

Project Report

Enhancing Guest Experience Through Data-Driven Journey Mapping and Analysis

Project Overview:

Universal Studios Singapore (USS) faces challenges in accurately forecasting visitor numbers, resulting in inefficient resource allocation and crowd management issues. These inefficiencies contribute to longer wait times and diminished guest satisfaction. We will leverage data analytics and predictive modelling to enhance attendance forecasting, optimise operations and improve overall guest experience.

Problem Statement:

Our project aims to enhance guest experience at USS through data-driven analysis and predictive modelling. Within six months, we target a 20% reduction in average wait times and a 20% increase in guest satisfaction scores by optimizing layout planning and manpower allocation. By analysing visitor demographics and behaviour, we will provide actionable insights that improve operational efficiency and ensure a more enjoyable experience for guests.

Industry Context:

USS is part of the theme park industry that thrives on efficient operations and guest satisfaction. Inadequate staffing leads to longer ride wait times and frustrated guests, impacting overall satisfaction. Conversely, overstaffing during low-traffic periods increases operational costs with no additional revenue. Poor crowd management results in congestion and safety risks, affecting its reputation.

Why It Is A Problem:

Inefficient resource allocation and crowd control issues at USS have a direct financial impact—increased operational costs. Long wait times and overcrowding reduce guest satisfaction, discouraging repeat visits, which may hurt ticket sales. Ineffective staffing strategies result in unnecessary labour costs that further impact profitability. Solving these issues is critical to maintaining revenue growth and optimising operational efficiency. Investing in data-driven forecasting and real-time crowd management will help USS improve guest experiences and strengthen its market position.

1. Key Factors Influencing Guest Satisfaction

Guest satisfaction is a critical factor for entertainment venues such as Universal Studios Singapore (USS). A high satisfaction rate enhances USS's reputation, attracting new visitors through positive reviews and word-of-mouth while encouraging repeat visits from guests who have had enjoyable experiences.

Conversely, poor guest satisfaction can lead to decreased customer retention and reduced foot traffic, ultimately impacting revenue and profitability. If sustained, this could pose financial challenges that may affect USS's long-term viability. To mitigate this risk, USS must implement strategic initiatives to enhance customer satisfaction, ensuring continued business growth and sustainability.

Business Question: Which categories related to USS have the highest dissatisfaction, and what key factors should be improved to enhance guest experience?

We conducted a survey with approximately 500 respondents to assess overall guest satisfaction at USS. The survey evaluated key aspects such as ticketing information, accessibility, and crowd management. To benchmark satisfaction levels against industry standards, we utilized business metrics including the Customer Satisfaction Score (CSAT) and Net Promoter Score (NPS), providing valuable insights into guest experiences and areas for improvement.

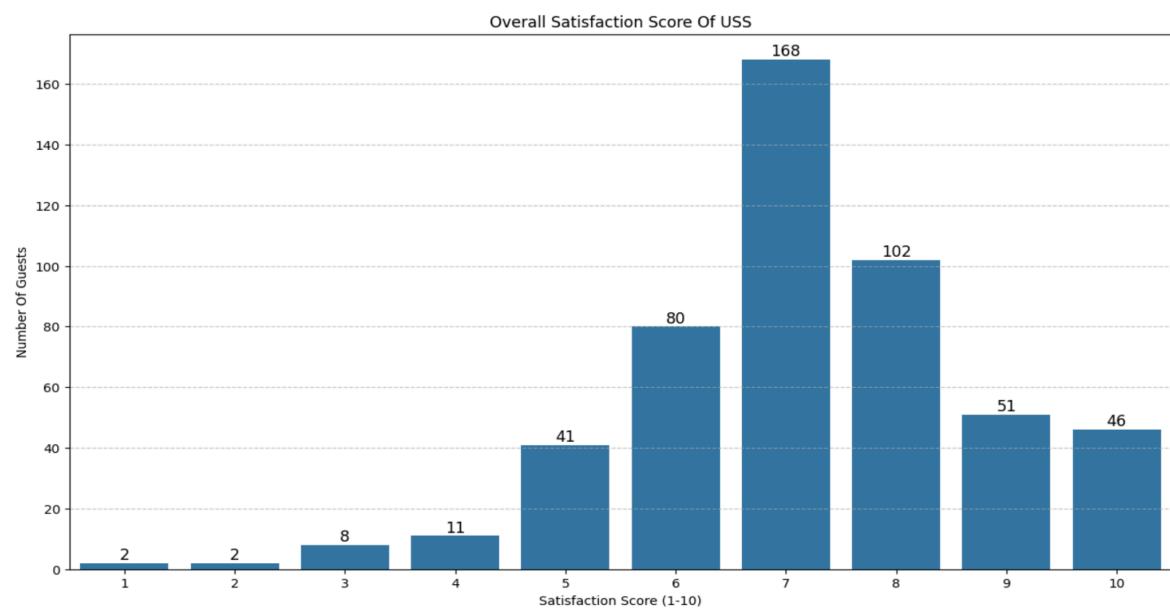


Figure 1: The Overall Satisfaction Score Of USS

The mode overall satisfaction score of USS from the guests surveyed is 7, which is in the passive category. This means that most guests are fairly satisfied with USS, but there might be several problems that USS is currently facing that reduce their satisfaction ratings from the promoters category to the passive category. There are a significant number of guests who gave an overall satisfaction score of 5 and 6, which is in the detractors range. This shows that more than 20% of the survey respondents are not satisfied with the overall USS experience. The number of guests who rated 9 or 10 in the overall satisfaction score contributed to less than 20% of the total participants.

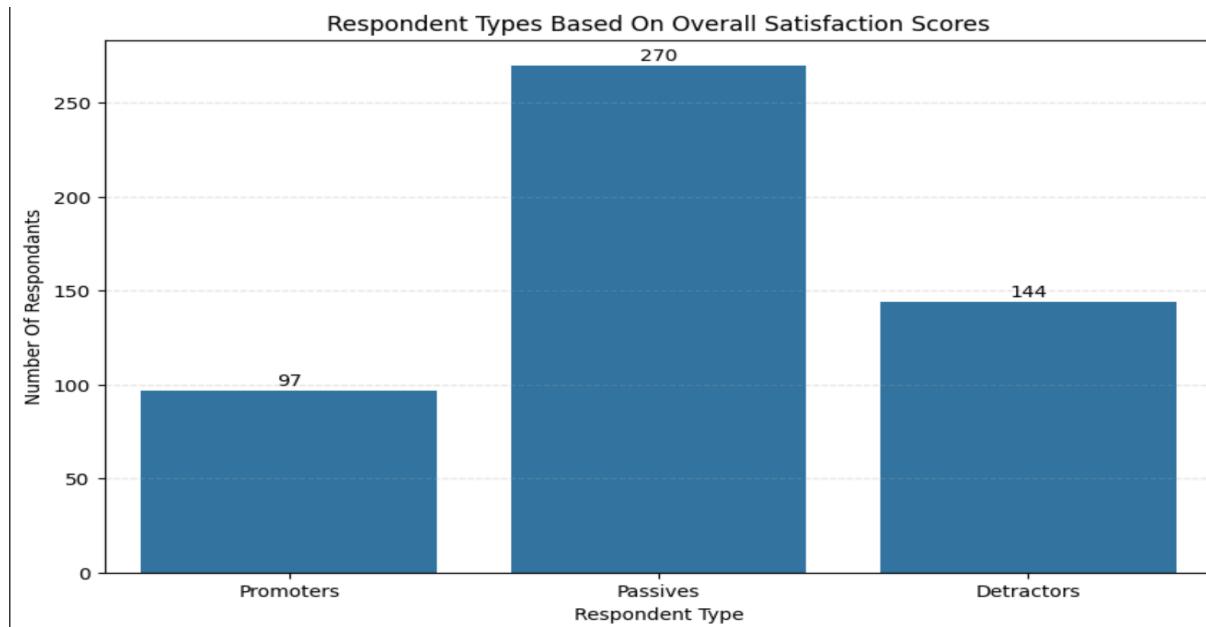


Figure 2: Respondent Types Based On Overall Satisfaction Scores

Overall guest satisfaction is currently below expectations, with more detractors than promoters. The NPS score obtained is -9.2%, which is less than the minimum benchmark of +30%, which suggests that USS is not doing enough to satisfy its customers.

Afterwards, we delve deeper into the various sections of USS and identify the sections with the lowest customer satisfaction rates.

The six sections in USS that we have identified are:

- Ticketing Information Accessibility
- Rides And Attractions
- Entertainment And Performances
- Food And Beverage
- Merchandise And Shopping
- Crowd Management, Comfort And Staff Helpfulness

