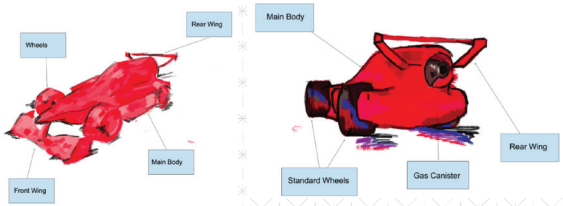
Portfolio

Produced by Louis Gan and Shi Hao Ng in Adobe Illustrator

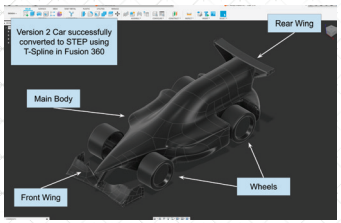
Research and Development Workflow

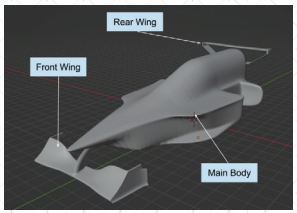
1 Sketches



Our journey began with Samson and Jane crafting the initial car designs using Blender. Although Blender is primarily an animation software, we chose it for our main CAD modeling due to our team's familiarity with the platform and its ease in translating our concept art into 3D models. These early versions (v1 & v2) were rich in creativity and aesthetics but lacked consideration for the competition's no-go zones and model block size specifications.

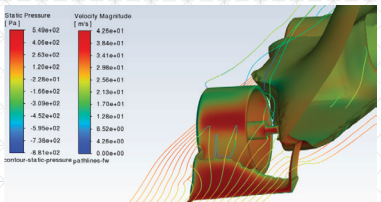
2 Transition to CFD Analysis

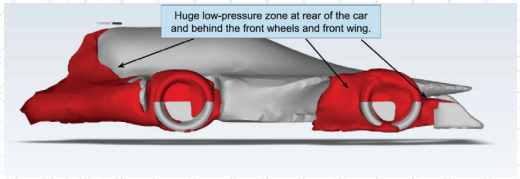




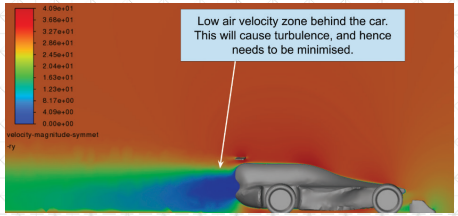
With our initial models ready, we proceeded to CFD testing using Ansys Fluent, assisted by University of Southampton Malaysia. Since CFD software requires meshable models, we exported our Blender designs as STL files and converted them to STEP files using the T-Spline function in Fusion 360. These STEP files were then imported into Ansys Discovery for preparation before running simulations in Ansys Fluent.

The simulations applied an inlet velocity of 30 m/s and an angular velocity of 2000 rad/s for all 4 wheels to mimic race conditions.





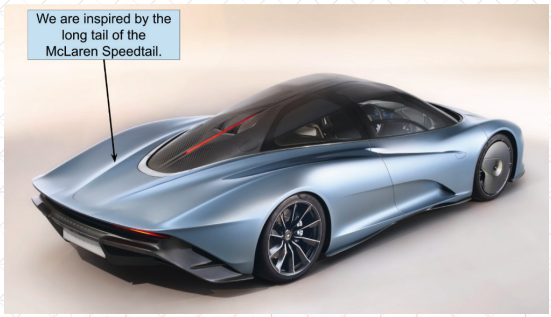
Iso-Pressure Zones: These zones (graphed out in image above) indicated inefficiencies in airflow around the car body, particularly due to the wake of the car. Notable iso-pressure zones were observed behind the front wing, behind the front wheels, and especially at the rear of the car.



