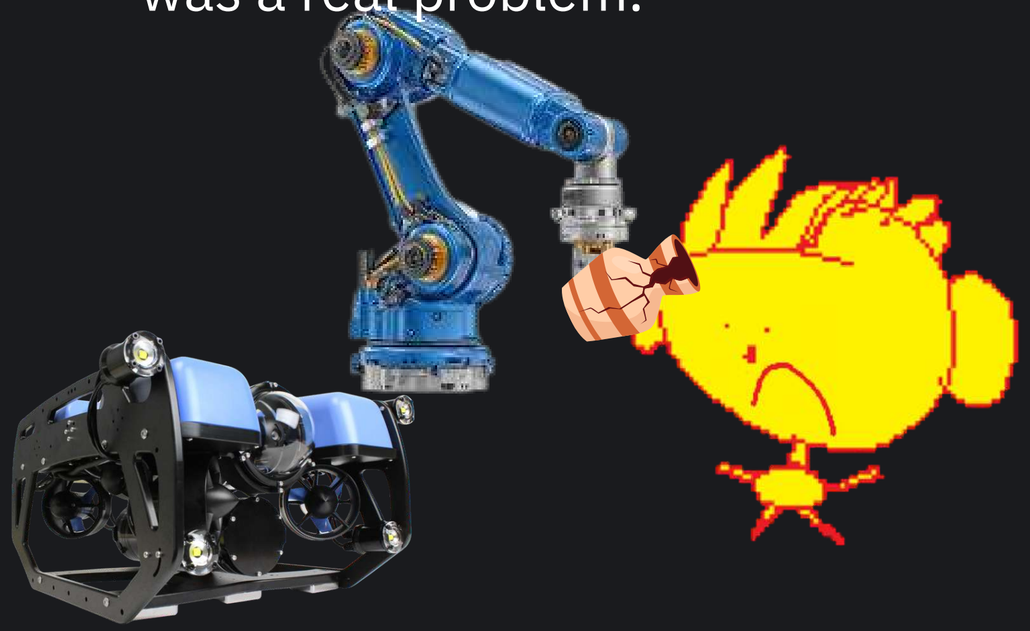
“There are more known sites than there is equipment to work them. The only way to recover something safely from 50 to 60 metres and beyond is a robot with actuator control.” - Patrick Morrison, WA Museum Curator

Main problem

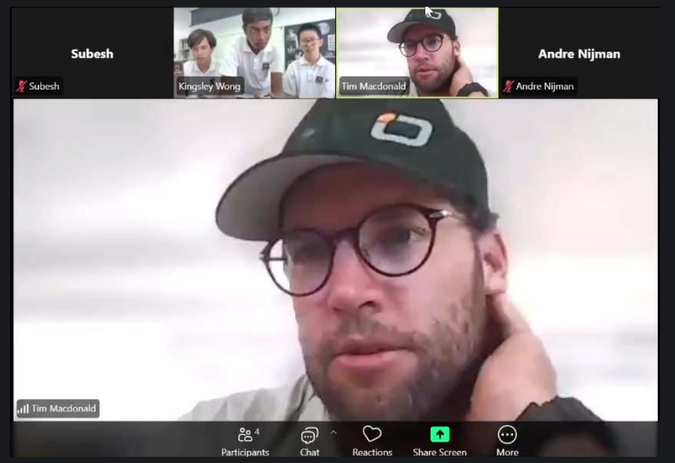
Recovering fragile artefacts underwater.

- Industrial arms are rigid.
- No force feedback.
- Expensive and slow.

Most the experts we visited said this was a real problem.



Validated by experts:



Tim Macdonald, subsea research expert

Woodside

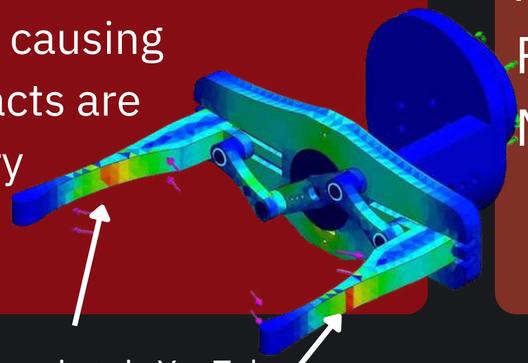
Woodside, Leading in Australia's energy sector

"Major commercial systems still lack essential features like pressure sensing."
- Tim

Problems

High risk of breakage

Since grippers are rigid, pressure concentrated on a small surface area, causing fractures and breakage. Broken artefacts are irreplaceable and can be lost to history forever.



Credit: MT Engineering via YouTube.

Poor grip on odd shapes

Artefacts are often curved, tapered or uneven.
Rigid, flat metal jaws can’t adapt.
Many objects can’t be picked up or will slip.

Limited awareness for pilots

ROV operators can’t know how much force the arm applies, especially in low-visibility water where the camera feed is the only signal, leading to breakage.
Can’t control the force with feedback well.

Cost and time pressures

High costs, due to materials, machining and transportation.
If a gripper breaks, this could result in a long delay.

Team roles

Kingsley	Brainstorm innovations collaboration, Meet with companies. Sponsorship outreach
Andre	SoftSense innovation lead. FEA testing. Sponsorship outreach. Material evaluation (PA12-GF + ether-TPU).
Sean	Team brainstorm, collaboration, business outreach, material organization for innovation.
Oliver	Co-owner on prototype builds v1 + v2, drivetrain T_safe fix, hyperbaric pressure test.
Subesh	Research lead: existing manipulator survey + case studies. Owns expert cold-email outreach and follow-up letters. Patrick Morrison site visit attendee.
Chris	Bench-testing operator: ran the 4-finger versus 2-finger trials with the bone, anchor, vase, and chest objects, captured the 26 / 96 / 411 / 288 gf data.
Aaron	Created diagrams to explain and communicate what we did for innovations. Put together simple understandable summaries in the presentation with appropriate images.
Leven	Owns the photo / video evidence trail across the season. Innovations team collaboration, co-ran the 4-finger vs 2-finger trials with the bone with chris, chassis design with Oliver.

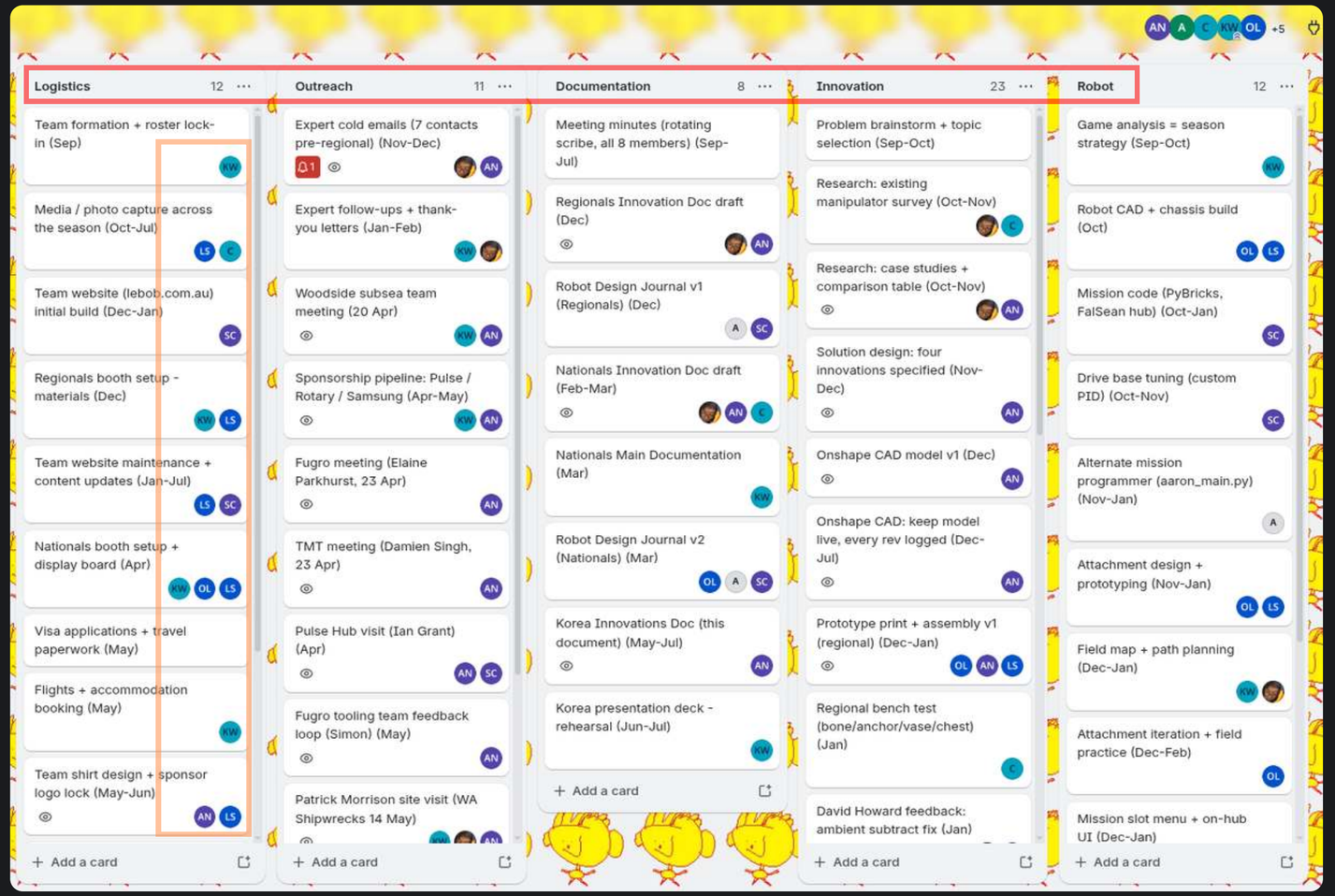
Project plan

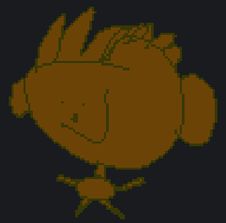
GENERAL DOCS
PAGE 9-11

Season-long Trello board spanning Sept 2025 - July 2026:

- Organised into 5 categories.
- Versions for each competition (Regionals, Nationals, Korea Open).
- Remade the plan as a team each competition.

Each block of work was assigned to different team members.

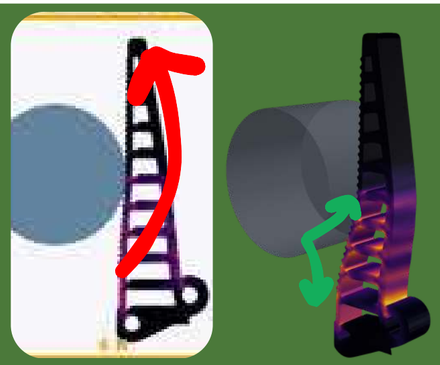




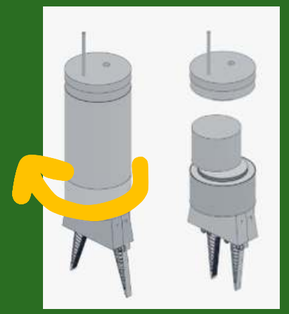
Features

Soft contact fingers

Flexible TPU on fingertips.
Distributes force across object's surface.
Lower maximum force.
Reduces risk of breakage.



Rotating finger platform



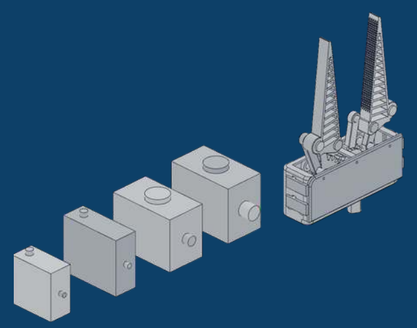
Fingers rotate around a pivot.
Allows grippers line up to artefact, increasing surface area that contacts the object.
Lowers local pressure and crush risk.

Pressure sensing

Actuator measures current to calculate pressure.
Warning preventing crushing.
Accounts for ambient water pressure.
Accounts for foam compressing under pressure.

$$F = K_t \cdot (I_{meas} - I_0) \cdot \frac{i_g}{2} \cdot MA(P) \cdot \eta$$

Modular printed kit



3D printed, cheaper cost with **USD$70** filament.
Modular, allowing swapping of broken modules, spares, don't have to wait for replacements.
And different types of kits.

Materials

"Stick with cheap 3D printed parts. Anyone can buy filament anywhere, and the whole thing can be manufactured anywhere like a kit."
Tim MacDonald, subsea engineer.

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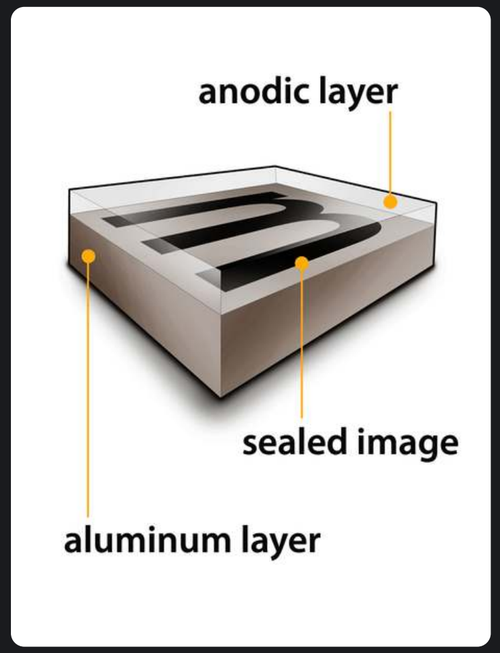
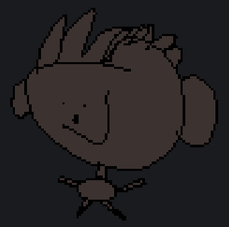


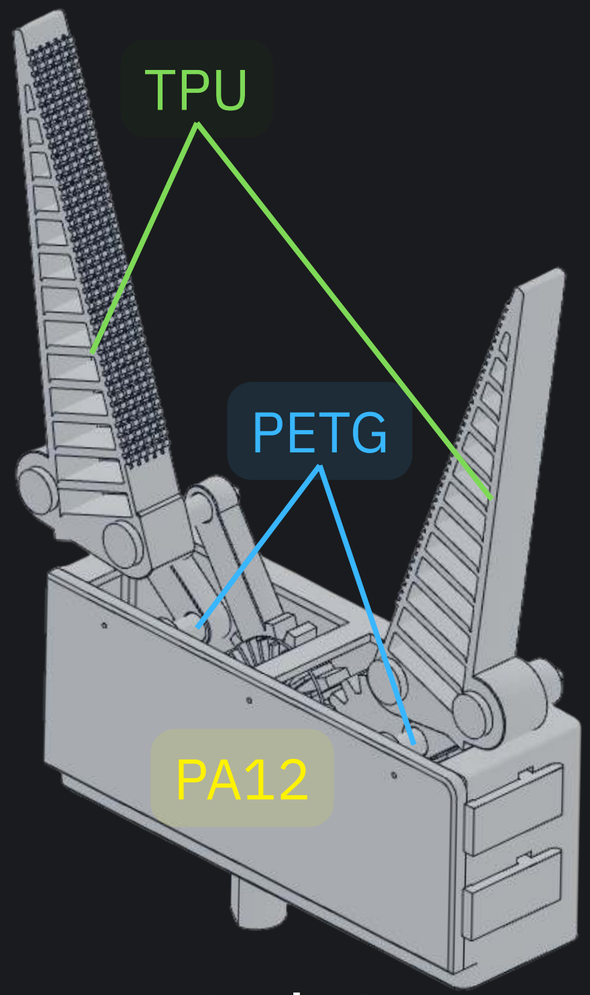
Credit: Sam.wainer

Material	Pros	Cons
Titanium	Very strong; excellent seawater corrosion resistance	Expensive; needs machining (not printable); galvanic corrosion risk with dissimilar metals
Anodised Aluminium	Lightweight; anodised layer resists corrosion; machinable	Anodised coating can scratch/pit and then corrodes; galvanic risk underwater; needs machining
3D printed with plastic	Cheap; printable anywhere; whole gripper ships as a buildable kit; no bought hardware	Lower strength than metal; performance depends heavily on which filament; some grades warp or absorb water
Nylon 12 Carbon Filled	Stiff with low creep; low water uptake; strong choice for rigid structural parts	Needs a 45-60 C heated chamber; warps and shows poor layer adhesion on the P1S; warp-prone on larger parts



Final Materials

Material	Pros	Cons
Bambu TPU 95A HF	Flexible TPU for the Fin Ray fingers; conforms and grips well; ether-based grade survives long immersion	Too soft for rigid structural parts; only suited to the flexing fingers, not gears or housing
PA12-GF	Stiff, low-creep and low water uptake; the best all-round rigid material for the seawater duty cycle	Glass fill is brittle - cracks instead of yielding; not suitable for parts that must flex, like the snap pins
PETG-HF	Ductile enough for the flexing snap pins; prints fast; it tolerates the 2.78% insertion strain that would crack PA12-GF	Lower stiffness and strength than PA12-GF; only used for the one-time snap pins, not load-bearing parts



~ USD $70

Pressure Sensing

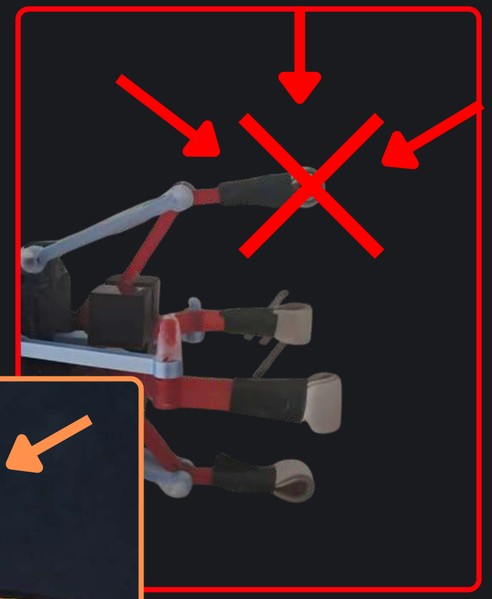
Original: Pressure sensors in conductive foam.