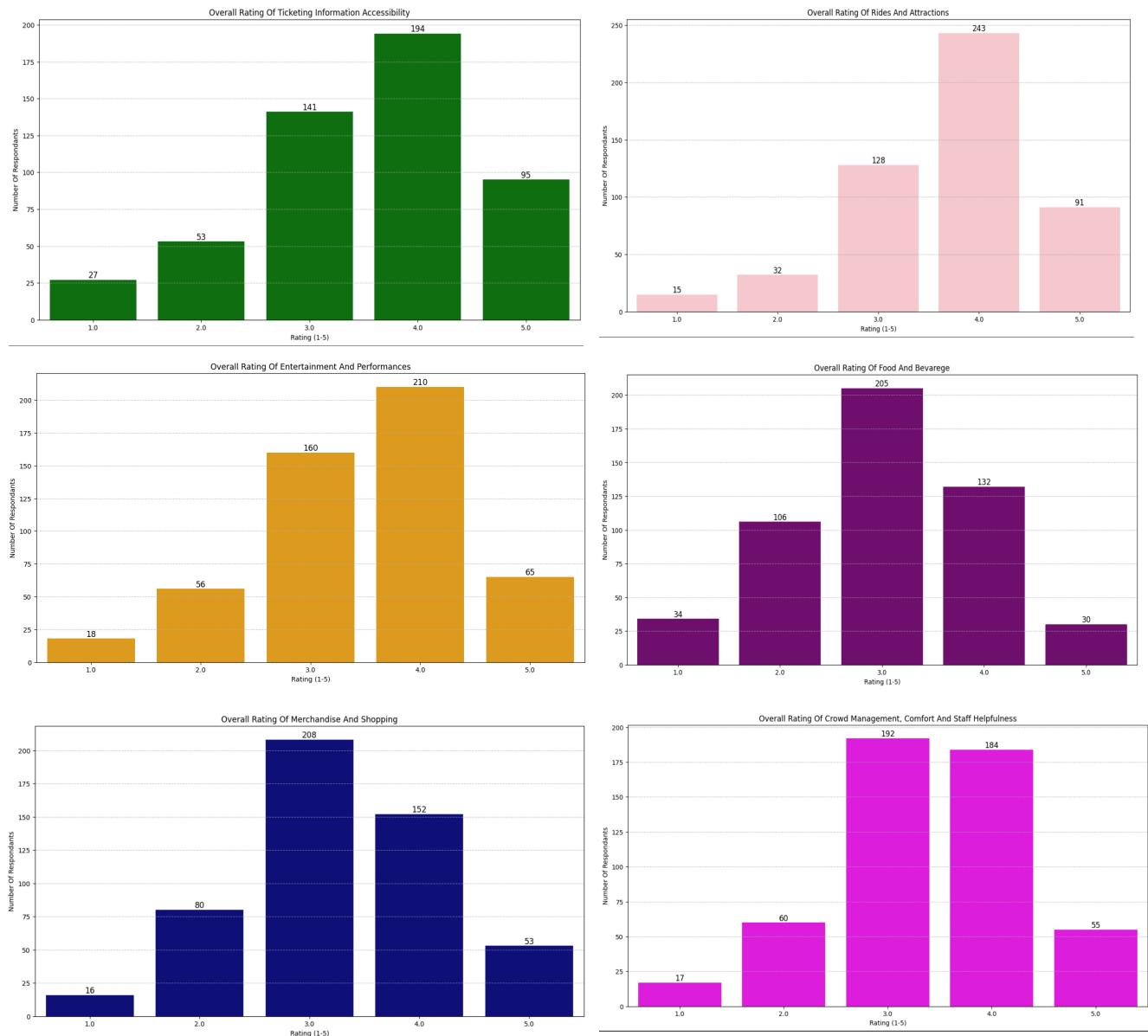


Figure 3: The Overall Ratings Of Various Sections Of USS

The mode ratings for Ticketing Information Accessibility, Ride And Attractions and Entertainment And Performances are 4, indicating a general slightly positive satisfaction rate among the survey respondents. However, the mode ratings for Food And Beverage, Merchandise And Shopping and Crowd Management, Comfort and Staff Helpfulness are 3, indicating that the majority of the survey respondents are less satisfied with these three categories, with barely passable satisfaction rates.

CSAT Scores:

Ticketing Information Accessibility : **56.6%**

Rides And Attractions : **65.4%**

Entertainment And Performances : **53.8%**

Food And Beverage : **31.7%**

Merchandise And Shopping : **40.1%**

Crowd Management, Comfort And Staff Helpfulness : **46.8%**

From the CSAT scores, we identified that Rides And Attractions section has the highest percentage of 65.3% while Food And Beverage section has the lowest CSAT score of 31.5%. The top three lowest CSAT scores are from the categories - Food And Beverage, Merchandise And Shopping and Crowd Management, Comfort and Staff Helpfulness. However, all the six categories have CSAT percentages lower than the recommended benchmark of 80%, indicating that USS is currently still not up to standard in maintaining customer satisfaction.

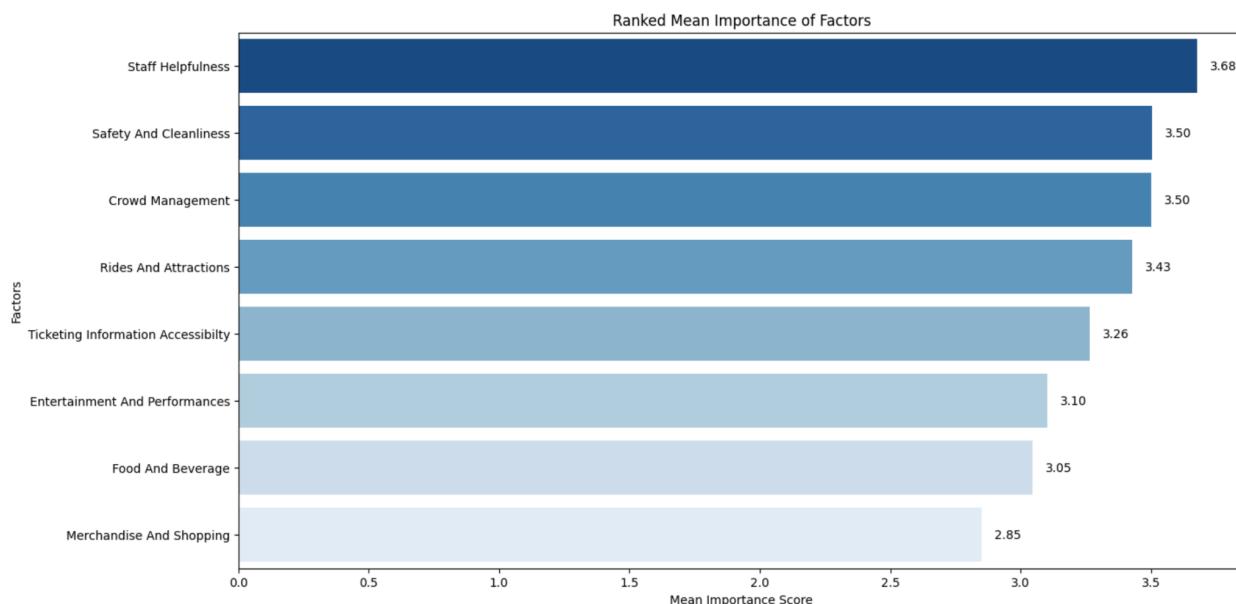


Figure 4: The Mean Importance Of Factors Ranked

Staff Helpfulness has the darkest blue bar, indicating that the mean importance of Staff Helpfulness is the highest. Other factors such as Entertainment And Performances, Food And Beverage and Merchandise And Shopping have lighter blue bars, indicating that their mean importance values are lower.

Top Three Dissatisfaction Reasons For Each Category:

Section Of USS	Top Unsatisfaction Reason	Second Unsatisfaction Reason	Third Unsatisfaction Reason
Ticketing Information And Accessibility	Queueing Time At Entry	Promotions/Discounts	Ease Of Accessing Information
Rides And Attractions	Wait Times For Attractions	Variety Of Rides And Attractions	Queue Management
Entertainment And Performances	Variety Of Performances	Availability Of Performances	Quality Of Performances
Food And Beverage	Price Of Food And Beverage	Quality Of Food And Beverage	Wait Times Of Food And Beverage
Merchandise And Shopping	Price Of Souvenirs	Availability And Variety Of Souvenirs	Quality Of Souvenirs
Crowd Management, Comfort And Staff Helpfulness	Crowd Management	Availability Of Shelters And Rest Areas	Safety And Security Of USS

The primary drivers of guest satisfaction for USS will be the top unsatisfaction reasons that USS is currently facing:

- Ticketing Information And Accessibility: Queueing Time At Entry
- Rides And Attractions: Wait Times For Attractions
- Entertainment And Performances: Variety Of Performances
- Food And Beverage: Price Of Food And Beverage
- Merchandise And Shopping: Price Of Souvenirs
- Crowd Management, Comfort And Staff Helpfulness: Crowd Management

For these unsatisfaction reasons identified, we can subsequently think of strategies that USS can adopt to increase customer satisfaction rates in the future. Our aim is to increase the NPS score to a value of at least 30%, as well as increase the CSAT scores of the various sections of USS to the benchmark of 80% (which illustrates satisfactory to well-performing in customer satisfaction) by the end of next year so that more guests can have more enjoyable experiences at USS with the strategies that will be implemented to improve customer satisfaction rates.

To enhance customer satisfaction, we are proactively addressing key pain points through strategic initiatives. These include increasing staff deployment to reduce waiting times, offering discounts on food and merchandise to improve affordability, and ensuring adequate staffing levels for effective crowd management (more detailed suggestions and explanations will be discussed in the later questions).

2. Guest Segmentation Model

A Guest Segmentation Model is a data-driven approach that can be used by theme parks, such as USS, to classify visitors into different groups based on shared characteristics, behaviors, and preferences. This model leverages data collected from various sources, including ticket purchases, ride preferences, spending patterns and demographic details.

By applying machine learning and clustering techniques such as K-Means, hierarchical clustering, or decision trees, the model can identify distinct guest segments, allowing USS to tailor its services and experiences to meet the unique needs of each group.

Typically, guests can be segmented into various categories (also known as clusters) based on their characteristics. Each segment might have different expectations, for instance families may prioritize child-friendly attractions and short wait times, while thrill-seekers focus on high-intensity rides. By understanding these distinctions, USS can enhance guest experiences, personalize marketing campaigns, and optimize operational efficiency.

Business Question: What are the key guest segments and their traits?

Several steps were taken to analyse the data:

- 1. Feature engineering to keep only the necessary rows.
- 2. Data cleaning to drop outliers.
- 3. Data scaling to One-hot-encode and scale categorical and feature variables.
- 4. PCA, as the number of rows present was an overwhelming number and risked putting the model under curse of dimensionality

After which, the K-Means model was chosen to cluster the data. It was picked over Hierarchical clustering and DBSCAN, as it is computationally efficient. Additionally, DBSCAN has an additional feature that removes ‘outliers’, which was unnecessary since we have already removed the clusters and are aiming to segment as many of the very few guests as we have available.