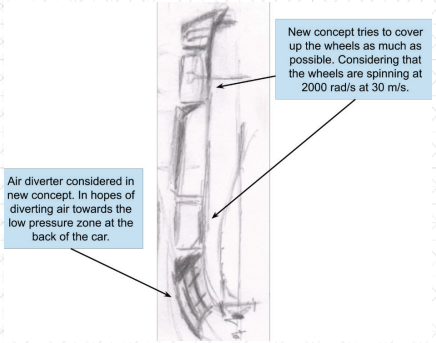
The analysis revealed several weaknesses:

1. Airflow into Wheels: Contour path lines indicated that airflow tended to enter the wheels, creating significant drag. Our per-component analysis showed that the front wing contributed to 70% of the total drag (47.68 mN). Additionally, the wheels, spinning at 2000 rad/s, exacerbated drag due to air bouncing around them.
2. Iso-Pressure Zones: These zones indicated inefficiencies in airflow around the car body, particularly due to the wake of the car. Notable iso-pressure zones were observed behind the front wing, behind the front wheels, and especially at the rear of the car.

3 Design Iterations: Version 3



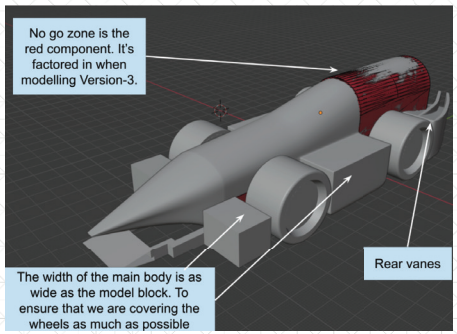
To address these issues, we focused on minimising the wheels' exposure to airflow. Inspired by the tail design of the McLaren Speedtail, we incorporated a longer tail with a gradual slope behind the rear wheels. This aimed to even out the airflow, reducing turbulence by allowing air to fill the area more gradually, thereby reducing iso-pressure zones at the rear.

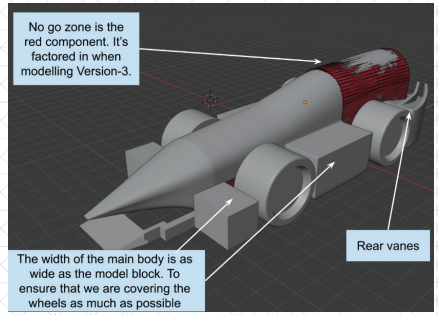


We also introduced air vanes (diverters) to direct airflow to the low-pressure recirculation zone in the rear middle of the car, further minimising turbulence. Concept art for Version 3 was created, showcasing the long tail design and the coverage of both front and rear wheels as much as regulations allowed. We then utilised this concept art directly within Blender to assist in the modelling process.

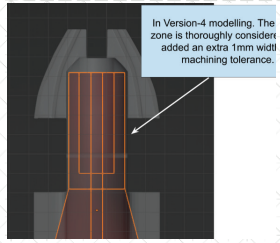
Using concept art within Blender to assist in modelling

3 Adhering to Regulations: Version 3 Onwards



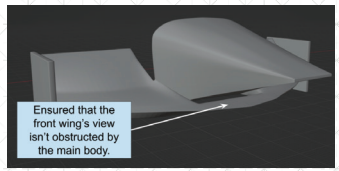


From Version 3 onwards, we began factoring in the actual model block and no-go zones as specified by the competition rules. We ensured that the front wheels were covered up to a maximum of 20 mm from the bottom of the track and maintained a 3 mm exclusion zone around the wheels, as per the regulations.



To meet no-go zone regulations, we pushed the entire car forward to retain the tail

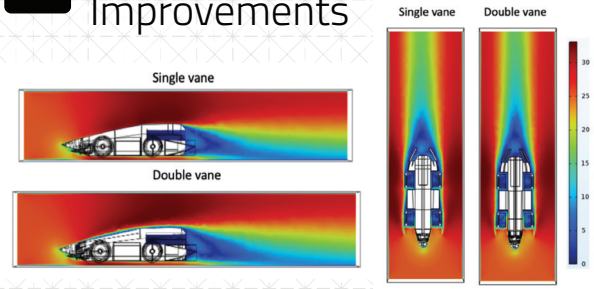
In Version 4, we maintained the long tail design but became more rigorous with regulatory compliance. To meet the no-go zone regulations, we adjusted th entire car forward, allowing us to retain the tail at the car's end while complying with the rules. We meticulously ensured that all aspects of the car met the regulatory requirements.



