PROJECT & TIME MANAGEMENT

BLACKWING

OUR **MISSION** & **VISION**

Blackwing has one goal: to revolutionise motorsport through innovative means and shape the future of F1, utilizing our creativity, engineering and teamwork. We also aim to progress STEM education, design F1 car models that will change the sport, and showcase what the younger generation has to offer in the world of F1 racing

TEAM **MASTER PLAN**

Our team master plan provides an outline for each team member's roles, duties and contributions. this technique creates a sense of awareness for each individual, boosting teamwork and responsibility. The master plan was updated regularly every two weeks based on the team's activity reports to reflect the new objectives. This showed us a clear path for team development

ROLES AND RESPONSIBILITIES

Name	Roles
Shashank S.	Team Principal, Social Manager, CFD Tech
Dheeran CH.	Team Identity, CAD Engineer, Graphics
Manvir S.	CAD Engineer, Materials Engineer
Pallav V.	Pit Display Manager, Asst. CAD
Anas M.	Financial Manager, CFD, Asst. CAD
Himani B.	Pit Display Designer, Asst. Social Manager

This roles and responsibilities table was rendered using Markdown. It clearly displays team member assignments for the project.

MARKETING STRATEGY

Blackwing's marketing strategy revolves around digital media, to reach our target audience. Our goal of boosting brand awareness and engagement is reached through social media platforms such as Instagram and Tiktok, or targeted online advertising and influencer collaborations. We also plan to take advantage of data analytics to personalize our advertising or run interactive campaigns that people can actively participate in, creating content that resonates with our target audience, boosting engagement and strengthening our digital presence.

STRATEGIC **BUDGETING**

rchandise		
sey #1	70	
sey #2	70	
sey #3	70	
sey #4	70	
sey #5	70	
sey #6	70	
tal	420 AED	

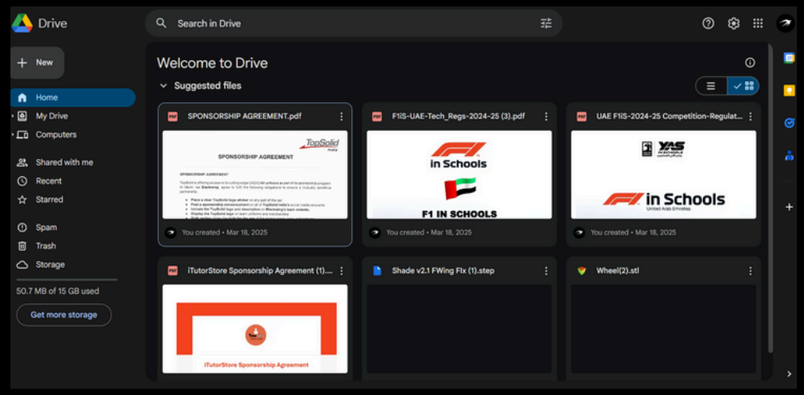
Display		
rdboard	50	Hardware Store
reen		Dubbizle
int	100	Amazon
am	50	BlueRhine
steners	20	Local
ops & Turntabl	0	3d printed
tal	500 AED	

Manufacturing	Cost		Number
Wings	5000 INR	GroundUp Tech.	8 Front, 8 Rear
Main Body (raw)	X AED	YasInSchools	2
Machining	Y AED	FMDIndia	4
F1is official parts	Z AED	Yas in Schools	2
Painting/Finishin	50 AED	Amazon	

Testing and R&D Cost	
CO2 cartridges	70
Testing	190
Travel	Free
Decals	50
Total	310 AED
= 2280 AED	

Budgeting is an important part of our journey because it ensures effective use of resources to achieve our goals. We ensure financial stability and exceptional results for the F1 in Schools competition by carefullly budgeting expenses across materials, marketing, and competition fees.

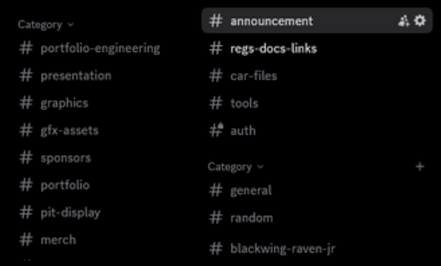
GOOGLE DRIVE



Google Drive enabled team collaboration through its shared document feature which let us jointly edit documents stored in its centralized environment. Nobody on the team experienced outdated versions of documents due to their immediate access to the most recent documents.