Having ran the K-Means model, we find that the optimal number of clusters would be 7, as shown below:

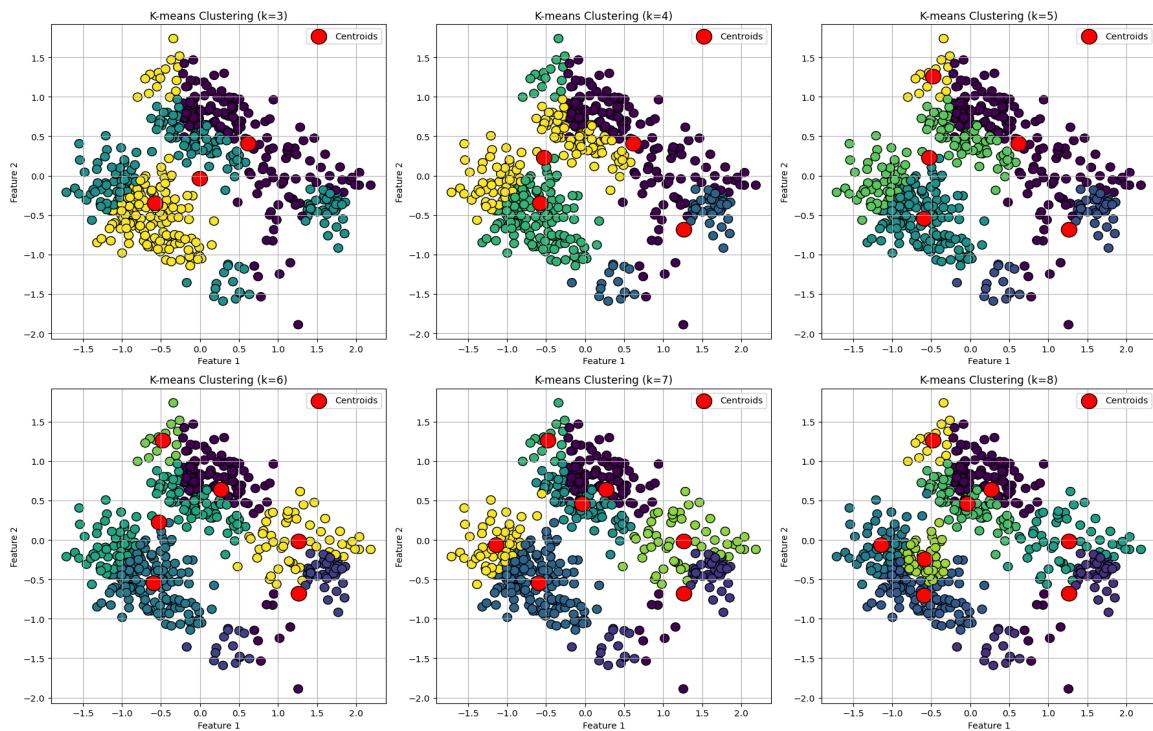


Figure 5: K-Means Cluster Diagrams (k = 3 To k = 8)

Since we observed that the data is best described by 7 clusters, here is the final plot of clusters:

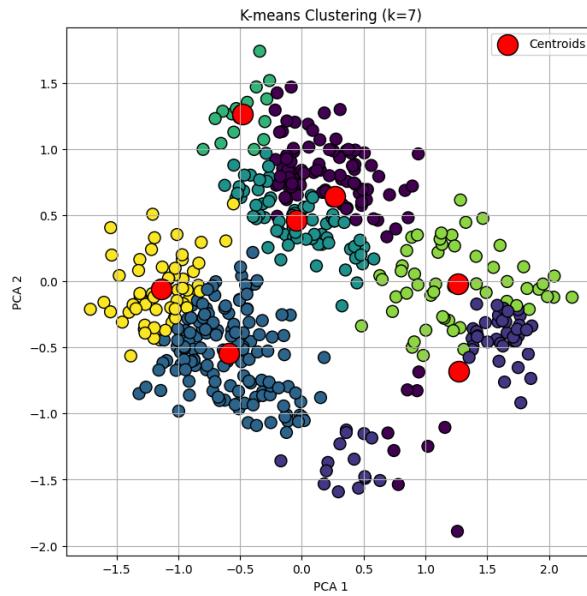


Figure 6: K-Means Cluster Diagram (Optimal k = 7)

After finalising the clusters present, we observed the various behaviours of each guest, such as preferences for various rides and features, factors that influence them coming to USS, the company they bring along and their demographics. We found distinct patterns in each of the clusters, of which can be described like so:

Cluster	Names	Description
0	All-Rounder	A mix of visitors like families, friends, and solo travelers. Prefers a balanced theme park experience with a variety of attractions.
1	Thrill-Seeking Socialite	Dominated by young adults visiting with friends. Prefers roller coasters, shopping, and spontaneous exploration.
2	Tourist Explorer	Composed entirely of tourists, with balanced preferences across attractions. Enjoys a mix of experiences and spontaneous navigation.

3	Family Fun-Seeker	Predominantly families with young children and local visitors. Prefers food, general rides, and holiday visits.
4	Young Family Planner	Most child-focused groups, preferring structured planning, shows, and special events. Visits mainly on public holidays.
5	Budget-Conscious Adventurer	Young adult locals who prioritise cost, weather, and efficiency. Balances spontaneous exploration with queue management.
6	Event Enthusiast	Primarily tourists who visit for special events and prioritise shows and standard rides. Enjoys weekdays and public holidays.

All-Rounder: Showcase various features available through advertisements. Present the park experience as a 'one-of-a-kind' experience.

Thrill-Seeking Socialite: Promote the thrill rides. Provide anecdotes of various other young adults enjoying the ride.

Tourist Explorer: Promote the locally unique rides and features in USS. Offer maps on the USS grounds.

Family Fun-Seeker: Market the USS trips as a family bonding activity to spend time with their children. Bundle ticket sales in family bundles.

Young Family Planner: Likewise market the USS experience to bring happiness to their children, offering bundle deals with free items e.g. soft toys, movie-themed T-shirts, etc. Adding family friendly facilities may be beneficial as well e.g. pram-parking spots or safety features.

Budget-Conscious Adventurer: Prioritise advertising of 'fast-passes' on discounts. Advertise on social media or school grounds.

Event Enthusiast: Market early-bird sales for events and offer event merchandise.

3. Guest Journey Patterns

Understanding guest journey patterns at Universal Studios Singapore (USS) is essential for enhancing customer satisfaction and optimizing operational efficiency. By analyzing visitor movement throughout the park using process mining and sequence analysis, USS can identify common pathways guests take, peak congestion points, and areas where engagement drops.

Different visitor segments — such as families, thrill-seekers, tourists, and annual pass holders - exhibit unique behaviors, influencing their ride preferences, dining choices, and show attendance. Recognizing these patterns allows USS to implement data-driven strategies to improve the overall guest experience.

Personalized recommendations, optimized ride wait times, and targeted promotions can help distribute crowds more effectively, reducing bottlenecks and ensuring a smoother park experience. Additionally, insights into guest flow can inform staffing decisions, enhance queue management, and improve layout planning for future park developments. By leveraging guest journey data, USS can align its operations with visitor expectations, fostering higher customer satisfaction, increasing repeat visitation, and ultimately driving greater revenue through improved experiences and guest engagement.

Business Question: How do common guest journey patterns provide opportunities for personalisation and operational improvements?

We used survey and cluster segmentation data to generate directed graphs representing guest transitions across attraction types and time slots, using the NetworkX package. This helped map the flow of experiences throughout the day. We identified the top 10 most common transitions overall, highlighting popular sequences and general guest behaviour. For a deeper level of analysis, we broke down the top 5 journey transitions within each cluster, uncovering segment-specific preferences.

By analysing the top 10 visitor journey transitions between different attractions and time slots across clusters, we discovered the following guest behaviour:

- Early Morning (08:00–10:00) is predominantly characterised by visits to eateries, indicating that guests generally prefer to begin their day with breakfast before engaging in other activities.
- Late Morning (10:00–12:00) displays two dominant patterns: guests commonly transition from eateries to either roadshows or other rides. This suggests a bifurcation in guest preferences post-breakfast, with some favouring entertainment-based experiences and others opting for more interactive attractions.
- The most prominent transition observed is from Late Morning roadshows to Early Afternoon other rides (58 transitions), highlighting a widespread behavioural pattern of alternating between passive and active experiences during the midday period.
- Early Afternoon (12:00–14:00) emerges as a key transition hub, with multiple inbound and outbound flows. Guests frequently move from “other rides” to 3D/4D shows, performances, and roller coasters during the Late Afternoon (14:00–16:00). The strong transition to roller coasters during this period indicates a peak in demand for thrill-based attractions around midday.
- Toward the end of the day, guests exhibit a shift toward more passive entertainment. The most common evening behaviour involves attending performances during 16:00–18:00, followed by 3D/4D shows between 18:00–21:00, suggesting a collective preference for more relaxed activities to conclude the park visit.