However, we strategically decided to accept a 5-point penalty related to the front wing chord length (Rule D7.9). Redesigning the front section to comply fully would have resulted in a structurally weaker and less aesthetically pleasing front wing. We deemed the penalty acceptable to maintain the integrity and performance of our design. Most importantly, we ensured that the front wing did not obstruct any other components of the car (e.g. main body).

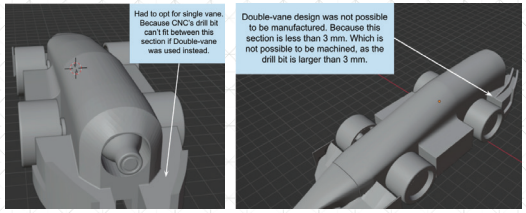
Due to the increased complexity of Version 4 compared to Version 2, we needed to remesh the STL file using Autodesk Netfabb before converting it to a STEP file with Fusion 360's T-Spline function.

4 Final CFD Testing and Improvements

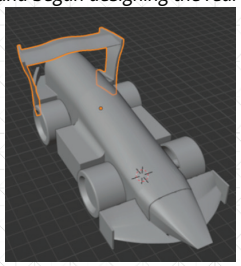


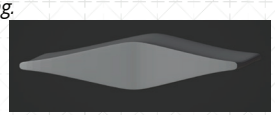
We conducted further CFD tests using the same setup as before. The results showed a significant reduction in drag:
- Version 2 Drag: 47.68 mN
- Version 4 Drag: 29.52 mN (single vane diffuser)
- Version 4 Drag: 30.36 mN (double vane diffuser)

These CFDs conducted using the Comsol fluid modulus indicate a substantial reduction in turbulence. The side profile of the air velocity graphs confirmed that our design modifications effectively minimised turbulence compared to Version 2.



Initially, we designed a triple vane rear diffuser, but material constraints and potential airflow disruptions limited us to single and double vane configurations. A double vane design required vanes only 20mm thick, risking breakage with our polyurethane car body. To mitigate this, we opted for a single vane diffuser with a 30mm thickness for Version 5. Once the design was finalized, we prepared the files for CNC machining and began designing the rear wing.





Cross-sectional profile of Rear Wing

<--- Final Version 5 car with rear wing

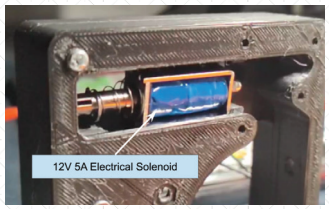
Once the main body and front wing are finalised, we worked on the rear wing. The rear wing was designed primarily for aesthetic purposes and to comply with competition regulations, as additional downforce was unnecessary for a straight-line race. The rear wing features a flat profile cross-section and complements the overall design of the car.

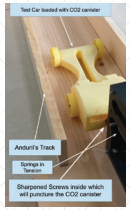
Finally, we sent our finalised design files to Nosco Asia for CNC machining. Concurrently, we used resin printers at UoSM to produce components like the front and rear wings.

Manufacturing

To save money for our school from buying the official expensive Denford Webshop equipments. We took on the ambitious task of manufacturing our own gas launcher, track timer system, and a 20-meter racing track to simulate race conditions accurately.

Gas Launcher



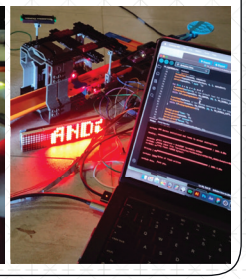


Our gas launcher was 3D-printed using PLA material, following a design courtesy of @TeachingTech on Printables.com. Key features of the gas launcher include:
- High-Tension Springs: Ensure rapid activation and consistent propulsion of the car.
- Sharpened Screw: Acts as a puncture mechanism for the CO_2 canisters.
- Electric Solenoid Integration: Allows for electronic control through the press of a button, providing precise timing and synchronisation with the timing system (mimicking the official Denford system).

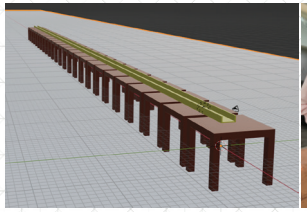
After assembly and testing, the gas launcher performed successfully, meeting our requirements for race simulations.

