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Formula 1 Racing Challenge: 2024 Strategy Analysis

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Introduction

On this report you will find…

Simple visualisations to illustrate the main trends in pit stops and tyre strategy, followed by **more sophisticated** visualisations such as the sankey for tyre transition.

Color Code

Data Cleaning: Analyzed all events, carefully averaging data by driver and event for accuracy.

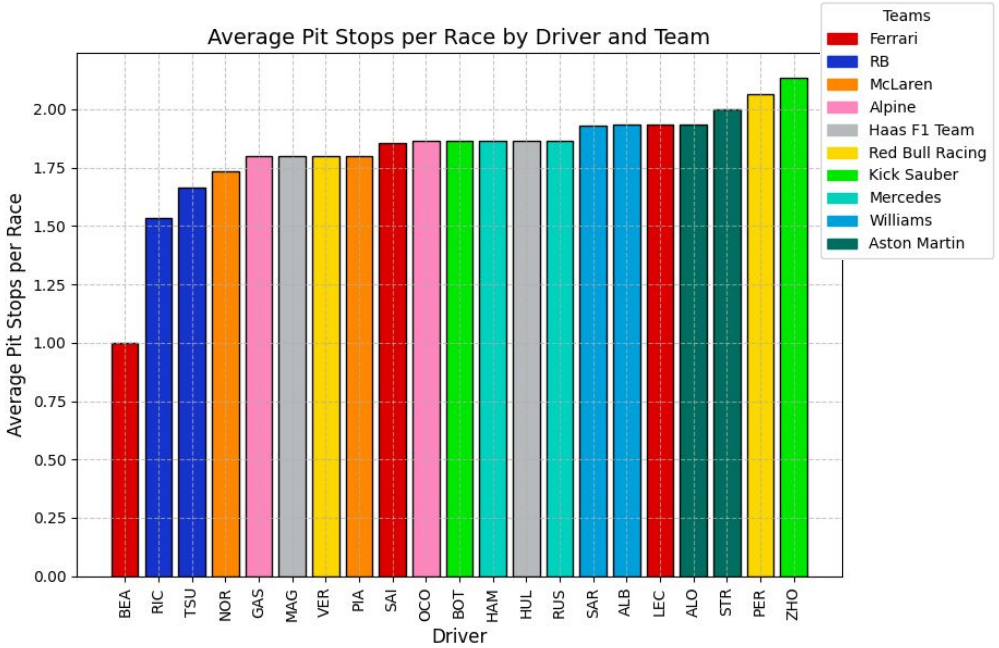
Strategic Insights: You will find some actionable recommendations based on comprehensive data analysis findings.

Data Accuracy Filtering: Applied *isAccurate* filter to ensure lap times are synchronized correctly across laps on certain plots.

Tire Compound Analysis: Explores usage patterns and performance of different tire compounds across various stints.

Exploratory Data Analysis (EDA)

Total Number of Pit Stops

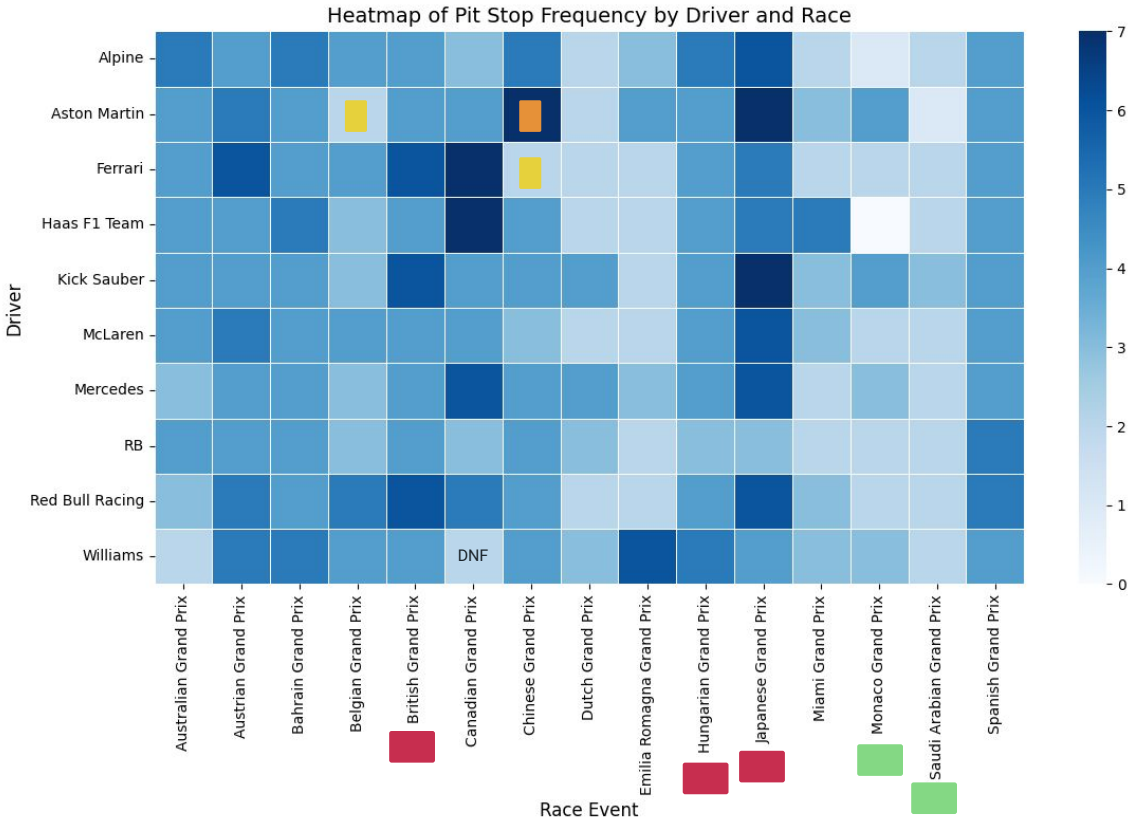


Insights

Drivers from teams like **Aston Martin, Red Bull, and Ferrari** tend to average **more pit stops** per race, indicating they may rely on more aggressive, multi-stop strategies. In contrast, teams like **McLaren, RB and Alpine** employ **more conservative strategies** with fewer stops, possibly prioritizing tire management and fewer pit interventions.

Exploratory Data Analysis (EDA)

Total Number of Pit Stops



Higher Pit Stop Variability by Track, this might suggest that these tracks are **more demanding** on tires or that race conditions frequently lead to more pit stops.

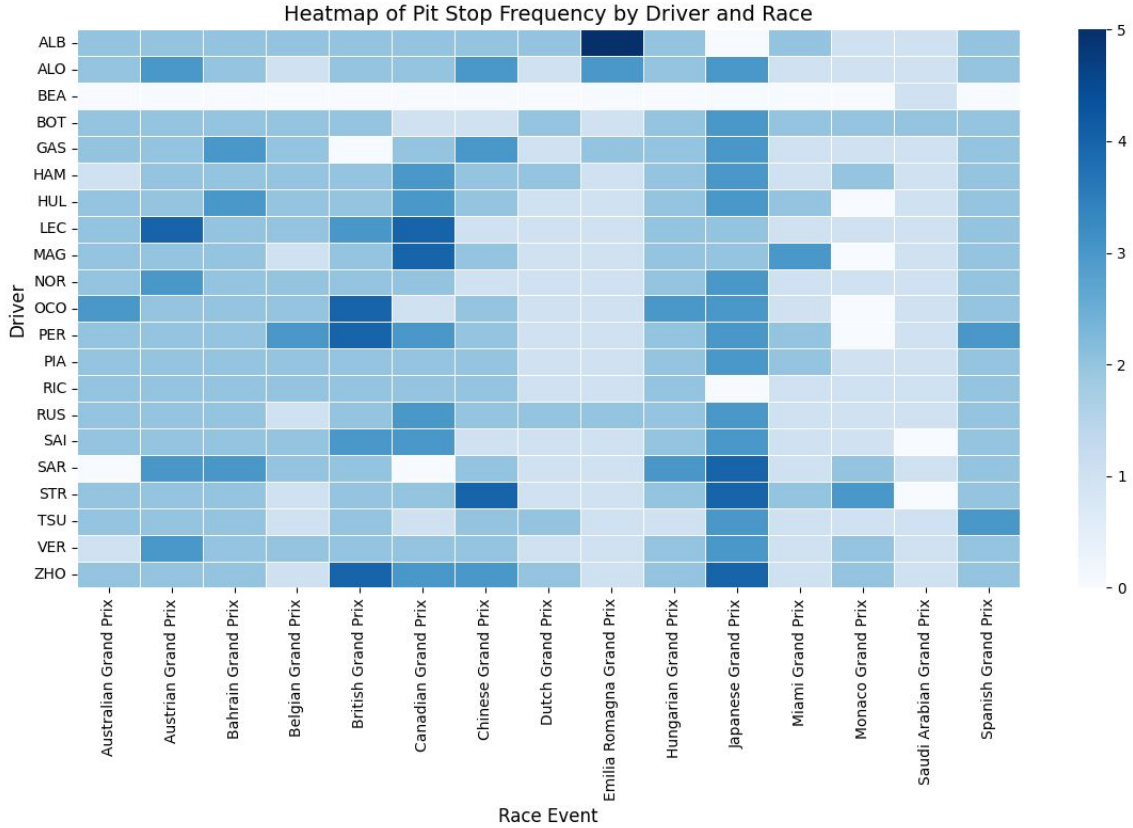
Low Pit Stop Frequencies for Specific Teams, this could imply that these teams adopt more **conservative tire strategies** at certain circuits, focusing on tire preservation.

Monaco and Saudi Arabian Grand Prix reflect the **specific characteristics** of these circuits, where overtaking is difficult, and teams **may prioritize fewer stops**.

Spikes in pit stops deviates from other teams, this suggest strategic changes or challenging conditions during these races.