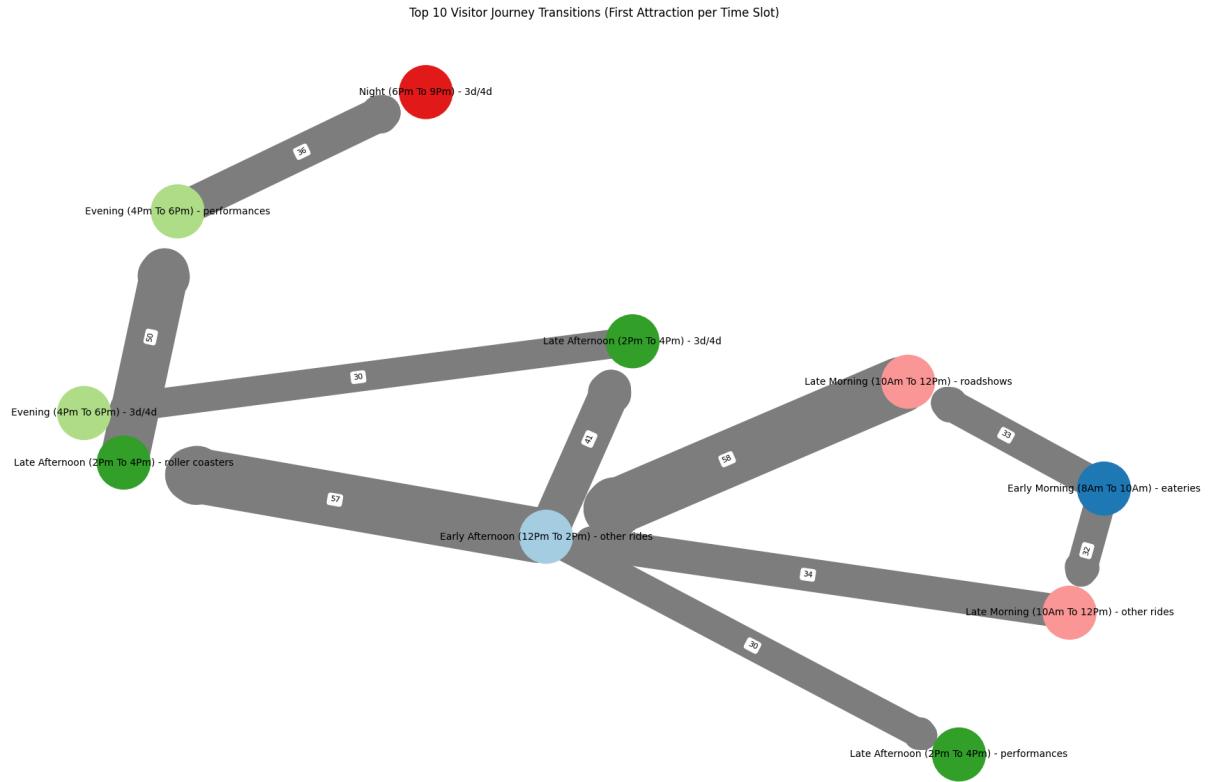


Figure 7: Top 10 Visitor Journey Transitions

For a more granular analysis of guest journey patterns at USS, we visualised the top 5 transition routes by cluster, with findings collated in table below:

Cluster Number	Early Morning -> Late Morning	Late Morning -> Early Afternoon	Early Afternoon -> Late Afternoon	Late Afternoon -> Evening	Evening -> Night
0	Water Rides -> Roadshows	Roadshows -> Other Rides	Other Rides -> Performances		Performances -> 3D/4D, 3D/4D-> Performances
1	-	Roadshows -> Other Rides	Other Rides -> 3D/4D	Roller Coasters	3D/4D -> Performances

				->Performances, 3D/4D -> 3D/4D	
2	-	Roadshows -> Other Rides	Other Rides -> Roller Coasters, 3D/4D	3D/4D -> 3D/4D	Performances -> 3D/4D
3	Eateries -> Roadshows	Roadshows -> Roller Coasters, Other Rides	Other Rides -> Roller Coasters	Roller Coasters -> Performances	-
4	3D/4D -> Roadshows	Roadshows -> Other Rides	Other Rides -> 3D/4D	Roller Coasters -> Performances	Performances -> 3D/4D
5	-	Other Rides -> Other Rides	Other Rides -> Roller Coasters, 3D/4D	Roller Coasters -> Performances, 3D/4D -> 3D/4D	-
6	Eateries -> Other Rides	Other Rides -> Other Rides, 3D/4D	Other Rides -> Roller Coasters	Roller Coasters -> Performances	-

- Midday Traffic: Roadshows to Other Rides (Late Morning to Early Afternoon)**
A prominent transition observed across clusters is from Late Morning roadshows to Early Afternoon other rides. This consistent movement highlights these attraction types and their connecting pathways as high-traffic zones during midday. The crowd concentration in this period suggests a need for operational interventions, such as queue management systems or strategic redistribution of attractions and facilities, to mitigate congestion.
- Afternoon Flow Dominated by Rides**
Guest journey patterns indicate a dominant flow from Other Rides in Early Afternoon to Roller Coasters in Late Afternoon, observed across nearly all clusters. Frequently, 3D/4D attractions appear as intermediate stops, pointing to guest preferences for alternating between high-adrenaline and immersive experiences. This trend reflects a paced engagement strategy, as visitors balance physical intensity with periods of sensory entertainment.

- **Evening Preferences: Performances and 3D/4D Attractions**

In the evening and night slots, transitions shift toward performances and 3D/4D shows, with many clusters exhibiting a back-and-forth pattern between these two types. This behavior suggests that guests tend to wind down their day with calmer, more passive forms of entertainment following an active afternoon, aligning with natural energy rhythms and relaxation preferences.

The observed overlaps in behavioral patterns across guest clusters provide valuable insights for enhancing both operational efficiency and visitor satisfaction at USS. Two key strategies are proposed:

- **Spatial Redistribution:** High-traffic attractions—particularly *Other Rides*, which see consistent midday surges—can be strategically distributed throughout the park to alleviate congestion and improve guest flow during peak periods.
- **Personalized Guidance:** USS can leverage mobile applications and digital signage to deliver real-time, segment-specific recommendations. For example, families may be directed to nearby eateries or entertainment zones, while thrill-seekers can be nudged toward underutilized rides with shorter wait times.

Building on the cluster segmentation insights, USS can further enhance personalization through targeted interventions:

- **Clusters 1 and 2 (Thrill-Seeking Socialites & Tourist Explorers)**

These guests exhibit transitions from roadshows to other rides, with strong engagement in 3D/4D attractions and roller coasters during the afternoon. USS can support this segment by promoting afternoon thrill itineraries, offering in-app alerts for 3D/4D show availability, and introducing timed express pass bundles aligned with their peak activity windows.

- **Clusters 3 and 4 (Families & Young Planners)**

These visitors typically begin their day earlier, moving through a structured sequence of eateries, roadshows, and family-friendly attractions, before ending with performances. Their experience can be enhanced through curated family-centric app routes, meal and show package deals, and real-time wait-time alerts for suitable attractions that align with their preferences and pace.

- **Cluster 0 (Evening Leisure Seekers)**

Guests in this group exhibit a strong preference for performances and 3D/4D attractions later in the day. USS can engage them with targeted evening show recommendations, reserved seating options, and dining suggestions scheduled prior to entertainment events, providing a seamless and relaxing end-of-day experience.

4. Impact Of Marketing Strategies On Guest Behaviour

To assess the impact of marketing strategies on guest behavior, it is essential to first identify the characteristics of customers who spend at Universal Studios Singapore (USS). Tailoring marketing efforts to underrepresented groups without considering the broader customer base may limit their effectiveness in enhancing the overall guest experience. This, in turn, could result in minimal or no significant increase in demand for USS, potentially restricting revenue growth and preventing the park from maximizing its financial performance.

However, merely identifying customer characteristics is not sufficient to develop effective marketing strategies. It is equally important to analyze shifts in customer trends over time - for example, observing a consistent increase in the percentage of visitors aged 13 to 21. By tracking these evolving patterns, USS can better predict future customer demographics and tailor its marketing efforts accordingly.

Focusing on growing customer segments allows USS to implement targeted strategies that align with emerging trends, maximizing demand and ensuring sustained business growth. By comparing past demographic data with current visitor profiles, we can assess percentage changes across different customer segments. This analysis enables USS to better understand evolving visitor trends and develop targeted strategies to align with shifting consumer behaviors.

Business Question: How have marketing strategies changed guest segments and satisfaction over time?

We used our current survey data, and historical TripAdvisor reviews obtained from Kaggle to compare how guest segments and satisfaction have changed over time through visualisations. Guest segments assessed include visitor demographics (age, gender, nationality), type of visitor (solo traveller, visiting with friends, families with young children/teenagers/elderly) and preferred time of day to visit USS.

The proportion of young adults, females and locals visiting USS increased over time. Since more people are visiting the USS for special events, this suggests that over the years, events like Halloween Horror Night have been attracting more locals, young adults and teenagers. However, overall guest satisfaction rates have fallen significantly.

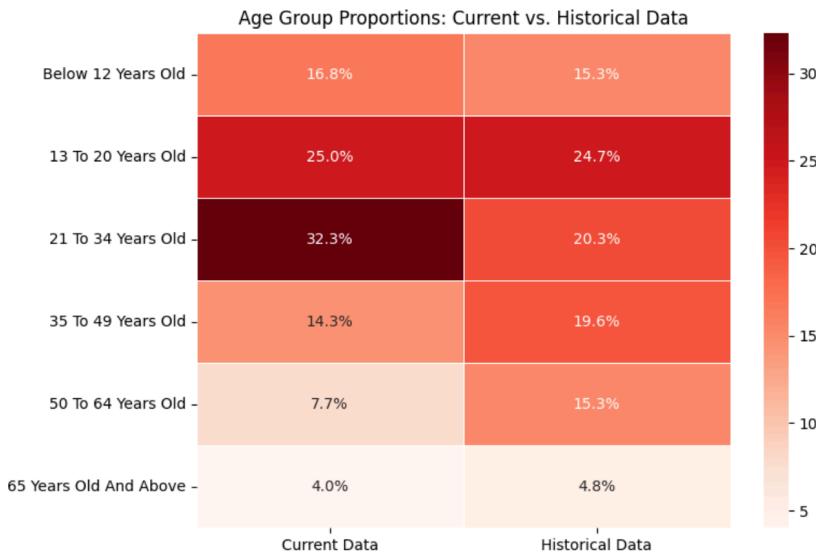


Figure 8: Proportions Of Categories Of Age Groups (Current vs Historical Data)

The visitor population has significantly shifted toward younger adults (21-34), which now make up nearly a third of all visitors. There has been a marked decline in middle-aged and older adult visitors (35-64 age groups). The proportion of children and teenagers remains relatively stable between the 2 periods. The current visitor profile is more heavily skewed toward younger demographics, suggesting a strategic repositioning or changing appeal of USS, with significantly strong attraction to young adults and slightly reduced engagement with older demographics.