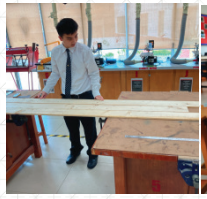
Track Timer System

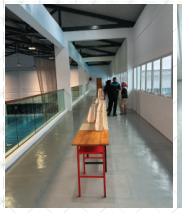
To accurately measure the performance of our car, our Electronics Engineer prefabricated a track timer system using an Arduino microcontroller paired with laser sensors and photoreceptors. The system was programmed in C++, enabling precise detection of the car's start and finish times, thus allowing us to gather essential data on speed and acceleration.



20m Track







We constructed a 20-metre track using pine wood through the following steps:

1. Design: Sketched and designed the track layout in Blender for ease of manufacturing and coordination with the Estates team.
2. Cutting & Sanding: Cut pine wood to required dimensions using a jigsaw and table saw, then sanded with orbital sanders while wearing safety goggles and aprons.
3. Track Connectors: Fabricated joints by modifying stainless steel brackets to securely connect track segments, ensuring safety gear was worn.
4. Assembly: Applied adhesive to join track sections and collaborated with Marlborough College Malaysia's Estates team to carry and assemble the track and tables.

With assistance from the Estates team, we assembled the track and tables in our designated testing area, repurposing unused old tables from MCM to promote sustainability.

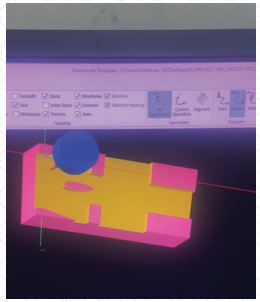
Finishing Touches

We painted the pinewood track to enhance its appearance and protect against Malaysia's humid conditions. Custom decals were added to personalize the track and promote our team branding.

Car Manufacturing

Nosco Asia facilitated our collaboration with a third-party CNC machining service in Larkin, Johor Bahru. Working closely with their team, we built the CAM file based on the STEP file of our final car design.

- CNC Machining: Precisely cutting the car's body from the specified material using computer-controlled equipment. We've assisted the 3rd party provider "Sticker Shop@Larkins, JB" with Mastercam and Fusion 360. To guide him with the process of machining our car.
- Sanding: Post-machining, we sanded the car's surface to eliminate any rough edges or imperfections.



Mastercam software. We guided the 3rd party Nosco Asia's CNC provider over Whatsapp on how to CNC our car, and the requirements.

Priming and Painting: To prepare the car for painting, we applied six layers of primer, meticulously alternating between spraying and sanding each layer. This iterative process ensured a smooth surface that minimizes the drag coefficient, providing an ideal foundation for the final paint.

- 3D printed front wing: We've used the resin printers of University of Southampton to facilitate the printing of our front wings and rear wings.
- Assembly: We've used adhesives to attach components such as the front and rear wings.
- Final Painting and Sticker: The car is then spray painted to metallic black. However, applying the sticker will be an outstanding task, as of 2/10/2024. But we will be applying our team colours and sponsorship stickers to align with our branding.

Through this meticulous process, we aimed to produce a car that not only meets the competition's technical specifications but also embodies our team's dedication to excellence in engineering and aesthetics.

Team Roles & Responsibilities

About Us

Our team, Andúril Racing, is composed of six dedicated members, each bringing unique skills to the table:

Shi Hao Ng: *Project Manager & General Engineer – Oversees project coordination with all stakeholders, technical lead for CFD and car design, and manages track manufacturing tasks.*

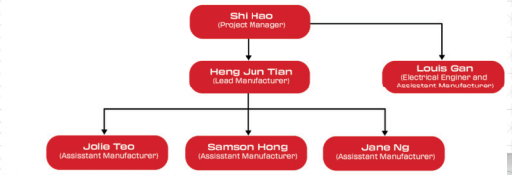
Louis Gan: *Electronics Engineer & Lead Graphic Designer – Designer for brand identity such as logos, merchandise and banners, and develops electronic systems for testing the car.*

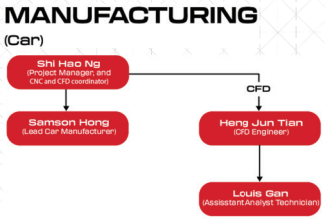
Samson Hong: *Design Engineer – Leads the car manufacturing and CAD modelling process, and ensures high quality Blender animation & rendering.*

