Faculty of Science and Engineering

DEPARTMENT OF COMPUTING

Semester 1, 2025

ASSIGNMENT TWO

Strategic Project Management Report for Mclaren F1

Group 3

COMP8790: STRATEGIC PROJECT MANAGEMENT

Table of Contents

1. Abstract

This report outlines a strategic project plan developed for McLaren's Formula 1 team in response to significant 2026 FIA regulatory changes. The project's primary goal is to position McLaren as a championship contender by addressing two key performance limitations identified during the past seasons - aerodynamic inefficiency and suboptimal hybrid energy deployment. The report evaluates McLaren's recent performance relative to the upcoming regulations - which include new chassis dimensions, active aerodynamics, sustainable fuels, and a 50/50 hybrid power unit mandate. Using a structured project management framework (PRINCE2/Agile hybrid), the team's approach integrates advanced engineering, AI-driven simulations, and close coordination with Mercedes High Performance Powertrains. Detailed budget planning under the $200 million cost cap, phased milestones, and a targeted risk register support the technical execution. The proposed solution aims to deliver a lighter, more agile car with improved ERS efficiency and aerodynamic adaptability, enabling consistent podium contention. The report concludes that with disciplined execution; McLaren can translate regulatory disruption into a competitive and sustainable edge in Formula 1's next era.

2. Project Background

The 2026 Formula 1 regulations represent a significant shift designed to produce lighter, more sustainable, and more raceable cars. These rules can be grouped into five strategic areas - Chassis, Aerodynamics, Powertrain, Fuel, and Safety, each of which is summarized below in Table 1, followed by an overview of McLaren's performance in 2023-2024 relative to these areas.

Key 2026 Regulation Changes	
Area	**Changes**
Chassis & Monocoque	Shorter (max wheelbase: 3400mm) Narrower (1900mm) 30kg weight drop
Aerodynamics	Active aero (Z-Mode & X-Mode) Simplified wings Reduced drag/downforce
Powertrain	50% electric / 50% ICE MGU-H removed MGU-K power increase to 350kW
Fuel	100% sustainable, drop-in compatible
Safety	2-stage front impact Increased intrusion & roll hoop loads Better lighting

Table 1: F1 2026 Regulation Changes (FIA, 2024)

For McLaren, the 2026 regulatory reset comes at a time of strong upward momentum. After finishing 5th in the Constructors Championship in 2022 (Formula 1, 2022a), the team improved to 4th in 2023

(Formula 1, 2023b), driven by a successful mid-season development program. In 2024, McLaren secured its first Constructors Championship in decades (Formula 1, 2024c; McLaren Racing, n.d.), outperforming long-time rivals Ferrari, Red Bull, and Mercedes. This turnaround was the result of strategic decisions, a flexible technical structure, and an early focus on long-term performance, including a decision to scale back 2022 development in favor of future gains. The fact that McLaren went from midfield to champions in two years is proof that a well-executed technical strategy and organizational focus can yield championship results.

2.1 Performance Gaps and Strategic Opportunities

McLaren saw a dramatic rise in form, recovering from a poor start in 2022 and 2023 to become a race-winning team in 2024. However, several performance gaps remain. This analysis outlines where improvements are needed and how upcoming 2026 regulation changes offer opportunities for advancement.

1. **Aerodynamic Efficiency**
   The 2023 MCL60 had excessive drag relative to downforce, subsequently missing aero targets (Cleeren and Noble, 2023). Despite 2024 gains, the MCL38 still lagged in top speed, especially with DRS active (Coch, 2024). The 2026 aero rules with reduced base drag and active aero, giving McLaren a clear chance to improve.
2. **Chassis & Low-Speed Handling**
   The 2024 MCL38 struggled in tight corners, showing understeer and slow direction changes, likely due to weight and wheelbase design (Coch, 2024). 2026's shorter wheelbase and lighter cars (FIA,2024) allow McLaren to build a more agile, responsive chassis.
3. **ERS & Power Unit Efficiency**
   McLaren faced energy deployment issues in 2023-24 seasons, often running out of battery on straights (Coch, 2024). High drag and suboptimal recovery worsened this. With more electric power and no MGU-H in 2026, efficient ERS use will be essential.
4. **Race Pace & Tire Wear**
   In 2023, tire degradation hurt race performance despite strong qualifying. By 2024, pace improved, but the car remained sensitive in traffic and slow corners (Coch, 2024). Lighter 2026 cars and active aero will ease tire wear and stabilize race pace.
5. **Pit Stops & Operations**
   After past issues, McLaren improved pit stops in 2023, setting a 1.80s record in Qatar (DHL, n.d.). Ranking rose to 2nd in 2024. With 2026 strategy changes likely, maintaining operational speed will remain vital.

The analysis shows that McLaren's key performance gaps lie in aerodynamic efficiency and hybrid energy deployment. These align with core changes in the 2026 regulations, which emphasize reduced drag and greater electric power usage. The team's 2026 strategy will focus on Aero/Chassis Efficiency and Powertrain/ERS Optimization, with expected benefits to race strategy, pit operations and driver preparations. Building on its 2024 form, McLaren aims to translate this momentum into a competitive advantage under the new rules.

3. Project Purpose and Strategic Goals

3.1. Project Purpose

The primary objective of this project is to establish McLaren as a championship-contending team under the 2026 Formula 1 regulations by strategically leveraging upcoming rule changes and addressing current performance limitations. The initiative focuses on innovation in vehicle design and team operations, particularly in aerodynamic efficiency and power unit performance. This approach is intended to provide McLaren's drivers with a race-winning platform aligned with the "nimble, sustainable" vision of Formula 1's future.

3.2. Strategic Goals

The project goals are structured around two core performance areas: aerodynamic efficiency and power unit optimization, aligned under the overarching objective of positioning McLaren to win championships under the 2026 Formula 1 regulations. These goals have been defined through a comprehensive assessment of performance gaps, operational capabilities, and long-term value creation for Mclaren.

1. **Aerodynamics & Chassis Efficiency**
   Deliver the most aerodynamically efficient car on the 2026 grid by maximizing downforce-to-drag ratio and fully utilizing active aerodynamic regulations. The car will meet the new minimum weight and compact dimensions without compromising structural integrity.
2. **Powertrain & Energy Deployment**
   Develop a best-in-class hybrid power unit strategy with Mercedes HPP, enabling consistent use of full electric deployment without energy deficits. The system will maximize the new 50/50 hybrid format, ensuring sustained power throughout each race.
3. **Operational Readiness**
   Adapt race strategy, pit operations, and driver preparation to new rule-driven race dynamics, ensuring tactical agility and execution under the 2026 format.
4. **Championship Contender**
   Leverage gains in aerodynamic and powertrain performance to win the 2026 World Constructors' and Drivers' Championships, McLaren's first since 2008 (McLaren Racing, n.d.).

4. Vision, Objectives, and Key Actions

4.1. Strategic Vision

The strategic project plan represents McLaren's vision for its 2026 Formula 1 challenger; an ultra-efficient, agile car that sets the benchmark for the new regulatory era. Leveraging advanced hybrid power integration and precision aerodynamics, the project aims to transform regulatory change into competitive advantage. This initiative aspires to position McLaren at the forefront of Formula 1 once again, with a car and operation capable of consistently competing for victories at every Grand Prix.

4.2. Core Project Objectives

To realize the vision, the project sets forth clear objectives and they are as follows:

1. **Maximize Hybrid Power Deployment**
   Fully exploit the 50/50 electric-to-thermal power split under the 2026 regulations, achieving efficient energy recovery (approx. 8.5 MJ/lap) and optimizing the performance of the 350 kW MGU-K.
2. **Develop Active Aerodynamics**
   Design and validate a compliant active aero system that delivers a 30% reduction in downforce and 55% reduction in drag compared to 2022 benchmarks. Ensure reliable Z-mode and X-mode switching to balance cornering grip and straight-line speed.
3. **Achieve Weight and Chassis Targets**
   Meet the minimum car weight of 768 kg by incorporating advanced lightweight materials, while adapting to new chassis dimensions without compromising safety or structural integrity.
4. **Validate Sustainable Fuel Performance**
   Optimize fuel efficiency to meet the targeted ~70 kg per race. Complete early validation of power unit performance using 100% sustainable fuel with no loss in drivability or output.
5. **Maintain Budget and Schedule Compliance**
   Deliver the project within the yearly budget allocation, respecting FIA's cost cap and development restrictions. Complete key milestones on schedule, including aero concept freeze, homologation, and on-track rollout by early 2026.