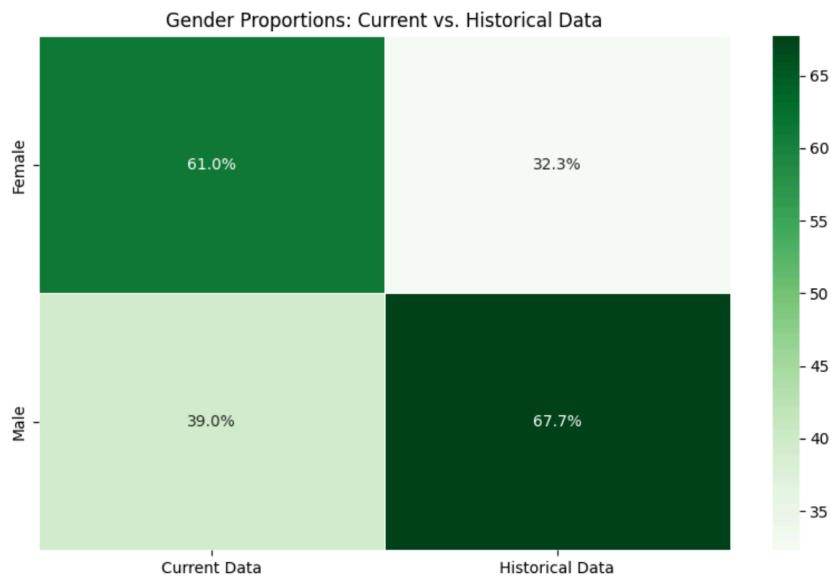


Figure 9: Proportions Of Gender (Current vs Historical Data)

There has been a complete inversion in the gender proportions between the historical and current periods. Historically, males dominated the visitor demographics, representing over 67.7% of all visitors. Currently, females constitute the clear majority at 61.0% of visitors. This significant gender proportion reversal suggests a possible fundamental change in either: the attraction's appeal or marketing strategy, the programming or exhibition content, targeted outreach efforts or the organizational culture or reputation.

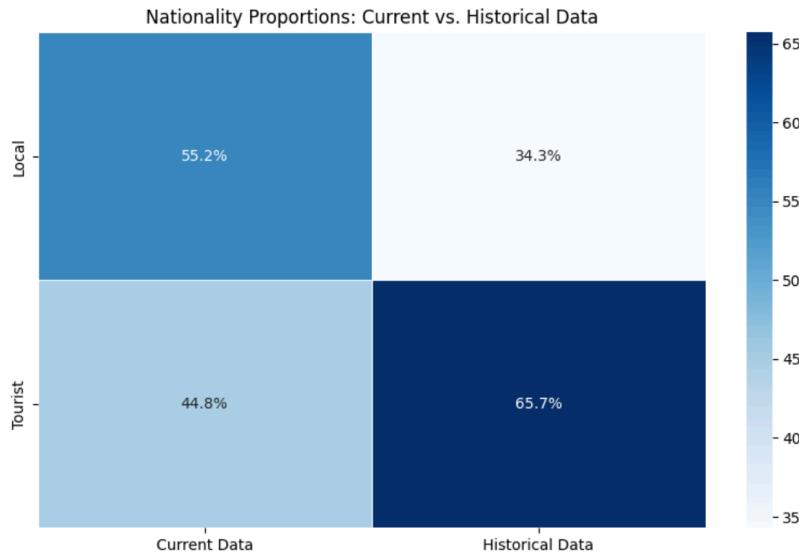


Figure 10: Proportions Of Nationality (Current vs Historical Data)

There has been a significant shift in the visitor composition, with the proportions essentially inverting between the two time periods. Historically, tourists were the dominant visitor group, making up 65.7% of all visitors. Currently, locals constitute the majority at 55.2% of visitors. This change potentially suggests a shift in focus towards attracting and serving the local community, reduced international or out-of-area tourism, or a possible reorientation of programming or exhibits to appeal more to local interests. There could also be changes in marketing strategy to target the local market.

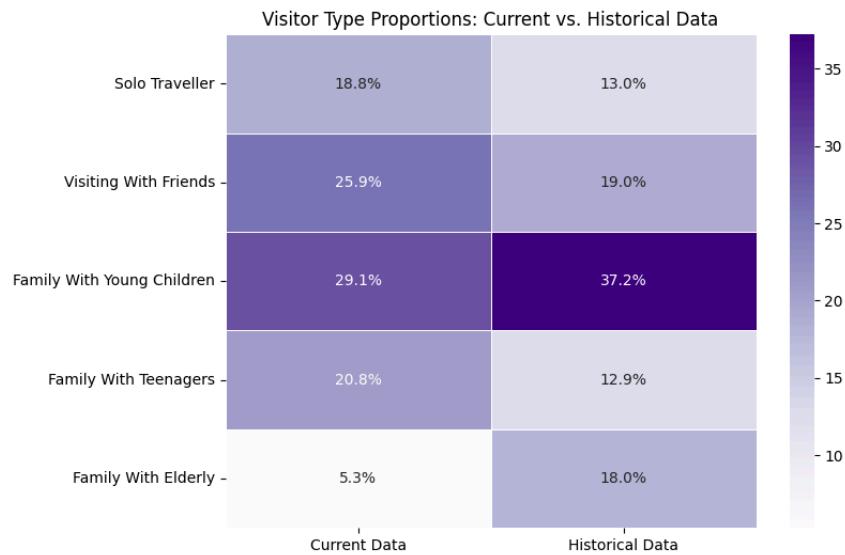


Figure 11: Visitor Type Proportions (Current vs Historical Data)

We observe that though ‘Family with Young Children’ has decreased by 8.1 percentage points, it remains the largest visitor segment in both periods. Meanwhile, ‘Family with Elderly’ has seen the most dramatic decrease from 18.0% to just 5.3%. On the other hand, the proportion of guests travelling alone or visiting with friends has significantly increased. Overall, USS has transitioned from being primarily a family destination (particularly for young children and elderly family members) to a more diversified attraction that appeals to varied groups, especially friends, solo visitors and families with teenagers.

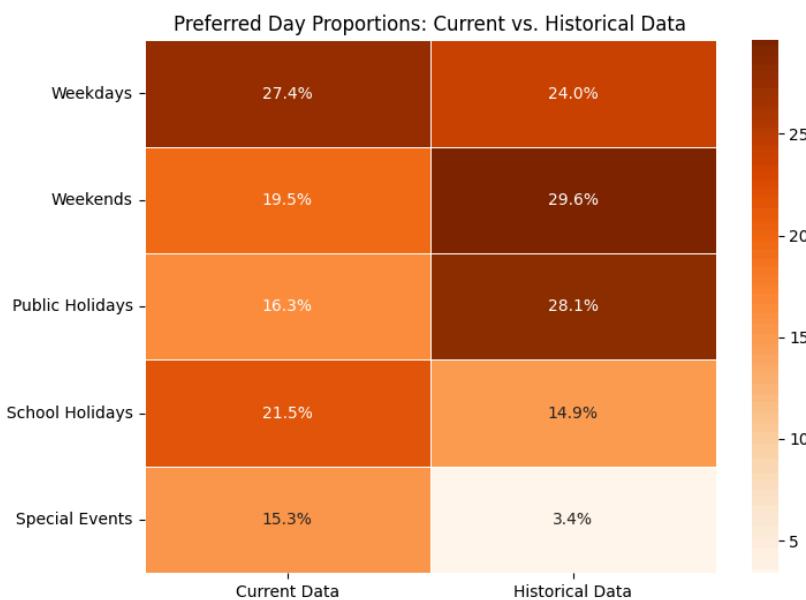


Figure 12: Proportions Of Preferred Day To Visit USS (Current vs Historical Data)

Historically, visitation was concentrated during weekends and public holidays, which together accounted for 57.7% of visitors. However, weekdays have now become the most popular time to visit, followed by school holidays. Special events have also seen a dramatic increase in popularity, rising from just 3.4% to 15.3%. Overall, this comparison heatmap suggests that USS has transitioned from a destination primarily visited during traditional peak tourism periods (weekends and public holidays) to one with more balanced attendance throughout different time periods, with special emphasis on weekdays, school holidays, and special events.

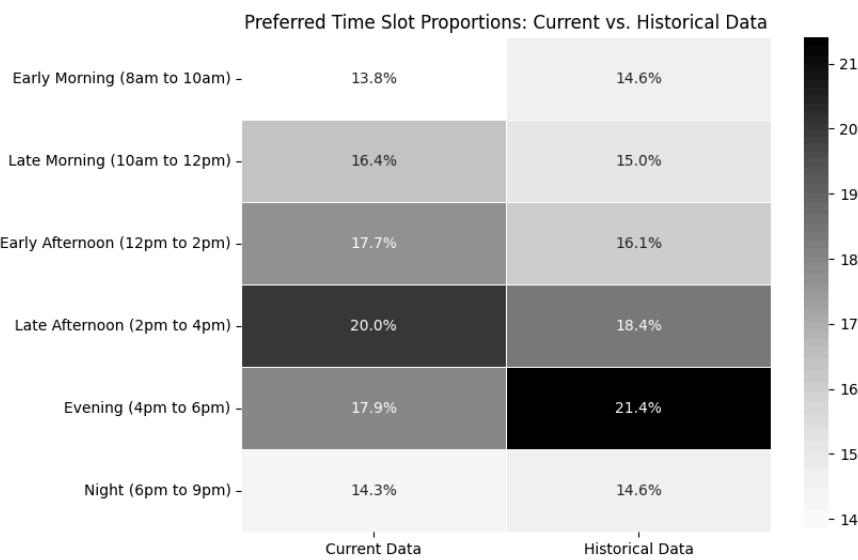


Figure 13: Proportion Of Preferred Time To Visit USS (Current vs Historical Data)

Late afternoon (2pm to 4pm) has become the most popular time slot, while evenings (4pm to 6pm) was historically the most popular. The current distribution is more balanced across time slots, with no single time period strongly dominating. This may reflect the greater proportion of local visitors who have more flexibility in their visiting times.