DISCORD

The structured channel system of the Discord platform improved both communication and project management as well as idea sharing within our team.

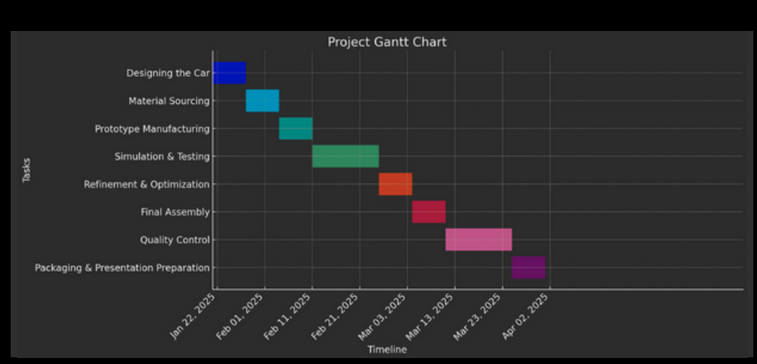


PERT CHART

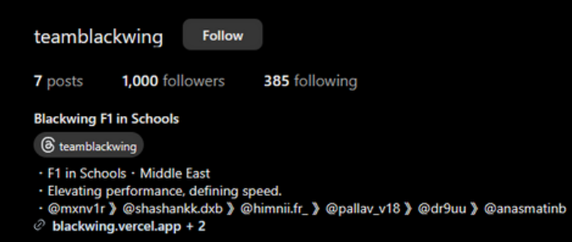
A PERT chart is a useful project management chart for visualizing task dependencies, crucial paths, and estimated time frames on a project timeline. This graphical representation allows for efficient resource allocation, risk reduction, and overall project timeline optimization.

Category	Task	Responsible	Deadline	Progress	Notes Not Nc Not N No Notesnot Not N Not Nc Not Notes Nc Not Notes Not N Not Nc Not Notes
Engineering	Front Wing Refinement	Anas M. / Pallav V.	-	Hold	
	Wheel Manufacturing	Manvir S.	-	Done	
	Ball Bearing Acquisition	Manvir S.	-	Done	
	Rear Wing Optimization	Shashank S.	-	Done	
	3D Printed Components	Anas M. / Pallav V.	-	Done	
	Final Car Rendering	Dheeran CH. / Manvir S.	-	Late	
Team Identity	Logo Evolution	Dheeran CH.	-	Late	
	Brand Color Palette	Himani B. / Shashank S.	-	Done	
	Uniform Design & Production	Dheeran CH.	-	Done	
	Merch Concept Development	Dheeran CH.	-	Hold	
	Social Media Campaign	Himani B. / Shashank S.	-	Done	
	Brand Leaflet Creation	Himani B.	-	Late	
	Design Finalization	Everyone	-	Done	
Pit Display	Acrylic Stand Fabrication	Manvir S.	-	Done	
	Design Input (CAD)	Anas M. / Pallav V.	-	Hold	
	Full Background Print	Himani B. / Shashank S.	-	Done	
	Colored Decal Printing	Anas M. / Pallav V.	-	Done	
	Display Design Execution	Himani B.	-	Done	

GANTT CHART



The development of this Gantt chart through Matplotlib within Python framework served to showcase the project's design along with prototyping phases. Our strategic planning and data analysis abilities are showcased through this chart because it enables effective task duration monitoring and resource allocation tracking as well as complete schedule management.



TEAM IDENTITY

BLACKWING

TEAM **EXPERIENCE**

We are Blackwing, a new team passionate about F1 in Schools and participating in our first year in the competition. The name we have is significant because it stands for strength and dreams to soar high and fight all odds. As wings that spread and fly high we welcome our capacity to struggle and learn, as success is not bound without struggle.