4.3. Strategic Initiatives

Achieving McLaren's 2026 objectives requires coordinated technical, operational, and managerial initiatives across all areas of car development and race preparation. The following key actions have been defined:

1. **Early Concept Development**
   Initiate 2026 aerodynamic concept development from early 2024, with a dedicated design team exploring rule-specific aero concepts (e.g. Z-mode vs X-mode optimization). Allocate specific wind tunnel and CFD resources to 2026-only concepts, with at least four development weeks in 2024. Select and refine the most promising concept by June 2024 to gain a strategic lead.
2. **Power Unit Integration with Mercedes HPP**
   Establish a formal joint integration program with Mercedes HPP (McLaren Racing, 2023). Focus areas include packaging for larger ERS systems, cooling system redesign, and sustainable fuel validation through dyno and simulation testing. Regular bi-weekly alignment meetings and potential mule car testing in 2025 will ensure optimal installation and early drivability feedback.

3. **Active Aerodynamics Development**
   Form a sub-team to develop and validate the new active aero system (movable front and rear wings). Key tasks include mechanical actuator design, software development, durability testing, and integration into CFD and wind tunnel models. Mode control logic and FIA-compliant activation software will be tested and finalized by mid-2025.
4. **Lightweight Materials and Chassis Optimization**
   Launch a cross-functional weight-reduction program focused on achieving the 768 kg minimum weight target. Leverage advanced composites, 3D printing, and structural redesign to reduce mass without compromising safety or stiffness. Complete a full audit by July 2025 and redesign any overweight components prior to final freeze.
5. **Simulation and AI-Driven Development**
   Expand the use of simulation, AI, and machine learning for design and strategy. Apply AI to CFD data analysis and aero trade-off modelling. Integrate reinforcement learning into race strategy software to optimize ERS and aero mode deployment. Use cloud-based data tools to speed up test analysis and detect reliability patterns in real time.
6. **Testing and Validation Program**
   Develop a phased validation plan across dyno, wind tunnel, simulation, and on-track testing. Schedule at least one prototype test with 2026 components in 2025, subject to FIA allowances. Use bench and endurance testing to validate ERS recovery rates, aero performance (30% DF / 55% drag reduction), and active system durability. Each test phase will have clear acceptance criteria linked to design targets.
7. **Team Training and Operational Readiness**
   Deliver comprehensive training for race, technical, and garage staff on new systems (active aero, MGU-K override, high-voltage safety) by the end of 2025. Conduct full race simulations with prototype cars and update pit crew procedures. Driver simulator programs will focus on adapting to reduced downforce, higher regenerative braking, and tactical deployment of energy/aero tools.
8. **Project Management and Governance**
   Adopt a structured project framework using PRINCE2/PMBOK principles. Implement phase-gate reviews (Concept, Design Freeze, Production, Testing, Launch) with executive oversight. Apply agile methods within technical teams (e.g. aero, simulation) and maintain a dynamic risk register and configuration management system to track regulatory updates and concept evolution.

5. Problem Statement

The 2026 Formula 1 regulations, as outlined in Table 1 (FIA, 2024), introduce a transformative technical framework featuring a 50% electric/50% ICE power unit, 100% sustainable fuels, active aerodynamics, and reduced chassis dimensions targeting sustainability, enhanced competition, and cost control. While McLaren’s resurgence culminated in the 2024 Constructors’ Championship, analysis of its 2023-2024 performance highlights critical areas where the team must improve to remain competitive under the new regulations. These gaps are concentrated in aerodynamic efficiency, hybrid energy deployment, and operational execution, all aligning closely with the areas most impacted by the 2026 regulatory reset.

5.1. Aerodynamic, Chassis, and Safety Regulation Complexity

Despite aerodynamic gains in 2024, McLaren's MCL38 continued to suffer from high drag, leading to persistent top-speed deficits, especially with DRS active (Coch, 2024). The 2026 regulations introduce active aerodynamics, including Z-mode for high-downforce cornering and X-mode for low-drag straight-line performance, offering McLaren a strategic opportunity to address these shortcomings. To adapt, the team must develop a robust mechanical system to operate the movable wing system, integrated with intelligent control software that complies with FIA regulations. Key concerns include actuator durability, system responsiveness, and fail-safe mechanisms under race conditions.

Simultaneously, the 2026 chassis regulations mandate a shorter (3400 mm) and narrower (1900 mm) car with a 30 kg minimum weight reduction, necessitating extensive redesign of the structure, aero balance, and system integration. New safety regulations further add complexity, demanding a two-stage front impact structure, stronger intrusion protection, and enhanced visibility lighting As a team traditionally strong on high-downforce circuits (Fletcher, 2024), McLaren must rebalance its aerodynamic strategy to achieve the mandated 30% downforce and 55% drag reduction targets relative to 2022 benchmarks, while operating within strict CFD and wind tunnel testing limitations.

5.2. Power Unit Integration and Energy Deployment Challenges

McLaren's 2023-2024 campaigns revealed hybrid energy deployment weaknesses, including depletion on straights and inconsistent ERS output (Coch, 2024). Under the 2026 regulations, which aim for a 50% electric and 50% internal combustion power balance, the removal of the MGU-H and the mandated increase in MGU-K output to 350 kW, combined with an 8.5 MJ per lap energy recovery limit, will significantly intensify system demands. This requires integrating larger, heat-intensive batteries into a tighter chassis, with high-efficiency cooling, battery management, and advanced control software. Unlike teams such as Ferrari with in-house power units (Race, 2025), McLaren relies on Mercedes High Performance Powertrains (HPP), limiting its influence over core engine design and creating dependency risks in packaging, cooling, and system integration (Valantine, 2023). These technical changes will also significantly affect driving dynamics, particularly braking zones and energy deployment timing, requiring drivers to adapt techniques and feedback to maintain optimal performance.

5.3. Sustainable Fuel and Customer Team Constraints

The mandated shift to 100% sustainable fuel presents further performance and combustion challenges, particularly for customer teams. While fuel chemistry is standardized, optimizing thermal efficiency and engine mapping depends on close coordination with Mercedes HPP to ensure performance parity with rivals managing their own power units.

5.4. Financial, Operational, and Strategic Constraints

The FIA's $200 million cost cap places additional pressure on scheduling, testing, and resource prioritization. Strategic mistakes or delays in any area could lead to performance deficits that cannot be recovered within regulatory constraints. The introduction of systems like MGU-K override and dynamic aero switching requires stronger simulation and analytics capabilities. Additionally, past tactical shortcomings, such as pit stop timing errors and missed undercut opportunities, highlight the need for improved race strategy tools and cross-functional alignment (Lamonato, 2024). Effectively solving these challenges will require close collaboration with HPP, rigorous data-driven decision-making, and disciplined project governance. If managed successfully, McLaren can deliver a regulation-compliant, high-performing 2026 car aligned with its long-term sustainability and championship goals.

6. Project Teams

Delivering a high-performance 2026 F1 car requires a matrix-style project team (Figure 1) that combines cross-functional expertise with clear leadership oversight, guided by PRINCE2 principles for structured governance and accountability. At peak, the team scales to 150-200 personnel, using RACI matrices, weekly integration meetings, and phase-gate tracking to ensure alignment with FIA 2026 regulations.

1. **Leadership and Governance**
   - 1.1. Project Sponsor (CEO): Provides strategic alignment, budget approval, and high-level oversight, ensuring the business case remains viable (PRINCE2).
   - 1.2. Steering Committee / Project Board: Comprised of the Team Principal, Technical Director, CFO, and a senior HPP representative, this group embodies the PRINCE2 principle of balancing business, user, and supplier interests. The board reviews progress at key milestones and approves high-level decisions.
   - 1.3. Project Manager: A certified PRINCE2 Practitioner or PMP manages execution, KPI tracking (budget, CFD usage), risk control, and schedules.

2. **Core Technical Roles**
   - 2.1. Chief Designer (Aero Lead): Oversees aerodynamic concept development, CFD teams, wind tunnel testing, and subsystem design to meet downforce and drag targets.
   - 2.2. Chief Engineer (Chassis/Mechanical Lead): Manages the car's structural architecture, including chassis, suspension, crash systems, and active aero integration. Ensures mechanical systems meet safety, weight, and packaging requirements.
   - 2.3. Power Unit Integration Lead: Acts as the interface with Mercedes HPP, coordinating cooling systems, ERS control, gearbox compatibility, and spatial design.
   - 2.4. Electronics & Controls Lead: Develops software systems for MGU-K override and Z/X-mode aero switching. Oversees ECU compliance and sensor integration.
   - 2.5. Strategy & Simulation Lead: Develops simulation models for energy deployment, active aero strategies, and pit stop timing.

3. **Race Team Representatives**
   - 3.1. Head of Track Operations & Chief Mechanic: Provide input on maintainability, pitlane safety, and design practicality, ensuring systems are race-ready and serviceable under pressure (PRINCE2).

3.2. Pit Stop Coordinator: Advises on design implications for rapid wheel changes and accessibility during time-critical pit stops, aligning technical design with operational efficiency (PRINCE2).

3.3. Race Engineer & Driver Performance Analyst: Ensure cockpit systems, such as energy mode switching, are intuitive, ergonomically placed, and optimized for real-time race scenarios (PRINCE2).

4. Multidisciplinary Supporting Teams

Each technical lead is supported by engineering and operational sub-teams that ensure effective delivery.