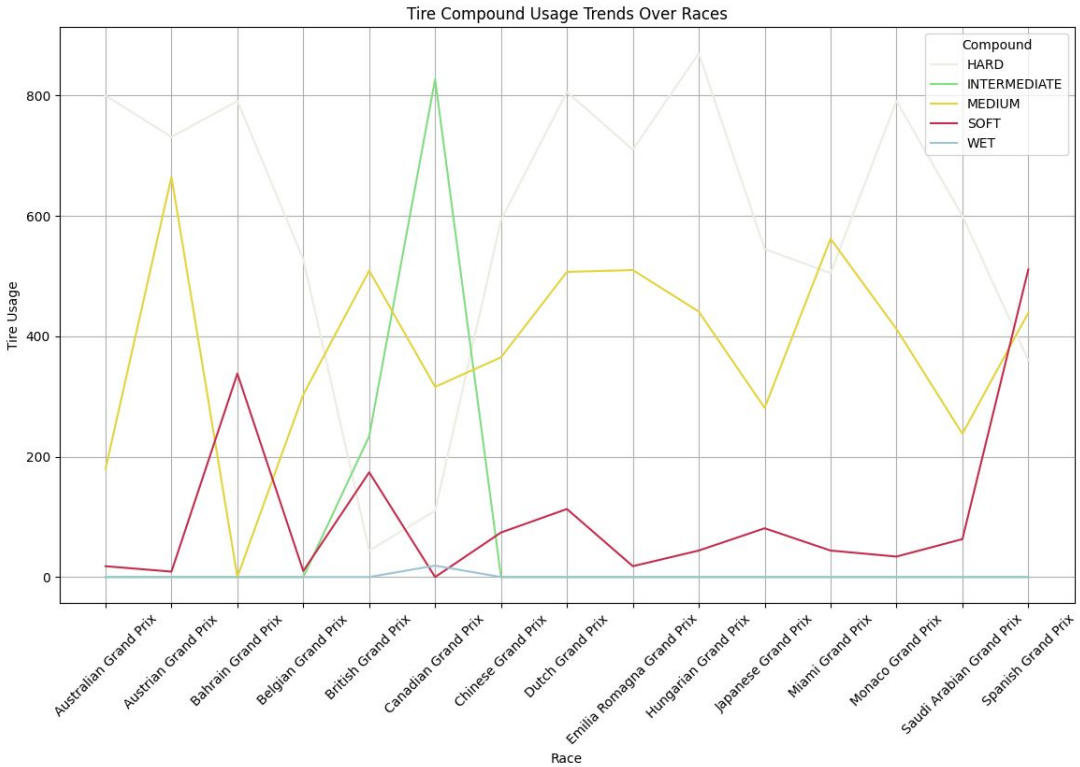
Exploratory Data Analysis (EDA)

Total Number of Pit Stops



Exploratory Data Analysis (EDA)

Tire Compounds Used During the Race

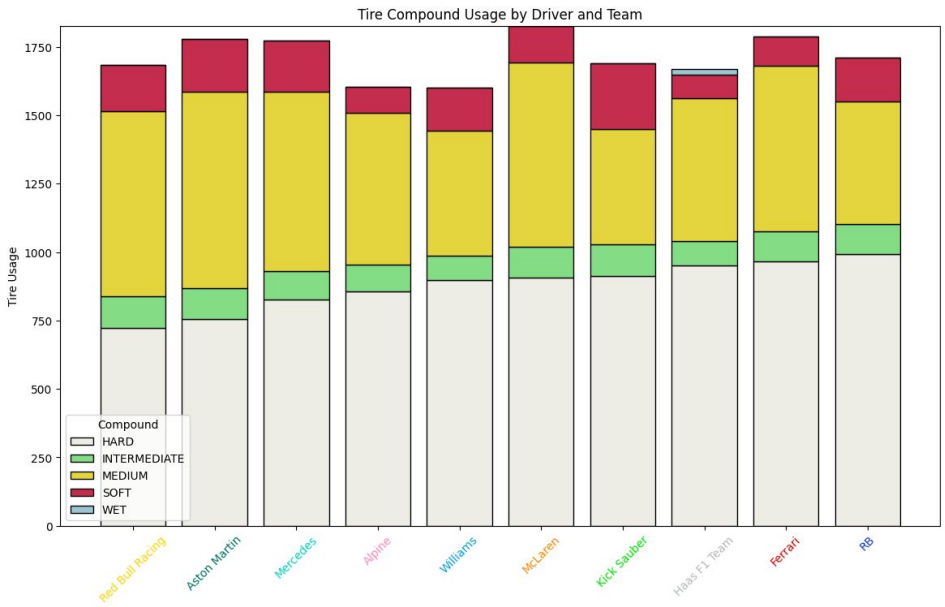


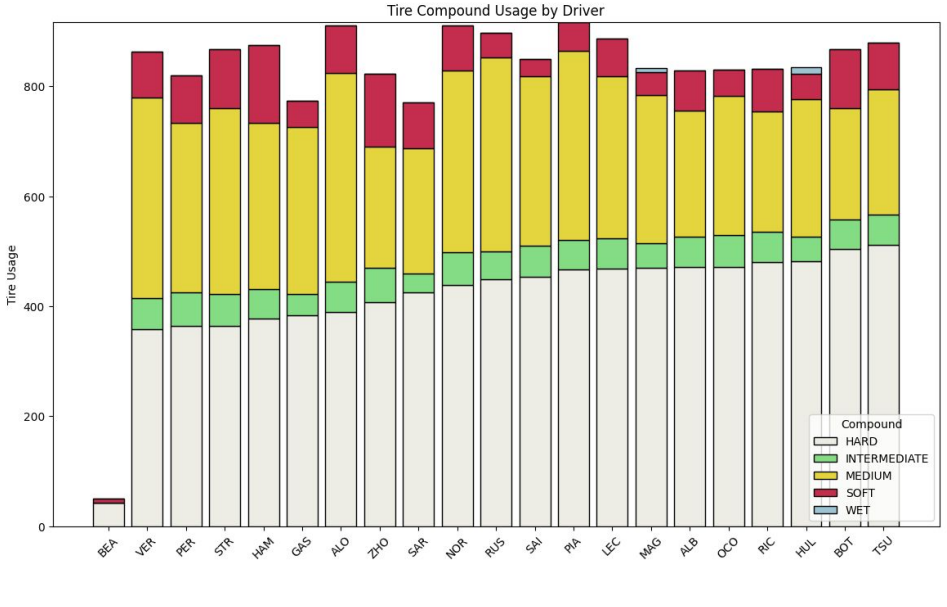
Insights

The data shows a significant variation in tire strategies across different races, with **HARD** and **MEDIUM** compounds being **the most used**. Races like the **Bahrain Grand Prix** and **Spanish Grand Prix** saw **higher usage of SOFT compounds**, likely due to **specific track** demands or conditions. The British Grand Prix and Canadian Grand Prix stand out with considerable use of **INTERMEDIATE** tires, suggesting **weather or track conditions that required more adaptive tire choices**.

Exploratory Data Analysis (EDA)

Tire Compounds Used During the Race

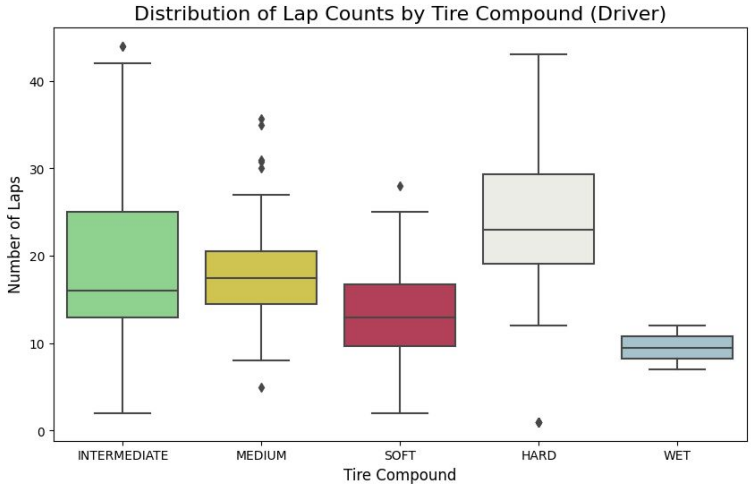




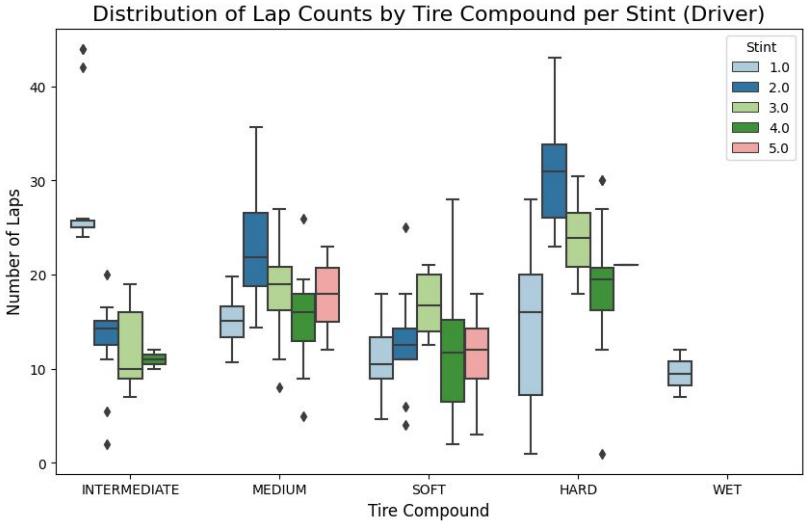
Red Bull Racing, Aston Martin, and McLaren favor the **MEDIUM** compound heavily, with significant use of **SOFT for flexibility** in performance. **Mercedes and Ferrari** show a balanced approach, while Haas and Kick Sauber allocate more tire usage to the HARD compound, possibly indicating longer stints. Among drivers, **Verstappen and Alonso** maximize the **MEDIUM** compound, suggesting an emphasis on race pace consistency, while **Bottas and Tsunoda** use more of the **HARD** compound, indicating **endurance strategies**. Overall, teams with leading drivers (e.g., Red Bull, Aston Martin) seem to **prioritize faster compounds for agility** in races, while **midfield teams rely on harder compounds for longevity**.

Exploratory Data Analysis (EDA)

Number of Laps Completed on Each Tire Compound



Detailed view by Stint



Hard compound is favored for **long stints**, with many drivers averaging 25-35 laps, particularly in stint 1 and 2. This reflects the **tire's endurance qualities for longer stints**.

Soft compound is used for **shorter stints**, with most drivers completing between 10-20 laps. Stint 3 sees a slight peak in usage, indicating a **strategy shift towards higher performance mid-race**.

Medium compound has greater variation in lap counts across different stints, but its usage peaks in stint 2, showing its **importance for mid-race performance**.

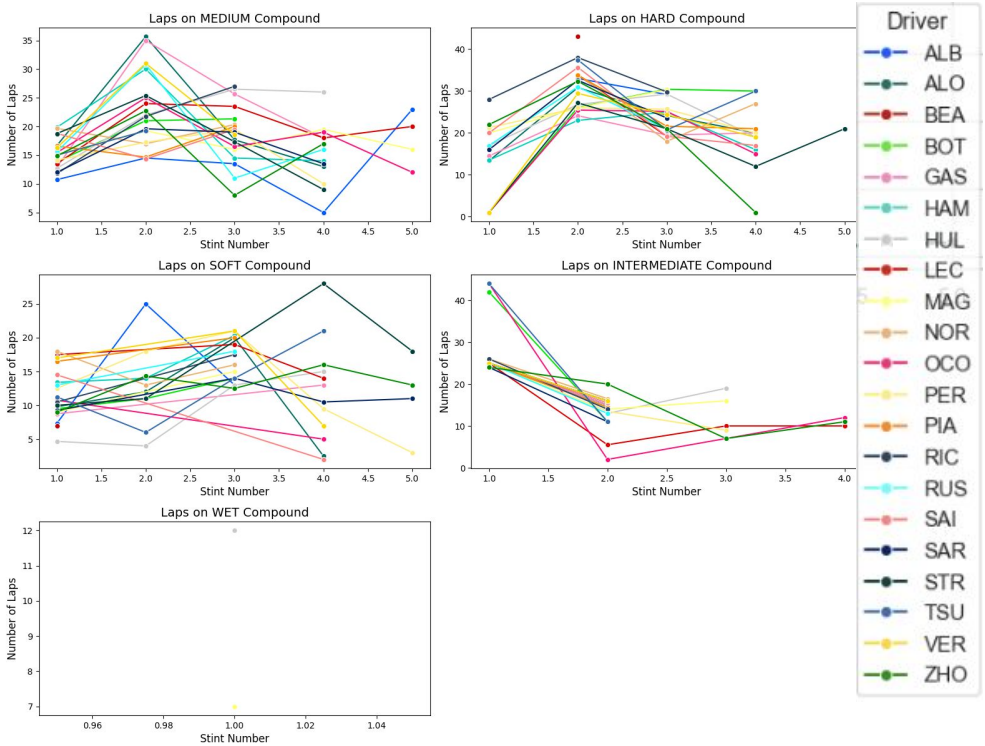
Intermediate compound is used in **early stints**, as drivers adjust to changing track conditions. Its usage decreases sharply after stint 2.