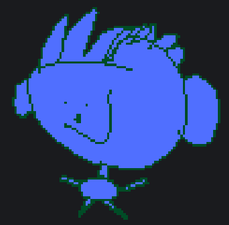
- David Howard: ambient water pressure.
- Patrick Morrison: foam compressing, air bubbles shrink.

$$F = K_t \cdot (I_{meas} - I_0) \cdot \frac{i_g}{2} \cdot MA(P) \cdot \eta$$

Current (Amps)

Already shown to work:
Maxon, Schunk



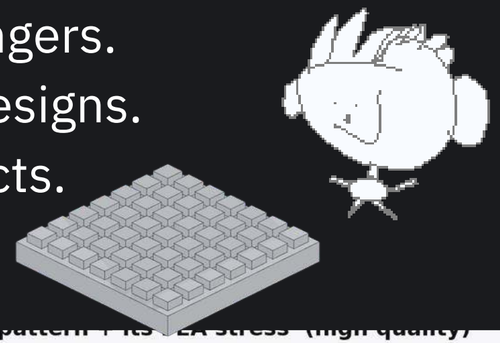


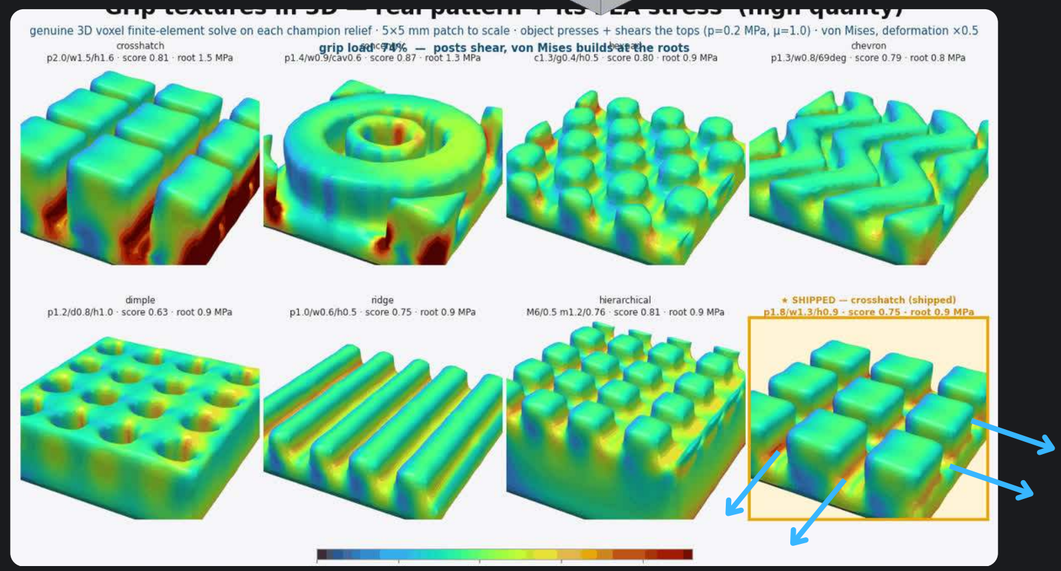
This improves sealing, reliability, overall consistency

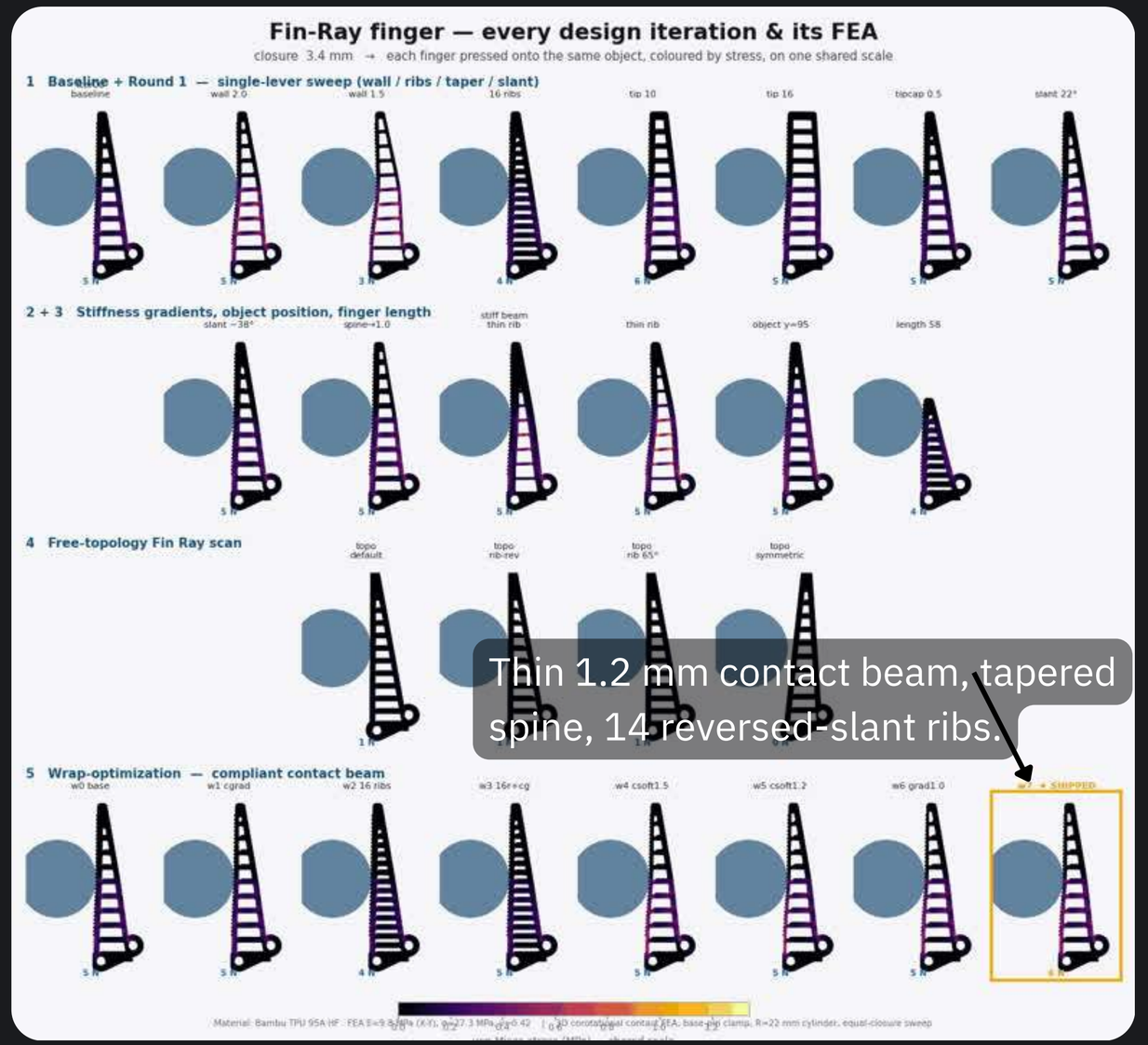
Finite Element Analysis

We used FEA to Simulate:

- 2 families of fingers.
- Variations of designs.
- Variety of objects.
- Grip textures.

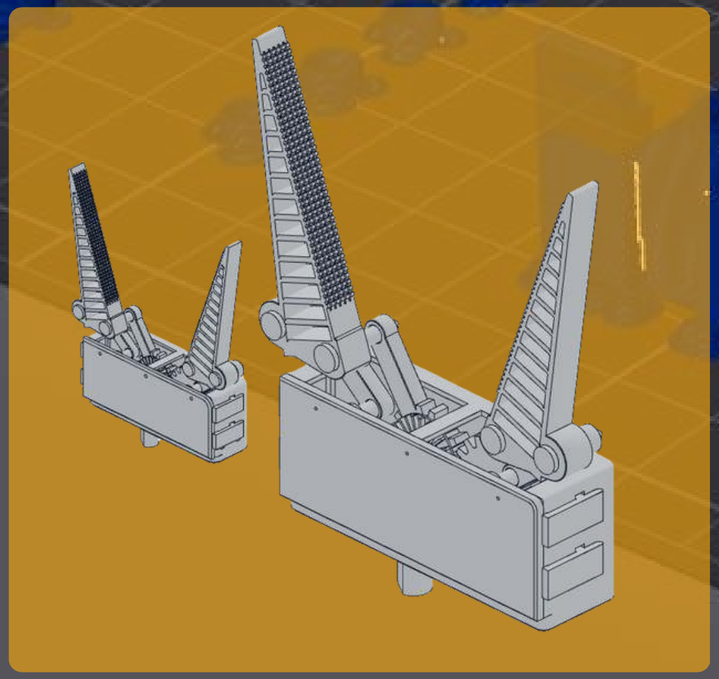






Thin 1.2 mm contact beam, tapered spine, 14 reversed-slant ribs.

Modular printed kit



Features:

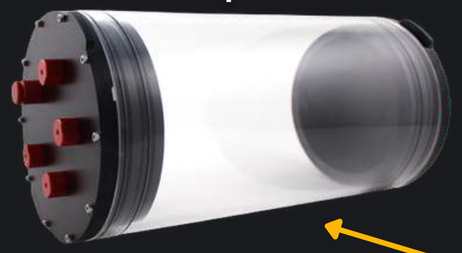
- Easily swap parts.
- 3D printed.
- Modular.
- Minimal tools required.

Saving cost: Filament and printing is much cheaper than machining.
Saving time: Crews can carry spares and swap broken ones. Or reprint mid-drive.
Adaptability: Mounts Reach Bravo 7 wrist, ISO 9409 cobot flanges and the BlueROV2 chassis.

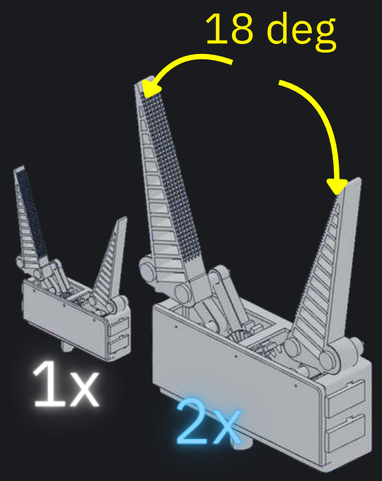
Video assembly guide

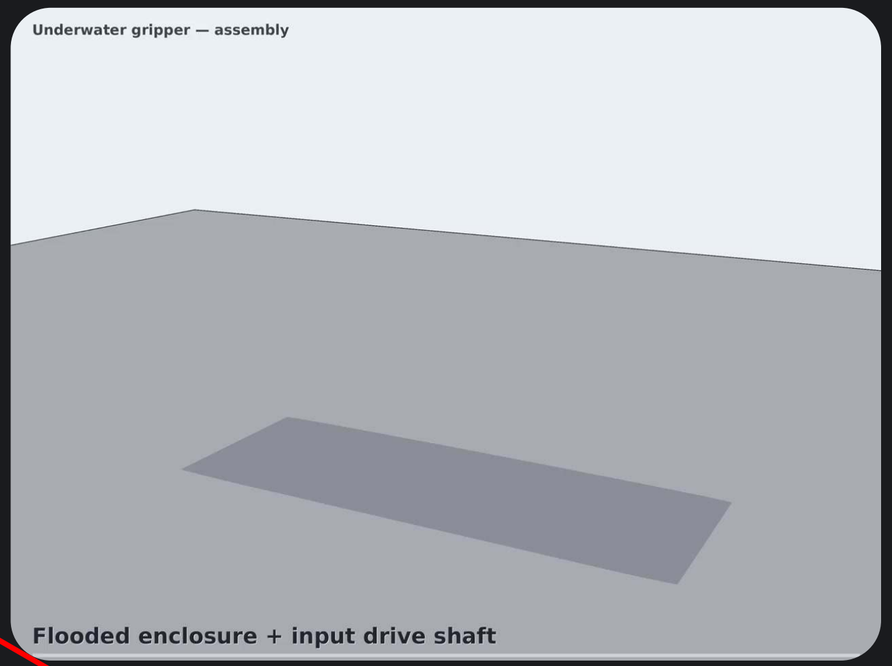
Final Model

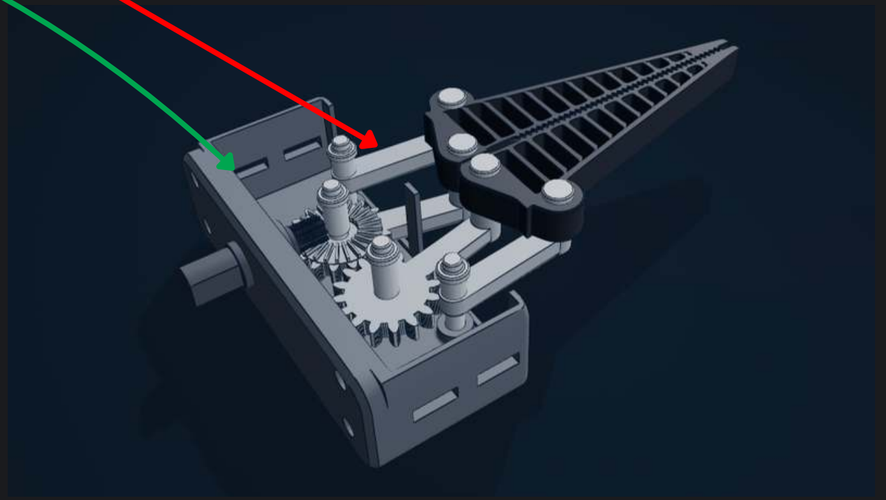
- Single degree of freedom four bar linked gripper.
- Fingers splay ~18 deg outward as they open to fit larger items.
- The gearbox can flood and drain to match the pressure at the depth.
- 1.5x and 2.0x scaled variants all generated and proven to work.



Blue ROV Pressure Canister





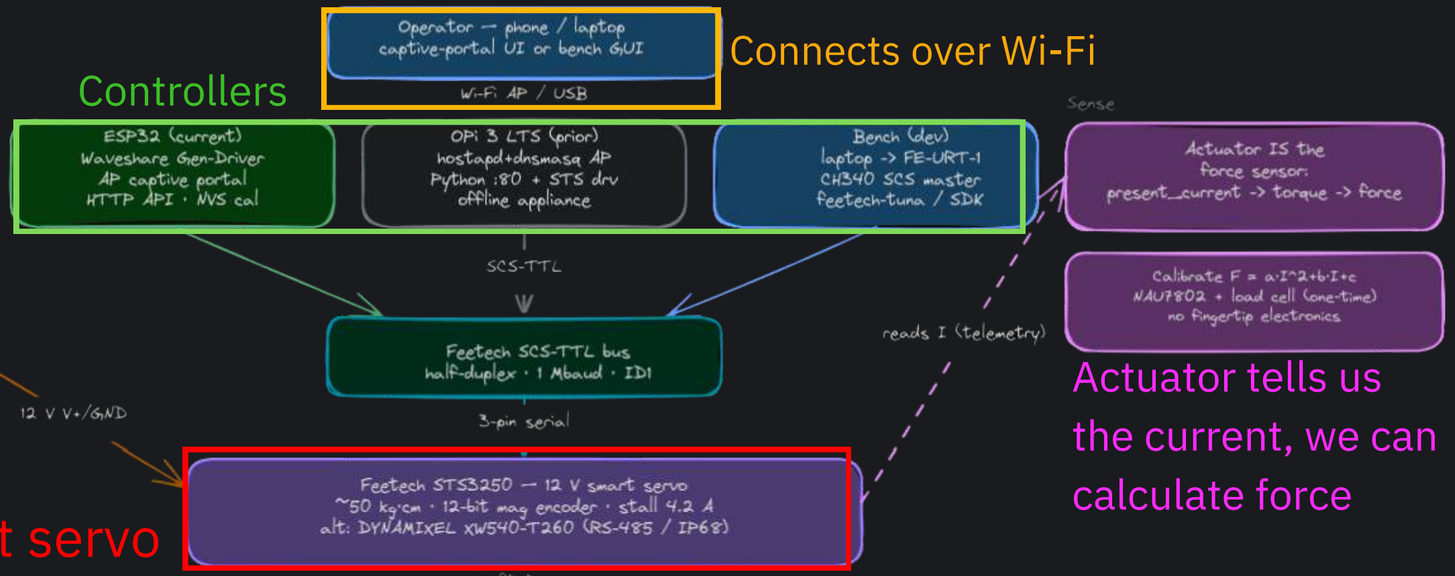


Electronics

Power, 12V supply

Controllers

Connects over Wi-Fi



Actuator tells us the current, we can calculate force

Smart servo

Standard BlueROV tether bus

Impact

Groups:

- Archaeology teams.
- Museums.
- Marine biology.