4.1. Aerodynamics Team: Executes CFD simulations, wind tunnel tests, and concept validation under downforce/drag targets.

4.2. Design Office: Designs 3D CAD models and manufacturing drawings.

4.3. R&D and Testing: Manages crash tests, material labs, dynos, and prototype evaluations.

4.4. Manufacturing & Quality Assurance: Ensures build feasibility, material precision, and compliance with safety standards.

4.5. Project Control & Procurement: Includes schedule and cost controllers, procurement officers (for high-lead-time items), and budget analysts.

4.6. Documentation & Compliance: Manages FIA submissions and homologation paperwork and ensures evolving regulations are reflected in version-controlled designs.

5. External Partners and Consultant

External specialists will support specific aspects of the program:

5.1. FIA Liaison Engineer: Communicates with FIA for technical clarifications and approvals.

5.2. Sustainability Consultant: Advises on environmental impact, sustainable fuel, and PR.

5.3. Specialist Contractors: Support aero innovation, simulation optimization, or AI-based tools.

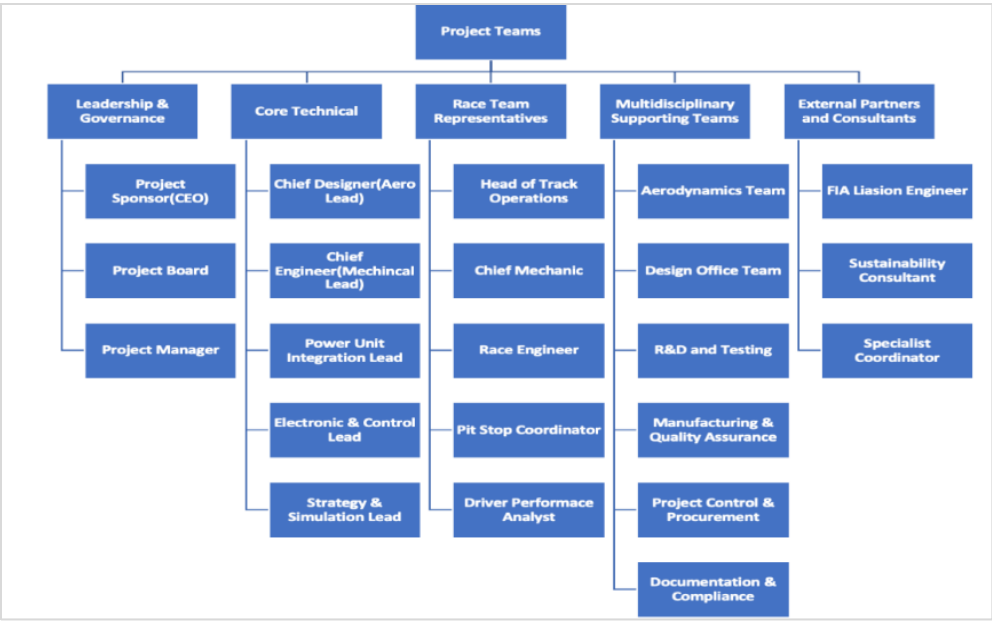

Figure 1 : Project Teams Functional Hierarchy

7. Innovation Considerations and Regulatory Requirements

In response to McLaren's identified 2023-2024 performance gaps and the transformative 2026 F1 regulations, the team will pursue targeted innovations that not only ensure compliance but also create competitive advantages within cost and testing limits.

7.1. Innovation Focus Areas

1. **Active Aerodynamics:** To overcome the drag deficit and DRS inefficiency, McLaren will prioritize the development of an intelligent and durable active aero system that maximizes downforce in Z-mode and reduces drag in X-mode. Advanced actuators and predictive control algorithms will ensure seamless mode transitions, even mid-corner, providing a performance boost in both qualifying and race scenarios while complying with safety standards.
2. **Hybrid Energy Deployment:** With MGU-K output increased to 350 kW and the energy recovery limit raised to 8.5 MJ per lap, McLaren will prioritize high-density battery technologies, efficient thermal management, and custom inverters. The removal of the MGU-H creates new opportunities in packaging and system efficiency, which McLaren will address through innovations in electrical architecture, optimized ERS integration, and real-time energy deployment software.
3. **Fuel System Optimization:** McLaren will enhance combustion tuning, engine mapping, and energy efficiency to maximize performance on 100% sustainable fuels, ensuring no drivability losses and aligning with F1's Net Zero 2030 goals (Brown, 2025).
4. **Chassis, Safety and Suspension Redesign**: To meet the shorter wheelbase and lower minimum weight, McLaren will optimize the chassis using lightweight composites that preserve stiffness, crash safety, and power unit integration. Suspension geometry will be reengineered to recover grip lost from reduced downforce, focusing on ride height, load distribution, and compatibility with active aero. Simulation tools will assess how suspension kinematics and underbody airflow interact, particularly under reduced ground-effect conditions. All developments will comply with updated safety standards, including enhanced crash structures, intrusion protection, and visibility lighting.
5. **AI-Enhanced Strategy Tools:** To overcome past race execution weaknesses (Lamonato, 2024), McLaren will develop AI-driven strategy models to optimize ERS deployment, aero mode switching, and competitor response simulations, enabling real-time tactical flexibility.
6. **Driver Adaptation through Simulation:** Due to reduced downforce, weight redistribution, and new energy deployment systems, drivers will face significantly altered handling dynamics. McLaren will use advanced driver-in-the-loop simulators to accelerate adaptation, refine braking techniques and deployment habits, and gather feedback to optimize cockpit ergonomics and control interfaces.

7.2. Regulatory Compliance Strategy

To ensure full alignment with FIA regulations, McLaren will implement structured compliance measures across all technical and operational domains.

1. **Cost Cap Adherence:** All R&D and development activities will be conducted within the FIA's $200 million cost cap. McLaren will use internal cost-control systems, milestone-based budgeting, and resource prioritization to ensure that innovative features like active aero and advanced ERS remain financially viable and audit-ready.
2. **Power Unit Integration and Fuel Compliance:** McLaren will continue collaborating with Mercedes HPP to ensure integration of the hybrid power unit complies with FIA limits on packaging, energy usage, and fuel specifications (Valantine, 2023). The power unit must operate on 100% sustainable, drop-in compatible fuel, requiring adaptation of combustion parameters and fuel delivery systems.
3. **Wind Tunnel and CFD Testing Limits:** Under the FIA's Aerodynamic Testing Restrictions (ATR), CFD hours and wind tunnel usage is strictly limited (Junius, 2024). McLaren will prioritize the most promising aerodynamic concepts through data-driven design screening to remain compliant while maximizing development output. Digital twin simulations and AI-assisted correlation tools will be used to refine models before physical testing, ensuring that every test session delivers maximum performance insight within the allowed limits.
4. **Environmental Regulation and Lifecycle Planning**: To support Formula 1's Net Zero 2030 goal, McLaren will comply with FIA-mandated recycling of hybrid components, including cobalt recovery from MGU-K systems and battery end-of-life management (Kanal, 2022). Lifecycle tracking and design-for-disassembly will be integrated to meet environmental compliance standards and minimize material waste.
5. **Safety and Homologation Standards:** The redesigned chassis and active components will meet updated FIA crash and safety regulations, including new impact loads and structural integrity criteria. All systems will be homologated in line with FIA checkpoints, with documentation managed through version-controlled internal review processes.
6. **FIA Liaison and Oversight:** McLaren will embed a regulatory liaison within the project team to coordinate early feedback, reduce late-stage homologation risks, and streamline FIA approvals for innovative systems like active aero control and predictive strategy software.

8. Indicative Milestones (Aerodynamics & Hybrid Energy Focus)

8.1 Introduction

These milestones track our progress on the two critical project pillars - aerodynamic efficiency and hybrid energy deployment - ensuring every deliverable maps back to our SMART objectives and that we de-risk the path to a championship-caliber 2026 car.