Wet compound shows **minimal use**, indicating rare or brief wet track conditions during the events analyzed.

Hard compound in stint 1 and 2 to manage endurance, while medium and soft compounds are used more variably across stints for shorter bursts of performance.

Exploratory Data Analysis (EDA)

Number of Laps Completed on Each Tire Compound



Medium and Soft Compound Usage

x The **medium compound peaks in stint 2** with 25-30 laps per driver, indicating it's used for **balanced performance** in the race's mid-stage.
x Soft tires show more variability, **used for shorter stints** (around 15-20 laps), where high performance is prioritized.

Hard Compound Usage

x The hard compound is **heavily used in stint 2** with 30-35 laps, showing its importance for endurance.
x Usage declines after stint 2, suggesting **teams switch to more performance-focused tires** in later stints.

Intermediate and Wet Compound Usage

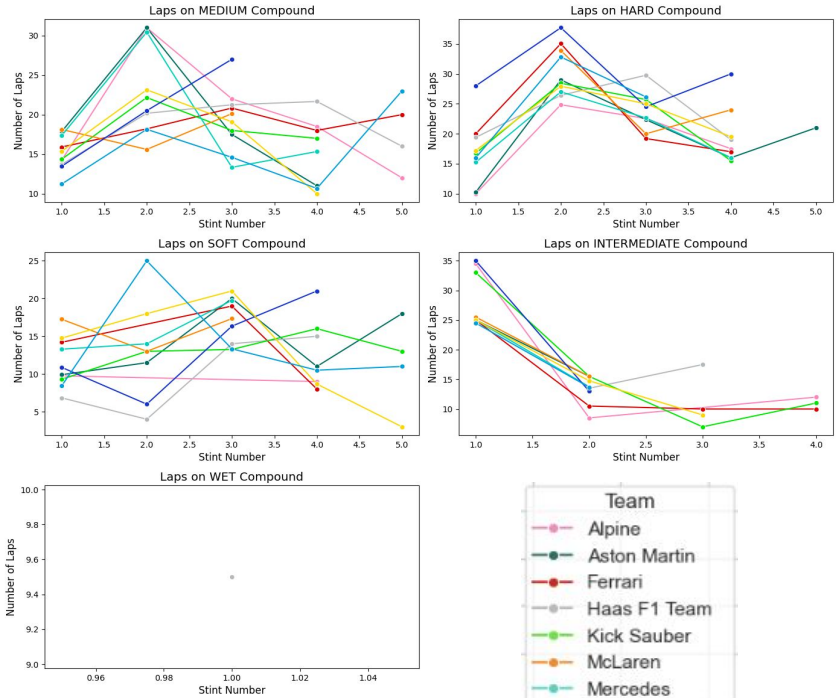
x Intermediate tires are used in early stints, with usage dropping sharply after stint 2 as track conditions improve.
x Wet tires see almost no usage, reflecting minimal wet conditions across events.

Stint Patterns

x Across all compounds, **stint 2 sees the most tire usage,** showing its **critical phase in tire strategy**.
x Teams tend to shift to **shorter stints with softer tires** in later stages of the race, optimizing performance over durability.

Exploratory Data Analysis (EDA)

Number of Laps Completed on Each Tire Compound



The trend looks the same as those of the drivers, but here are a few insights for the teams

Hard Compound Usage

x McLaren avoids the hard compound entirely in stint 1, preferring other compounds early in the race.

x Only Aston Martin utilizes the hard compound in stint 5, showing a **unique strategy for tire durability towards the race's end.**

Medium and Soft Compound Usage

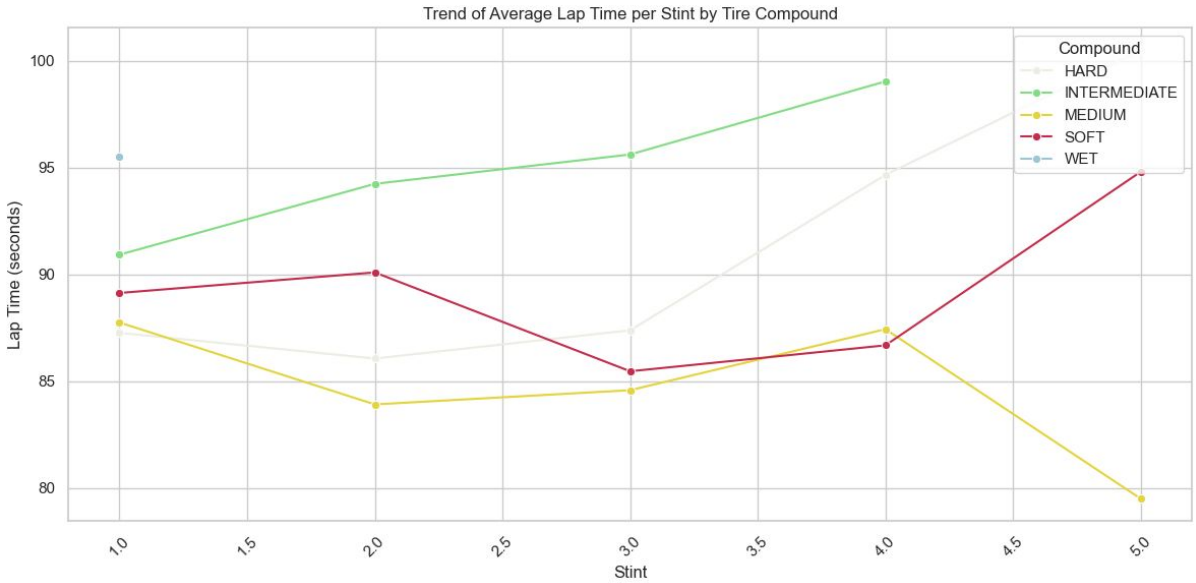
x Aston Martin, Alpine, and Mercedes rely heavily on the **medium compound in stint 2**, completing a significant number of laps on average.

x Williams takes risks by using the **soft compound in stint 2 to gain positions,** while McLaren opts for it in stint 1.

x Red Bull shows a high average usage of the soft compound in stint 2, focusing on performance during this phase.

Exploratory Data Analysis (EDA)

Average Lap Time per Stint and Delta Time per Tire Compound



MEDIUM

The best overall performers, with their fastest lap times recorded towards the end of the race, especially in Stint 5.

HARD

Provide decent early performance but degraded heavily in the later stints.

SOFT

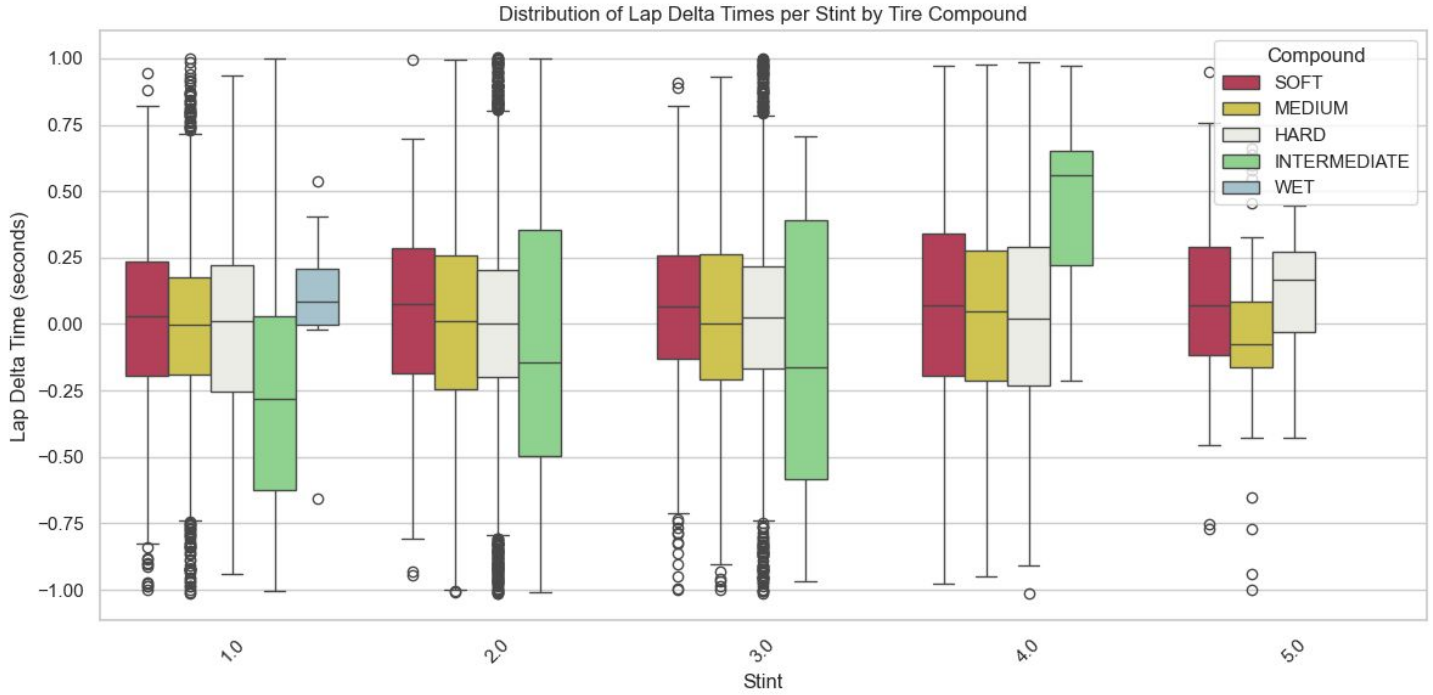
Mixed performance, struggling initially, improving mid-race, and then degrading again in the final stint.

WET & INTERMEDIATE

Ineffective as the track dried, leading to significant performance drops in later stints.

Exploratory Data Analysis (EDA)

Average Lap Time per Stint and Delta Time per Tire Compound



Analysis next slide

Exploratory Data Analysis (EDA)

Average Lap Time per Stint and Delta Time per Tire Compound

Soft Compound

- **Lap Times:** Peaks at **85.47s** (Stint 3) and slows to **94.81s** in Stint 5.
- **LapDelta:** Large dip in **Stint 2** with **-0.55s**, indicating rapid degradation.