COLOR **SCHEME**

#FFFFFF

#00000

#4D4D4D

For us, it's **black**, **white**, and grey. We wanted something that felt clean and focused, like everything we create. It’s about being simple, making things easy to use, and having a look that’s elegant.

DESIGN CHOICES

To optimize the readability and the performing of our portfolio/logo we tried many different fonts. **Garet** was simple and robust; **Poppins** was elegant and minimalistic; **Horizon** was bold and futuristic. We utilized each font in all of our branding materials in order to give the branding a coordinated and dynamic look.

LOGO **DESIGN**

A first impression is a must when presenting anything in any form, It defines who we truly are and what we do. Blackwing came to designing the logo with a clean and versatile mindset. We wanted to ensure simplicity for uniqueness and a design that captures the spirit of competition while being sleek and modern.

Logo Design **#1:**

Version #1

BW.

In our first design we used horizon, an amazing type-face font with a bird to symbolize speed and stealth. This logo lacked the uniqueness as the font eliminated the originality that we aimed for. Nonetheless, it served as a good base to start on.

Final Logo Design **#2:**

Version #2

The second design built upon this idea with more professionalism and uniqueness, it exceeded our requirements and a pictorial mark ensures it is easy to remember and that it looks clean. The font is still used to denote the name of our team in certain graphics.

TEAM **JERSEY**

Front Veiw

Back Veiw

TEAM **SPONSORS**

TopSolid India

iTutorStore INSTANT TUTORS

We’re proud to present our sponsors; iTutor Store, and TopSolid, showcasing their invaluable support. These partnerships play a crucial role in our journey, and we display their logos with pride and gratitude.

TopSolid, our gold sponsor, provided us their powerful and productive CAD/CAM software and investment that guided us to stride towards success.

iTutorStore, our silver sponsor, provided us with their investment and guidance to push us to the best version of ourselves.

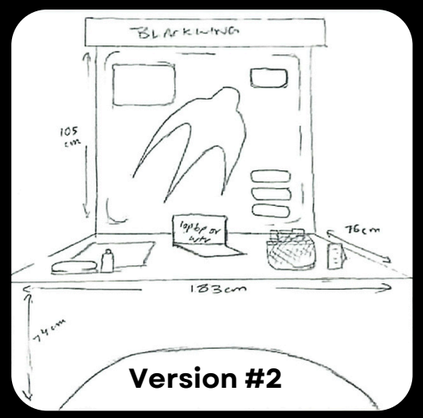
We look forward to the search for more sponsorships in the future to add more support and improvement in our projects.

PIT DISPLAY & CFD ANALYSIS

BLACKWING

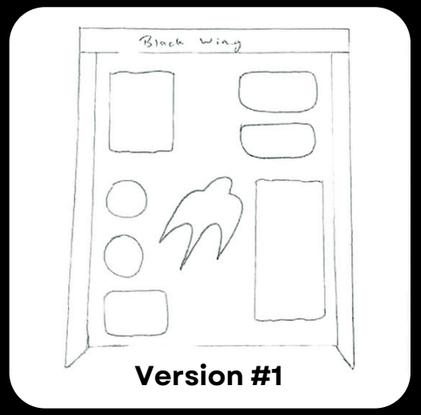
PIT **SKETCHES**

Our first pit sketch enabled us to display as much information as possible without the use of unnecessary accessories.
It is a simple and limited display which shows our teams information and elements in a clean and basic way.



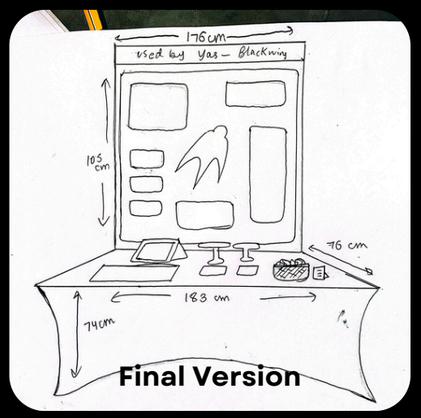
Version #2

Our pit display balances a sleek, informative design. A rotating turntable features our cars, complemented by four clear posters outlining our mission and values. We prioritize sustainability with two minimal-electricity ambient LED lights. We also highlight our team's waste reduction efforts, reinforcing our commitment to eco-friendly practices.