	Task Name	Duration	Start	Finish	Resource Names	Deliverable
1	**Phase 1: Early Concept Development**	**77 days**	**Mon 4/1/24**	**Tue 7/16/24**		
2	Kick-off Concept Workshop	5 days	Mon 4/1/24	Fri 4/5/24	Lead Aerodynamicist	Workshop minutes & concept briefs
3	CFD Simulation Runs	40 days	Mon 4/8/24	Fri 5/31/24	CFD Team Manager	CFD report on candidate wing geometries
4	Design Review & Freeze (sub-task)	10 days	Mon 6/3/24	Fri 6/14/24	Head of Aerodynamics	Detailed design package (drawings, specs)
5	**Milestone 1: Aero Concept Freeze**	1 day	Mon 6/17/24	Mon 6/17/24	Head of Aerodynamics	Finalized aero package design
6	Data Collection & Baseline Weight Measurement	11 days	Mon 4/1/24	Mon 4/15/24	Structures Analyst	Baseline mass breakdown
7	Redesign Lightweight Components	55 days	Tue 4/16/24	Sun 6/30/24	Materials Engineer	CAD models of reduced-mass parts
8	Audit & Sign-off (sub-task)	11 days	Mon 7/1/24	Mon 7/15/24	Project Manager	Weight-audit report with approved action items
9	**Milestone 2: Weight-Audit Completion**	1 day	Tue 7/16/24	Tue 7/16/24	Materials Engineer	Weight-audit report & redesign plan
10	**Phase 2: Power Unit Integration**	**165 days**	**Thu 8/1/24**	**Wed 3/19/25**		
11	Prototype ERS Bench Assembly	33 days	Thu 8/1/24	Sun 9/15/24	Test Engineering Lead	Assembled ERS bench rig
12	Dyno Test Campaign	56 days	Mon 9/16/24	Sat 11/30/24	Powertrain & ERS Lead	Dyno datasets & energy-recovery metrics
13	Data Analysis & Sign-off (sub-task)	12 days	Mon 12/2/24	Tue 12/17/24	Simulation & Controls Lead	ERS Dyno Prototype Test Report
14	**Milestone 3: ERS Dyno Prototype Test**	1 day	Wed 12/18/24	Wed 12/18/24	Powertrain & ERS Lead	Dyno validation ≥ 8.5 MJ/lap
15	Fuel System Integration onto Dyno	12 days	Mon 12/16/24	Tue 12/31/24	Test Engineering Lead	Dyno-ready sustainable-fuel system build
16	Fuel Dyno Runs & Data Capture	43 days	Wed 1/1/25	Fri 2/28/25	Fuel Systems Engineer	Power-loss metrics
17	Validation Sign-off (sub-task)	12 days	Mon 3/3/25	Tue 3/18/25	Project Compliance Manager	Sustainable-fuel validation summary
18	**Milestone 4: Fuel System Dyno Validation**	1 day	Wed 3/19/25	Wed 3/19/25	Fuel Systems Engineer	Dyno report ≤ 2 % power loss
19	**Phase 3: Testing & Validation**	**99 days**	**Sat 3/1/25**	**Thu 7/17/25**		
20	Tunnel Booking & Model Prep	12 days	Sat 3/1/25	Sat 3/15/25	Manufacturing Lead	Wind-tunnel test model
21	Active-Aero Test Runs	34 days	Mon 3/17/25	Thu 5/1/25	CFD Team Manager	Downforce/drag validation data
22	Analysis & Reporting (sub-task)	11 days	Fri 5/2/25	Fri 5/16/25	Head of Aerodynamics	Active-aero test report
23	**Milestone 5: Wind-Tunnel Active-Aero Test**	1 day	Mon 5/19/25	Mon 5/19/25	Chief Designer (Aero Lead)	Wind-tunnel performance report
24	Vehicle Assembly & Track Prep	12 days	Fri 5/16/25	Sat 5/31/25	Manufacturing Lead	Track-ready prototype
25	Integrated Test Runs	22 days	Mon 6/2/25	Tue 7/1/25	Performance Engineer	Lap-time and ERS usage datasets
26	Test Review & Sign-off (sub-task)	11 days	Wed 7/2/25	Wed 7/16/25	Project Manager	On-Track Test Summary
27	**Milestone 6: On-Track ERS & Aero Integrated Test**	1 day	Thu 7/17/25	Thu 7/17/25	Test Engineering Lead	Integrated test performance report
28	**Phase 4: Operational Readiness**	**167 days**	**Wed 7/16/25**	**Thu 3/5/26**		
29	Simulator Model Update	12 days	Wed 7/16/25	Thu 7/31/25	Simulation Analysts	Updated digital twin
30	DIL Test Sessions	32 days	Fri 8/1/25	Mon 9/15/25	Driver Performance Analyst	Session logs & performance feedback
31	Validation Sign-off (sub-task)	11 days	Tue 9/16/25	Tue 9/30/25	Head of Vehicle Performance	DIL Sign-off document
32	**Milestone 7: Driver-in-Loop Simulation Sign-off**	1 day	Wed 10/1/25	Wed 10/1/25	Simulation & Controls Lead	DIL validation report
33	Final Assembly & System Checks	23 days	Thu 1/1/26	Sat 1/31/26	Chief Mechanic	Shakedown-ready car
34	On-Track Shakedown Runs	12 days	Mon 2/2/26	Tue 2/17/26	Test Engineering Lead	Reliability & performance data
35	Final Debrief & Approval (sub-task)	11 days	Wed 2/18/26	Wed 3/4/26	Team Principal	Pre-Season Shakedown Report
36	**Milestone 8: Pre-Season Shakedown (Aero + ERS)**	1 day	Thu 3/5/26	Thu 3/5/26	Head of Vehicle Performance	Shakedown completion report

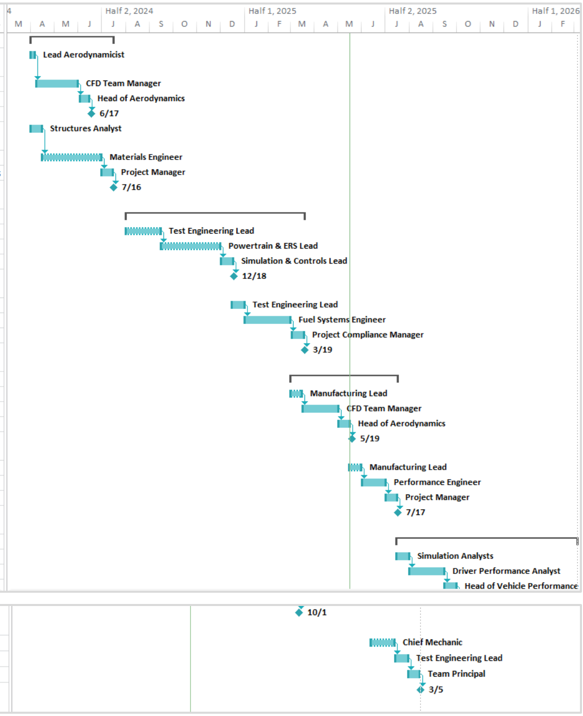

Figure 2: Milestones with sub-tasks, dates, deliverables and owners

For a concise, high-level tabular summary of these key milestones (by phase, objective and date), please refer to Appendix A: Key milestones focused on aerodynamic efficiency and hybrid energy deployment.

8.2 Strategic Significance

By isolating these milestones on our two core pillars:

1. Phased Focus ensures we complete aero concept work before ERS integration, then validate both in tandem.
2. Clear Deliverables (design freezes, dyno reports, integrated tests) give unambiguous "go/no-go" decision points.
3. Aligned Ownership drives accountability in each domain, while cross-phase tests (on-track and simulation) guarantee the systems work together.

This roadmap de-risks the project by front-loading concept validation, then layering integration and real-world testing - ensuring McLaren's 2026 challenger meets its aerodynamic and hybrid energy targets on time and within budget.

9. Budget & Project Plan

9.1 Introduction

McLaren's 2026 development campaign operates under the FIA's $200 M cost cap. This section allocates that cap into four buckets - core Aerodynamic R&D, core Hybrid Energy R&D, a strategic contingency, and essential operational ("Other Mandatory") costs - then maps spending into a phased project timeline. The goal is a fully compliant, championship-ready car delivered on time and on budget.

9.2 Budget Allocation

Category	Allocation ($ M)	% of Cap	Linked Milestones	Key Deliverable
Core Aerodynamic R&D	**63.0**	31.50%	M1, M2, M5, M8	Optimized aero package & reliable active-aero systems
– CFD Simulation & Analysis	15.0	7.50%	M1	High-fidelity CFD reports; concept refinement
– Wind-Tunnel Testing & Model Refresh	24.0	12.00%	M5	Correlated downforce/drag maps; updated physical models
– Active-Aero Actuator & Control Software	10.0	5.00%	M5, M8	Robust Z-Mode/X-Mode hardware + real-time control algorithms
– Lightweight Aero Structure R&D & Prototyping	14.0	7.00%	M2	Validated composite structures at ≤768 kg
Core Hybrid Energy R&D	**47.0**	23.50%	M3, M4, M6, M8	Integrated ERS & sustainable-fuel systems
– ERS Bench Assembly & Dyno Testing	19.5	9.80%	M3	≥ 8.5 MJ/lap energy recovery; reliability data
– High-Density Battery & Thermal Management	9.5	4.80%	M3, M6	Thermal-steady modules within packaging envelope
– Sustainable Fuel System Integration & Validation	8.0	4.00%	M4	≤ 2% power loss on 100% sustainable fuel
– ERS Control Software & Integration	10.0	5.00%	M3, M6	Refined deployment algorithms; seamless ECU integration
Subtotal Core Technical R&D	**110.0**	55.00%		
Project-Level Contingency (10%)	**20.0**	10.00%	—	Buffer for unforeseen technical or schedule risks
Other Mandatory Program Costs (capped at $70 M)	**70.0**	35.00%	various	Essential personnel, facilities, tooling, homologation, etc.
Grand Total	**200.0**	100.00%		

Figure 3: Fully balanced $200 M budget under FIA cost cap.