Soft tires are **strong in short stints** but degrade quickly, making them less reliable for longer runs, especially when pushed hard early in the race.

Medium Compound

- **Lap Times:** Best improvement from **87.75s** (Stint 1) to **79.51s** (Stint 5).
- **LapDelta:** Consistent across all stints, with minimal variation.

The Medium compound is the **most versatile**, performing well across varying conditions with minimal degradation, making it the most reliable choice throughout the race.

Wet Compound

- **Lap Times:** Only **95.51s** in **Stint 1**.
- **LapDelta:** High variability due to unpredictable conditions.

Wet tires are **only effective in heavy rain** conditions, and their limited use throughout the season reflects changing weather and drying track conditions.

Intermediate Compound

- **Lap Times:** From **90.93s** (Stint 1) to **99.03s** (Stint 4).
- **LapDelta:** High variability in early stints, with a **1.90s** deviation in Stint 1.

Intermediate tires struggle with consistency, performing best in wet or mixed conditions but becoming **less effective as the track dries** or conditions stabilize.

Hard Compound

- **Lap Times:** From **87.27s** (Stint 1) to **100.48s** (Stint 5).
- **LapDelta:** Small variation early, larger deviations in **Stint 5**.

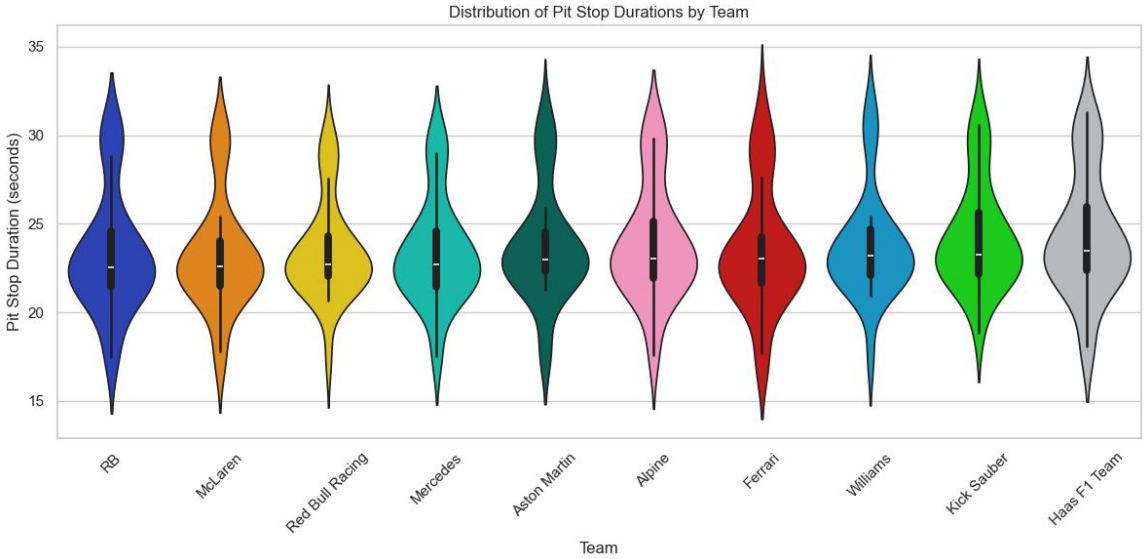
Hard tires perform reliably in the early stints, but show significant degradation as the race progresses, making them less effective for longer runs.

General Insights

Across multiple events, the **Medium** compound consistently proved to be the most reliable tire, showing minimal variability and improving performance as races progressed. **Soft tires** were strong early on but degraded quickly, while **Hard tires** maintained stability in early stints but fell off in longer runs. **Intermediate and Wet tires** exhibited high variability, reflecting the difficulty of managing these compounds in changing weather conditions.

Exploratory Data Analysis (EDA)

Time Spent in Pits



Team Performance in Pits Stops

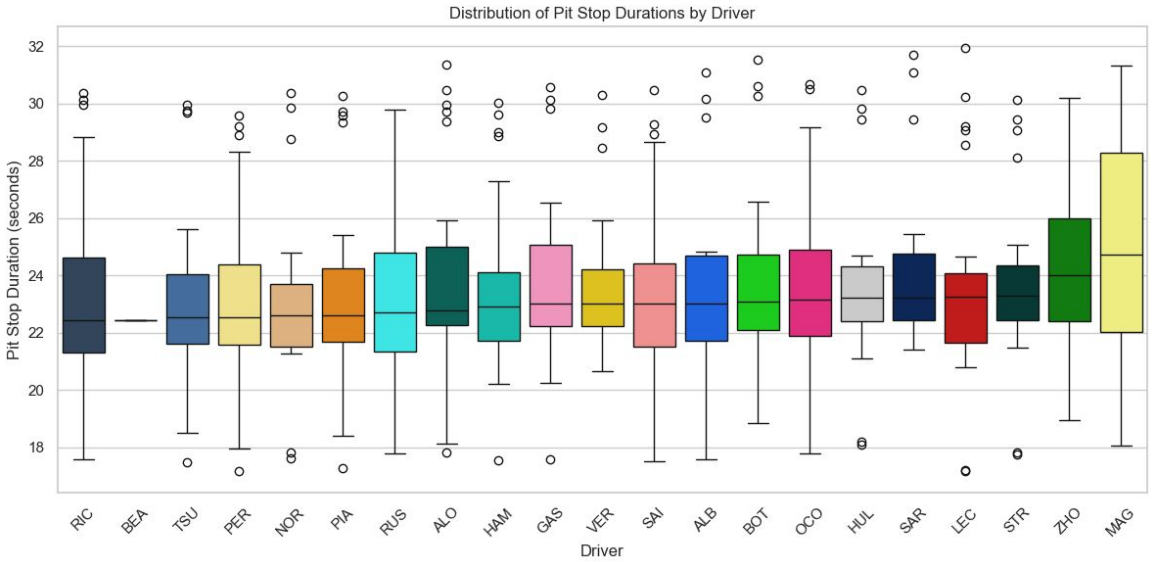
x McLaren leads in pit efficiency with the fastest average pit stop time of **23.23 seconds**, showing their highly effective pit crew operations.

x In contrast, **Haas F1 Team records the slowest average** at **24.31 seconds**, indicating potential areas for improvement in their pit procedures.

x This over one-second difference per pit stop can accumulate, significantly impacting race positions over the course of a Grand Prix.

Exploratory Data Analysis (EDA)

Time Spent in Pits



Team Performance in Pit Stops

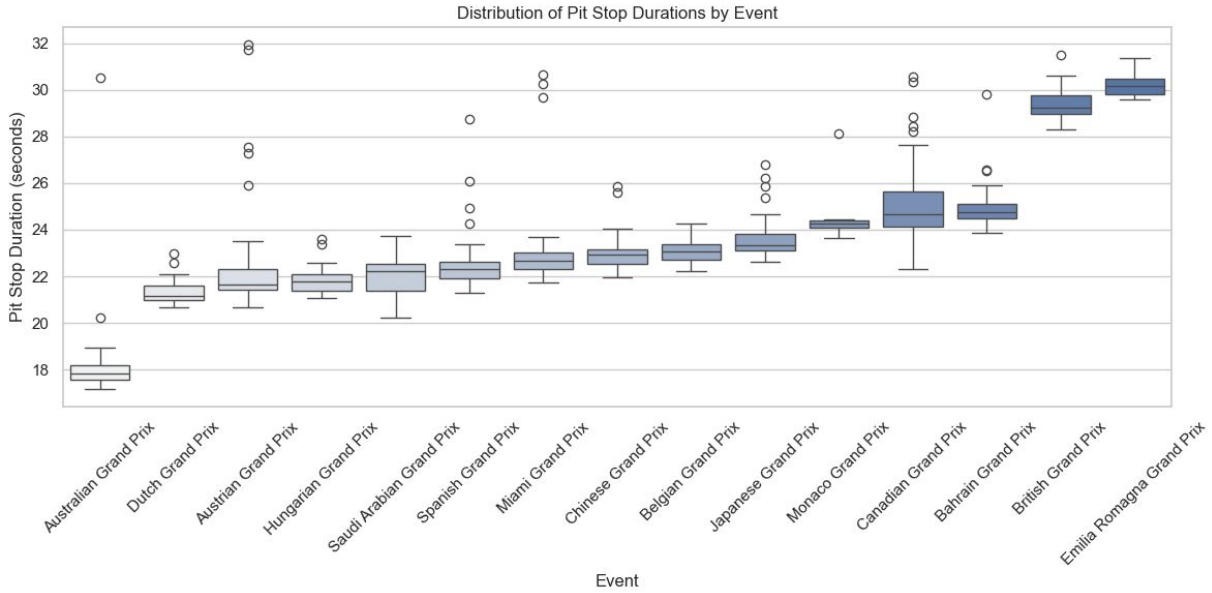
x Lando Norris of McLaren boasts the quickest average pit stops among drivers at **23.06 seconds**, reflecting his team's overall pit stop proficiency.

x Conversely, **Kevin Magnussen from Haas F1 Team has the slowest average at 25.08 seconds**, which may adversely affect his race outcomes.

x The consistency of a team's pit stop efficiency appears to directly influence individual driver performance during races.

Exploratory Data Analysis (EDA)