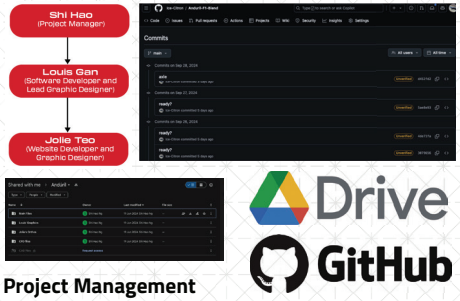
Jolie Teo: *Web Designer & Graphics Designer – Develops and maintains our team's website and creates graphics materials, also assisting in manufacturing and sponsorships.*

Hengjun Tian: *CFD Engineer & Manufacturer – Conducts Computational Fluid Dynamics (CFD) with Ansys Fluent and implements the track manufacturing process.*

Jane Ng: *Concept Artist & Sponsorship Manager – Creates concept art for car and manages sponsorship outreach and relationships.*







Drive

GitHub

Project Management

Effective communication and coordination are the backbone of our project management strategy. While each team member has clearly defined roles, flexibility is maintained as members step into different responsibilities when needed to ensure smooth progress and efficiency.

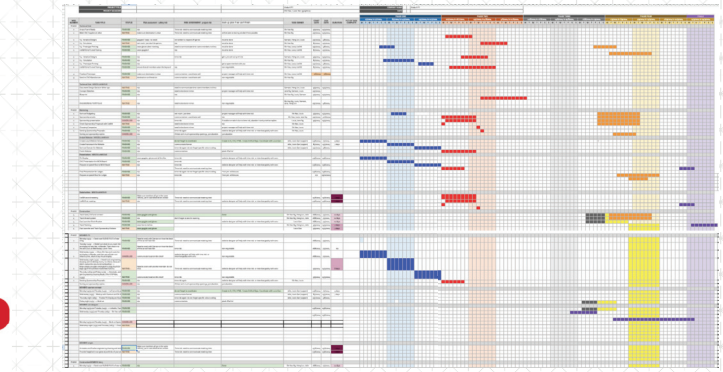
Google Drive: *Acts as our centralized repository for all documents, facilitating real-time collaboration and easy access for every team member.*

GitHub: *Utilized for storing larger files such as CAD models and website code, ensuring robust version control and seamless updates.*

Emails: *Serve as the primary method for assigning tasks, sharing detailed information, and communicating daily goals.*

Instant Messaging (Instagram Messages): *Preferred during holidays for quick communication. During regular school days, we alternate between Instagram messages and emails based on accessibility and convenience.*

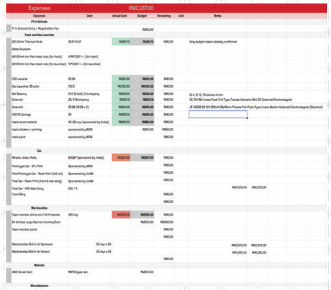
Instagram Calls: *Employed for emergency meetings and real-time collaboration, especially when team members are working remotely.*



Gantt Charts (Google Sheets): Used to outline task expectations and deadlines, providing a clear timeline and efficient progress tracking. Our Gantt Charts include:

Job Descriptions: Clearly define each task and responsibility.
Job Status: Track the progress of each task.
Time Remaining: Monitor deadlines to ensure timely completion.
Potential Safety Risks: Identify necessary Personal Protective Equipment (PPE) for each task.
Risk of Timeline Delays: Assess the likelihood of delays and prepare backup plans. For example, on October 2, 2024, when Jolie fell ill last minute, causing a portfolio submission delay, we activated our backup plan by adjusting our schedule the following day to accommodate the change.

In-Person Meetings: Conducted for group work and tackling complex tasks, leveraging the productivity and clarity of face-to-face interactions.



Expense Tracking (Excel Sheets): Managed all expenses and finances using Excel sheets, ensuring transparent and accurate financial oversight.

Emails: The project manager often reaches out to teammates to distribute work and to communicate what each member should get done for the day.

We purchased custom email domains for our team for a streamlined electronic mail experience as well as a professional look when sending sponsorship requests via email.