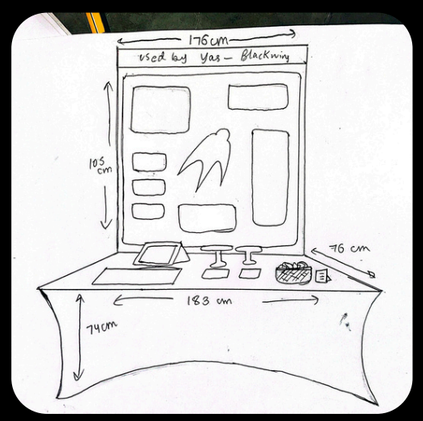


Version #1

Our second display sketch showcases the elements of our team in a more physical form rather than being fully textual. This design makes use of the provided materials to give a efficient and simple display.



Final Version

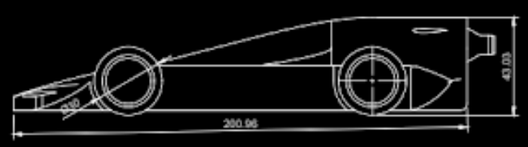


FINAL PIT RENDER

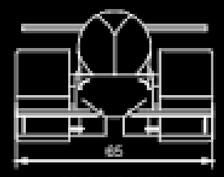
The final pit render delivers an exhaustive view that displays both design and information arrangement of our display interface. Our approach combines visual appealing features with clear communication through methods including a rotating car display and poster arrangements for displaying team work effectively.

CFD **(Computational Fluid Dynamics)**

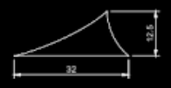
One of the essential aspects for guiding the development process and learning vital insights related without the effort required in making physical prototypes is CFD (Computational Fluid Dynamic) simulations. Our project utilizes Ansys Discovery and Simscale, both being effective softwares for CFD analysis. This allows us to evaluate if our design is inept or effective in the field of aerodynamics, and optimize it to ensure maximum efficiency



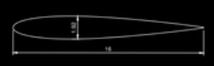
SIDE VIEW



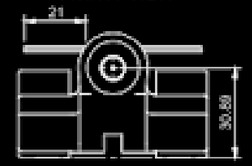
FRONT VIEW



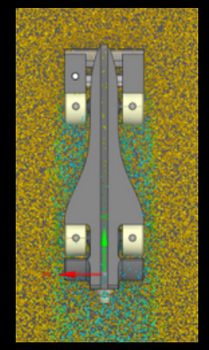
WHEEL COVER



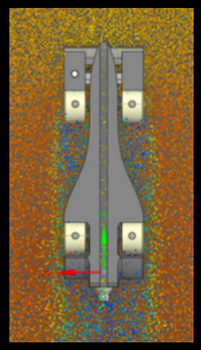
NACA 0012



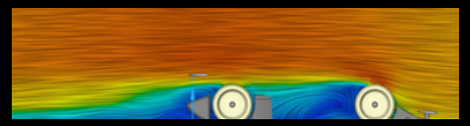
BACK VIEW

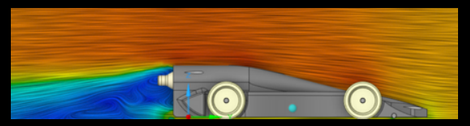


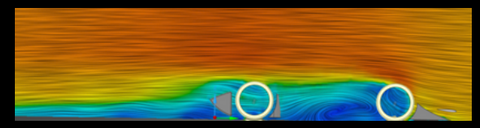
TOTAL PRESSURE



VELOCITY







VELOCITY (RED IS HIGHER)

ENCORPARATING **SDGS**

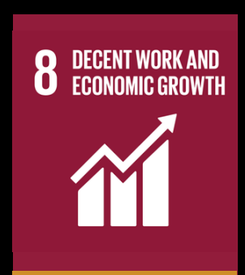
Our team fully supports the link between our project and the United Nations Sustainable Development Goals (SDGs). According to our team innovation requires equal consideration with sustainability benefits. We have included these specific SDGs into our project through this approach:

This goal is about ensuring sustainable consumption and production patterns.