Time Spent in Pits



Team Performance in Pit Stops

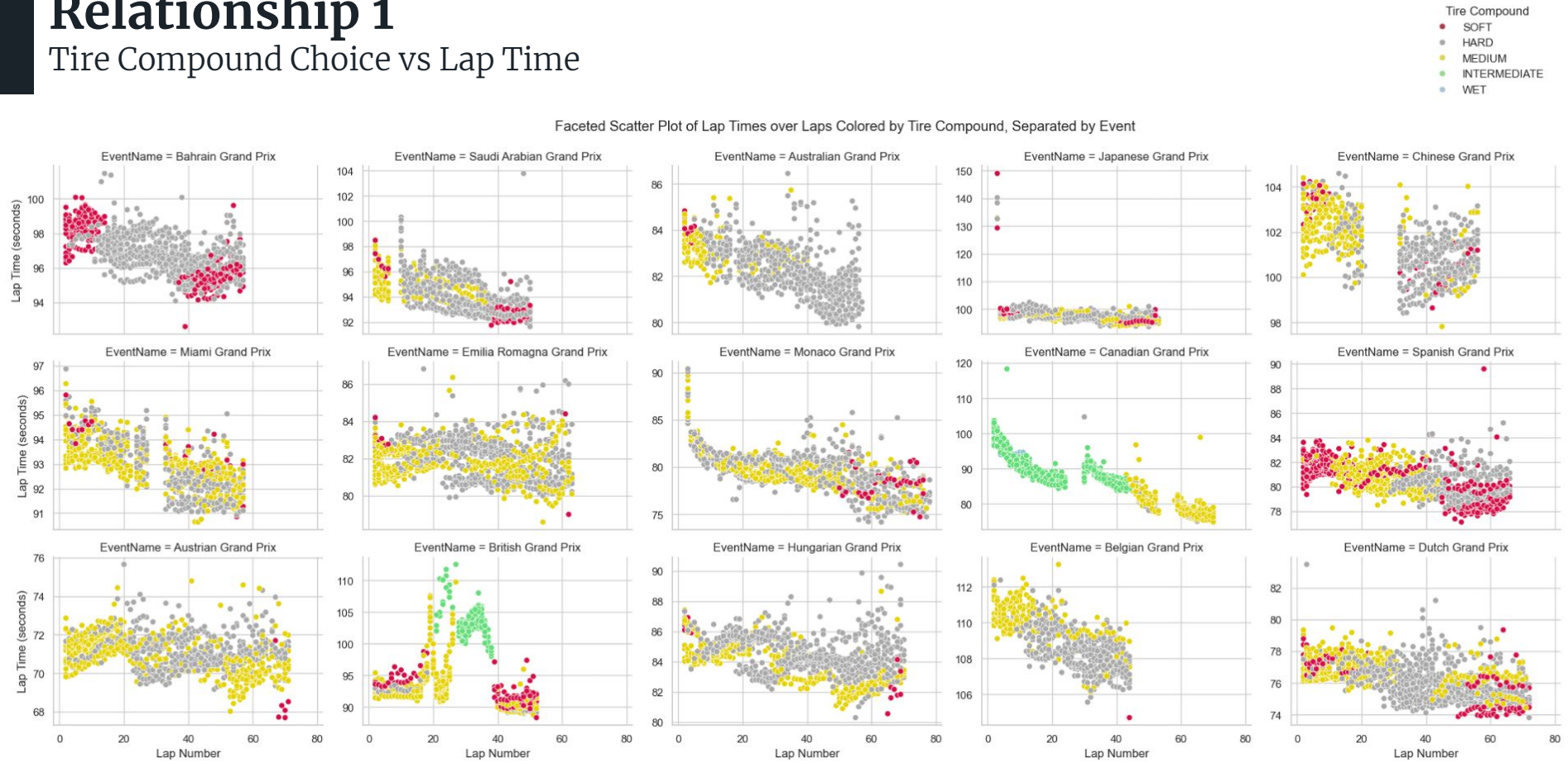
x The **Australian Grand Prix features the shortest average pit stop time** at **18.31 seconds**, whereas the **British Grand Prix has the longest at 29.38 seconds**.

x These variations suggest that **track-specific factors** like pit lane length and speed limits significantly affect pit stop durations.

x Teams must **adapt their pit strategies to each event** to optimize performance and minimize time lost in the pits.

Relationship 1

Tire Compound Choice vs Lap Time



Relationship 1

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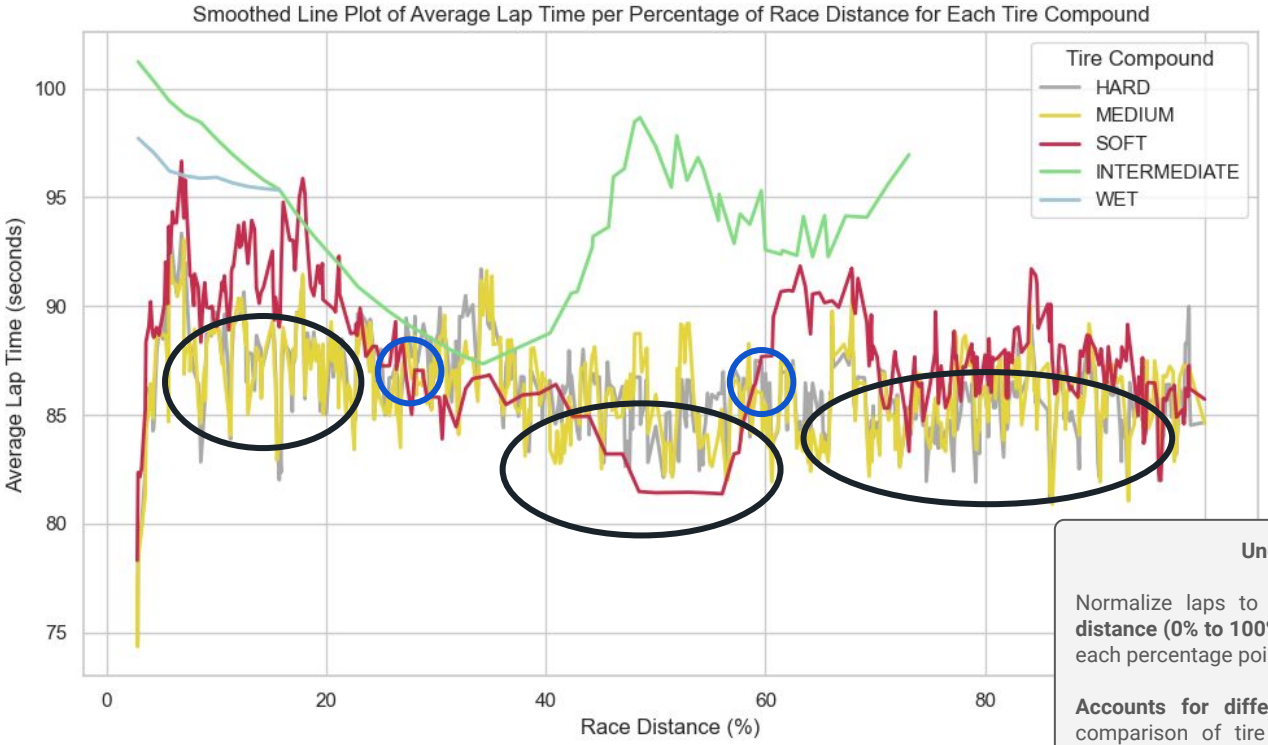


Faster Tire Compound based on the phase of the race

Interesting phase to switch tire compound

Insights

x The **MEDIUM** and **SOFT** compounds tend to offer the best average lap times, making them ideal choices for the early phase (0% - 20%) and the final phase (65% - 100%) of the race, where speed is crucial.

x The **HARD** compound, with its durability and consistent performance, is well-suited for the middle phase of the race (20% - 65%), providing stability and longevity when managing tire wear is key.

Understand the plot

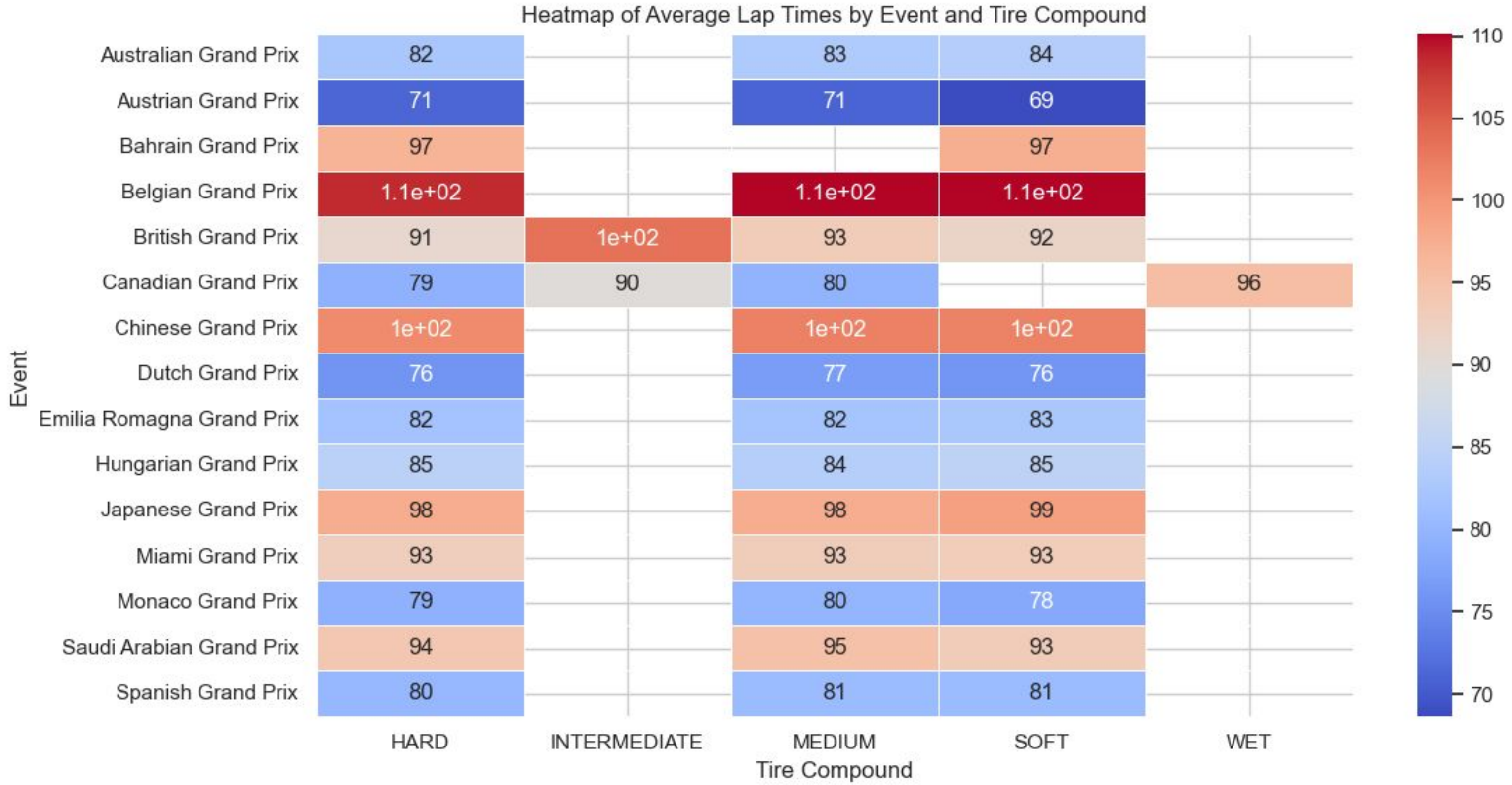
Normalize laps to a percentage of the total **race distance (0% to 100%)** and plot the average lap time at each percentage point for each tire compound.

Accounts for different race lengths, allowing for comparison of tire performance over **race phases across multiple events**.

Relationship 1

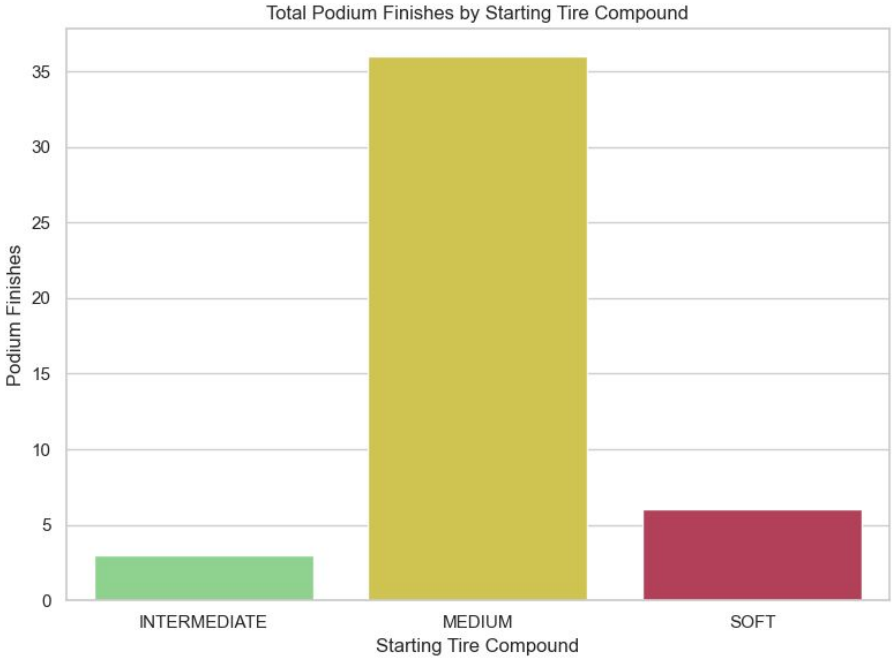
Tire Compound Choice vs Lap Time

Use this plot as a summary for the performance across events, revealing where certain compounds excel or underperform.