Environmental impact.

Affordability for accessibility.

Validation:

- Tim MacDonald (subsea engineer, DSV Limiting Factor).
- Patrick Morrison (WA Shipwrecks Museum).

INNO
PAGE 5 & 47 (Inno)

Research & Refinement

Research

Artefact recovery.

- Needs ROV.

Breaking and crush risk.

- Pressure concentration.
- No force feedback.

Problems with ROV grippers.

- Rigid.
- Corrosion.
- Cost.

Refining the problem

Narrowing the problem.

- Recovering artefacts.

Finding the issue.

- Crush risk.

Creating a solution.

- Adaptive fingers.
- Pressure feedback.

Researching the solution.

- Materials.
- Electronics.

Expert advice

Contacted companies and museums.

Material change.

- Woodside and Tim MacDonald told us to switch from metals to plastic.

Museums explaining:

- Why artefacts fragile.
- Safe handling.

Validating the problem.

Experts and Institutions

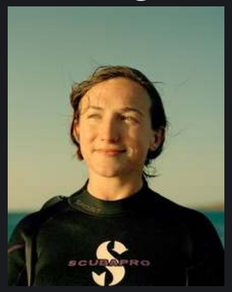
Nationals and PreNationals

1. Dr John McCarthy
2. Associat Professor Jonathan Benjamin
3. Chelsea Wiseman
4. Michael O’Leary (UWA)
5. Jeremy Leach
6. Ingrid Ward
7. Hiro Yoshida
8. Australasian Institute for Maritime Archaeology
9. Minderoo-UWA Deep Sea Research Centre
10. Western Australian Museum

1

2

3



4

5

6

7

8

9

10

INNO
PAGE 49 (Docs)

Experts and Institutions

Post-nationals

1. Tim MacDonald (Inkfish) [plastic call, validated the novelty]
2. Patrick Morrison (Curator of Maritime Heritage WA)
3. David Howard (Principal Research Scientist at CSIRO) [depth-pressure problem]
4. Fiona Stachowiak [material risk, TRL, reliability]
5. Woodside Subsea Team
6. Elaine Pankhurst (Fugro Australia) [sponsor + routed to tooling team]
7. Simon (Fugro ROV manager) [channels opened]
8. Damien Singh (Total Marine Technology) [sponsor + mentorship]
9. Paul (CEO of TMT)
10. Ian Grant (Pulse Technology Hub) [sponsor (bundled)]
11. Connel (Oceaneering)
12. WA Robotics Education
13. Fugro
14. Pulse Technology Hub
15. EFFEE On Site Robotics [bundled sponsors]
16. CP Maritime
17. Australian National Maritime Museum
18. International Marine Contractors Association
19. Schilling Robotics
20. TechnipFMC
21. UWA Engineering
22. Samsung
23. Bundaberg
24. Curtin Underwater Sensing and Robotics Lab
25. CSIRO Oceans and Atmosphere
26. Australian Institute of Marine Science
27. NOAA Ocean Exploration
28. OpenROV
29. Sofar Ocean
30. Monterey Bay Aquarium Research Institute

1


2


3


4


5
Woodside

6


7


8
tmt

9


10


11
OCEANEERING

12


13
FUGRO

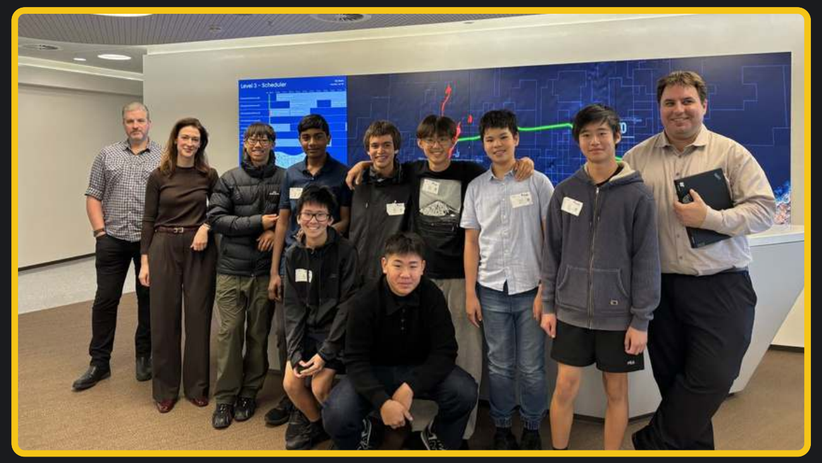
14
PULSE
TECHNOLOGY HUB
The Operational Network

15
effee
on site robotics

16
CP MARITIME


Communications

Meeting with Pulse,
leading in subsea ROV systems



Meeting with Woodside, leading in
Australia's energy sector

Meeting with Effee, Leading expertise on Induction heating and Robotic Welding

Select Meetings

1. Regionals

2. Nationals

3. Internationals

DEMO

TODO

- Fix red text
- Fix referring to page on every slide

Robot Design

Team #	Team Name	Judging Room

Instructions
Teamsshouldcommunicate to the judges their achievement in each of the following criteria.
This rubric should be filled out according to the Robot Design explanation.

Judges are **required** to tick one box on each separate row to indicate the level the team has achieved. If the team **EXCEEDS**, a short comment in the exceeds column is required.

BEGINNING 1	DEVELOPING 2	ACCOMPLISHED 3	EXCEEDS 4	*How hastheteamexceeded?*
IDENTIFY –Team determined which missions to attempt, explored building and coding resources, and sought guidance as needed.				
☐ Minimal evidence of mission strategy	☐ Partial evidence of mission strategy	☐ Clear evidence of mission strategy	☐	
⚙ Minimal use of building or coding resources	⚙ Some use of building or coding resources	⚙ Clear use of building or coding resources to support their mission strategy	⚙	
DESIGN – Team members worked collaboratively on their designs and developed the building and coding skills needed.				
⚙ Minimal evidence that all team members contributedideas	⚙ Partialevidencethatallteam memb erscontributedideas	⚙ Clearevidencethatallteam members contributed ideas	⚙	
☐ Minimal evidence of building and coding skills in all team members	☐ Partial evidence of building and coding skills in all team members	☐ Clear evidence of building and coding skills in all team members	☐	
CREATE – Team developed original designs or improved on existing ones according to their mission strategy.				
☐ Unclear explanation of attachments and their purpose	☐ Simple explanation of attachments and their purpose	☐ Clear explanation of innovative attachments and their purpose	☐	
☐ Unclear explanation of code and/or sensor use	☐ Simple explanation of code and/or sensor use	☐ Clear explanation of innovative code and/or sensor use	☐	
ITERATE – Team repeatedly tested their robot and code to identify areas for improvement and incorporated the findings into their solutions.				
☐ Minimal evidence of testing their robot and code	☐ Partial evidence of testing their robot and code	☐ Clear evidence of repeated testing of their robot and code	☐	
⚙ Minimal evidence of improvements based on testing	⚙ Partial evidence of improvements based on testing	⚙ Clear evidence of improvements based on testing	⚙	
COMMUNICATE –Team effectively explained what they learned from the robot design process and celebrated their progress.				
⚙ Unclear explanation of process and lessons learned	⚙ Simple explanation of process and lessonslearned	⚙ Detailedexplanationofprocess and lessons learned	⚙	
⚙ Team shows minimal pride or enthusiasmfortheir work	⚙ Team shows partial pride or enthusiasm for their work	⚙ Teamclearlyshowsprideor enthusiasm for their work	⚙	

⚙ *Criteria on this page with this style of check box count dually toward Robot Design and Core Values awards rankings*

LEBOB

FLL Team KOI34 - Perth, Western Australia

— *ROBOT DESIGN* —

Part 1

PLANNING

Mission Ranking

IDENTIFY
PAGE 2 (Robot)

Mission No. and Name		*Distance*	*Programming*	*Mechanical*
1 Surface Brushing	30 (10+10+10)	1	1	3 (for left and right) 2 (for removing the stick)
2 Map Reveal	30 (10+10+10)	3	4 (for all three) 3 (for 2 only) 2 (for only the rotate one)	2
3 Mineshaft Explorer	40 (30+10(technically))	5	4	2
4 Careful Recovery	40 (30+10)	5	5 (with standing) 3 (without)	5 (with standing) 3 (without)
5 Who Lived Here?	30	3	2	1
6 Forge	30 (10+10+10)	3	3	1
7 Heavy Lifting	30	5	3	3
8 Silo	30 (10+10+10)	1	4	2
9 What's on Sale?	30 (20+10)	1.5	2	3
10 Tip the Scales	30 (20+10)	2	4	2.5
11 Angler Artefacts	30 (20+10)	2	4 (time wise)	3
12 Salvage Operation	30 (20+10)	1	3	2
13 Statue Rebuild	30	3	4	2
14 Forum (Might do some only)	35 (5+5+5+5+5+5+5)	10	5	5
15 Site Marking (Won't unless on the way)	30 (10+10+10)	7	5	3

MAX RUN LINK: https://www.youtube.com/watch?v=c62qryVwEQw

Green: Might Do

Red: see again

Blue: Will DO

None: won't do

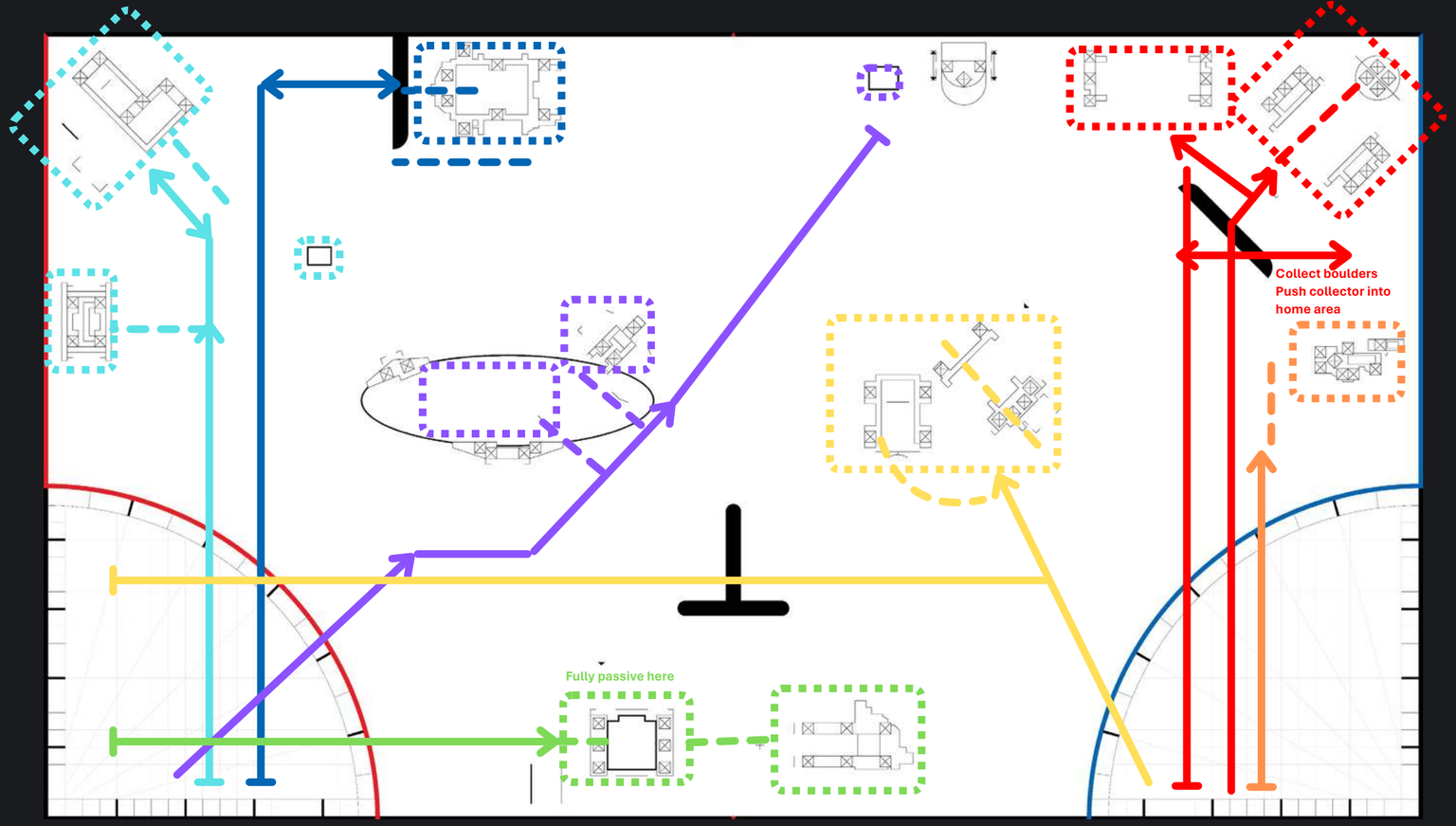
MECHANISMS for the missions we are doing

Mission Number	Name	Dist	Side	Diff
1	Push	1	L	1
1	Brush	1	L	4
2	Map	3	L	4
3	Your minecart	4	L	1
3	Other minecart	4	L	0
4	Artefact	4	L	5
4	Support	0	L	0
5	Flip	3	R	2
6	Forge	3	R	3
7	Heavy	5	R	5
8	Silo	1	R	2
9	Roof	2	R	4
9	Market	2	R	1
10	Bucket	2	R	2
10	Pan	2	R	3
11	Raised	1	R	5
11	Flag	1	R	5
12	Sand	1	L	1
12	Ship	1	L	1
13	Statue	4	L	2
14	Forum items	2	L	5
15	Site flag	5	A	1

Mission Number	Name	Dist	Side	Diff
4	Artefact	4	L	5
7	Heavy	5	R	5
11	Raised	1	R	5
11	Flag	1	R	5
14	Forum items	2	L	5
1	Brush	1	L	4
2	Map	3	L	4
9	Roof	2	R	4
6	Forge	3	R	3
10	Pan	2	R	3
5	Flip	3	R	2
8	Silo	1	R	2
10	Bucket	2	R	2
13	Statue	4	L	2
1	Push	1	L	1
3	Your minecart	4	L	1
9	Market	2	R	1
12	Sand	1	L	1
12	Ship	1	L	1
15	Site flag	5	A	1
3	Other minecart	4	L	0
4	Support	0	L	0