- Using sustainable materials.
- Minimizing waste during manufacturing.
- Designing products for longevity and recyclability.

This goal promotes sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.

- Ethical sourcing of materials from local businesses.
- Ensuring fair and inclusive teamwork.
- Promoting innovation that contributes to economic growth.



This goal focuses on ensuring access to affordable, reliable, sustainable, and modern energy for all.

- Using energy-efficient lighting in our pit display.
- Exploring renewable energy sources for powering our equipment.

This goal focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation.

- Using innovative technologies like CFD analysis to optimize our car's design.
- Improving manufacturing processes to be more efficient and sustainable.

CAR DEVELOPMENT & MANUFACTURING

DESIGN AND DEVELOPMENT

PROTOTYPES

We tested two radically different ideas.

^ Shade. Shaped on aerodynamics, reducing frontal surface area and improving drag results.

Drag: 0.389 N

^ Mono. As barebones as possible and focused on the a COM perfectly aligned with the thrust vector, and being as close to the minimum weight as possible.

Drag: 0.523 N

NOSECONE

- We decided to go for a flat, simple nose cone that included covers for the wheels to minimize drag.

SIDEPODS

- **Curved** sidepods were chosen because they effectively route the wake from the wheels away from the car.
- **Boxed** sidepods increased drag and leaked some of the wheel wake, hence they were not selected.

REARPODS

- Curved rearpods were chosen because the effectively handled the wake and reduced vortex formation. Drag: 0.431 N
- Converging rearpods had a drag value higher than that of the curved rearpods, and the air behind them was turbulent wake. Drag: 0.438 N

WINGS

The NACA 0012 airfoil was chosen, because:

- It fit regulations. A 16mm chord resulted in a maximum thickness of 1.92mm, which fit the regulations and had a margin for dimensional inaccuracies.
- Instead of producing a fixed amount of lift, it produced no lift and could therefore be angled to produce any amount of lift we wished.

FINAL CAR: RAVEN.

FEATURES

- Canister-attached Rear Wing
- Simple front wing
- Curved Sidepods
- Curved Rearpods

- Drag: 0.431 N
- Lift: -0.1 N
- Weight: 60.2 grams

RESEARCH AND ANALYSYS

TIPPING MOVEMENT AND CENTER OF MASS

After observing slow-motion F1is races, we noticed the cars ever-so-slightly tip forwards, during the initial few milliseconds of the race. This can be attributed to the COM and the Thrust vector of the car not being perfectly aligned, causing torque form. This causes a loss in energy, increasing the time it would take for the car to finish the race. In order to solve this, we moved the COM closer to the thrust vector.

Moreover, a COM closer to the front increases overall stability. The faces of the car behind the COM act as vertical stabilizers (similar to those found on aircraft) and increase lateral stability. We improved the COM positioning by using a nose cone made out of PA12, which is denser than PU and moved the COM forwards, quite a bit.

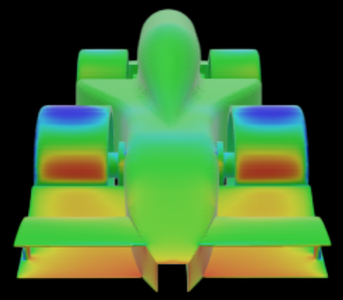
LENGTH

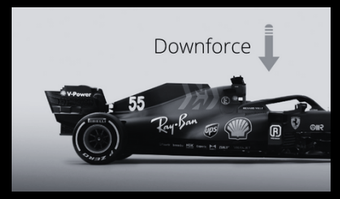
Based on the previous paragraph about COM, we can conclude that the faces of the car behind the COM help improve stability, so we made the car longer.

LIFT COEFFICIENT

In order to acheive minimal drag, we optimized the angle of attach (AOA) of the wings so that the lift co-efficient would be -0.1 Newtons.

The result: a 5 degree tilt on the front wing and a 0 degree tilt on the rear wing.