Relationship 2

Starting Tire Type vs Final Classification

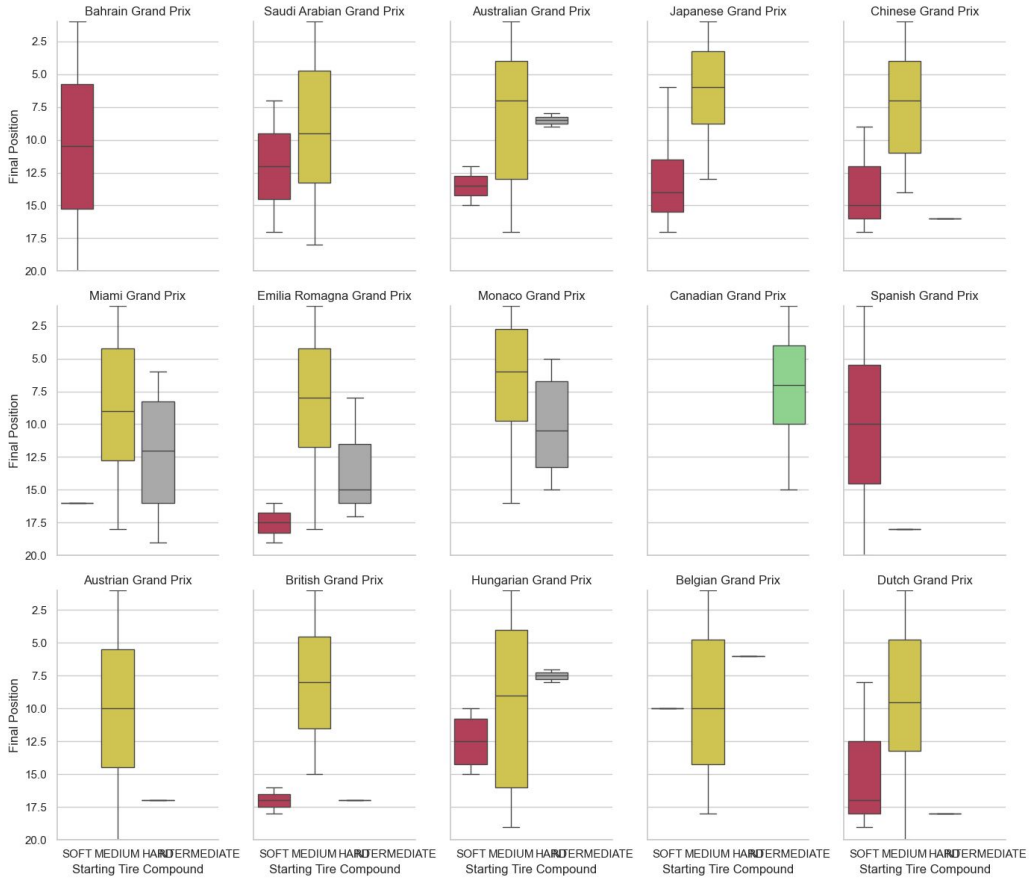


Insights

This bar chart visualizes the relationship between starting tire compounds and podium finishes. The **MEDIUM** compound led to the most success, contributing to over **35 podium finishes.** The **SOFT** compound follows with just over 5 podiums, while the **INTERMEDIATE** compound trails behind, indicating its limited use in achieving top finishes. This highlights the dominance of the **MEDIUM** tire in race strategies leading to podium results.

Relationship 2

Starting Tire Type vs Final Classification



Insights

This boxplot highlights the relationship between starting tire compounds and final race positions across various events.

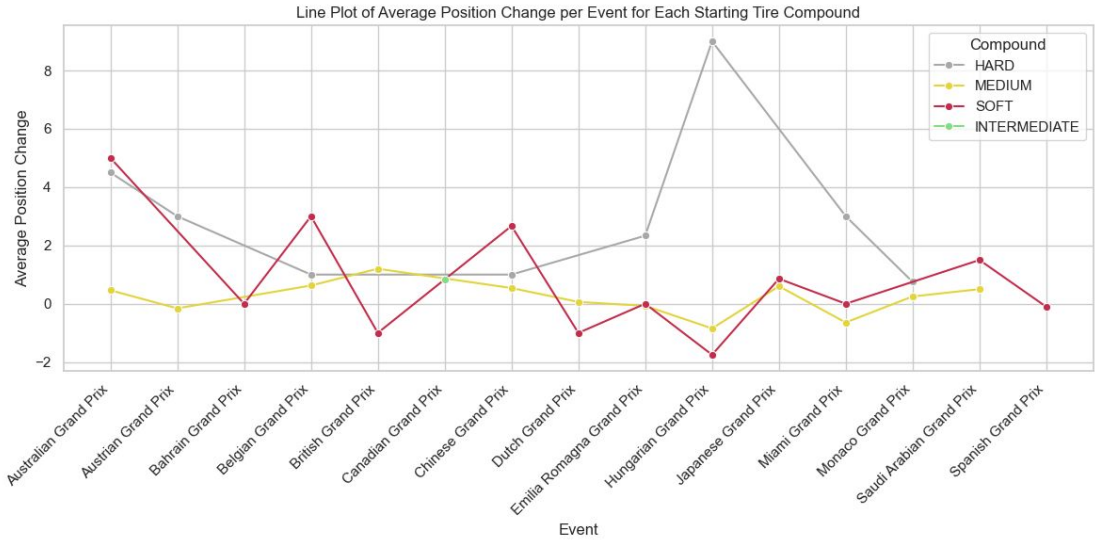
x The **MEDIUM** compound often results in competitive positions, although its larger interquartile range suggests some variability in outcomes.

x In contrast, **HARD** compounds are used less frequently and generally lead to mid-pack finishes, with limited success in securing top positions.

x **SOFT** compounds show more focused, lower final positions in some races, indicating their strategic use in shorter stints but occasionally leading to higher variability.

Relationship 2

Starting Tire Type vs Final Classification



MEDIUM Compound

x Minimal position changes, indicating **stability** and **consistency**.
x Average position change is close to neutral, with a maximum gain of just 1 place.
x Reflects a **conservative strategy**, offering steady performance across races.

SOFT Compound

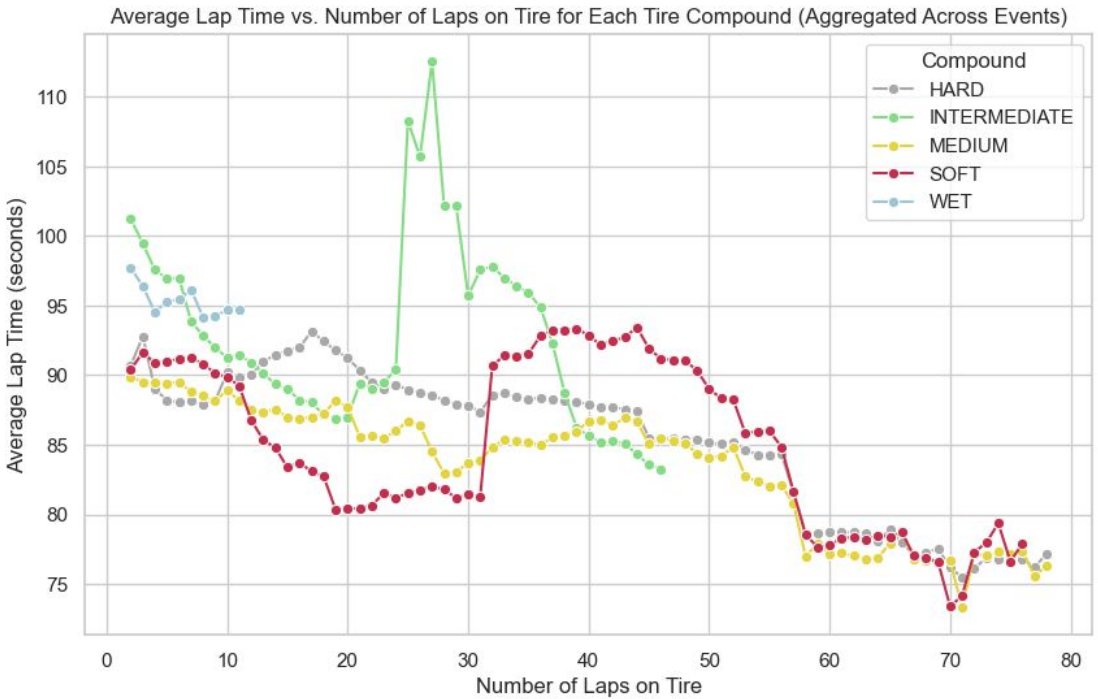
x Greater variability in position changes, making it a higher-risk, higher-reward option.
x Drivers can gain up to **5 places** in some races but risk losing positions in others.
x Offers opportunities for **aggressive gains** but comes with increased variability in outcomes.

HARD Compound

x Surprisingly effective for gaining positions, despite not typically leading to podium finishes.
x Shows **consistent positive gains**, with an average improvement of up to 9 places in the Hungarian Grand Prix.
x Presents a safer, **more reliable option for drivers aiming** to steadily climb the field.

Relationship 3

Number of Laps on a Compound vs Delta Time



Soft Compound: Fastest initial lap times but degrades quickly, with noticeable lap time increases after 20 laps. Sharp lap time drops around laps 50-70 suggest fresh tires or pit stops.

Medium Compound: Stable performance up to 30 laps, followed by gradual degradation. Lap times stay within a manageable range, making it a versatile compound for moderate stints.