Making the Plan

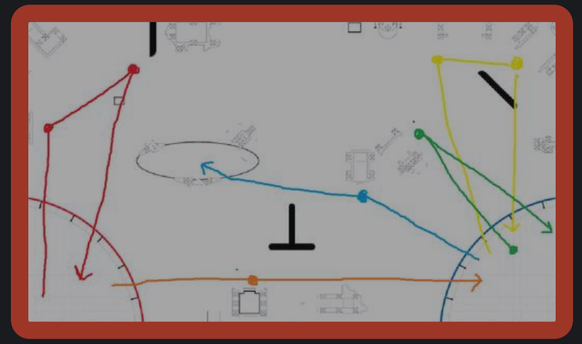
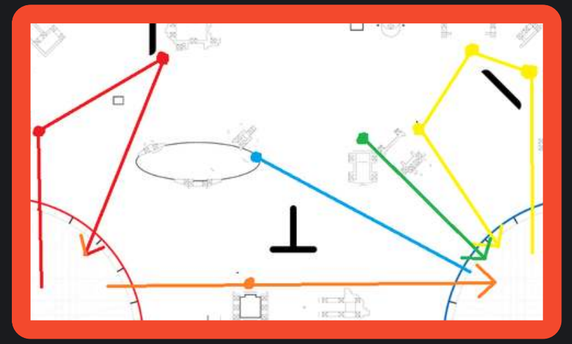
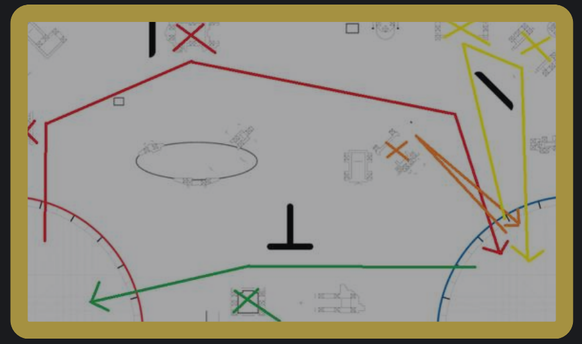
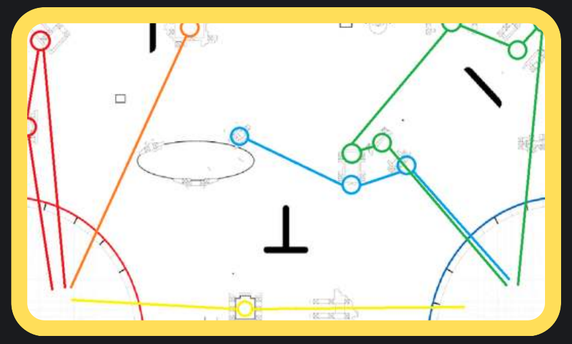
IDENTIFY
PAGE 3 (Robot)



Mission Number	Name	Dist	Side	Dif
4	Artefact	4	L	5
7	Heavy	5	R	5
11	Raised	1	R	5
11	Flag	1	R	5
14	Forum items	2	L	5
1	Brush	1	L	4
2	Map	3	L	4
9	Roof	2	R	4
6	Forge	3	R	3
10	Pan	2	R	3
5	Flip	3	R	2
8	Silo	1	R	2
10	Bucket	2	R	2
13	Statue	4	L	2
1	Push	1	L	1
3	Your minecart	4	L	1
9	Market	2	R	1
12	Sand	1	L	1
12	Ship	1	L	1
15	Site flag	5	A	1
3	Other minecart	4	L	0
4	Support	0	L	0

Iterations & Goals

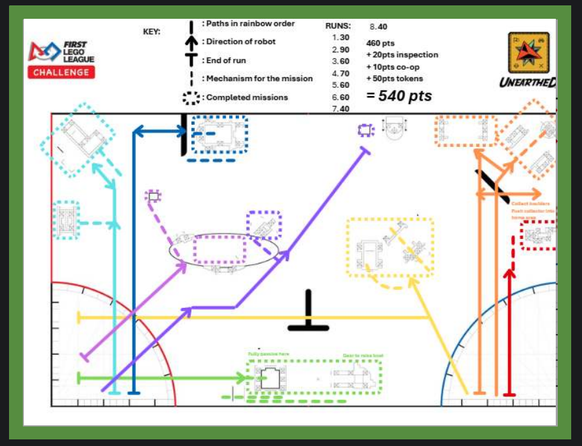
IDENTIFY
PAGE 2-4 (Robot)

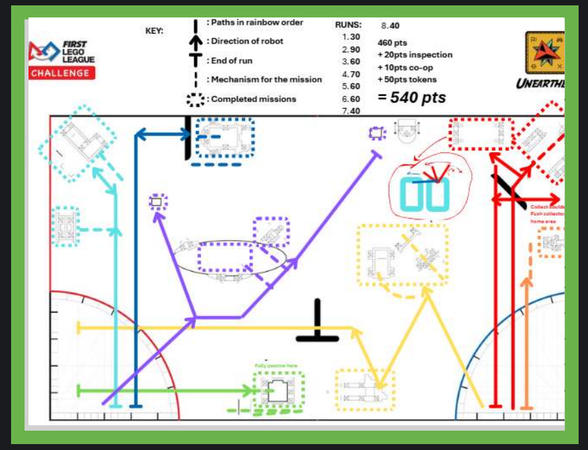





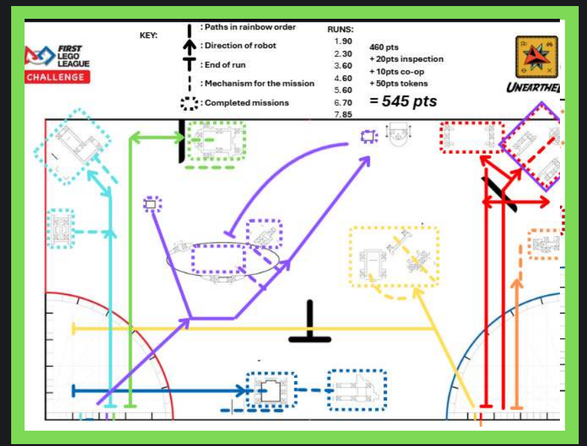
Regionals (270)

Nationals (340)

Internationals (Max 545)





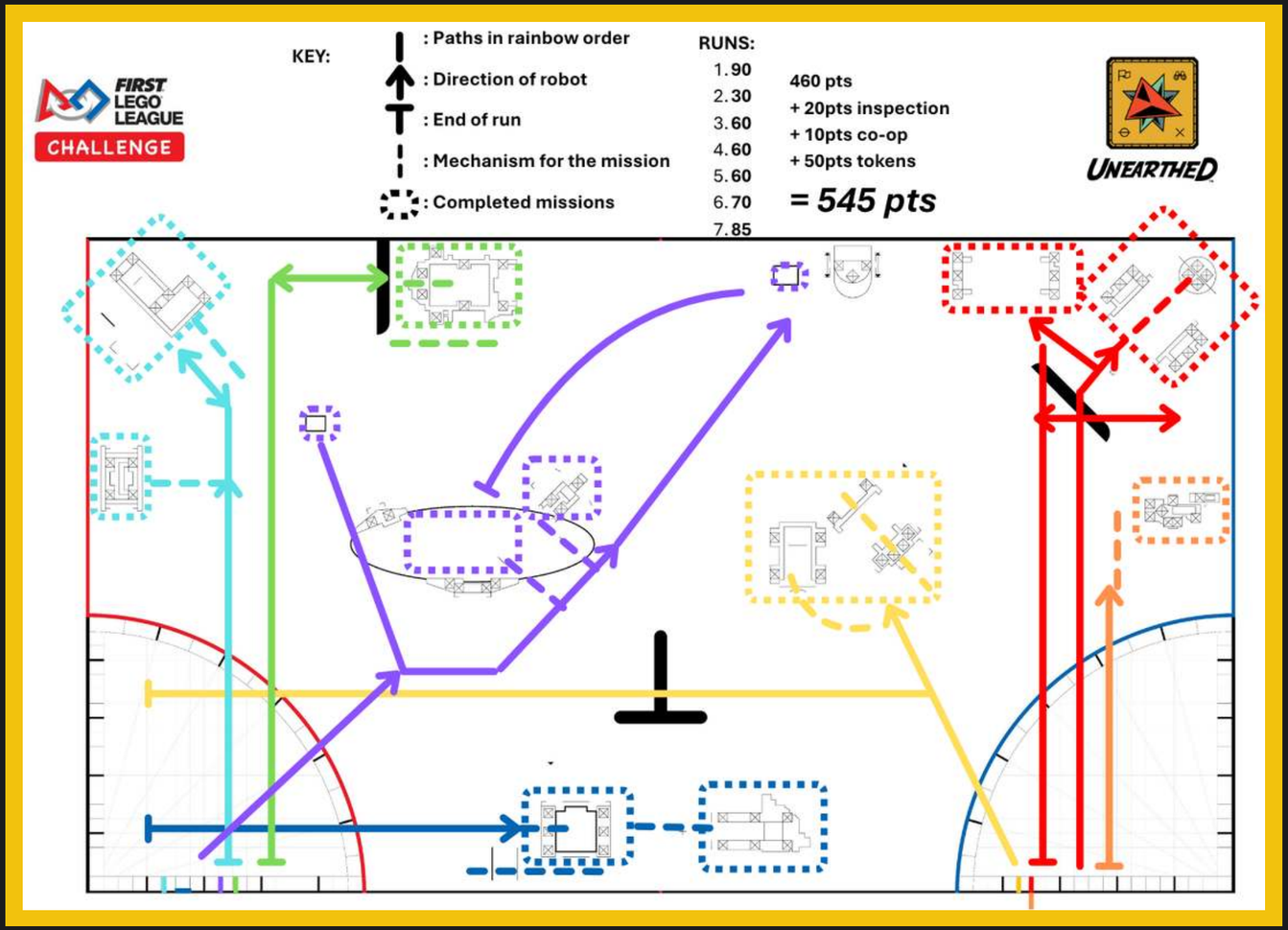


Link to Mission version doc

Final Plan

IDENTIFY
PAGE 2-4 (Robot)

- Detailed plan with key.
- Clear for all team members.
- Multiple versions stored in shared document.
- Uses official game board document.



Resources

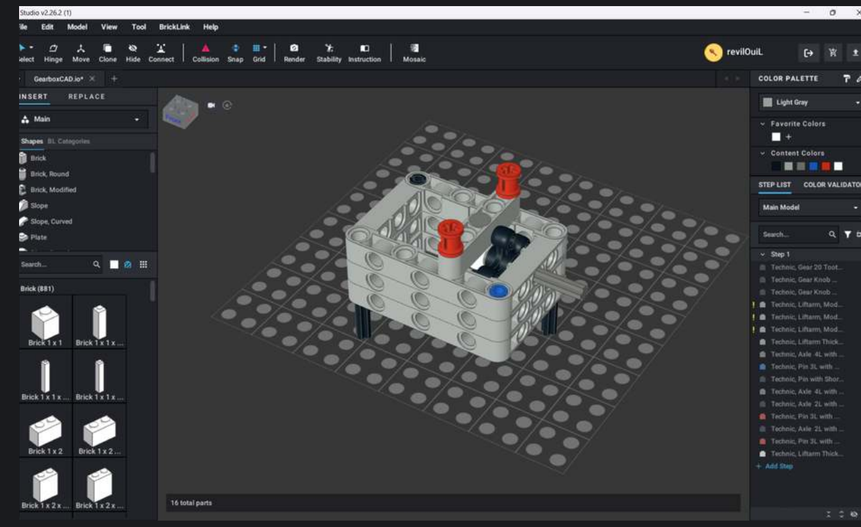
IDENTIFY
PAGE 4-8 (Robot)

```
class Motor(port, positive_direction=Direction.CLOCKWISE, gears
reset_angle=True, profile=None)
```

LEGO® Powered Up motor with rotation sensors.

Parameters:

- **port** (*Port*) - Port to which the motor i
- **positive_direction** (*Direction*) - Which motor should turn when you give a posit value or angle.
- **gears** (*list*) - List of gears linked to the motor. The to the motor comes first and the gear c the output comes last. For example: `[12, 36]` represents a gear 12-tooth gear connected to the motor ar gear connected to the output. Use a lis



Python for Beginners

Learn to code with Python! Perfect for beginners of all ages. Pairs well with Introduction to Programming - Python.

Python

8-15 hours

Introduction to Programming 1 - Python

An introductory course using the Python programming language. Pairs well with Python for Beginners.

Python

8-20 hours

to tair.n.2020

Hello,

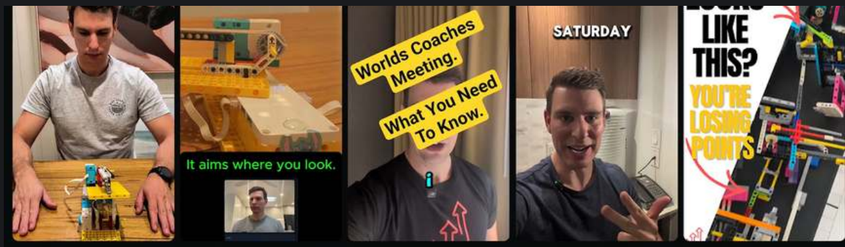
We hope this email finds you well. We are team Lebob from WA, Australia (3237), and this is ou and accurate when turning and driving. Could you give us some tips for achieving this?

This is our code: https://github.com/prawny-boy/FLL-Lebob-2025Unearthed

Thanks,
Team Lebob

Tair Nazar <tair.n.2020@gmail.com>
to me

Hi from Kazakhstan! I checked your code and I am really impressed. Your team already uses bot Analyzing your code I saw that your team uses PID with delta t and integral buffering. However, I of PID it would almost guarantee fix of the wheel slippage problem. Also, in order to boost your F



My LEGO turret now tracks my face 🎯… 30K views

My LEGO robot aims where I look (no … 3.3K views

I just sat through the FLL Worlds … 1.4K views

I'm Flying To FLL Worlds 2026 – … 1.5K views

This FLL Strategy Helped Set an … 10K views

Videos

FIRST LEGO League Line Following on BIOGLOW 362 views · 1 day ago

I Just Saw The Future Of FLL- Here's What's… 4K views · 1 month ago

FLL Robot Keeps Drifting? Here's Why … 2.4K views · 3 months ago

How We Beat the HARDEST FLL Mission: … 9K views · 6 months ago

FLL Unearthed- How To Deliver The Artifacts… 10K views · 9 months ago

Part 2

DESIGN

Team Roles

DESIGN

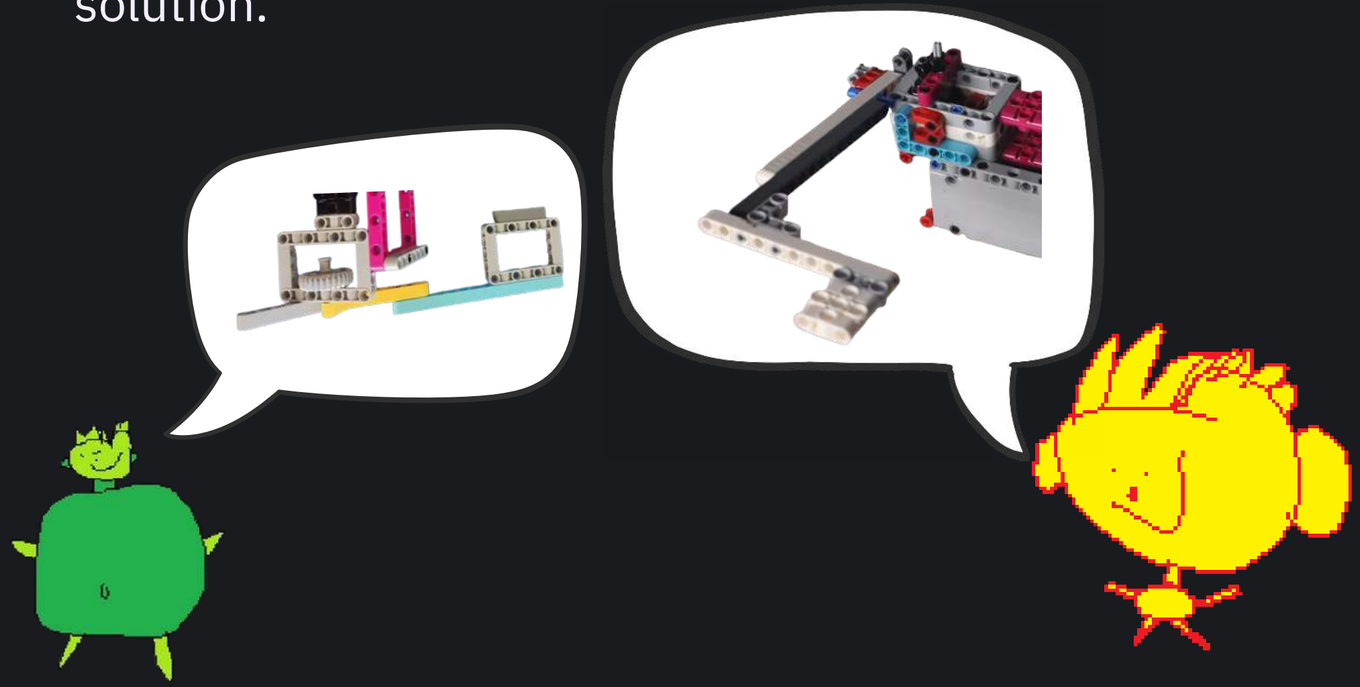
For Robot, Innovations and Documentation