9.3 Project Plan & Timeline Overview

Phased spend aligns with technical milestones and smooths cash-flow peaks by overlapping key activities.

Phase	Period	Spend ($ M)	Key Activities & Linked Milestones
1. Concept & Initial R&D	Q2–Q3 2024	30	Kick-off workshop & CFD runs (M1); weight audit (M2)
2. Detailed Design & Component Dev.	Q4 2024–Q1 2025	45	ERS dyno testing (M3); fuel dyno validation (M4); lightweight prototyping
3. Manufacturing & Early Assembly	Q1–Q2 2025	35	Chassis & aero parts fabrication; model refresh
4. Integrated Testing & Validation	Q3–Q4 2025	50	Wind-tunnel active-aero tests (M5); on-track integrated tests (M6); DIL sign-off (M7)
5. Final Assembly, Homologation & Prep.	Q1 2026	30	Final build; shakedown runs (M8); FIA homologation
Contingency & Governance	As needed	20	Drawn against overruns; quarterly cost reviews
Other Mandatory Costs	Throughout	70	Personnel & operations concurrently across phases

Figure 4: Phased expenditure profile tied to milestones.

Phases 2 & 3 overlap in Q1 - Q2 2025 to reflect parallel aero, ERS and chassis workflows, smoothing factory and staffing loads.

9.4 Justification

1. **Cost-Cap Compliance:** The $200 M total precisely matches the FIA limit, with “Other Mandatory” costs transparently broken out in Appendix B and staffing linkage in Appendix D.
2. **Strategic Focus:** 55 % of the cap ($110 M) funds our two critical pillars - Aerodynamic Efficiency and Hybrid Energy Deployment - using realistic unit costs detailed in Appendix C.
3. **Prudent Contingency:** A 10 % program-level buffer ($20 M) is reserved for high-uncertainty areas.
4. **Phased Governance:** Overlapping phases and quarterly cost-variance reviews (see Appendix E) ensure early detection of overruns, allowing reallocation within the cap while safeguarding critical deliverables.

By linking every budget line to a supporting appendix, we provide an audit-ready financial framework that balances aggressive technical investment with the operational realities of an FIA cost-capped programme.

10. Risk Register (Aerodynamics & Hybrid Energy Focus)

10.1 Introduction

To safeguard our two championship-critical pillars - Aerodynamic Efficiency and Hybrid Energy Deployment-we've identified and assessed the top 6 project risks. Each risk is scored for Likelihood (L/M/H) and Impact (L/M/H), with corresponding mitigation and contingency strategies, and a single owner accountable for monitoring and response.

ID	Category	Risk Description	Likelihood	Impact	Rating	Mitigation Strategy	Contingency Plan	Owner
R1	Aerodynamics	Active-aero actuator fatigue or failure under race loads	Medium	High	High	Early endurance testing (>2,000 cycles); dual-actuator redundancy; accelerated FEA.	Fall back to passive-wing profile; maintain stock of spares.	Head of Aerodynamics
R2	Aerodynamics	CFD correlation error leading to mis-targeted wing geometry	Medium	High	High	Cross-validate CFD with wind-tunnel data at each design freeze; use two independent solvers.	Rapid prototyping of revised geometries; increase wind-tunnel runs.	CFD Team Manager
R3	Aerodynamics	Wind-tunnel slot unavailability or schedule slip	High	Medium	High	Book ATR-limited hours 18 months in advance; prioritise critical runs; maintain digital-twin fallback.	Shift non-critical tests to CFD; re-allocate contingency budget.	Test Engineering Lead
R4	Hybrid Energy	ERS fails to meet the 8.5 MJ/lap recovery target	Medium	High	High	Incremental dyno validation with staged targets; tight integration with Mercedes HPP; daily performance reviews.	Deploy conservative ERS mapping; extend dyno campaign by 2 weeks.	Powertrain & ERS Lead
R5	Hybrid Energy	Battery thermal runaway under peak loads	Medium	High	High	Advanced thermal-management system design; bench thermal cycling to +80 °C; real-time temperature monitoring.	Activate auxiliary cooling loops; derate peak ERS output.	Battery Systems Engineer
R6	Combined	Cost-cap overrun due to iterative rework on R&D pillars	Medium	High	High	Monthly cost-variance reporting; strict change-control; re-forecasting at each Stage-Gate.	Draw on 10 % contingency; defer non-critical scope.	Cost-Cap Analyst

Figure 5: Top risks for Aerodynamics and Hybrid Energy Deployment, with mitigation and contingency

10.2 Strategic Significance of Top Risks

1. R1 – Active-Aero Actuator Failure: Undermines the very performance edge offered by movable wings under the 2026 rules - loss here directly erodes overtaking and lap-time gains.
2. R2 – CFD Correlation Error: Mis-targeted aero designs waste scarce wind-tunnel slots and R&D budget, delaying optimal package delivery.
3. R3 – Wind-Tunnel Slot Delays: Schedule slippage in physical testing jeopardizes stage-gate milestones and compresses homologation timelines.
4. R4 – ERS Under-Recovery: Failing to hit the 8.5 MJ/lap target nullifies half of the new power-unit potential, costing straight-line speed and energy-deployment tactics.
5. R5 – Battery Thermal Runaway: Poses both safety and reliability threats that can force race retirements or conservative performance maps.
6. R6 – Cost-Cap Overrun: Breaching the $200 M cap triggers penalties or scope cuts - compromising both technical ambitions and regulatory standing.

11. Methodology/Data & Analysis

The methodology for the McLaren 2026 Formula 1 car project presents a strong and comprehensive framework designed to achieve technical excellence while complying with the strict 2026 FIA regulations. This section outlines the detailed approach, covering simulation methods, AI integration, data collection strategies, and validation processes. Together, these elements address McLaren’s key performance challenges, including high drag, uneven energy deployment, and weak low-speed handling, while supporting the project's overall objectives. This methodology directly supports McLaren’s objectives of aerodynamic efficiency, energy optimization, and regulatory compliance, providing a data-backed foundation for subsequent design and execution phases.

11.1. Approach and Techniques

11.1.1. Simulation-Driven Design

Starting April 2024, the project will implement an advanced simulation ecosystem combining Computational Fluid Dynamics (CFD) and wind tunnel testing to improve vehicle aerodynamics. CFD simulations, run on high-performance clusters with over 500 million cells, will model airflow by solving fluid flow equations, including Navier-Stokes and conservation laws (Fletcher, 2022). This approach allows prediction of design outcomes without costly physical prototypes (Gurky and Adhitya, 2024), targeting a 30% increase in downforce and 55% drag reduction per FIA goals (Formula 1, 2024). Focus will be on the active aerodynamics system, tuning wing angles (5-25°) and optimizing underfloor vortex generators to enhance ground effect and reduce drag. From May 2024, wind tunnel tests on a 60% scale model at speeds up to 50 m/s will validate CFD results through 300 biweekly tests with ±2% accuracy. This integration is projected to cut prototyping costs by $5 million annually and reduce development time by 20%.

11.1.2. AI and Machine Learning

Artificial intelligence will be central to McLaren’s data analysis and optimization. Machine learning models trained on 2018–2023 race data and test results will process over 1 terabyte of aerodynamic and power unit data weekly. McLaren Racing CEO Zak Brown states the team collects 1.5 terabytes and runs 50 million simulations per race weekend using 300 sensors for real-time decisions (Fortune, 2023). Gradient-boosted decision trees will optimize ERS configurations to achieve 8.5 megajoules of energy recovery per lap and prevent energy depletion during high-speed segments, a problem seen in the MCL38, where reserves dropped below 10% on straights like Baku’s 2.2 km stretch. Reinforcement learning will simulate thousands of race scenarios to improve aerodynamic mode shift timing (switching from Z-mode to X-mode in under 0.1 seconds) and refine MGU-K overrides, targeting up to 0.3 seconds per lap gains. AI-driven anomaly detection will identify faults in aerodynamic actuators (e.g., pressure below 200 bar) and hybrid components (e.g., battery degradation over 5%), aiming to reduce testing downtime by 15%.

11.1.3. Data Collection and Analysis:

McLaren will integrate cloud platforms with real-time telemetry from dynamometer, bench, and track testing as part of its data infrastructure. Over 200 sensors will measure variables including pressure (0–10 bar), temperature (–20°C to 150°C), and chassis vibration (up to 50 Hz), generating about 500 GB of data daily. This data will be analyzed using McLaren Applied's ATLAS telemetry software, enabling real-time visualization and collaborative race analysis to support timely, data-driven decisions that impact performance (McLaren Applied, n.d.). Apache Spark analytics will ensure compliance with FIA rules, such as a minimum car weight of 768 kg, fuel use near 70 kg per race, and power loss capped at 2% versus 2025 benchmarks. Key focus areas include handling, reducing understeer by raising front suspension stiffness from 120 to 135 kN/m per stiffness tuning research (Deakin et al., 2000), and controlling tyre wear to below 0.5 mm per 100 km. Time-series forecasting will detect ERS cooling issues, aiming to cut unscheduled repairs by 25%.