Team Identity

Name Background

Our team name, Andúril, is inspired by the legendary sword from The Lord of the Rings. Reforged from the shards of Narsil, Andúril symbolises hope, renewal, and leadership in times of adversity. It serves as a powerful emblem of unity and strength, reflecting our team's commitment to overcoming challenges and striving for excellence.

Colours

We selected a palette of red, silver, and black to represent our team:
Red: Symbolises passion, energy, and speed, embodying the core values of Formula 1.
Silver: Represents precision, technical excellence, and innovation, highlighting our engineering prowess.
Black: Adds contrast and sophistication, enhancing the overall aesthetic of our design.
These colours were chosen based on extensive research and a team-wide questionnaire, ensuring they resonate well with our brand and are visually appealing.

Typography

Our chosen font, Transducer Extended Bold, conveys confidence and power. Its streamlined design mirrors the sleek form of Formula 1 cars, emphasising precision and high-tech performance. The metallic texture of the font enhances its high-tech, engineered aesthetic, aligning seamlessly with the advanced dynamics of racing.

The Andúril logo features the team name seamlessly integrated along a sword blade, symbolising the unity between our team and its legendary inspiration.

Team Motto

"Per Aspera Ad Astra"

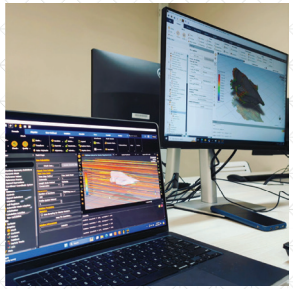
Our team's motto, "Per Aspera Ad Astra," embodies the essence of our journey and aspirations in the F1 in Schools competition. This Latin phrase translates to "Through Hardships to the Stars," reflecting our commitment to overcoming challenges and striving for excellence in every aspect of our project.

Uniform

Our team uniforms are designed to showcase both unity and our brand identity. Key considerations in the design include:
Clear and Memorable Branding: Ensures our team is easily identifiable. **Professional Appearance:** Reflects our values of excellence and dedication. **Strategic Placement of Sponsor Logos:** Guarantees visibility and return on investment for our sponsors. **Comfort and Suitability:** Designed to be worn comfortably in Malaysia's humid climate, ensuring team members can perform optimally.

ANDÚRIL

Partnership and Sponsorship



University of Southampton MALAYSIA

Our partnership with the University of Southampton Malaysia allowed us to use their program "Ansys Fluent" to test our F1 in car's model's movement and design. Their research assistance not only helped us save funds but also time. They had also provided us with resin printing equipment, which helped our production of the actual car.

To enhance our design's aerodynamic efficiency, we attended courses with Professor Azam Bakir at the University of Southampton Malaysia (UoSM). These sessions provided a foundational understanding of the Navier-Stokes equations and fluid dynamics principles. Recognizing that solving Computational Fluid Dynamics (CFD) simulations analytically is impractical for complex designs, we agreed with Professor Bakir's assessment to focus on computational methods and fluid flow theories. Concepts such as how holes lead to suction and how low-pressure zones lead to turbulence became central to our design considerations.

Henley Business School MALAYSIA

University of Reading MALAYSIA

We worked on the business aspects with UoRM and most of these include the sponsorship proposal. Although our sponsorship proposal wasn't as successful as we wished for it to be (as we only managed to receive Nosco Asia's support), we wish to flesh it out further and try out a different technique for the nationals. They had also helped us with project management after advising our project manager to try "Gantt Chart" to distribute tasks and communicate deadlines; and dealing with issues such as conflict between team members; also when we were forced to remove a member due to the severe lack of contribution.

[redacted] – but I would like to add that I am over the moon that this F1 is getting some traction (pun intended!) at MCM – so, both in terms of estates helping to secure the track (as required) in the SS Sports Hall Balcony and the support for setting up an appropriate accounting facility etc. – this all has my support/approval etc.