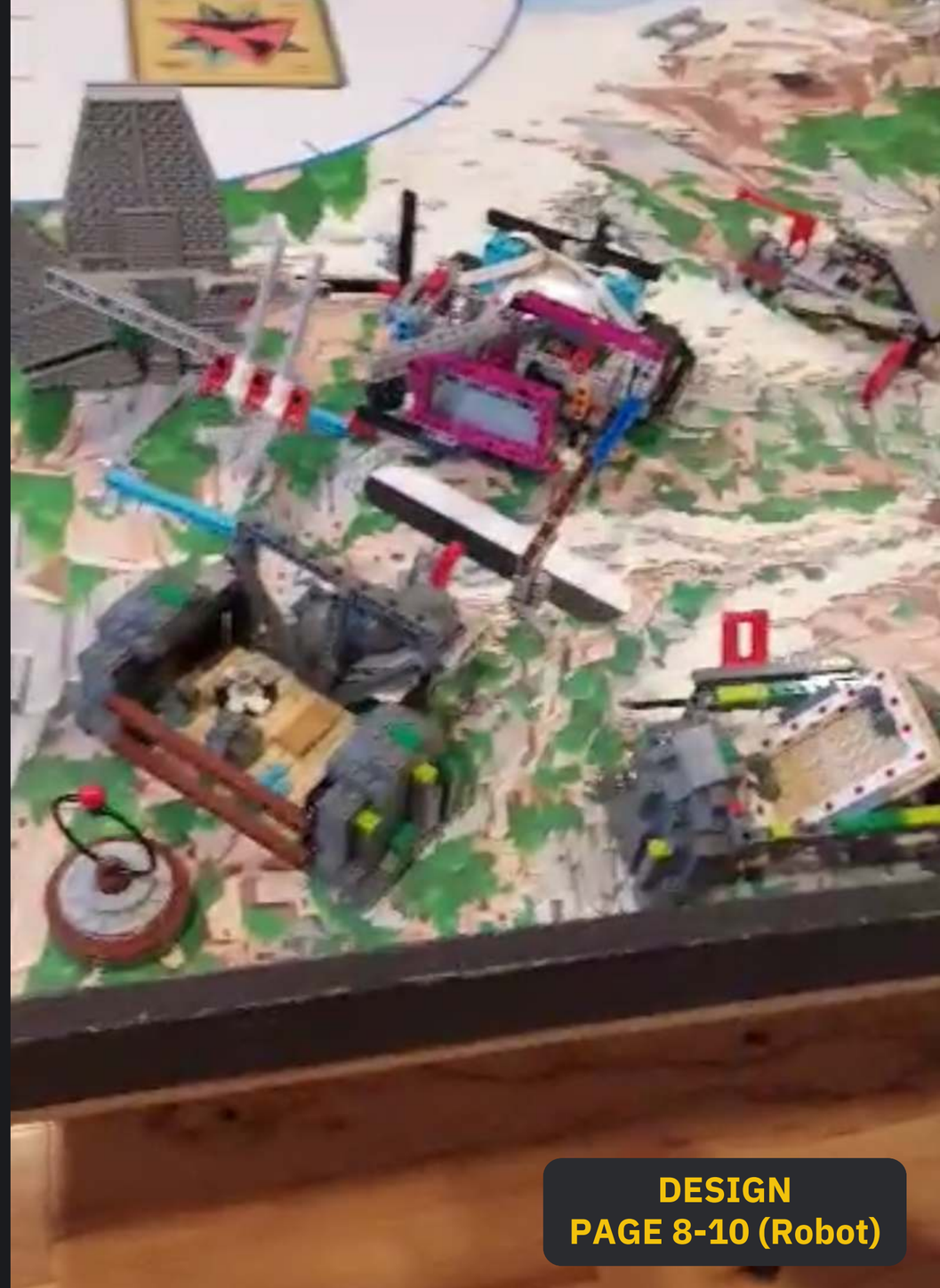
Key	Importance
1	*Main*
2	*Secondary*
3	*Other*

Name	Programming	Mechanical	Innovations	MediaDocs
Sean	1	2		3
Subesh		1	2	3
Kingsley		1	2	3
Aaron	1	2		3
Leven		3	2	1
Chris	3		1	2
Oliver	3	1		2
Andre	2		1	3

Prototyping

- Prototyping allowed us to test different mechanisms and mission approaches.
- Helped us compare ideas, evaluate effectiveness, and refine designs through testing.
- After exploring multiple options, we discussed them as a team and agreed on the most reliable and efficient solution.





DESIGN
PAGE 8-10 (Robot)

Conflicts

DESIGN
PAGE 8-10 (Robot)

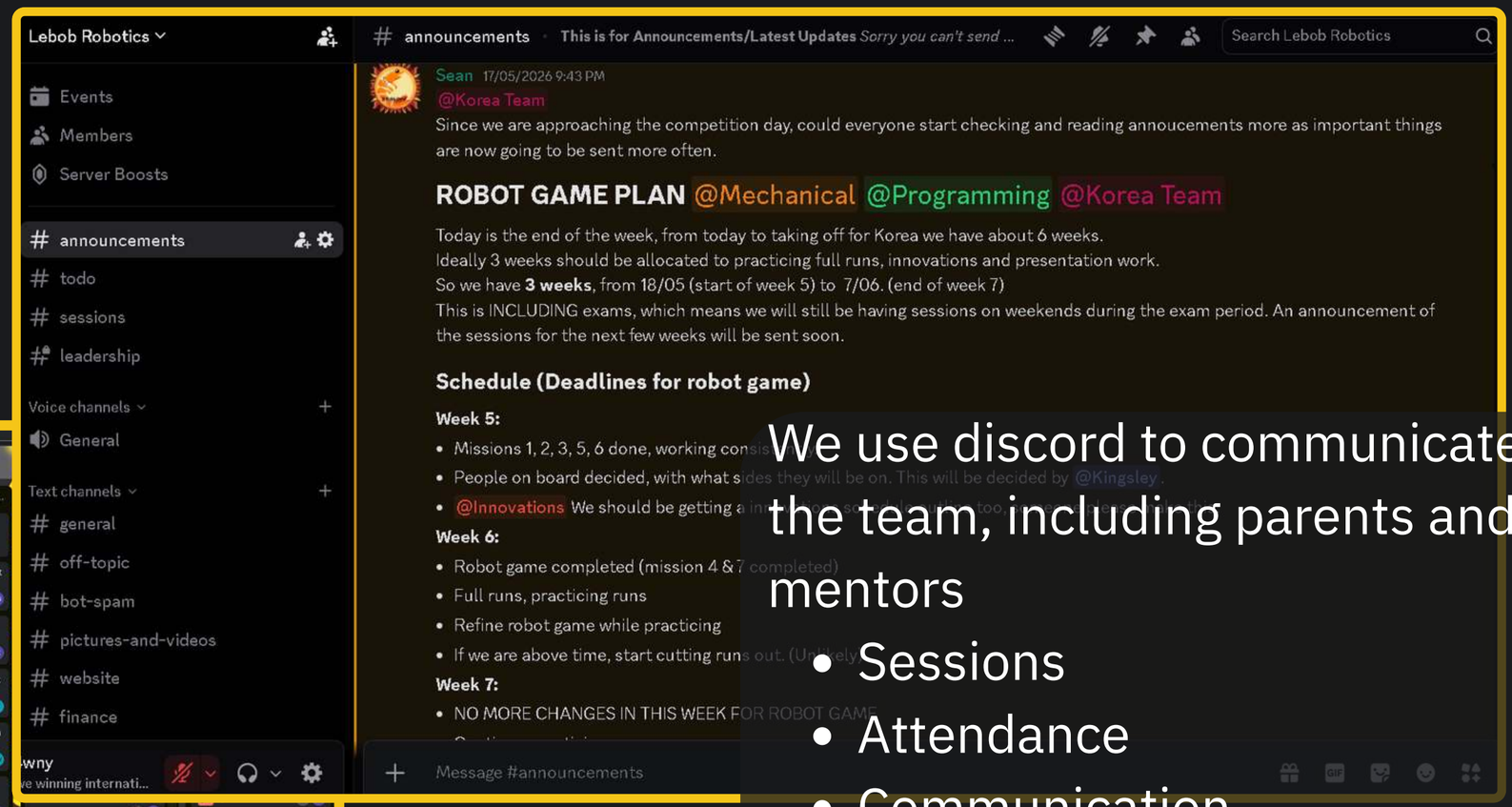
Order	Example
1	Uneven workloads and communication issues.
2	Some members left out, others felt that some members weren’t doing any work.
3	Win internationals, so everyone had to contribute.
4	Last time we just let them be, which we decided was a bad idea since less work would be done.
5	Making it more clear to all team members about work assignments and more discussions.
6	More follow-up is needed after discussions, members could forget.

Practice Judging with experienced seniors

Organisation

DESIGN
PAGE 8-10 (Robot)

We also used Trello for robot design.



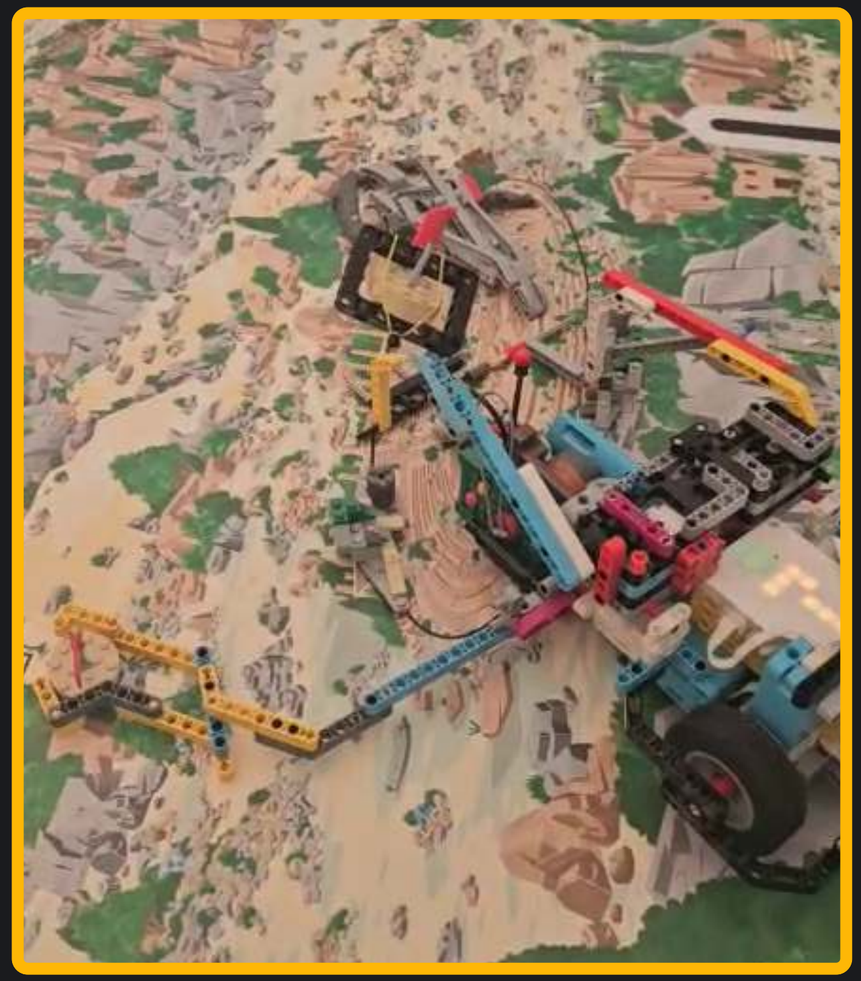
We use discord to communicate with the team, including parents and mentors

- Sessions
- Attendance
- Communication
- Updates
- Todo Lists

Building Skills

DESIGN
PAGE 11-13 (Robot)

- Every team member contributed to the attachments for the runs.
- Each attachment was tested and considered before choosing to use or not use it.
- We collaborated to make sure attachments fit the robot properly and were useful in the runs.
- For example, the robot design was created by Oliver and Kingsley, but it was modified by Sean and Subesh.



Meeting Minutes

DESIGN
PAGE 78 - 84 (Docs)

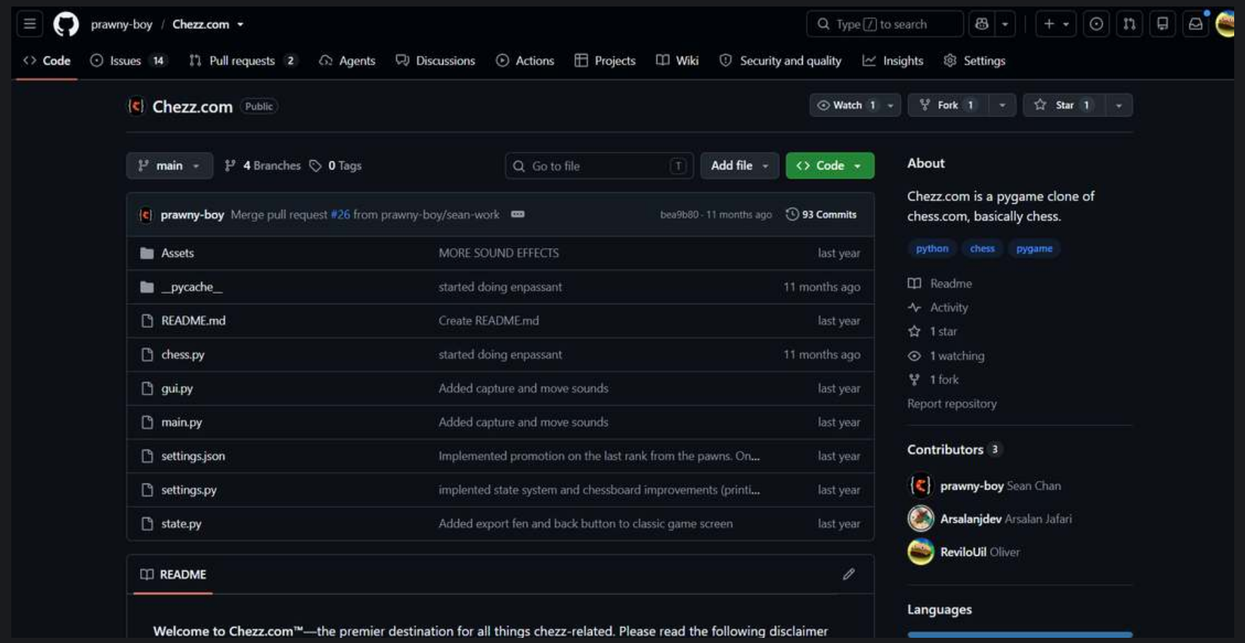
- Over the season we had many sessions for our team.
- We recorded attendance to show commitment, teamwork, and workload contribution
- Shows that every team member contributes research, building, coding, and testing.

Member	Attended	Rate
Andre Nijman	46 / 49	93.90%
Oliver Liu	46 / 49	93.90%
Sean Chan	46 / 49	93.90%
Kingsley Wong	45 / 49	91.80%
Chris Wang	44 / 49	89.80%
Subesh Sukumuran	48 / 49	98.00%
Aaron Zhang	45 / 49	91.80%
Leven Shi	45 / 49	91.80%

Coding Skills

DESIGN
PAGE 13 (Robot)

- School and personal projects. (Python simulations, games)
- Experienced members taught less-experienced members.