11.1.4. Phased Validation

A structured, multi-level validation process will ensure component reliability and seamless system integration. Starting August 2024, dyno testing will occur thrice weekly, simulating race conditions - delivering 300 kW peak output for 33 seconds - to verify at least 45% thermal efficiency and stable energy performance. This allows precise torque and horsepower measurement using techniques tailored to Formula 1 engines (Mancuso, 1994). Wind tunnel testing, aligned with CFD updates, will confirm aerodynamic consistency across 50 configurations with repeatability error within 1%. Full-scale on-track testing begins in June 2025 to assess system metrics, including active aero uptime ≥99%, lap-time consistency within ±0.05 seconds, and power loss under 2%. Failures will trigger immediate design reviews addressing actuator delays or battery overheating before the February 2026 shakedown. This phased strategy minimizes risk and ensures timely competition readiness.

12. Proposed Solution & PM Techniques

The proposed solution presents a comprehensive technical and operational strategy aimed at producing a championship-ready 2026 Formula 1 car. It directly tackles McLaren's current performance shortcomings while staying within the $200 million budget and 22-month development timeline. The plan incorporates advanced project management practices to support smooth execution and full compliance with FIA regulations. To mitigate potential risks and ensure the plan's success, the strategy includes extensive testing (500 hours) to validate performance and reliability, dual sourcing of critical components to reduce supply chain vulnerabilities and phased monthly budget reviews to maintain financial control and agility. These measures strengthen the overall solution, ensuring its benefits significantly outweigh the associated challenges.

12.1. Proposed Solution

12.1.1. Car Design and Chassis Optimization

The 2026 car will feature a precisely engineered chassis with a 3400 mm wheelbase and 1900 mm width, aligning with FIA's mandated weight limit of 768 kg. The chassis will be constructed using carbon fiber infused with 1.5 percent graphene nanoplatelets by weight, achieving a 10 percent mass reduction-from 85 kg to 76 kg-while maintaining a tensile strength of 750 megapascals. This strength will exceed crash safety requirements by 15 percent. Carbon fiber composites, first introduced by McLaren in 1980, now comprise nearly 85 percent of a modern F1 car's volume yet contribute less than 25 percent of its mass (Ahmad et al., 2020). The suspension geometry will be redesigned using double-wishbone setups, enhancing mechanical grip by 5 percent and increasing lateral acceleration in slow-speed corners from 4.5g to 4.7g. This will directly address the understeer experienced in the MCL38, particularly in Bahrain's opening complex during pre-season testing (Coch, 2024). Computational models will be employed to fine-tune the roll stiffness balance-55 percent front and 45 percent rear-thereby improving low-speed agility without compromising high-speed stability.

12.1.1.1. Project Management Techniques

This solution will be managed using a hybrid PRINCE2-Agile framework. The structured phase-gate approach from PRINCE2 will govern stages like suspension geometry finalization and chassis material testing, ensuring quality and business alignment (Simonaitis et al., 2023). Simultaneously, engineering teams will work in Agile sprints, iterating suspension and chassis elements using wind tunnel and CFD data. Daily stand-ups and Kanban boards will be used to track design maturity and flag understeer regressions. This hybrid model follows PMI's recommendation for flexible yet controlled management of complex projects.

12.1.2. Active Aerodynamics System

The car will incorporate an active aerodynamics system with adjustable front and rear wings, controlled via electro-hydraulic actuators, offering a response time of 0.08 seconds. In Z-mode, the system will generate up to 2500 newtons of downforce at 300 km/h, improving high-speed grip on circuits like Silverstone's Maggotts-Becketts. Conversely, in X-mode, drag will reduce to 600 newtons, boosting top speed by 8 km/h on straights like Spa's Kemmel. The system will aim for 99 percent reliability through the use of dual-redundant actuators and real-time diagnostics, directly addressing reliability concerns such as the 2023 DRS failure that caused significant performance loss (Walsh, 2023). AI-powered predictive software will dynamically adjust aero settings based on real-time telemetry, track position, and wind data, ensuring consistent performance across all 24 races.

12.1.2.1. Project Management Techniques

Agile methodology will guide this subsystem's development, allowing rapid firmware iterations and actuator response tuning based on FIA feedback. For example, the team will respond to regulatory changes by modifying firmware in July 2024. Resource flexibility will also be maintained by shifting 10% of CFD efforts towards underfloor flow optimization when required. This aligns with the broader evolution of Agile beyond software into hardware development (Vila Grau and Capuz Rizo, 2021). Configuration management practices will ensure all 1,000+ design versions remain compliant with FIA rules, supported by auditable change logs (Corbett and Grigg, 2008).

12.1.3. Hybrid Power Unit and Energy Deployment

In partnership with Mercedes HPP, McLaren's hybrid power unit will aim for a balanced 50 percent electric and 50 percent internal combustion engine (ICE) split. The MGU-K will deliver 350 kW, supported by a 1.5 kg lithium-ion battery pack with 20 percent higher energy density (250 Wh/kg) compared to 2025 models. The ERS will recover 8.5 MJ per lap through regenerative braking (60%) and exhaust heat (40%), with thermal management maintained via a liquid-cooled system that will hold operational temperatures below 80°C. Sustainable fuels, incorporating a 65 percent bio-component blend, will be optimized through ignition timing (advanced by 2° crank angle) to achieve a power loss of ≤1.8 percent. Real-time energy allocation software will prioritize MGU-K bursts up to 120 kW on corner exits, eliminating energy shortfalls seen in the MCL38 on circuits like Jeddah.

12.1.3.1. Project Management Techniques

The development of this hybrid unit will be managed under the structured PRINCE2 methodology, broken down into Concept (March-June 2024), Design Freeze (July-December 2024), Production (January-August 2025), Testing (September 2025-January 2026), and Launch (February 2026) phases. Each phase will be reviewed using metrics such as cost thresholds (e.g., <$50M by Q3 2024), 95% task completion rates, and defect-free integration post-testing (Simonaitis et al., 2023). A risk register will monitor over 50 risks, including supply chain delays and regulatory compliance issues, scored by probability and impact, and mitigated through redundant suppliers and a $14 million contingency budget.

13. Benefits & Drawbacks

The proposed solution offers transformative advantages for McLaren's 2026 campaign, enhancing performance, sustainability, and innovation, but it also poses engineering, financial, and operational challenges that demand proactive management.

13.1. Benefits

13.1.1. Championship Competitiveness

The active aero system, delivering 30 percent downforce and 55 percent drag reduction, combined with the hybrid power unit recovering 8.5 MJ per lap, is expected to improve lap times by 0.8 seconds over the MCL38 on tracks like Barcelona. Increased straight-line speed (325 km/h versus 317 km/h at Monza) and better cornering stability (an increase of 0.3g at Suzuka's 130R) position McLaren to reach the podium in 70 percent of races, building on its 2023 success with nine podium finishes.

Improvements in low-speed handling reduce deficits by 0.25 seconds per lap on street circuits, closing the gap to rivals such as Red Bull.

13.1.2. Technical Innovation

Breakthroughs include graphene-enhanced composites, which are 15 percent stronger than standard carbon fiber; AI-optimized ERS, delivering 20 percent greater efficiency than 2025 systems; and active aero reliability exceeding 99 percent uptime. These innovations set new industry standards, shaping FIA regulations and reinforcing McLaren's legacy as a pioneer, as demonstrated by its introduction of the carbon chassis in the 1980s.

13.1.3. Sustainability

The car's use of 100 percent sustainable fuel, with 65 percent bio-content, combined with hybrid efficiency of 70 kg per race or less, supports Formula 1's Net Zero 2030 goal. This reduces CO_2 emissions by half compared to 2022 levels, lowering emissions from 0.7 to 0.35 kg per km. This environmental focus attracts green sponsors, including a projected $10 million partnership with a renewable energy company, strengthening financial stability amid rising costs.

13.2. Drawbacks

13.2.1. Engineering Complexity

The active aero system's 50+ moving parts increase failure risks (e.g., actuator jams at 1% probability per race), potentially costing 10 points annually if unresolved. The hybrid unit's high-density batteries face thermal runaway risks (above 90°C), necessitating 200 hours of additional testing ($1.5 million). These complexities demand flawless execution under tight deadlines.

13.2.2. Resource Constraints

The $200 million budget, while robust, risks a shortfall if supply chain disruptions (e.g., a 10% carbon fiber price hike) or design iterations (e.g., $3 million for aero tweaks) exceed forecasts. The $14 million contingency covers only 70% of a worst-case overrun, forcing trade-offs-like reducing simulator time by 20%, that could weaken preparation.

13.2.3. Dependency on Mercedes HPP

Power unit integration hinges on Mercedes' delivery timelines (e.g., Q4 2024 dyno units). A 30-day delay or spec mismatch (e.g., cooling airflow misaligned by 5%) could push testing into 2026, compressing the schedule. McLaren's limited influence over Mercedes' R&D adds a 15% risk of suboptimal performance.