Downforce

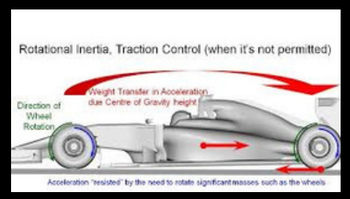
Downforce is the type of downward force that acts upon a vehicle due to the aerodynamic features. This helps the car move forward with greater speeds and provide more grip. However, F1is Cars already have a CO2 canister that is above the COM, so optimizing car geometry for increased downforce is not needed.

Drag

also known as air resistance, is the force that opposes an object's movement through air. This slows down the movement of an object, or in this case, a car's motion, resulting in more effort being put in. It influences the fuel consumption, stability, passenger comfort, and performance of a vehicle.

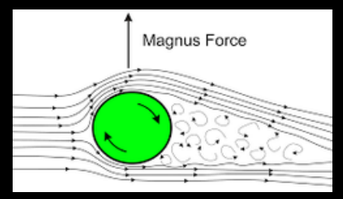
Friction

Friction is the force that resists motion when the surface of one object comes in contact with the surface of another. Friction always works in the direction opposite to the direction in which the object is moving, or trying to move. Friction always slows a moving object down.



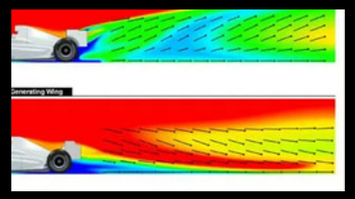
Inertia

Inertia is the inherent property of a body that makes it oppose any force that would cause a change in its motion. **F = ma**. The force F coming from the CO2 is constant. So, the only way to maximize the acceleration from the force F would be to decrease mass m. Thus, we need to make the car as light as legally permitted: which means 60 grams.



Magnus effect

Magnus effect: The Magnus effect occurs when air is deflected by the counter-directional spin of the top half of the front wheel and the directional spin of the bottom half of the front wheel.This creates a low-pressure zone above the center of mass and a high-pressure region at the bottom of the wheel, leading to increased drag and lift.



Wake

The rotating surface of the wheel pulling air into a high pressure region, before being forced sideways. This increases turbulence and drag of the area behind the wheel. Thus, it reduces the aerodynamic efficiency of the components behind the wheel.

KEY DESIGN PRINCIPLES

1. Minimizing Weight
To reduce weight while maintaining strength and performance, optimized designs are to be used.

2. Aerodynamics
Streamlined shapes, flat underbody, wake reducing systems, and optimized wings minimize drag for better speed and efficiency.

3. Stability and Raceworthiness
COG aligned with the thrust vector, durable materials, and reliable joints and adhesives.

4. Following Regulations
Regulations to be viewed while designing the car, designated team member for reviewing regulations.

Designing and Testing

Our primary CAD software is Fusion 360. We chose Fusion because (1) two of our members were already experienced with it, and (2), it allowed us to use parametric modelling.

We used Ansys Discovery to CFD our cars, since it is quick, easy to learn, and provides satisfactory results.

Simscale allowed us to compare drag values of different designs and components, as Discovery seemed to provide inconsistent drag forces. This was crucial for the designs of our critical aerodynamic components.

TopSolid, our gold sponsor, provided us with a copy of their CAD/CAM software. We used their software to simulate machining and verify manufacturability.

Material Choice

- As per the guidelines, the main body must be machined out of Polyurethane.
- The front and rear wings are going to be made out of SLS-PA12. Our main objective was to have sturdy wings that could withstand multiple crashes, while being easily manufacturable.
- Our front wheel covers are also going to be made out of SLS-PA12, in order to move the COM forward.

Material	Manufacturing	Density (g/cm³)	Izod Impact (kJ/m²)	Tensile Strength (MPa)	Young's Modulus (MPa)
Nylon PA12	SLS 3D print	1.01	12.9	53	3000-4000
Accurate X	SLA 3D print	1.19	6-10	38-44	2000-2500
PBT-GF	FDM 3D print	1.32	60	50	1930-3000
ABS-CF	FDM 3D print	1.14	7	111	3200-3300
Foaming PLA	FDM 3D print	0.476	25-30	23.2	2306-2996