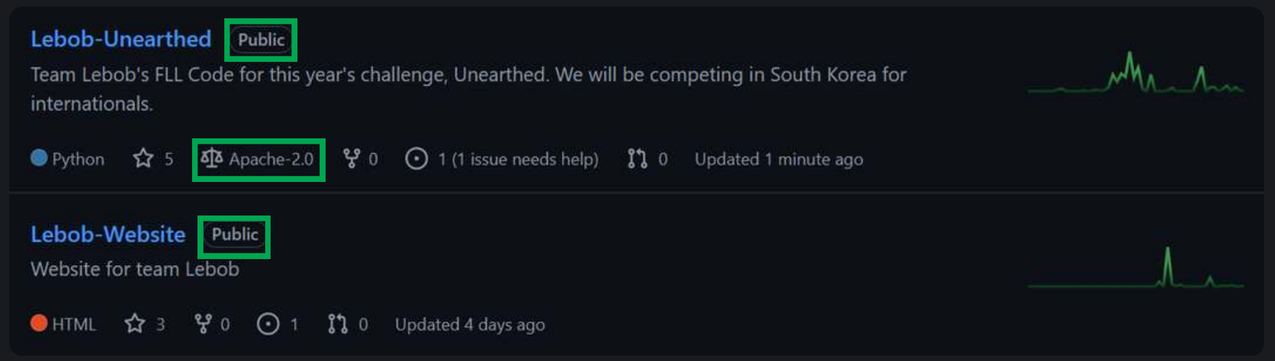
GitHub

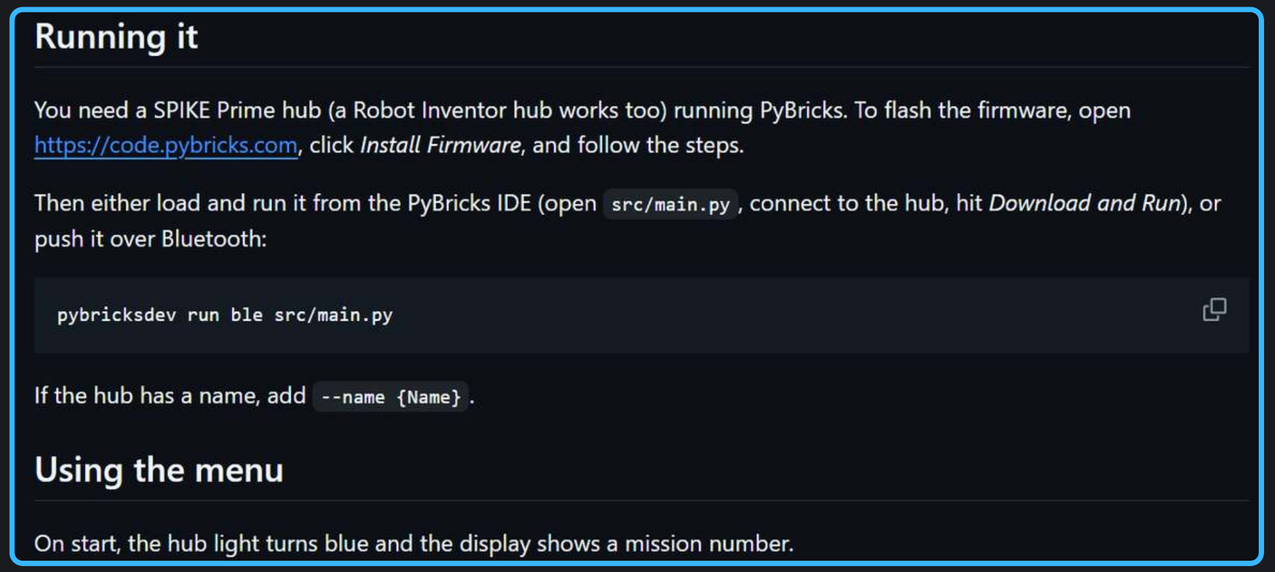
DESIGN
PAGE 9-10 (Robot)

Public (open source and open license) so that other FLL teams can view and get inspiration from our coding projects.

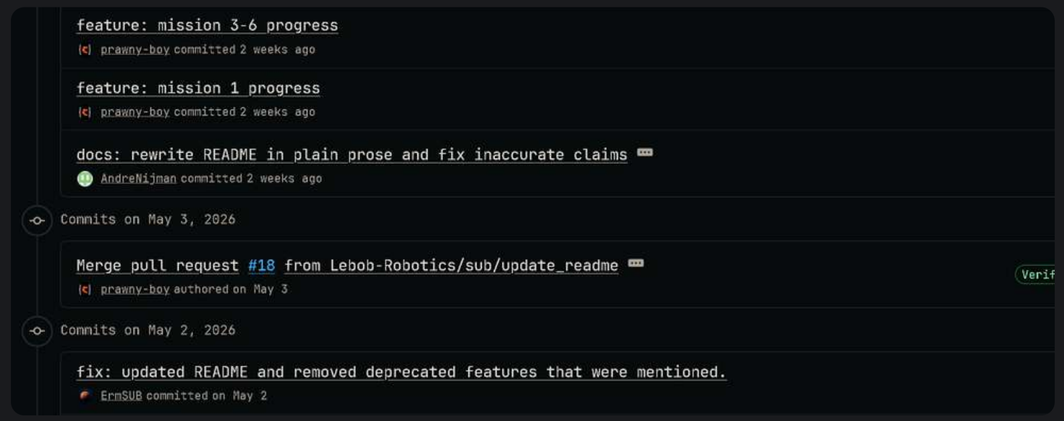
Experienced programmers created a guide so all team members know how to use the code, how to run it, and how it works.

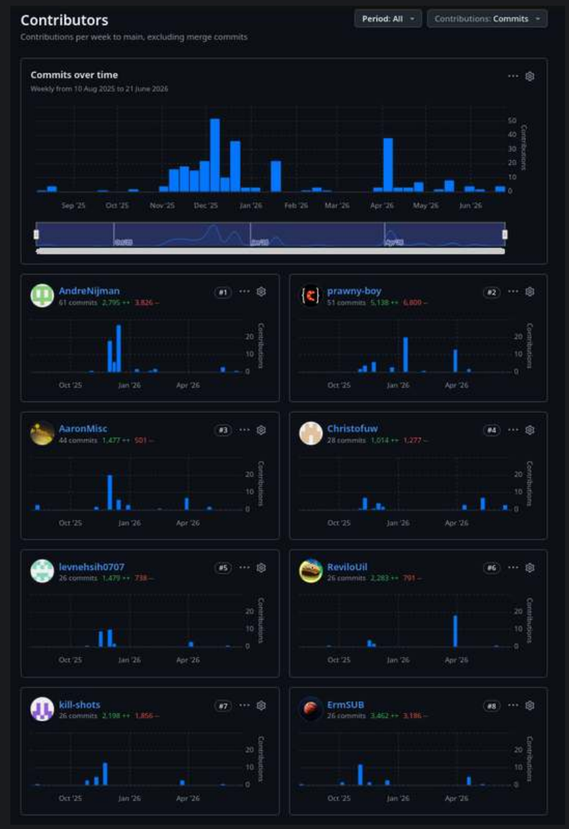
Lebob Robotics GitHub to organise our repositories into a single account.





Commits





Using GitHub commits meant that we could see what, who, when and why code was changed, allowing for iteration and seeing improvement over time

- **Conventional commits** to standardise and ensure commits were clear.
- **Branches** so multiple people could work on different things, for collaboration.

ITERATE
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Coding Contribution

Every member contributed to a part in our code, shown by our GitHub contributors stats. These are the contributions to main.

- Andre: 61
- Sean: 51
- Aaron: 44
- Chris: 28
- Leven: 26
- Oliver: 26
- Kingsley: 26
- Subesh: 26

ITERATE
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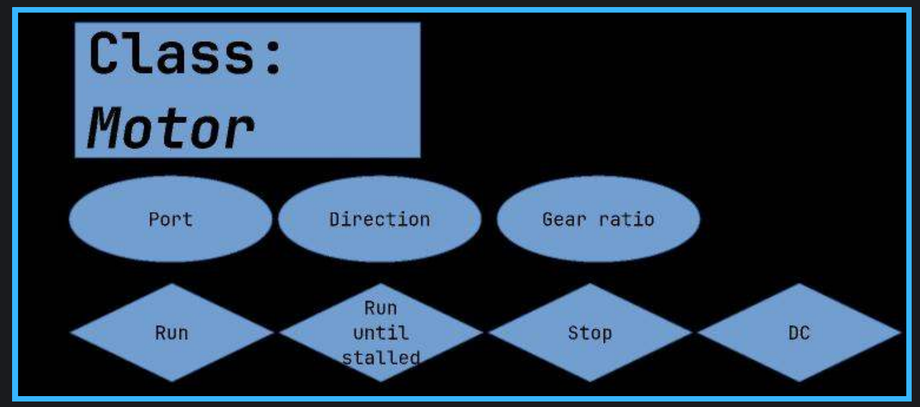
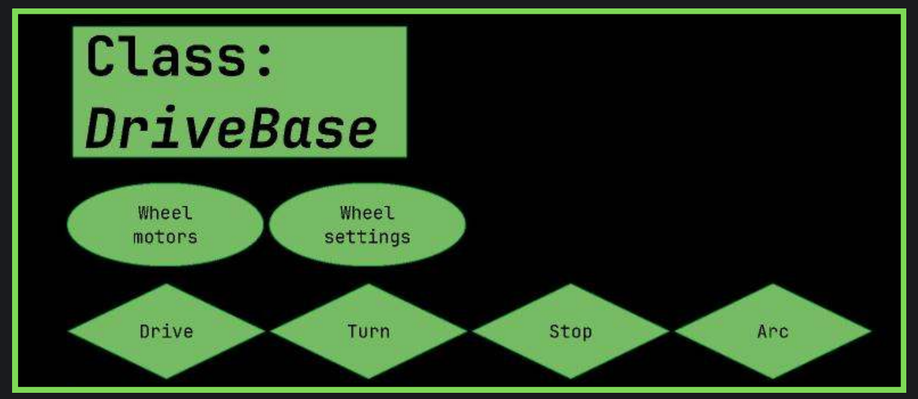
Part 3

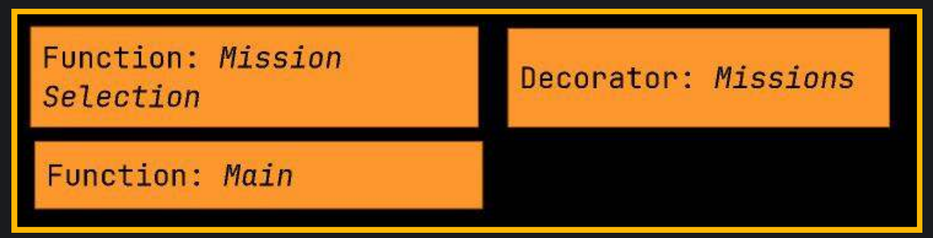
CREATE

Code Planning

CREATE







Coding

Python: Flexibility and Familiarity.

PyBricks: Robot control.

Organisation: Object Oriented Programming.

- Classes for types.
- Objects for instances.
- Organisation.
- Reusability.

Plan

1. Classes, methods.
2. Functions.
3. Mission decorator.

Imports and DB Class

```
#!/usr/bin/env pybricks-micropython
# Default db.settings(): (straight_speed=217, straight_acceleration=816, turn_rate=160, turn_acceleration=720)
# Default motor stall_tolerances: (speed=20, time=200)

from pybricks.hubs import PrimeHub
from pybricks.parameters import Button, Color, Direction, Port, Side, Stop
from pybricks.pupdevices import Motor
from pybricks.robotics import DriveBase
from pybricks.tools import wait, StopWatch

DRIVEBASE_WHEEL_DIAMETER = 62.4  # Medium treaded wheel diameter (mm)
DRIVEBASE_AXLE_TRACK = 130


class LebobDriveBase(DriveBase):
    def _stop_with(self, then):
        self.stop()
        if then == Stop.HOLD:
            ld.hold()
            rd.hold()
        elif then == Stop.BRAKE:
            ld.brake()
            rd.brake()

    def _wait_until_stalled(
        self, speed_tolerance: int = 0, turn_tolerance: int = 0, then=Stop.COAST
    ):
        """Wait until the robot stalls based on tolerance thresholds.

        Args:
            speed_tolerance: Max drive speed (mm/s) to consider stalled. 0 uses default stalled().
            turn_tolerance: Max turn rate (deg/s) to consider stalled. 0 uses default stalled().
            then: What to do after stalling (Stop.COAST, Stop.BRAKE, Stop.HOLD).
        """
        if speed_tolerance == 0 and turn_tolerance == 0:
            while not self.stalled():
                wait(10)
        else:
            wait(200)  # Let motors spin up before checking
```

CREATE PAGE 13-15 (Robot)

Importing: Allows control for components from pybricks (driving, rotating motors).

Class the robot for organisation: extends the built in DriveBase class, but adds extra functionaility.

Custom functions:
The default DriveBase class had limited functionality when we wanted to do something until stalled. These were useful for when the robot needed to drive up to something.

Setup and Functions

```
1
108  # Hub
1    hub = PrimeHub()
2
3    # Drive motors
4    ld = Motor(Port.D, positive_direction=Direction.COUNTERCLOCKWISE)
5    rd = Motor(Port.C, positive_direction=Direction.CLOCKWISE)
6
7    # FLL attachment motors
8    lbm = Motor(Port.F, gears=[12, 20])
9    rbm = Motor(Port.E, gears=[12, 20])
10   db = LebobDriveBase(  # DriveBase
11       ld,
12       rd,
13       wheel_diameter=DRIVEBASE_WHEEL_DIAMETER,
14       axle_track=DRIVEBASE_AXLE_TRACK,
15   )
16   db.use_gyro(True)
17
18   # Missions
19   MISSIONS = []
20
21
22   def mission(func_ptr):
23       """Register a mission function in menu order."""
24       MISSIONS.append(func_ptr)
25       return func_ptr
26
27
28   def reset_robot():
29       db.reset()
30       hub.imu.reset_heading(0)
31       lbm.reset_angle(0)
32       rbm.reset_angle(0)
33       db.stop()
34       lbm.stop()
35       rbm.stop()
```

Defining hub:For configuring buttons and lights for the mission selector.

Defining motors: For controlling motors, used documentation to specify the positive direction and the gear ratio, so we didn't have to update numbers when changing gearbox.

Mission decorator: For organising our missions, we used a decorator to put a pointer for each mission into a MISSIONS list.

Reset robot: A helper function to reset the robot whenever we needed to reset to measure an angle, reset the speed between missions or stop the robot.

```
class Motor(port, positive_direction=Direction.CLOCKWISE, gears=None,
reset_angle=True, profile=None)

  LEGO® Powered Up motor with rotation sensors.

    Parameters:   • port (Port) - Port to which the motor is connected.
                  • positive_direction (Direction) - Which direction the
                  motor should turn when you give a positive speed
                  value or angle.
                  • gears (list) -
                  List of gears linked to the motor. The gear connected
                  to the motor comes first and the gear connected to
                  the output comes last.
                  For example: [12, 36] represents a gear train with a
                  12-tooth gear connected to the motor and a 36-tooth
                  gear connected to the output. Use a list of lists for
                  multiple gear trains, such as [[12, 36], [20, 16, 40]].
                  When you specify a gear train, all motor commands and
                  settings are automatically adjusted to account for
                  the resulting gear ratio. The motor direction remains
                  unchanged by this.
```

CREATE PAGE 13-15 (Robot)

Mission (eg. 3)

CREATE
PAGE 13-15 (Robot)

```python
@mission
def mission_3():
    """Scales and raise pan."""
    db.straight(220) # Drive to raise
    db.turn(-45)
    db.straight(210)
    rbm.run_angle(380, -140, then=Stop.COAST, wait=False) # Arm down onto the platform
    wait(800)
    rbm.stop()
    db.settings(straight_speed=100)
    db.straight(-70)
    rbm.run_angle(400, 150, wait=False)  # Raise
    db.straight(-26)  # Pull the platform up at the same time
    db.settings(straight_speed=400)
    db.straight(80)  # Let go of the arm and go up to the scales

    # Go to pan
    rd.run_time(
        400, 1000, then=Stop.COAST
    )  # Turn left by only moving the right wheel, and knock the scales
    db.turn(-50)
    db.straight(110)
    db.arc(131, 164)
    db.straight(20)
    rbm.run_angle(400, -160)  # Arm down to hit pan
    wait(200)
    rbm.run_angle(600, 120)
    db.straight(-110)  # Take pan out
    db.settings(straight_speed=1000)
    db.turn(-95)
    db.straight(60)
    db.turn_until_stalled(tolerance=20, then=Stop.HOLD)
    lbm.dc(100)
    rd.run_time(-50, 1500)
```

Mission decorator: Automatically puts this function into the MISSIONS list for the mission selector.

Documentation and clarity: Docstrings for what missions this function does, and comments for what each line is for. So all team members knew what was happening.

Wait=false: Motors running concurrently to save time.

Time scarcity: Last robot game at nationals, we lost points due to running out of time, so we focused on saving time and optimising missions.

Changing speed: To save time, we went fast for simple drives, and slow for when it needed to be precise.

Arc: Also saves time, shorter distance.