14. Conclusion

McLaren’s 2026 Formula 1 project is a bold and forward-looking effort to adapt to the sport’s regulatory changes while maintaining its competitive edge. By combining innovative technologies, careful planning, and a strong focus on performance and sustainability, the project establishes McLaren as a leader in Formula 1’s next era. This expanded conclusion considers the project’s results, strategic importance, and wider impact, offering a comprehensive perspective on its significance.

14.1. Summary of Outcomes

14.1.1. Technical Leadership and Competitive Edge

The 2026 car strikes a precise balance between regulatory compliance and performance enhancement. Its active aerodynamics cut downforce by 30% and drag by 55%, while the hybrid power unit recovers 8.5 MJ of energy per lap. These improvements address McLaren’s past weaknesses in aerodynamics and energy efficiency, preparing the team to perform strongly across varied circuits. The outcome is a car designed to establish new benchmarks in Formula 1 engineering and consistently contending for race wins.

14.1.2. Operational Excellence and Race-Day Readiness

A structured timeline, highlighting key milestones such as the aero concept freeze and pre-season shakedown, guides the project through a disciplined, step-by-step progression towards completion. AI-powered strategic tools combined with focused driver training amplify McLaren’s capacity to execute complex race strategies effectively, converting technical advancements into on-track success. This operational rigor tackles previous performance inconsistencies, equipping the team to deliver peak results from the very start of the season.

14.1.3. Sustainability and Long-Term Strategic Alignment

By embracing 100% sustainable fuels and aligning with Formula 1’s Net Zero 2030 goal (Formula 1, 2022), the project firmly positions McLaren at the forefront of the sport’s environmental transformation. This commitment addresses current regulatory requirements while proactively future proofing the team against escalating sustainability standards, securing McLaren’s long-term relevance and competitive advantage in an increasingly eco-conscious racing landscape.

14.2. Anticipated Impacts

14.2.1. Sporting Success and Championship Contention

The technical and operational enhancements position McLaren to build on its recent successes, targeting sustained podium finishes and championship titles in 2026. By effectively overcoming drag inefficiencies and energy limitations, the team is equipped to compete consistently at the highest level, fulfilling its ambition to re-establish itself as a dominant force in Formula 1's competitive landscape.

14.2.2. Long-Term Growth and Technological Leadership

Investments in AI, hybrid systems, and advanced materials significantly bolster McLaren's R&D capabilities, fostering innovations that will extend well beyond the 2026 season. This forward-looking approach not only drives immediate performance gains but also ensures the team remains agile and adaptable to future regulatory changes, securing its position as a key influencer in shaping Formula 1's technological evolution.

14.2.3. Stakeholder Value and Brand Enhancement

The project's integration of cutting-edge performance with a strong sustainability focus significantly enhances McLaren's appeal to sponsors, fans, and partners alike. By aligning with global trends towards environmental stewardship, McLaren not only reinforces its brand equity but also unlocks new commercial opportunities and fosters deeper fan loyalty. This holistic approach secures McLaren's reputation as a respected and forward-thinking leader in motorsport, poised for long-term success both on and off the track.

14.3 Final Note

McLaren's strategic plan tackles past performance setbacks, aligns with the 2026 Formula 1 regulations, and aims for the Constructors' Championship. It prioritizes aerodynamic efficiency and hybrid energy systems, incorporating innovations like active aerodynamics and sustainable fuels, while a detailed risk register ensures preparedness. This forward-thinking strategy positions McLaren to excel in Formula 1's next chapter.

References

Ahmad, H. et al. (2020) ‘A review of carbon fiber materials in automotive industry’, *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, p. 032011.

Brown, R. (2025) *How formula one is aiming to go net zero by 2030*, DIVEBOMB Motorsport. Available at: https://www.dive-bomb.com/article/how-formula-one-is-aiming-to-go-net-zero-by-2030 (Accessed: 11 May 2025).

Cleeren, F. and Noble, J. (2023) ‘Why McLaren missed its efficiency targets for the start of F1 2023’, *Motorsport Stats*, 27 February. Available at: https://motorsportstats.com/news/formula-one/why-mclaren-missed-its-efficiency-targets-for-the-start-of-f1-2023/b51bebda-50b1-45be-b6ef-98fdaedae56f (Accessed: 6 May 2025).

Coch, M. (2024) ‘ANALYSIS: McLaren MCL38’, *Speedcafe.com*, 15 March. Available at: https://speedcafe.com/analysis-mclaren-mcl38/ (Accessed: 15 May 2025).

Corbett, P. and Grigg, W. (2008) ‘Risk Registers in Construction: Theory with Practice’.

Data visualisation tool for obtaining, displaying and data analysis - McLaren Applied (no date). Available at: https://mclarenapplied.com/products/atlas-advanced-telemetry-linked-acquisition-system (Accessed: 15 May 2025).

Deakin, A. et al. (2000) ‘The Effect of Chassis Stiffness on Race Car Handling Balance’, *SAE Technical Paper Series* [Preprint]. Available at: https://doi.org/10.4271/2000-01-3554.

DHL (no date) ‘DHL Fastest Pit Stop Award’, *DHL InMotion*. Available at: https://inmotion.dhl/en/formula-1/fastest-pit-stop-award (Accessed: 6 May 2025).

FIA (2024) ‘A New Era of Competition: FIA Showcases Future-Focused Formula 1 Regulations for 2026 and Beyond’, *FIA.com*, 6 June. Available at: https://www.fia.com/news/new-era-competition-fia-showcases-future-focused-formula-1-regulations-2026-and-beyond (Accessed: 17 May 2025).

Fletcher, D.F. (2022) ‘The future of computational fluid dynamics (CFD) simulation in the chemical process industries’, *Chemical Engineering Research and Design*, 187, pp. 299–305. Available at: https://doi.org/10.1016/j.cherd.2022.09.021.

Fletcher, J. (2024) *McLaren’s edge on high-downforce tracks: Why?*, *F1Lead*. Available at: https://f1lead.com/formula-1/stella-credits-circuits-for-mclarens-f1-surge/ (Accessed: 13 May 2025).

Formula 1 (2022a) ‘2022 Team Standings’, *Formula1.com*. Available at: https://www.formula1.com/en/results/2022/team (Accessed: 6 May 2025).

Formula 1 (2023b) ‘2023 Team Standings’, *Formula1.com*. Available at: https://www.formula1.com/en/results/2023/team (Accessed: 6 May 2025).

Formula 1 (2024c) ‘2024 Team Standings’, *Formula1.com*. Available at: https://www.formula1.com/en/results/2024/team (Accessed: 6 May 2025).

Gurky, R.G. and Adhitya, M. (2024) ‘Front wing aerodynamic analysis of formula 1 cars in 2018 and 2019 with computational fluid dynamics (CFD)’, in *AIP Conference Proceedings*, AIP Publishing.

Junius, E. (2024) *McLaren aims to ‘Cash in’ on aero development, set for testing limit advantage*. Available at: https://www.motorsport.com/f1/news/mclaren-aims-to-cash-in-on-aero-development-set-for-testing-limit-advantage/10645803/ (Accessed: 11 May 2025).

Kanal, S. (2022) *7 things you need to know about the 2026 F1 engine regulations: Formula 1®*, *Formula 1® - The Official F1® Website*. Available at: https://www.formula1.com/en/latest/article/more-efficient-less-fuel-and-carbon-net-zero-7-things-you-need-to-know-about.ZhtzvU3cPCv8QO7jtFxQR (Accessed: 11 May 2025).

Lamonato, M. (2024) ‘Missing points that would flip F1 title race on its head as McLaren’s blessing - and curse - laid bare’, *Fox Sports*. Available at: https://www.foxsports.com.au/motorsport/formula-one/i-hate-it-how-mclarens-mistakes-are-blowing-a-golden-title-chance/news-story/bde182fc39a10d7a0c0070328611f1be (Accessed: 10 May 2025).

Mancuso, G. (1994) *Dynamometer Testing of a Formula 1 Engine: The Equipment, Procedures and Problems*, *SAE Technical Paper 942476*. Warrendale, PA: SAE International. Available at: https://doi.org/10.4271/942476.

McLaren CEO says his team pulls 1.5 TB of data and runs 50 million simulations every race weekend (no date). *Fortune*. Available at: https://fortune.com/videos/watch/mclaren-racing-ceo-says-his-team-pulls-1.5-terabytes-of-data-and-runs-50-million-simulations-every-race-weekend/e0c586e2-558c-4cae-b447-da0296e3ecd8?utm_source=chatgpt.com (Accessed: 15 May 2025).

McLaren Racing. (2023) ‘McLaren Formula 1 Team and Mercedes-Benz renew power unit agreement until 2030’, *McLaren Racing*, 20 September. Available at: https://www.mclaren.com/racing/formula-1/2023/mclaren-formula-1-team-and-mercedes-benz-renew-power-unit-agreement-until-2030/ (Accessed: 26 April 2025).