To enhance guest satisfaction, USS should implement strategies catering to underrepresented groups (eg. tourists), ensuring broader appeal, whilst improving its effectiveness of special events to create more engaging and memorable experiences for all visitors. Below are some proposed strategies:

- **Elderly:** Senior discounts can be offered during off-peak times to attract elderly visitors. At the same time, these discounts can also help fill up the park during slower periods, increasing overall attendance. Relaxation zones, rest areas and accessibility options such as wheelchair rentals can also be provided for seniors to promote inclusivity towards elderly guests. Creating a positive and comfortable environment for the elderly can enhance their satisfaction, encouraging visitation.
- **Tourists:** Unique tourist-centric experiences and packages can be developed to attract tourists. Unique and tailored experiences can command higher prices and encourage

tourists to spend more than they would on standard tickets, boosting overall revenue per guest.

- **Families with Young Children:** Interactive learning stations can be set up as engaging educational experiences are highly attractive to families, especially when they are tied to popular characters and themes that kids love. This tailored engagement strategy will lead to memorable experiences for parents and children alike, increasing the likelihood of word-of-mouth recommendations and repeat visits, which drives future revenue.

Such strategies aim to provide more engaging experiences for various groups of visitors so as to raise guest satisfaction while simultaneously increasing revenue.

5. External Factors and Guest Segmentation

Understanding the factors that influence visitor trends at Universal Studios Singapore (USS) is essential for effective park management, guest satisfaction, and operational efficiency. Several external factors, such as seasonality, local events, public and school holidays, and weather conditions, play a critical role in determining the segment size of visitors. These fluctuations in crowd levels can directly impact the overall guest experience, from wait times to ride availability and service quality.

One of the primary factors influencing guest segmentation is seasonality. Visitor numbers tend to increase during peak travel seasons, such as summer and year-end holidays when international tourists flock to Singapore. Additionally, local school holidays and long weekends contribute to a surge in domestic visitors. During these peak periods, families and large groups often make up a significant portion of the park's guests, leading to longer wait times and potentially lower satisfaction rates due to overcrowding. Conversely, off-peak months see a different visitor profile, with more adults, young professionals, and international tourists who prefer quieter experiences.

Local events and holidays also play a significant role in shaping visitor segmentation. Major public holidays such as Chinese New Year, National Day, and Deepavali bring a spike in local visitors, while international events like F1 Singapore Grand Prix can influence the influx of tourists. The number of public holidays within a month can directly correlate with crowd levels, as people take advantage of long weekends for leisure activities. Similarly, the number of school holidays within a given period can significantly alter the guest demographic, with more families and younger visitors in attendance.

Additionally, weather conditions contribute to variations in visitor numbers and satisfaction. Rainy months or extreme heat may deter some guests, leading to fluctuating attendance patterns. Visitors tend to be more satisfied during pleasant weather conditions, as it enhances the overall park experience. Unfavorable weather, combined with high crowd levels, can result in lower satisfaction due to ride closures and discomfort.

By analysing these external factors, USS can better predict visitor segmentation patterns and optimise resource allocation to maintain high satisfaction levels. Implementing crowd control measures, adjusting operational schedules, and enhancing guest services during peak periods can help mitigate the negative impact of external influences on the guest experience.

Business Question: Investigate the influence of external factors on segment size and behaviour. Suggest operational adjustments for high-impact periods.

Using a Multi Linear Regression model and a Random Forest model, we analysed the relationships between theme park attendance (dependent variable) and weather conditions, public holiday and school holidays (independent variables). Survey data was used to analyse each cluster's sensitivity to external factors. We utilised visualisation methods such as heatmaps and bar graphs to reveal peak visit timings and behavioural drivers for each cluster, which were identified in Subgroup A Question 2.

Using Theme Park - Weather-Holiday Dataset:

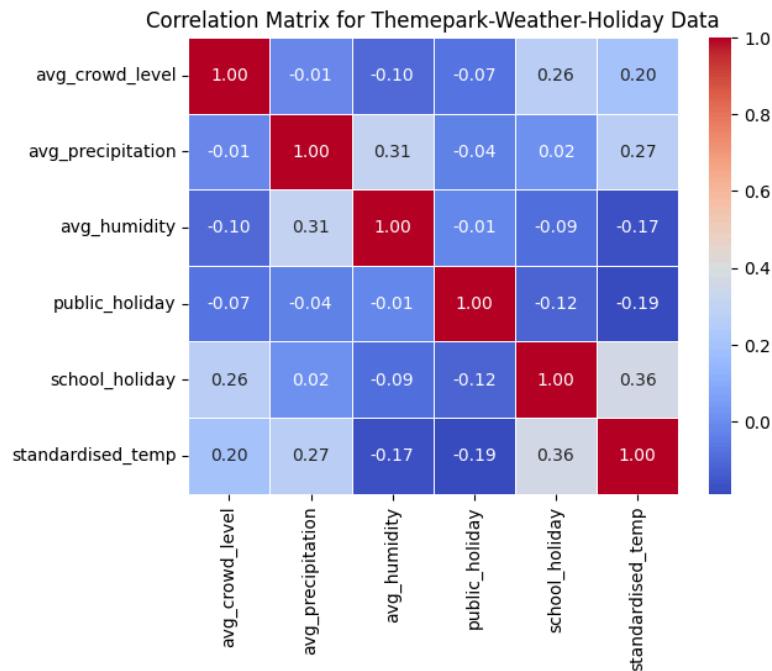


Figure 14: Correlation Matrix Of External Factors And Average Crowd Level

Based on the correlation matrix obtained from the dataset, school holidays and temperature have positive correlation with average crowd levels, implying that visitors are more likely to visit theme parks during school holidays and when temperatures are higher. In contrast, precipitation and humidity show negligible correlation with crowd levels due to their low magnitude of association. Among all external factors, humidity has the strongest negative correlation with average crowd levels.

Metric Used	Multiple Linear Regression	Random Forest
Mean Absolute Error (MAE)	10.11	8.15
Mean Squared Error (MSE)	170.96	130.16
R-Squared (R ²)	-0.03	0.22

Figure 15: Comparison Of Models' Performance

The Random Forest (RF) model had a lower MAE and MSE than Multiple Linear Regression (MLP) model, indicating that the RF model tends to produce fewer errors and has predictions closer to the actual crowd level.

The R-Squared value for the MLP model is negative, indicating that there is a lack of strong linear relationships between the external factors and average crowd level. On the other hand, the RF model has a positive R-Squared value of 0.22, indicating that 22% of the variance in crowd levels is explained by the model. However, the low value indicates that other unaccounted factors significantly influence crowd levels.

The above observations could be due to the complexities introduced by the varying behavior patterns of different guest clusters, driven by their differing needs and preferences. Therefore, to better predict guest behavior and propose operational improvements, we should incorporate survey data to gain deeper insights into visitor motivations, preferences and decision-making processes.

Using Survey Data:

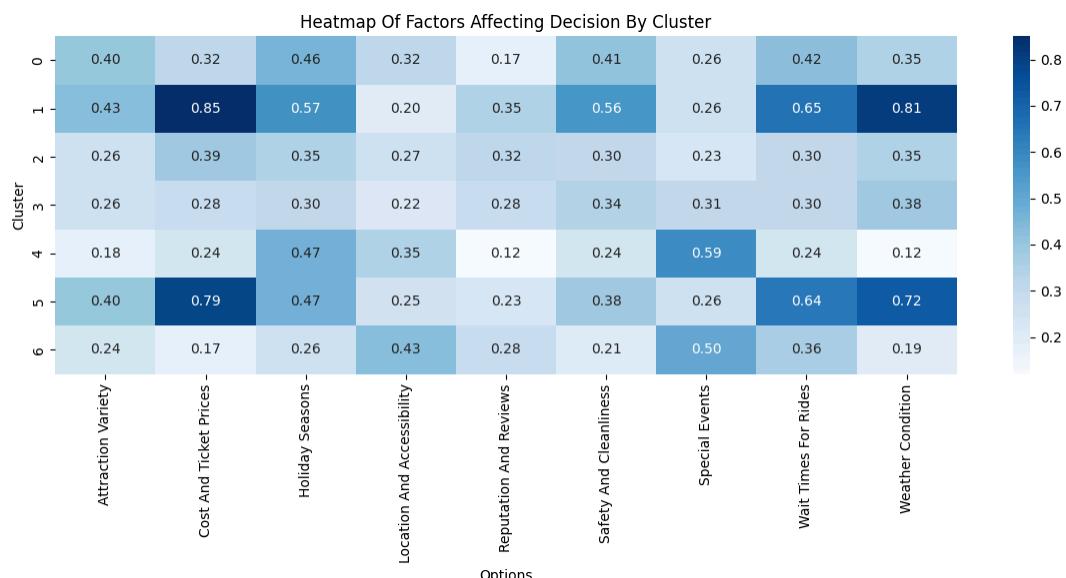


Figure 16: Factors Affecting Each Cluster's Decision To Visit USS

Clusters 1 and 5 are the most sensitive to cost, weather, and wait times. The influence score of “Cost and Ticket Prices”, “Weather Condition” and “Wait Times for Rides” are highest in Cluster 1 at 0.85, 0.81 and 0.65 respectively, and in Cluster 5 at 0.79, 0.72 and 0.64 respectively. This similarity is likely due to the comparable composition of both clusters, which are primarily made up of visitors with friends.

Meanwhile, Clusters 4 and 6 show the greatest interest in “Special Events”, which refers to USS-exclusive events such as Minionland Grand Opening and Halloween Horror Nights.

In contrast, Clusters 2 and 3 exhibit relatively moderate values across all factors, suggesting that no single factor strongly influences their decision to visit USS.