Duty cycle: We found this in the documentation, allowing us to use 100% power through the motor, for when a lot of force was required.

```
dc(duty)

  Rotates the motor at a given duty cycle (also known as “power”).

    Parameters:   duty (Number, %) - The duty cycle (-100.0 to 100).
```

Innovative Code

Mission Autosave: This uses the hub's non-volatile storage to save the next mission index before a run begins, so the robot can be ready to run the next mission if the code ends forcefully. This saves time so that technicians don't need to reselect it from the mission menu.

```
STORAGE_OFFSET = 0


def load_saved_mission_index():
    try:
        data = hub.system.storage(STORAGE_OFFSET, read=1)
        if len(data) == 1:
            return data[0] % len(MISSIONS)
    except Exception:
        pass
    return 0


def save_mission_index(index):
    try:
        hub.system.storage(STORAGE_OFFSET, write=bytes([index]))
    except Exception:
        pass
```

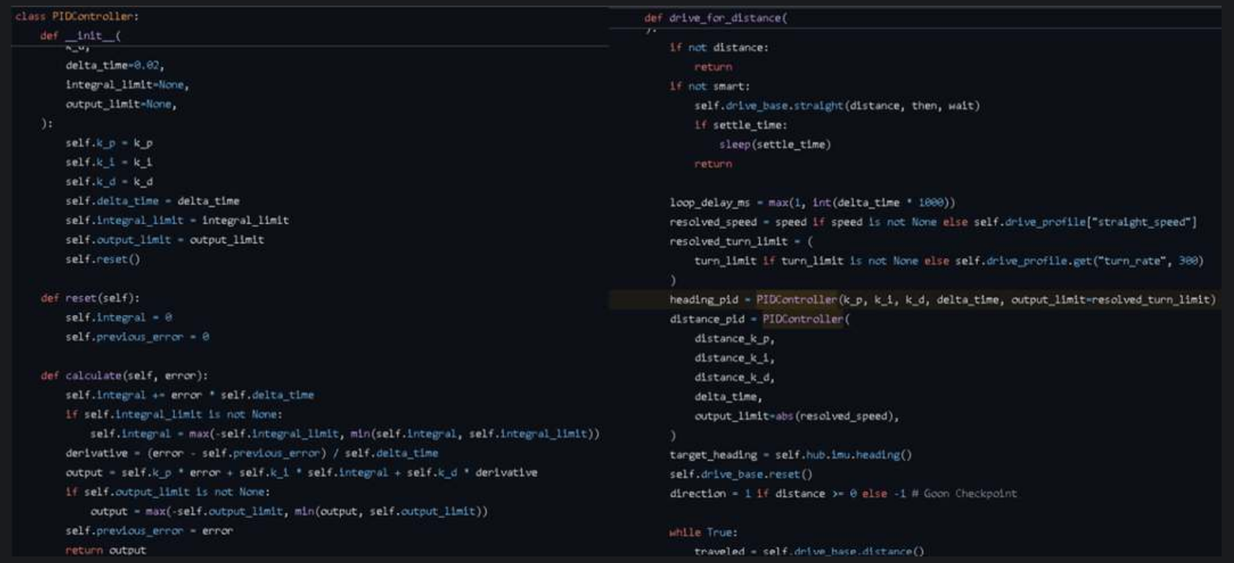
CREATE
PAGE 13-15 (Robot)

Innovative Code

CREATE
PAGE 13-15 (Robot)

Using PID (Proportional Integral Derivitive):

- To create smooth and accurate movements of arms, wheels etc.
- Uses the built-in gyro in the spike to account for errors on the mat, such as dust build up and random slippage.



```
class PIDController:
    def __init__(
        self,
        k_p,
        k_i,
        k_d,
        delta_time=0.02,
        integral_limit=None,
        output_limit=None,
    ):
        self.k_p = k_p
        self.k_i = k_i
        self.k_d = k_d
        self.delta_time = delta_time
        self.integral_limit = integral_limit
        self.output_limit = output_limit
        self.reset()

    def reset(self):
        self.integral = 0
        self.previous_error = 0

    def calculate(self, error):
        self.integral += error * self.delta_time
        if self.integral_limit is not None:
            self.integral = max(-self.integral_limit, min(self.integral, self.integral_limit))
        derivative = (error - self.previous_error) / self.delta_time
        output = self.k_p * error + self.k_i * self.integral + self.k_d * derivative
        if self.output_limit is not None:
            output = max(-self.output_limit, min(output, self.output_limit))
        self.previous_error = error
        return output
```

```
def drive_for_distance(
    if not distance:
        return
    if not smart:
        self.drive_base.straight(distance, then, wait)
        if settle_time:
            sleep(settle_time)
        return

    loop_delay_ms = max(1, int(delta_time * 1000))
    resolved_speed = speed if speed is not None else self.drive_profile["straight_speed"]
    resolved_turn_limit = (
        turn_limit if turn_limit is not None else self.drive_profile.get("turn_rate", 300)
    )
    heading_pid = PIDController(k_p, k_i, k_d, delta_time, output_limit=resolved_turn_limit)
    distance_pid = PIDController(
        distance_k_p,
        distance_k_i,
        distance_k_d,
        delta_time,
        output_limit=abs(resolved_speed),
    )
    target_heading = self.hub.imu.heading()
    self.drive_base.reset()
    direction = 1 if distance >= 0 else -1 # Goon Checkpoint

    while True:
        traveled = self.drive_base.distance()
```

```
def mission_selector():
    mission_index = 5

    while True:
        hub.display.char(str(mission_index + 1))
        pressed = hub.buttons.pressed()

        if Button.LEFT in pressed:
            mission_index = (mission_index + 1) % len(MISSIONS)
            while hub.buttons.pressed():
                wait(20)

        elif Button.RIGHT in pressed:
            mission_index = (mission_index - 1) % len(MISSIONS)
            while hub.buttons.pressed():
                wait(20)

        elif Button.CENTER in pressed:
            while hub.buttons.pressed():
                wait(20)
            hub.light.on(Color.GREEN)
            timer = StopWatch()
            try:
                timer.resume()
                MISSIONS[mission_index]()
            finally:
                print(f"Time Elapsed: {timer.time()}ms")
                reset_robot()
                hub.light.on(Color.BLUE)
            mission_index = (mission_index + 1) % len(MISSIONS)

        wait(20)
```

Left and right buttons to select the mission number

Centre to run the mission.

Automatically times how long the mission takes.

Automatically goes to the next mission.

Engineering Principles

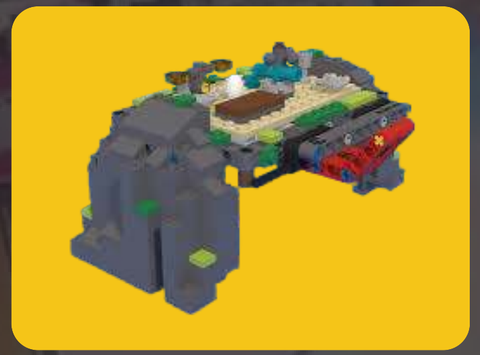
CREATE
PAGE 11 (Robot)

For each attachment we based each of them on 3 engineering principles:

- Simplicity
- Efficiency
- Reliability

Attachment One

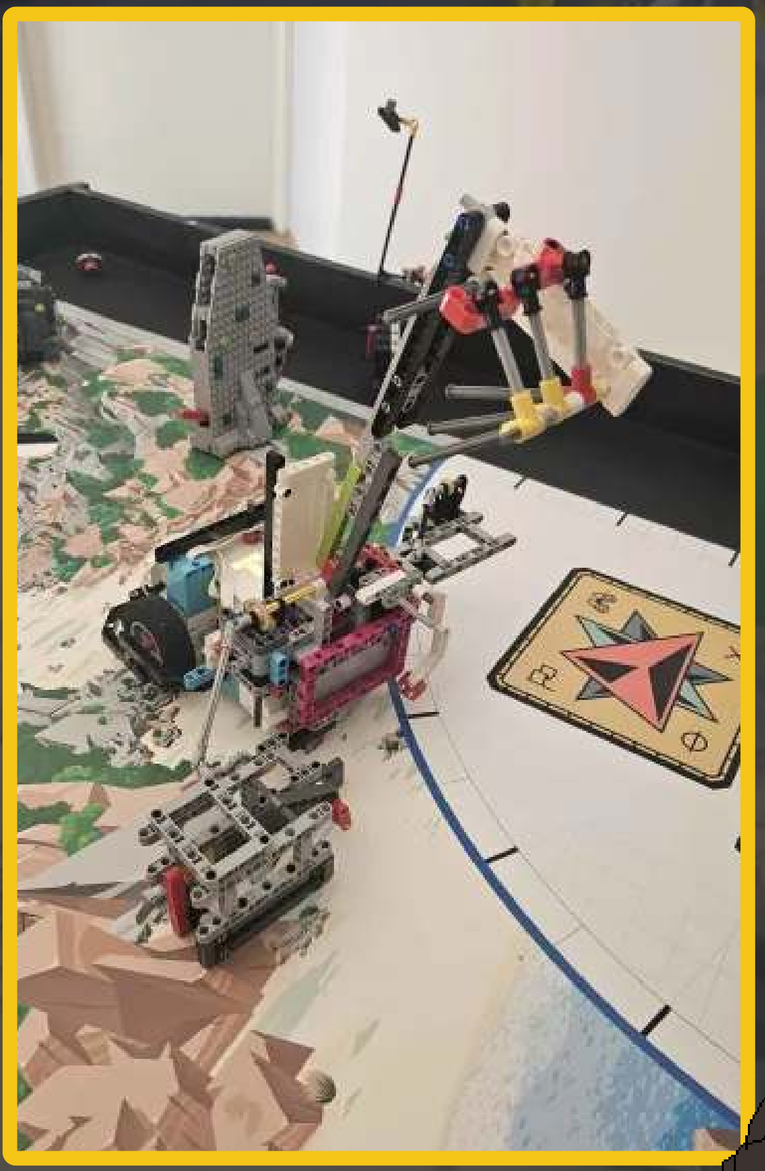
Innovative Mechanism #1 (Chungus)



This mechanism is for run 1.

It does these missions:

- **M05:** Who Lived Here?
- **M06:** Forge
- **M07:** Heavy Lifting



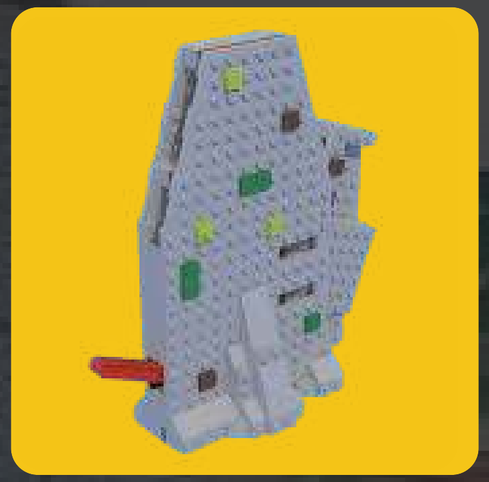
CREATE
PAGE 12 (Robot)

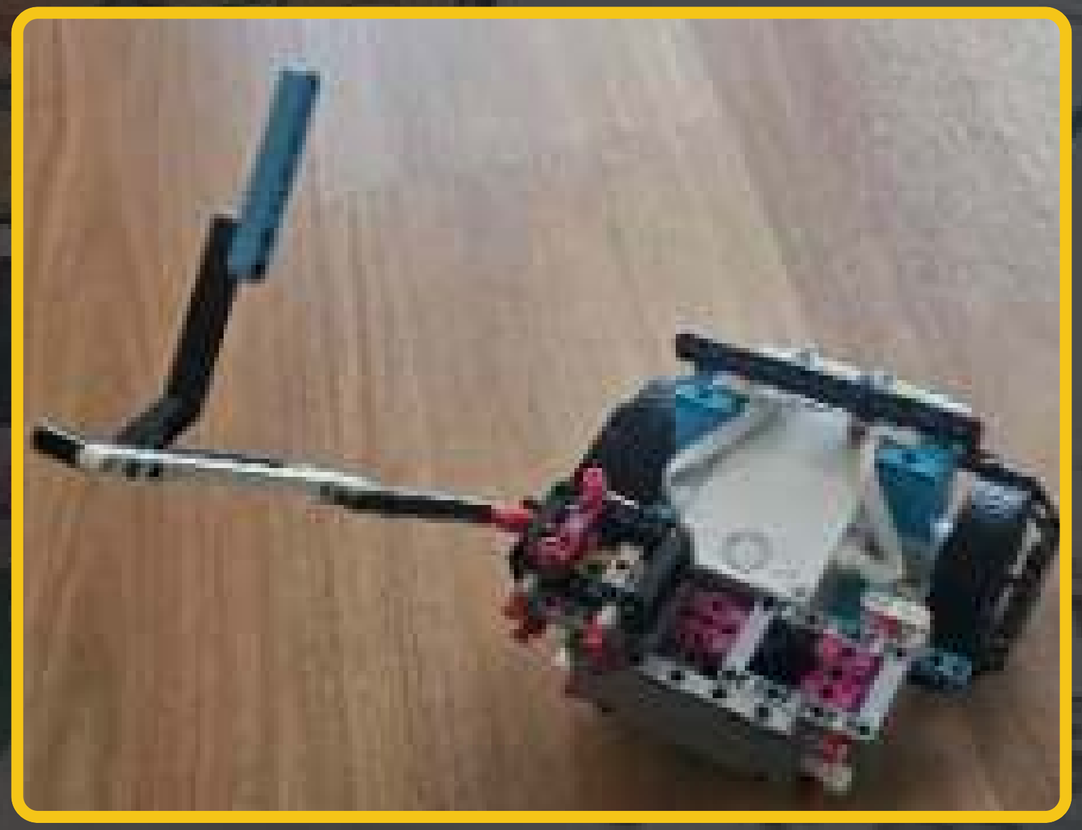
Attachment Two

Innovative Mechanism #2 (Sheet Metal)

It does these missions:

- **M08:** Silo





CREATE
PAGE 12 (Robot)

Attachment Three

Innovative Mechanism #3 (Cerberus)

This mechanism is for run 3.

It does these missions:

- **M10:** Tip the Scales
- **M09:** What's on Sale?

We used the video from Robotics Rules Competition to create the one way gate.

CREATE
PAGE 12 (Robot)

Attachment Four

Innovative Mechanism #4 (Pitchfork)

This mechanism is for run 4.

It does these missions:

- **M03:** Mineshaft Explorer
- **M04:** Careful Recovery

CREATE PAGE 12 (Robot)

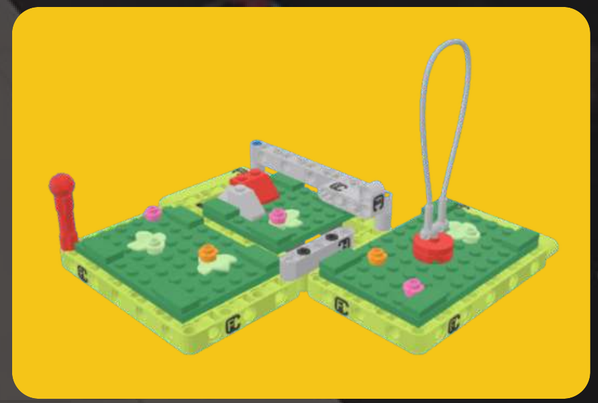
Attachment Five

Innovative Mechanism #5 (Dimentionally Transcendent Plasma Forge Dissection Apparatus)

This mechanism is for run 5.

It does these missions:

- **M01:** Surface Brushing
- **M02:** Map Reveal



CREATE PAGE 12 (Robot)

Attachment Six

Innovative Mechanism #6 (Giraffe)

CREATE
PAGE 13 (Robot)

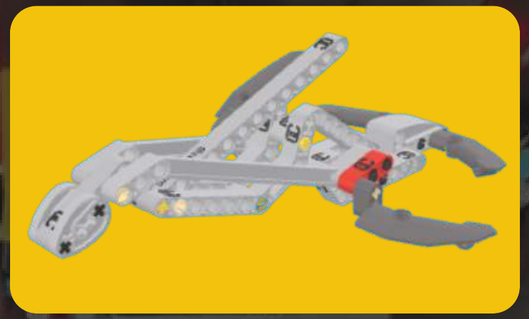
It does these missions:

- **M12:** Salvage Operation
- **M11:** Angler Artifacts
- **M15:** Site Marking 1/3

One motor controls the main movement of the arm, while the other rotates a set of gears on the arm to trigger more actions. Has multiple passive elements that don’t require motors to function.

Attachment Seven

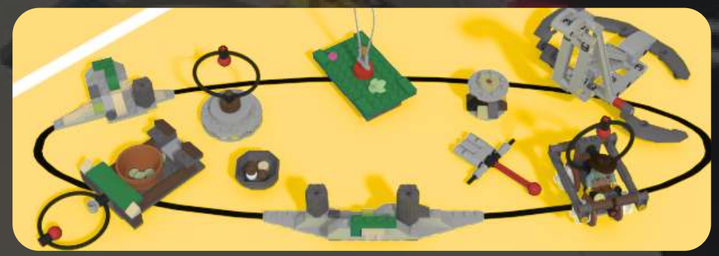
Innovative Mechanism #7 (Vomit)



This mechanism is for run 7.