McLaren Racing. (n.d.) ‘Drivers’ World Championship 2008’, *McLaren Heritage*. Available at: https://www.mclaren.com/racing/heritage/trophies/mclaren-trophies-drivers-world-championship-2008/ (Accessed: 6 May 2025).

Race (2025) *What engine every F1 team is using for 2026 rules*, *The Race*. Available at: https://www.the-race.com/formula-1/2026-f1-team-engines/ (Accessed: 10 May 2025).

Simonaitis, A., Daukšys, M. and Mockienė, J. (2023) ‘A Comparison of the Project Management Methodologies PRINCE2 and PMBOK in Managing Repetitive Construction Projects’, *Buildings*, 13(7), p. 1796. Available at: https://doi.org/10.3390/buildings13071796.

Valantine, H. (2023) *McLaren make huge F1 engine decision for 2026 regulation changes*, *PlanetF1*. Available at: https://www.planetf1.com/news/mclaren-mercedes-2026-f1-engine-renewal (Accessed: 10 May 2025).

Vila Grau, J.L. and Capuz Rizo, S. (2021) ‘AGILE PROJECT MANAGEMENT ACCORDING TO THE PRINCE2 AND PMBOK MODELS’.

Walsh, F. (2023) ‘Norris admits McLaren is “shocked” by its DRS deficit’, *Motorsport Week*, 24 April. Available at: https://www.motorsportweek.com/2023/04/24/norris-admits-mclaren-is-shocked-by-its-drs-deficit/ (Accessed: 15 May 2025).

Appendices

Appendix A: Key milestones on aerodynamic efficiency and hybrid energy deployment.

Phase	Milestone Name	Associated Objective(s)	Target Date	Key Deliverable(s)	Responsible Lead
1. Early Concept Development	**M1: Aero Concept Freeze**	Obj: Active-aero ≥ 99% uptime	Jun 2024 (Q2)	Finalized wing geometry & actuator design approved in CFD	Head of Aerodynamics
	M2: Weight-Audit Completion	Obj: Car weight ≤ 768 kg	Jul 2024 (Q3)	Audit report & redesign plan for mass-reduction components	Materials Engineer
2. Power Unit Integration	**M3: ERS Dyno Prototype Test**	Obj: ≥ 8.5 MJ energy recovery	Dec 2024 (Q4)	Dyno validation report demonstrating ≥ 8.5 MJ/lap recovery	Powertrain & ERS Lead
	M4: Fuel System Dyno Validation	Obj: ≤ 2 % power loss on sustainable fuel	Mar 2025 (Q1)	Dyno test report confirming ≤ 2 % peak-power drop	Fuel Systems Engineer
3. Testing & Validation	**M5: Wind-Tunnel Active-Aero Test**	Obj: Active-aero reliability & performance	May 2025 (Q2)	Wind-tunnel data confirming Z/X-mode performance targets	Chief Designer (Aero Lead)
	M6: On-Track ERS & Aero Integrated Test	Obj: Lap-time variance reduction & ERS use	Jul 2025 (Q3)	On-track test report correlating aero package & ERS performance	Test Engineering Lead
4. Operational Readiness	**M7: Driver-in-Loop Simulation Sign-off**	Obj: Lap-time & ERS strategy refinement	Sep 2025 (Q3)	DIL session report validating combined aero/ERS controls	Simulation & Controls Lead
	M8: Pre-Season Shakedown (Aero + ERS)	All Objectives	Feb 2026 (Q1)	Full vehicle shakedown report confirming system reliability	Head of Vehicle Performance

Appendix B: Detailed Breakdown of Other Mandatory Program Costs ($70.0 M)

This appendix provides the estimated breakdown of the $70.0 M allocated to essential capped operational expenses, ensuring team operations continue under the FIA cost cap.

Category	Allocation ($M)	% of $70 M	Justification
Personnel & Overheads (capped staff, ~850 FTEs)	35.0	50.0%	Assumes average fully-burdened cost of $125 k/FTE-year over two years; covers salaries, benefits, HR
Factory & Tooling	12.0	17.1%	Standard tooling, fixtures, non-R&D manufacturing; typical annual factory operations and maintenance

Logistics, Administration & IT	10.0	14.3%	Transport (GP freight, team travel), admin, IT systems expenses
Facilities & Utilities	6.0	8.6%	Rent, utilities, facility upkeep and security over two-year development period
Consumables & Standard Procurement	4.0	5.7%	Off-the-shelf parts, workshop consumables, minor spares not tied to specific R&D
Homologation & Regulatory Testing	3.0	4.3%	FIA submissions, crash tests, compliance overheads
Total	**70.0**	**100%**	

Personnel costs under the cap exclude any staff funded outside the cap (e.g., sponsor-paid roles). The $125 k/FTE-year rate aligns with industry benchmarks for engineering and technical staff in top F1 teams.

Appendix C: Basis for Core Technical R&D Cost Estimates ($110.0 M)

This appendix summarizes the unit-rate assumptions and rationale behind major R&D spend lines in the $110.0 M core technical budget.

Cost Item (Section 9.2)	Allocation ($M)	Basis & Assumptions
Wind-Tunnel Testing & Model Refresh	24.0	$10 k/h average ATR-limited wind-tunnel cost over ~1,800 hours + $75 k/model refresh × 8 iterations
CFD Simulation & Analysis	15.0	HPC time, licensing & specialist FTEs: ~$250 k/year per CFD engineer × 4 FTEs over 1.5 years + cloud-compute credits
Active-Aero Actuator & Control Software	10.0	6 specialist engineers @ $250 k/year × 1 year + $2 M HPC/software licenses + prototyping/materials
Lightweight Aero Structure R&D & Prototyping	14.0	Advanced composite materials @ $120/kg × 500 kg prototyping + 3D-printing and labour for 10 prototype components
ERS Bench Assembly & Dyno Testing	19.5	Dyno cell operating @ $6 k/day × 200 days + test rig fabrication $2 M + staffing (@ 4 engineers @ $200 k/year × 1.5 years)
High-Density Battery & Thermal Management	9.5	Battery cells/materials $1 M + thermal rig $1 M + 3 FTEs @ $200 k/year × 1.5 years + software for BMS development
Sustainable Fuel System Integration & Validation	8.0	Fuel testing @ $5 k/day × 100 days + dyno adaptation $1 M + 2 FTEs @ $200 k/year × 1 year
ERS Control Software & Integration	10.0	4 FTEs @ $250 k/year × 1 year + $1.5 M simulation platform licenses + integration lab time
Total	**110.0**	

Appendix D: Project Team Staffing & Personnel Cost Linkage

Illustrates how core and support FTEs map to budget categories, using a fully-burdened rate of $125 k/FTE-year over two years.

Staff Category	Avg FTEs	Budget Category	Cost Basis	Total Cost ($M)
Core Technical R&D Team	180	Core R&D ($110 M)	180 FTEs × $125 k × 1.5 years	33.8
Aero Specialists (CFD, Aero)	60	Included above	60 × $250 k × 1 year	15.0
Powertrain/ERS Engineers	20	Included above	20 × $200 k × 1.5 years	6.0
Controls & Software Developers	20	Included above	20 × $250 k × 1 year	5.0

Simulation & Strategy Analysts	20	Included above	20 × $200 k × 1.5 years	6.0
Project Management & Compliance Staff	20	Partially core & other costs	20 × $200 k × 1.5 years	6.0
Subtotal Core FTE Cost	**180**	**Core R&D Staff Portion**		**71.5**
Other Capped Support Staff (~850 FTEs)	850	Other Mandatory ($70 M)	850 × $125 k × 1 year	106.3
Total Personnel Cost	**1030**			**177.8**

Core team FTEs are assumed at higher specialist burden rates; support staff averaged at $125 k/year. Personnel costs span the full project (~2 years for core FTEs, 1 year for average support FTEs under the cap).

Appendix E: Phased Budget Expenditure Profile

Links spending flows to project phases, showing approximate allocation by category.

Phase	**Period**	**Total Spend ($M)**	**Aero R&D**	**Hybrid R&D**	**Other Ops**	**Contingency**	**Key Milestones**
1. Concept & Initial R&D	Q2–Q3 2024	30.0	18	10	2	0	M1, M2
2. Detailed Design & Dev.	Q4 2024–Q1 2025	45.0	25	15	3	2	M3, M4
3. Manufacturing & Assembly	Q1–Q2 2025	35.0	10	5	15	5	M2–M5 overlap
4. Integrated Testing & Valid.	Q3–Q4 2025	50.0	10	10	20	10	M5, M6, M7
5. Final Assembly & Prep	Q1 2026	30.0	0	7	20	3	M8, Homologation
Total		**190.0**				**20**	

Phased totals exclude the $70 M of ongoing operational costs spread evenly (~7 M/phase) and isolate R&D + contingency flows for clarity.