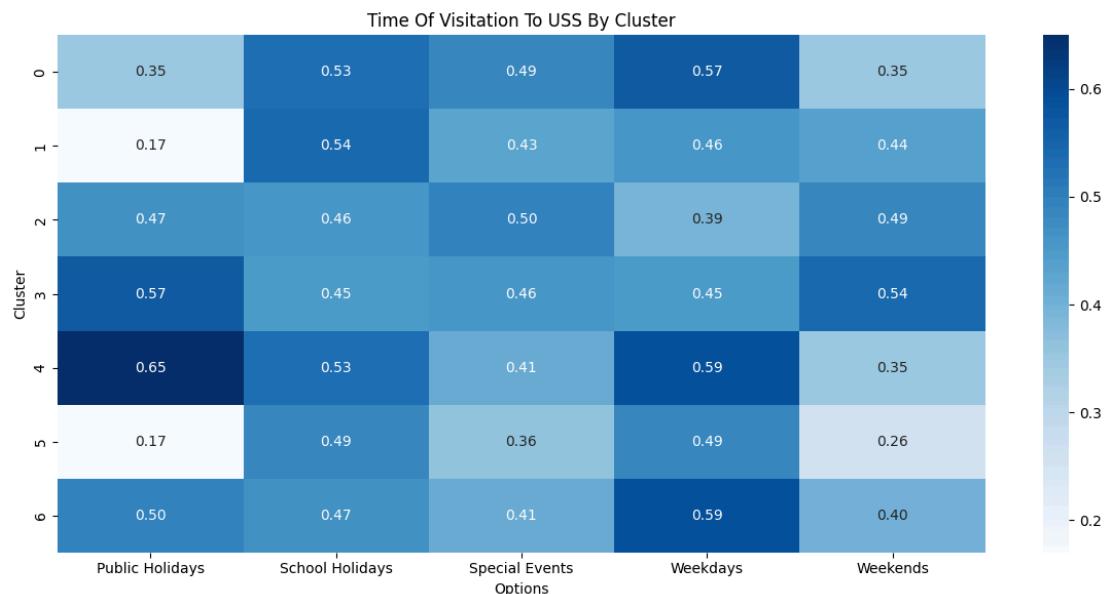


Figure 17: Preferred Visitation Times Of Each Cluster

Clusters 3 and 4 show the highest preference for visiting USS on public holidays, with scores of 0.57 and 0.65 respectively. As clusters 3 and 4 only comprise of locals, this could indicate that locals tend to take advantage of nationwide holidays for leisure activities.

Meanwhile, Clusters 0, 1, and 4 exhibit the strongest preference for visiting during school holidays, with scores of 0.53, 0.54, and 0.53, respectively. A possible reason for this could be the large representation of children, teenagers and young adults in these clusters.

Clusters 0, 4 and 6 have strong attendance on weekdays (0.57, 0.59 and 0.59, respectively), while special events and weekends are not dominated by any cluster.

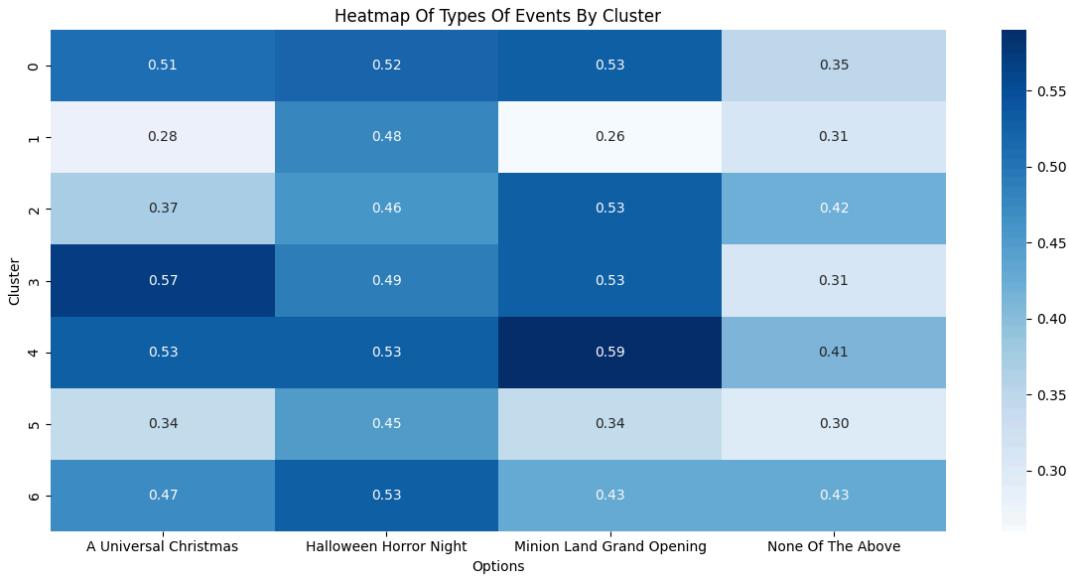


Figure 18: Preferred USS-Exclusive Events Of Each Cluster

Halloween Horror Night emerges as the most popular event, receiving the highest average score across all clusters. This indicates broad appeal across different visitor segments.

Cluster 1 had the lowest engagement with "Minion Land Grand Opening" (0.26) and "A Universal Christmas" (0.28), indicating that this group is less influenced by themed events when deciding to visit USS. In contrast, it had a significantly higher score for Halloween Horror Night, likely attributed to the large proportion of young adults and teenagers in this cluster, who may be more keen on thrill-based experiences over family-friendly events.

The "None Of The Above" category has relatively consistent values (0.30-0.43) across clusters, suggesting a significant portion of each segment visits regardless of special events.

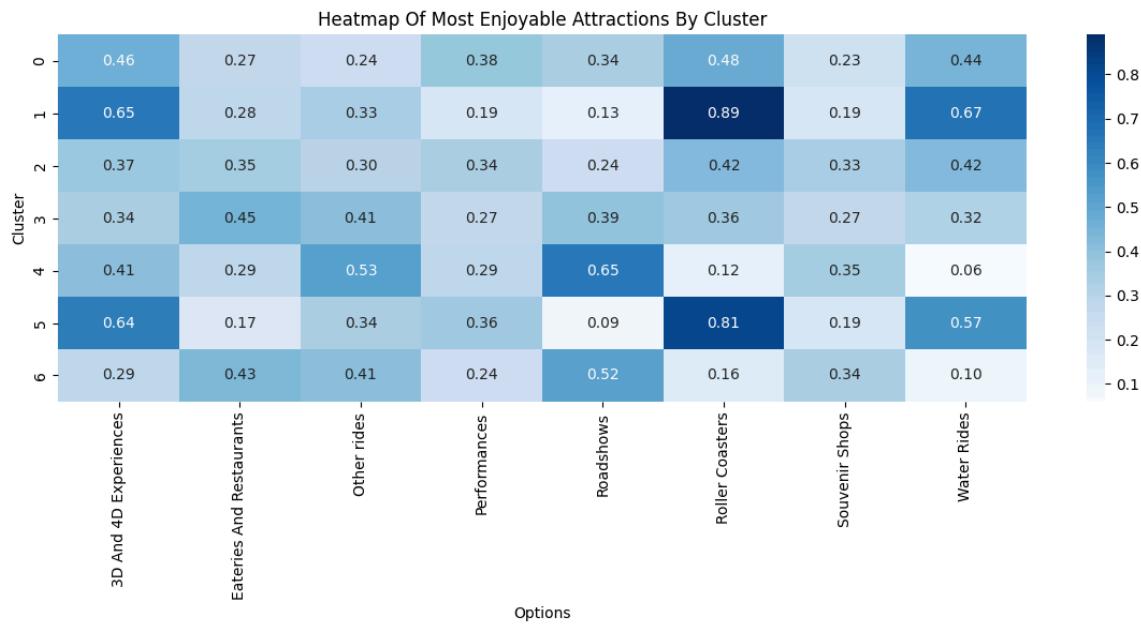


Figure 19: Most Enjoyable Attractions By Cluster

Roller coasters are most popular among Clusters 1 and 5, with very high preference scores of 0.89 and 0.81. Clusters 1 and 5 prefer thrill rides, as seen from their higher scores for 3D and 4D experiences, roller coasters and water rides.

Clusters 4 and 6 enjoy roadshows the most, with preference scores of 0.65 and 0.52 respectively. This could be due to the large representation of families with young children in these two clusters, increasing their preference for family-friendly attractions like roadshows.

Clusters 0, 2 and 3 do not display strong preferences for any attractions, with preference scores in between (0.24-0.48).

Based on the preferences and size of the clusters, USS can refine staff allocation, tailor promotions and adjust operational strategies to align with peak periods and cluster-specific sensitivities to enhance both guest experience and operational efficiency.

- **Flexible Staffing Plans:** Adjust staffing levels to match demand during high-impact periods such as weekends, holidays, or special events, to manage crowds effectively, especially at popular attractions, food counters, and guest services. For example, since cluster 6 shows the highest interest in visiting souvenir shops, more staff can be deployed to souvenir shops on days when cluster 6 is predicted to comprise a significant proportion of visitors.
- **Optimised Queue Management:** Virtual queues can be implemented for high-demand rides or attractions on certain days, allowing visitors to reserve a time slot on their phones. This allows visitors to explore the park and visit other attractions rather than waiting in long physical lines. For example, when Clusters 1 and 5 are predicted to make up a significant portion of visitors, virtual queues could be implemented for roller

coasters, as they are rated highly enjoyable by both clusters (with scores of 0.89 and 0.81 respectively) and are likely to experience high demand.

- **School Holiday Promotions:** Clusters 1 and 5 are highly cost-sensitive, with cost influence scores of 0.85 and 0.79 respectively. They are also more likely to visit during school holidays. Therefore, USS can offer discounted ticket bundles to attract visitors from these clusters during peak school holiday periods.
- **Wet Weather Promotions:** To sustain visitor numbers during rainy days, wet weather promotions can be aimed at Clusters 1 and 5, who are least weather-resilient (weather sensitivity scores of 0.81 and 0.72 respectively). Examples include free ponchos, indoor activity highlights, or discounted express passes to encourage attendance despite unfavourable weather conditions.