All the best,

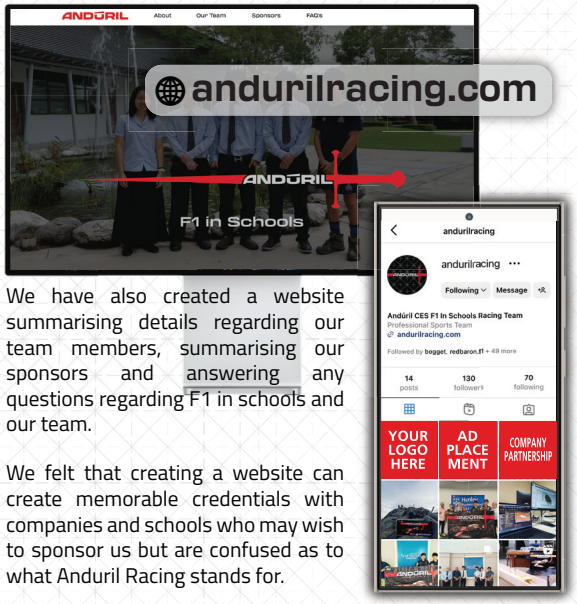
Simon

MARLBOROUGH COLLEGE MALAYSIA

Return on Investment

We have laid a strong foundation for future participants in F1 in Schools, not just at MCM, but in Johor. By building our own track, gas launcher and electronics timer system, we saved the school approximately **MYR 42,000**, excluding *30% import duties and taxes*. Considering their sponsorship of just MYR 6,000, this is a substantial return on investment for Marlborough College Malaysia.

Most importantly, we firmly believe that, because of us, because of our manufacturing of the track, gas launcher, and track timer system. We had laid out a strong foundation for many future teams from MCM to join the F1 in Schools programme.



We have also created a website summarising details regarding our team members, summarising our sponsors and answering any questions regarding F1 in schools and our team.

We felt that creating a website can create memorable credentials with companies and schools who may wish to sponsor us but are confused as to what Anduril Racing stands for.

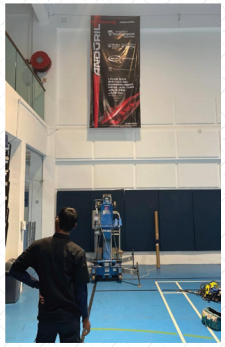
Nosco Asia
Hot repair specialist

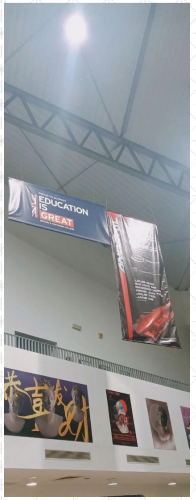
Nosco Asia Sdn Bhd played a crucial role in our manufacturing and marketing strategies. They facilitated our collaboration with a CNC machining service in Larkin, Johor Bahru, ensuring precise production of our car components. Nosco Asia also provided banner printing services and transportation support, which significantly boosted our marketing efforts and outreach campaigns. They had sponsored us **3,200 MYR** for the banner printing and the CNC machining services.

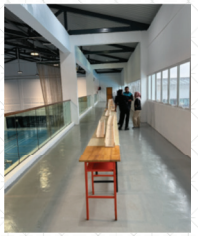
Our social media endeavours ranged from Instagram, later to Linkedin (to establish a professional identity for Anduril Racing) and lastly, Facebook. Our strategy begins with reaching out to familiar faces : we followed familiar people such as our family members, then our relatives, schoolmates and lastly, accounts that are associated with f1. We can help to build awareness on Anduril Racing's participation in F1 in schools and hence potentially gain partnerships. Social media was also a great way of allowing our partners to keep track of Anduril Racing's activities and recent goals.

Our school, Marlborough College Malaysia (MCM), has been our main sponsor for all of our respective expenses of up to 6k MYR.

MCM supported us in many different ways, including providing old desks for our track, allocating estate staff to assist in track manufacturing and moving equipment from one building to another. MCM also allowed us to display banners across the school to advertise. In return, we built a race track and an efficient timing system which is open to any schools established in Johor (to encourage new F1 in schools participants in Johor). Additionally, by reusing desks that were set to be scrapped, we contributed to reducing waste and reusing materials.







MARLBOROUGH COLLEGE MALAYSIA

Mount Kinabalu Teambuilding & Mountain Climbing Trip (4095m)

To advertise Anduril Racing, three of our members went on to hike Mount KInabalu and spread the word regarding Anduril Racing's participation in the competition (to different hikers that we met along the way). Many of our fellow hikers still check on our Instagram till this day.