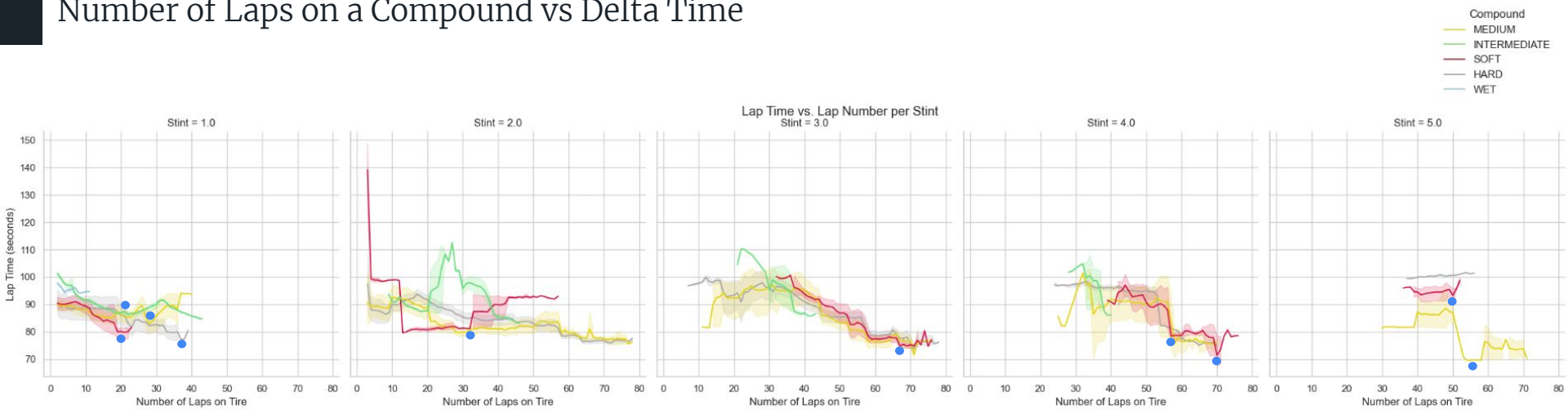
Hard Compound: Exhibits the most consistent performance over the first 50 laps, with minimal degradation. Ideal for longer stints due to lower lap time variability.

Intermediate and Wet Compounds: Display significant variability depending on weather conditions. Intermediate tires degrade quickly but stabilize later, while wet tires improve over time, possibly due to drying track conditions.

*Next, we will analyze the lap times and delta times **per stint** to get deeper insights into how tire degradation impacts performance over consecutive laps in specific race scenarios.*

Relationship 3

Number of Laps on a Compound vs Delta Time

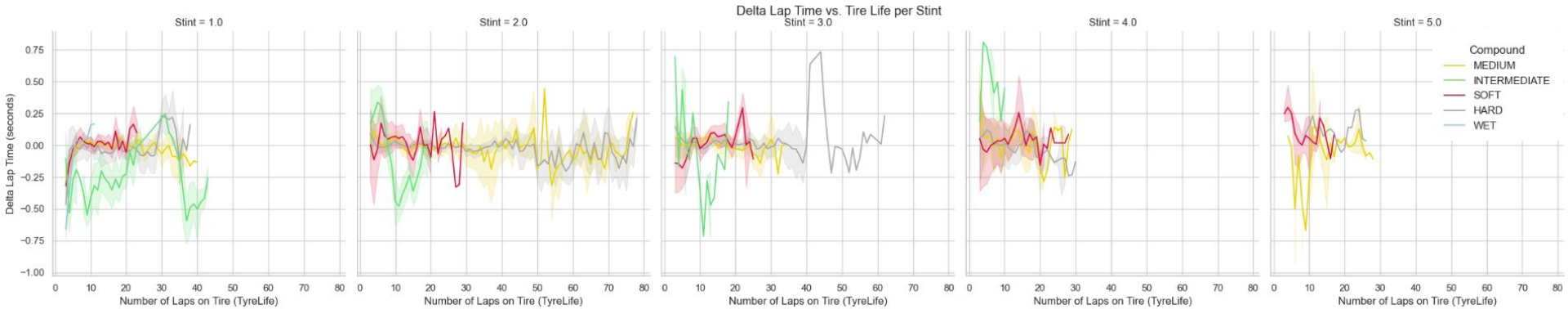


In each stint, the **SOFT** compound continues to show sharp lap time improvements initially, followed by significant degradation after 20-25 laps. Notably, the **MEDIUM** and **HARD** compounds exhibit much more stable performance across longer stints, with the **HARD** compound maintaining consistency even beyond 50 laps, suggesting it's ideal for endurance. Meanwhile, changes in lap times for **INTERMEDIATE** and **WET** compounds highlight the influence of track conditions on their wear patterns.

*The **blue points** in each stint highlight key moments of significant lap time shifts*

Relationship 3

Number of Laps on a Compound vs Delta Time



Across all stints, the **SOFT** compound shows the most noticeable fluctuations where the delta lap time increases after 20 laps.

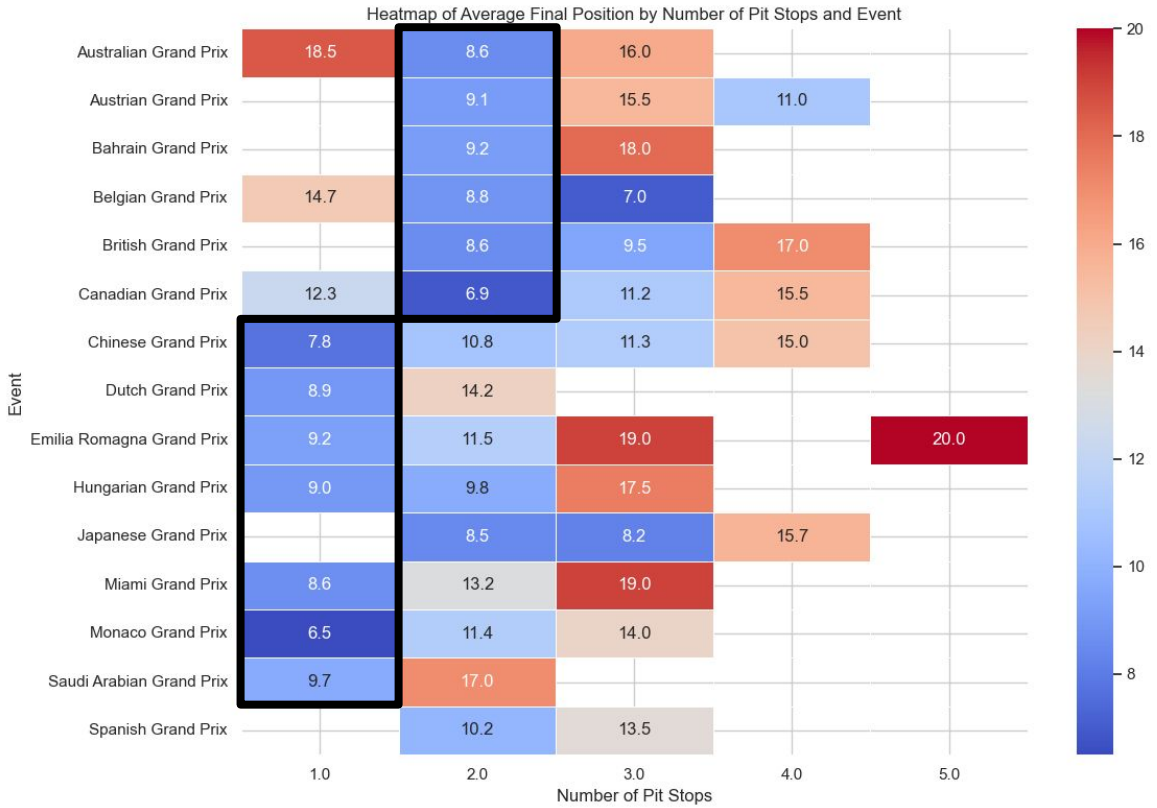
The **MEDIUM** and **HARD** compounds exhibit stable delta lap times at the beginning of each stint, particularly in Stints 2 and 3, but show some fluctuations after 30-40 laps. While these compounds are durable and consistent early on, their **performance becomes less predictable as they approach the end of their tire life**.

<u>Recommendation</u>

The **SOFT** compound should be used in shorter stints, where early performance gains can be maximized before the tire's sharp degradation impacts lap time consistency. On the other hand, the **MEDIUM** and **HARD** compounds are well-suited for longer stints but require close monitoring to avoid performance drops as their tire life extends.

Relationship 4

Number of Stops vs Final Position



Insights

Two-pit stop strategies tend to deliver the best results: In many Grand Prix events, drivers who made two pit stops consistently finished in better positions compared to those with fewer or more stops.

One-pit stop strategies can lead to weaker results: Often, drivers on a one-stop strategy end up with worse finishing positions, as longer stints on worn tires tend to slow them down.

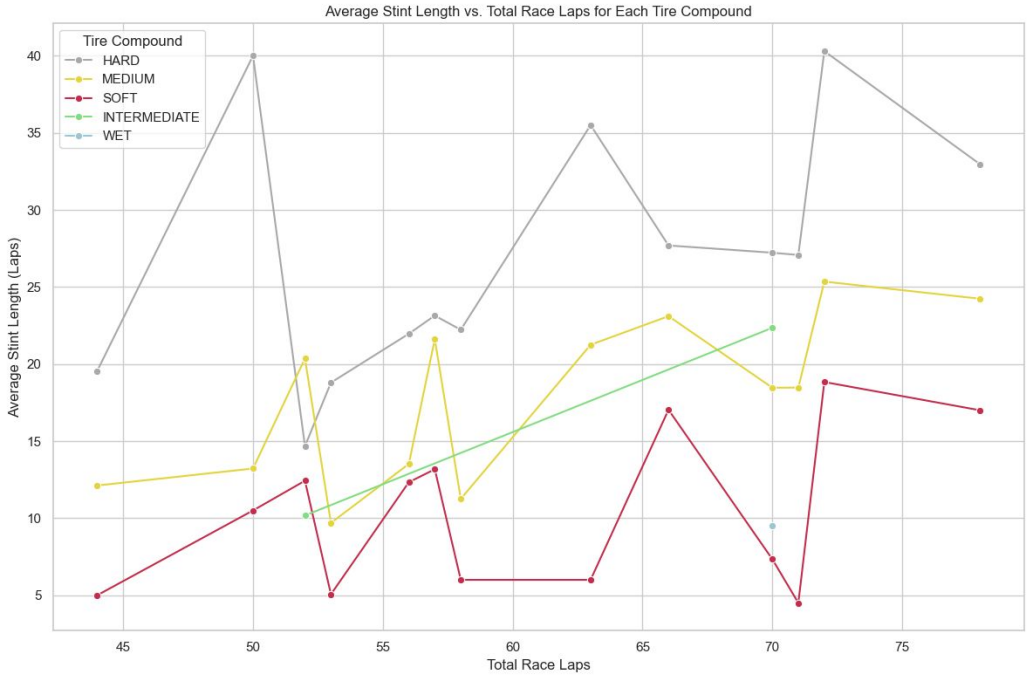
More than two pit stops usually hurt performance: Making three or more pit stops typically results in lower finishes, as the extra time spent in the pits outweighs the benefits of fresher tires.

The ideal strategy depends on the event: Some races, like Monaco and China, favor one-stop strategies, showing that the best approach varies based on track characteristics and tire wear.

The success of pit stop strategies hinges on specific race conditions, highlighting the importance of teams adjusting their tactics to suit each event.

Relationship 5

Race Length vs Strategy



Understand the plot
This plot will show how teams manage tire stints with respect to race length and tire compound.

Soft Tires

x Shorter Stints: **Soft** tires are typically used for **stints under 15 laps**, emphasizing speed over longevity.

x Selective Use in Longer Races: Teams use Soft tires sparingly in longer races, often for **performance boosts** in short bursts rather than consistent use.