It does these missions:

- **M13:** Statue Rebuild
- **M14:** Forum
- **M15:** Site Marking 2/3 3/3
- Opponent’s Minecart

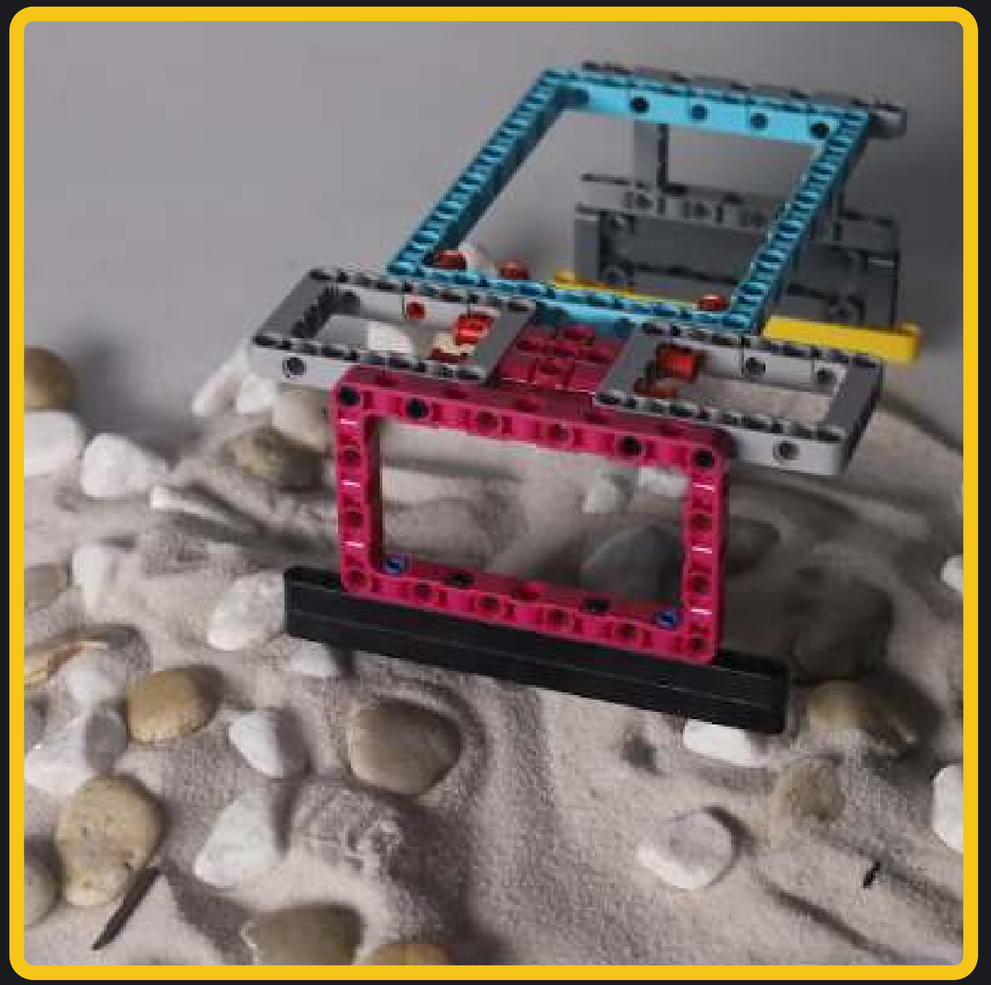


CREATE
PAGE 12 (Robot)

Fake Robot

CREATE
PAGE 13 (Robot)

We built a skeleton bot so we could keep coding on the main robot with the attachments already installed, while also developing and improving new mechanisms for other missions at the same time.



Part 4

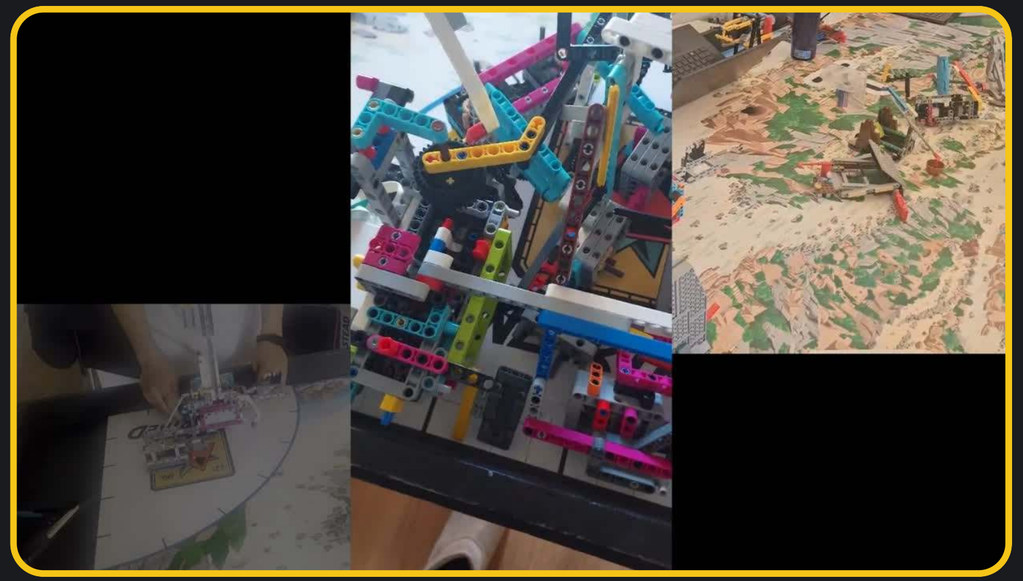
ITERATION

Iteration Timelapse

As we iterated on code and mechanisms for robot design, we made many logs about what happened each time we ran the robot.

E.g. 13:16:33 – run 2. We fixed the gearbox and ran it, but it misaligned with the mineshaft

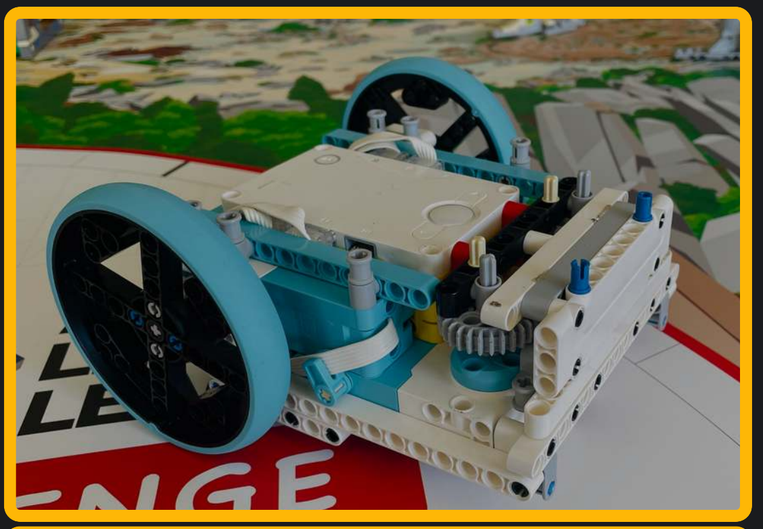
ITERATE
PAGE 9-78 (Docs)

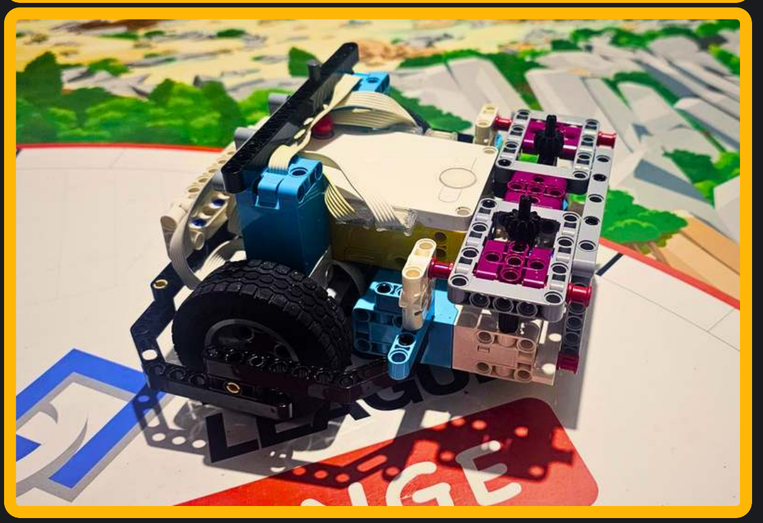


Robot Fixes

ITERATE
PAGE 9-78 (Docs)

Issue	Cause	Fix	Action
Inconsistency, lack of control	Wheels were thin, and raised the centre of gravity.	Lower centre of gravity.	Decrease wheel size, and incease width.
	Motors were upright.	Lower centre of gravity.	Put large motors on the bottom.
Strength	Gearbox was not stable enough.	Increase mechanical advantage.	Use gear ratios.
		Increase attachment strength.	Use pins on gearbox frame from many points.
Flexibility	Attaching mechanisms to motors only allowed them to move along a single axis.	Use gears to change direction of motion.	Make gearbox able to house larger mechanisms and attach via gears.
Alignment	Aligning the robot against the back was inconsistent.	Add a flat surface at the back.	Make back bumper for the wheels.





Base Robot Design

ITERATE
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Movement:

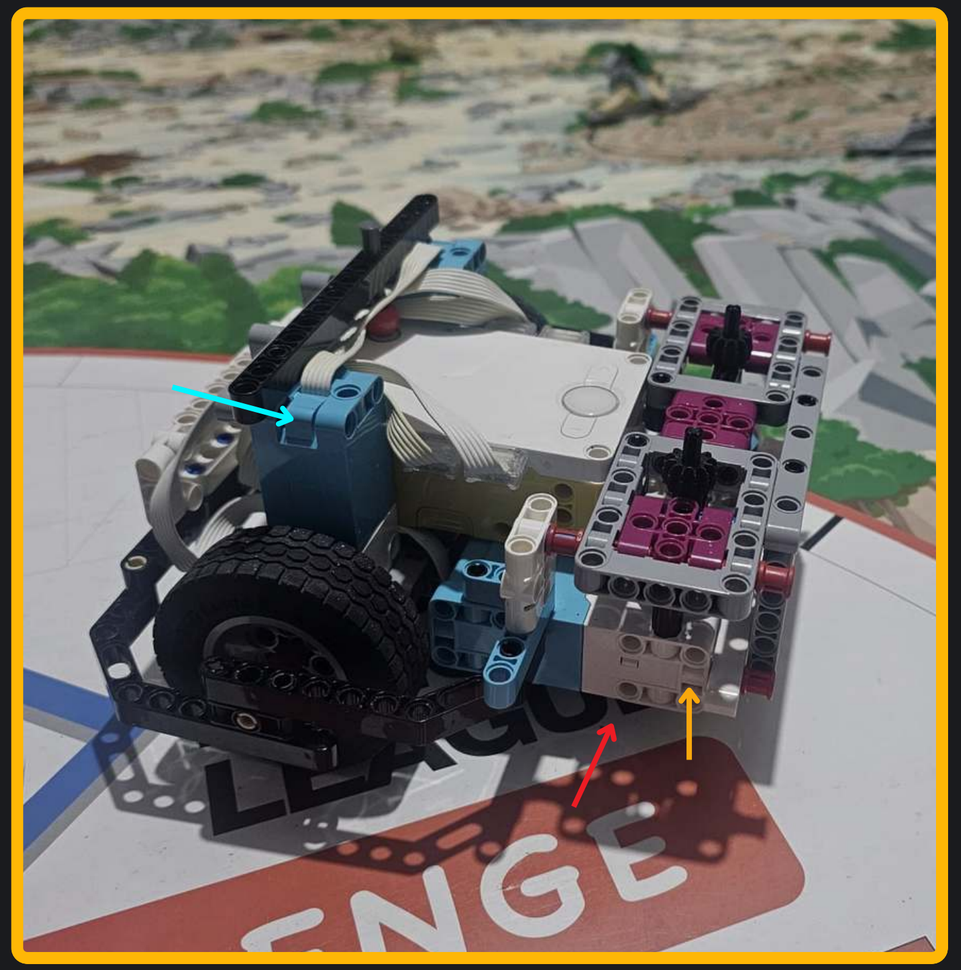
- 2 medium motors - wheels
- 1 non-friction nubs for balance

Attachments:

- 2 large motors with gears

Features:

- Low centre of gravity
- No hanging cables

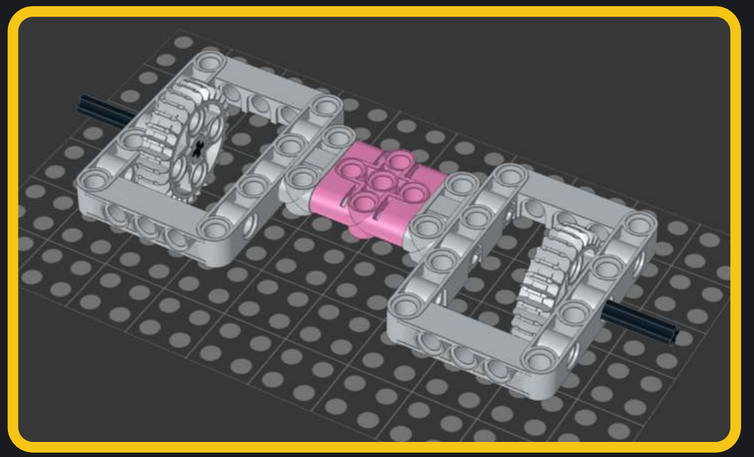


Gearbox Problems

ITERATE
PAGE 19 (Robot)

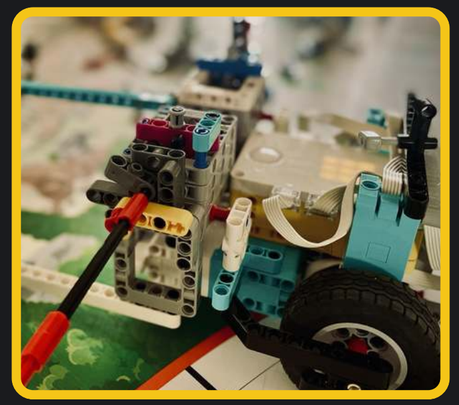
Iteration example #2

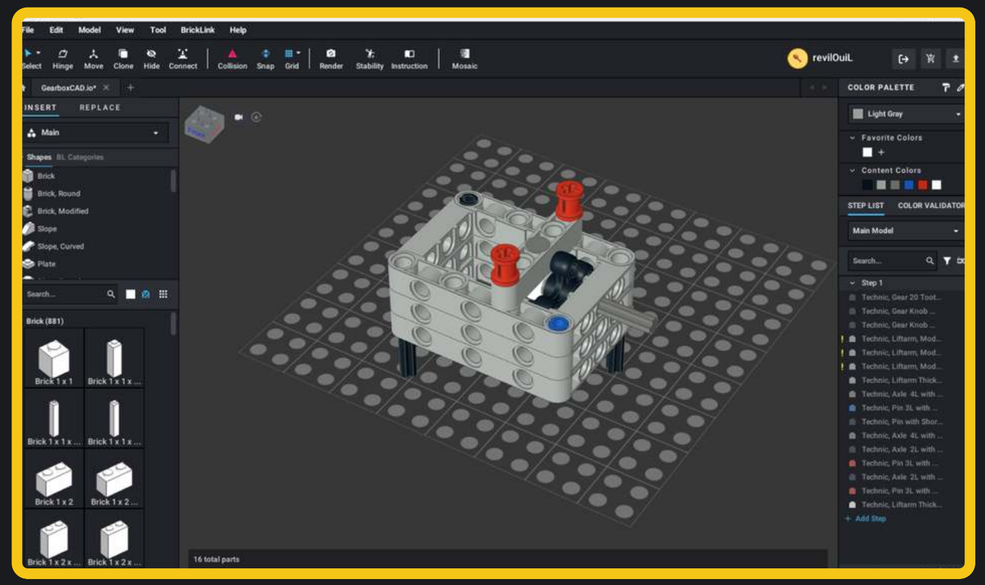
- The gears weren’t meshing when placed perpendicularly, leading to the gears skipping and the mechanisms not actuating.
- We temporarily fixed this by adding locking beams that attach to the drivebase, however this increased attachment change times.

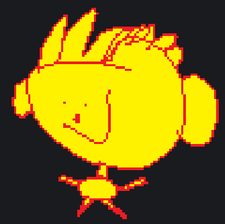


New Gearbox

- Easy attachment switching and no gear slippage, on every attachment
- Our new gearbox has gears that mesh in plane with each other
- We use 4 tooth gears for perpendicular transmission.
- We used Bricklink Studio 3.0







LEARNING

COMMUNICATION
PAGE 20-21 (Robot)

An important part of FLL is learning, so we want to share what the most impactful thing we've learnt from the season!

Sean - PID

Aaron - CAD, mechanical

Subesh - CAD

Kingsley - CAD

Chris - Mechanical

Andre - FEA

Leven - Programming

Oliver - simplicity

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THANK YOU

Chris the builder

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