Hard Tires

x Long Stints: Hard tires are preferred for extended stints, often **exceeding 30 laps**, especially in longer races.

x Consistency in Longer Races: Hard tires are a key strategy in longer races, allowing teams to minimize pit stops while maintaining stable performance over many laps.

Medium Tires

x Balanced Use: Medium tires are **versatile**, with stint lengths ranging between **15-25 laps** across different race lengths.

x Effective for Mid-Range Races: In races with 55-75 laps, **Medium tires offer a balance of durability and performance**, frequently used in moderate-length stints.

General Analysis

x Strategy Based on Race Length: In shorter and longer races teams favor more Hard tires for endurance.

x Tire Choice Flexibility: Medium tires are the most flexible, used in a wide range of race lengths and stints, offering a middle ground between performance and durability.

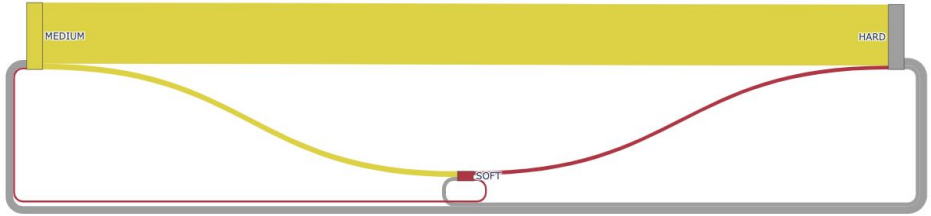
Relationship 5

Race Length vs Strategy

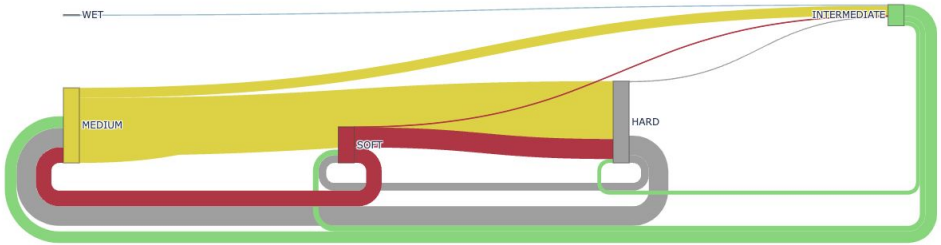
Understand the plot

The **Sankey diagram** will visualize the common tire strategies by showing the flow of compound changes throughout the race. It will highlight how strategies differ with **race length**.

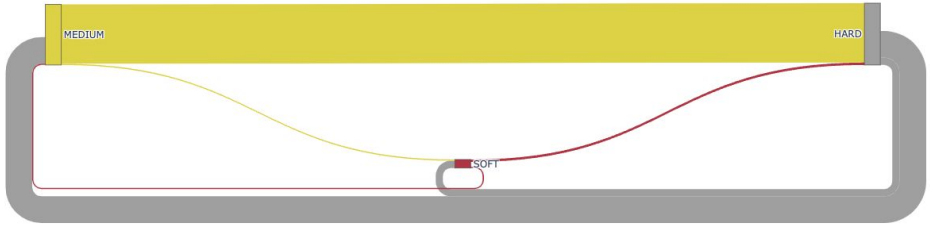
Sankey Diagram of Tire Compound Transitions - Short Races



Sankey Diagram of Tire Compound Transitions - Medium Races



Sankey Diagram of Tire Compound Transitions - Long Races



Short Races *(Less than 54 laps)*

Fewer Tire Transitions: **Medium tires dominate**, with a straightforward flow from Medium to Hard tires, focusing on durability.

Medium-to-Hard Strategy: The key strategy involves **switching to Hard** tires for longevity, minimizing pit stops.

Minimal Soft Tire Usage: Soft tires are **rarely used**, mainly for short stints or aggressive pushes towards the race's end.

Medium Races *(55 to 70 laps)*

More Complex Transitions: Tire strategies are varied, with frequent use of Medium, Soft, and Hard compounds.

Intermediate Tires Appear: Intermediate tires are occasionally used, likely due to **weather or track-specific needs**.

Soft Tires for Performance: Soft tires are used more frequently, especially in the beginning or end, for performance gains during key stints *[slide 17]*.

Long Races *(More than 70 laps)*

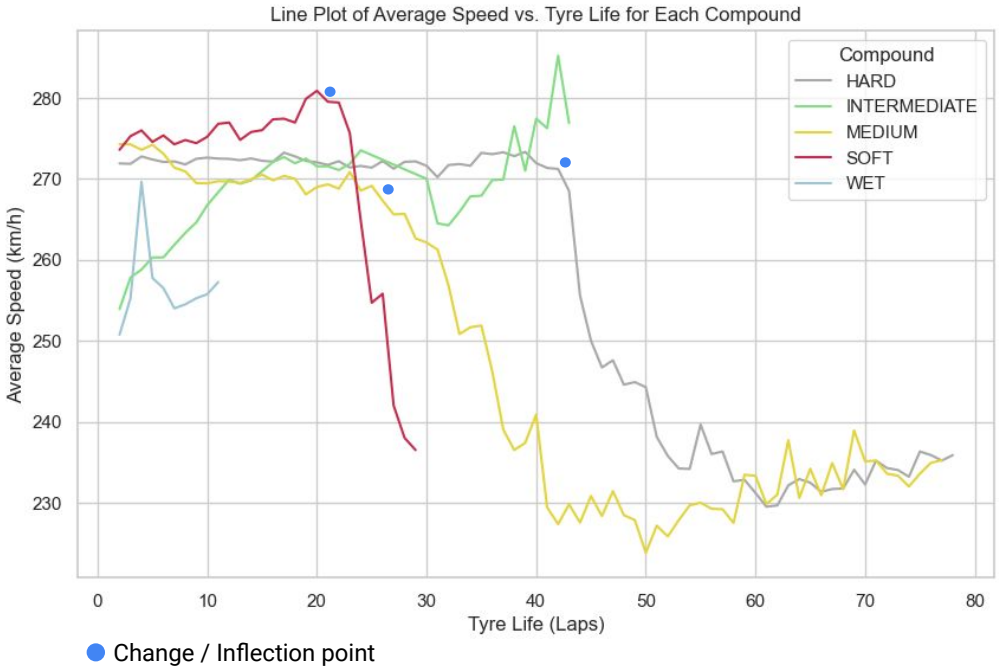
Dominant Hard Tire Strategy: **Hard tires are heavily favored for durability**, with frequent transitions from Medium to Hard tires.

Soft Tires for Brief Stints: Soft tires are used minimally, primarily for short, high-performance bursts.

Simple Strategy: Teams prioritize endurance and consistent performance, **with fewer aggressive tire transitions compared to medium races**.

Bonus Question

Speed vs Tire Compounds



Insights

Soft Tires

High initial speed but rapid performance drop after 20 laps, making them ideal for short, high-speed stints.

Hard Tires

Consistent speed for up to 50 laps with a gradual decline, offering durability for long stints.

Medium Tires

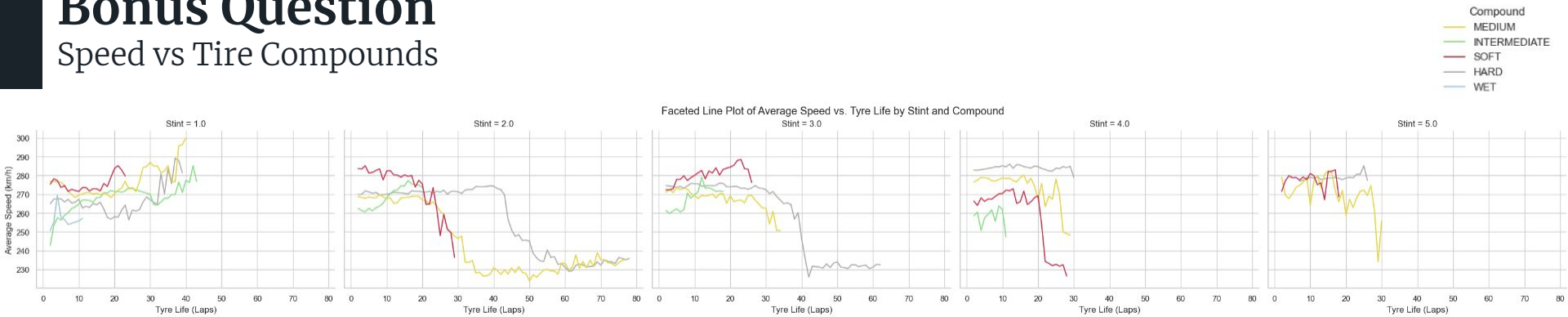
Balanced performance, suitable for medium-length stints with speed decline after 30 laps.

Comparison

Soft tires offer early speed but degrade quickly, while Hard tires provide consistent speed over a much longer duration, highlighting the trade-off between performance and longevity.

Bonus Question

Speed vs Tire Compounds



Stint 1

x **SOFT**: Maintain high speed for the first 20 laps, making them ideal for short aggressive pushes early in the race **as the fuel burn.**

x HARD: Stable performance for long stints, with minimal speed degradation even after 40 laps, making them suitable for **endurance**-focused strategies.

x **MEDIUM**: Slightly slower than Soft tires but show more consistent performance over 40 laps.

Stint 2

x SOFT: Performance declines quickly after 20 laps, indicating rapid degradation when used for mid-race pushes.

x HARD: Stable until about 45 laps, after which performance declines gradually.

x MEDIUM: Similar performance drop-off as Soft tires but more gradual, suitable for mid-range stints.

Stint 3

x **SOFT**: Experience a **steep drop in speed** after about 20 laps, making them unsuitable for longer stints later in the race.

x HARD: Continue to offer consistent speed for extended laps, though with a decrease.

x MEDIUM: Balanced performance with slower degradation compared to Soft tires, ideal for longer stints but with less speed.

Stint 4 & 5

x SOFT:Drop off quickly after 15-20 laps, indicating they're better suited for short bursts towards the race's end.

x HARD: Maintain stable performance with high speed, making them ideal for longer closing stints.

x MEDIUM: Performance remains steady, useful for moderate-length final stints without dramatic speed loss.

General Insight

x HARD: Consistent speed across all stints, making them ideal for endurance across the entire race **(Use on Stint 2, 3, 4)**

x SOFT: High initial speed but degrade rapidly after 15-20 laps, making them best for short, high-performance stints early in the race or for strategic bursts. **(Use on Stint 1, 5)**

x MEDIUM: Offer a balance between speed and endurance, with moderate degradation across all stints. **(Use on Stint 1, 4)**

Conclusion

To conclude…

We've discussed **pit stops, tire strategies, and team performances across 2024** events, offering a comprehensive view of the season.

Our analysis reveals how S**oft, Medium, and Hard tires** truly perform over race distances, informing **smarter compound choices**.

These insights lay the groundwork for predictive models, aiming to **optimize pit stops and tire changes** in real-time. (maybe soon)

Next up: **integrating weather data** to enhance strategy accuracy, particularly beneficial for races like the Canadian Grand Prix.

Teams can leverage these findings to refine their race strategies, **potentially gaining a competitive edge in upcoming events**.