On the other hand, Clusters 4 and 6 are less sensitive to weather (with scores of 0.12 and 0.19), and can be engaged through themed pop-ups or special event tie-ins to maintain their interest regardless of weather conditions.

- **Event-based Promotions:** For event-driven clusters, USS can introduce bundle deals that include event-specific perks. For example, guests can be offered VIP access, merchandise discounts or express passes to enhance their experience and encourage attendance.
-

6. Demand Prediction for Attractions and Services

Business Question: How can we predict visitor demand for attractions and services using historical trends, weather, and events to optimize resources and enhance customer experience?

Historical average wait times for individual rides were obtained from Thrill Seek, while weather data, including average temperature and rainfall, was retrieved from Meteorological Services Singapore. These datasets were subsequently processed to create the final dataset, waittime_df, which contains the hourly wait times for each ride from January 1, 2024, to February 28, 2025. The weather data was also refined to include the average temperature in the Sentosa area and the daily average rainfall.

(A) Demand Prediction Approach:

Demand prediction is a broad topic and we investigated it at different levels:

- Level 1: Hourly average wait time for each ride
- Level 2: Monthly average wait time for each ride for the subsequent month
- Level 3: Overall daily average wait times for USS

To model the predictions at different levels, we selected XGBoost and Random Forest as our primary machine learning models due to their ability to handle non-linear relationships and complex interactions between features. These models are particularly useful for predicting Level

1 (hourly wait times) and Level 2 (monthly ride wait times), where structured historical data with multiple influencing factors (temperature, rainfall, holidays, seasonal events, type of ride, day of the week) For Level 3 (overall USS wait times), SARIMAX (Seasonal AutoRegressive Integrated Moving Average with Exogenous Variables) and SARIMAX with exogenous variables (weather, events, etc.) were chosen due to its strength in capturing seasonality and time-dependent trends, which are crucial in aggregated wait time data.

As for services, we aimed to predict visitor count for eateries. Instead of predicting foot traffic for individual eateries, we aggregated predictions at the zone level. This decision was made because:

- Foot traffic patterns between eateries are complex and interdependent, making it difficult to model accurately.
- High variance in customer movement may lead to instability in individual eatery predictions.
- Zone-based prediction captures general demand trends more effectively which balances accuracy and interpretability.

Visitor counts were estimated using survey question 14.6, which provides percentages of visitors who visit eateries every two hours. Synthetic visitor data was generated using these percentages, via Faker to approximate real-world traffic distribution.

Retail stores were not prioritized for demand prediction because most of them are located in the Hollywood zone, rather than being spread across ride-heavy areas. This concentration makes synthetic data generation random and may not yield insightful predictions.

(B) Feature Engineering

To enhance predictive power, we incorporated events and holidays (public, school) as external features, stored in a dictionary for model training. Additionally, feature engineering was conducted to create:

- Day of the week (to account for weekday vs. weekend effects)
- Thrill level (1 for high intensity rides, 0 for family friendly rides)

For standardization across all models, the models were used to predict:

- The Accelerator ride for Level 1 (hourly wait time predictions)
- February 28 2025 for Level 2 (predicting the average wait time for each ride in February 2025)

(C) Results

Generally, hourly wait time predictions for a single ride have lower R^2 due to greater variance, while aggregated average wait times show higher RMSE since averaging loses time-based patterns which reduces predictive accuracy.

Level 1: Hourly Wait Time Prediction

XGBoost outperformed Random Forest, achieving a lower RMSE and higher R^2 , suggesting that it better captured complex relationships in hourly fluctuations.

This can be attributed to:

- XGBoost's ability to handle extreme values better, which is necessary in hourly predictions where sudden peaks in wait times often occur.
- XGBoost is effective in capturing short-term dependencies, unlike Random Forest, which averages out short-term variations.

Level 1: Model Performance for Hourly Wait Time (Accelerator Ride)

Model	RMSE (Hourly)	R^2 (Hourly)
XGBoost	2.85	0.6946
Random Forest	3.18	0.6201

Thus, XGBoost was chosen as the best model for hourly predictions.

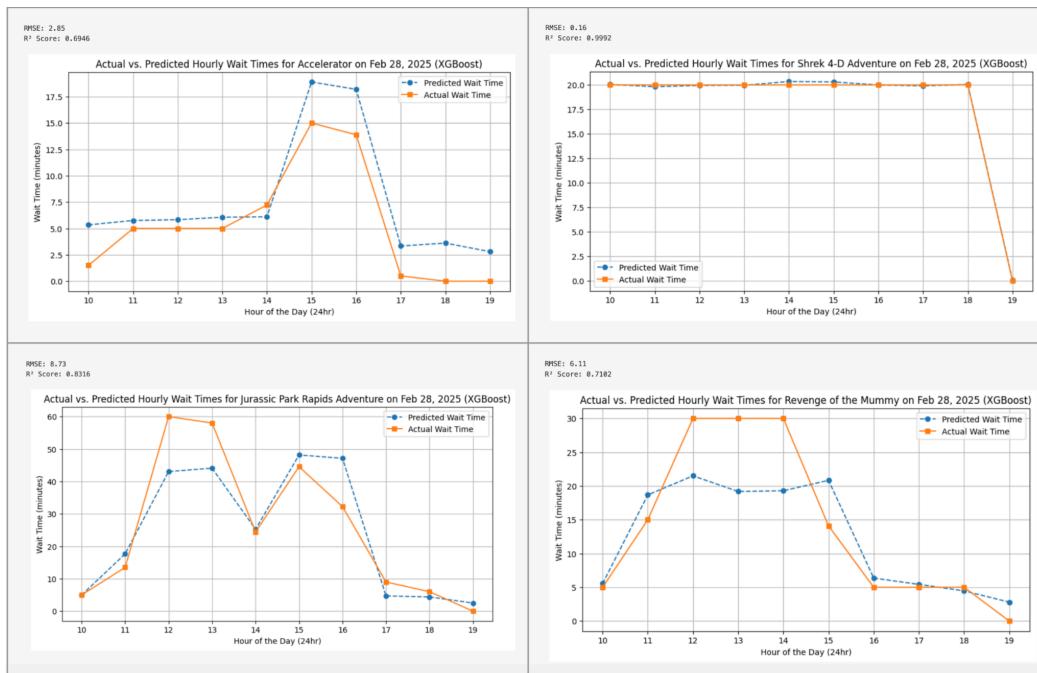


Figure 20: Actual vs Predicted Hourly Wait Times For A Ride In Each Zone Using XGBoost

Level 2: Monthly Average Wait Time Prediction

For predicting average wait times across all rides for February 2025, Random Forest performed slightly better than XGBoost, achieving a lower RMSE and higher R². This indicates that:

- Random Forest effectively captured overall trends across different rides, likely due to its ability to learn from multiple decision trees and reduce overfitting.
- XGBoost, while powerful for short-term hourly predictions, may be sensitive to fluctuations, reducing its effectiveness for long-term trend prediction performance.

Level 2: Model Performance for Monthly Average Wait Time (February 2025, All Rides)

Model	RMSE (Monthly)	R ² (Monthly)
XGBoost	5.75	0.8974
Random Forest	5.63	0.9016

Given these results, Random Forest was selected as the best model for predicting monthly ride wait times.

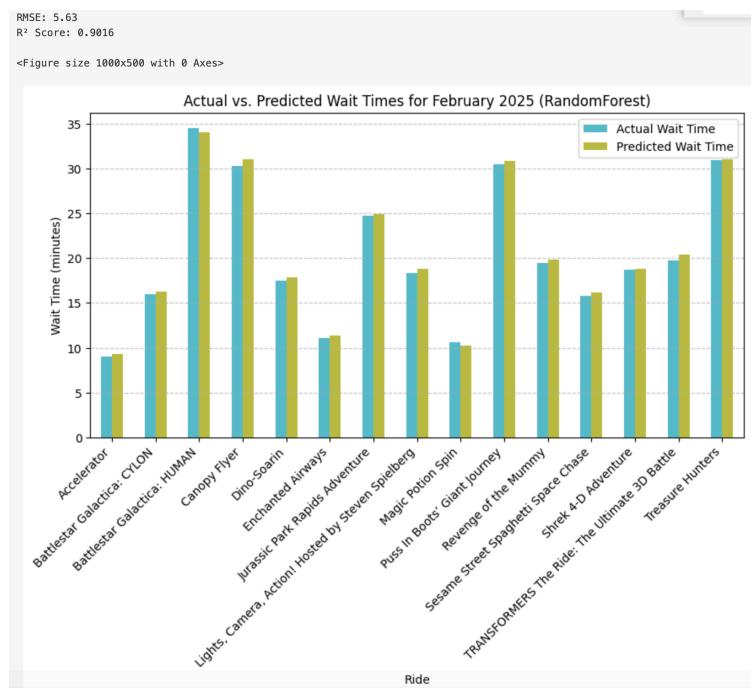


Figure 21: Actual vs Predicted Hourly Wait Times For February 2025 Using Random Forest

Level 3: Overall USS Average Wait Times

Both SARIMAX and SARIMAX with exogenous variables effectively capture general trends, likely due to the 90 day sliding window approach, but they struggle with day-to-day fluctuations, leading to less precise daily predictions.

- R^2 is not the best metric for time series prediction, as the data exhibits non-stationarity (seasonal trends and fluctuations). Instead, we focus on RMSE improvements.
- Incorporating exogenous variables such as weather and holidays led to a slight improvement in RMSE, but statistical tests indicated that these variables were not highly significant, as evidenced by their relatively low p-values.
- Therefore, while factors like weather and events have some influence on wait times, the primary drivers remain historical trends and seasonal effects.

Level 3: SARIMAX's Performance in predicting average wait times in USS

Model	RMSE (Bi-hourly)	R^2 (Bi-hourly)	MAE (Bi-hourly)
SARIMAX	7.83	0.156	5.9247
SRIMAX (with exogenous variables)	6.05	-0.001	4.8817

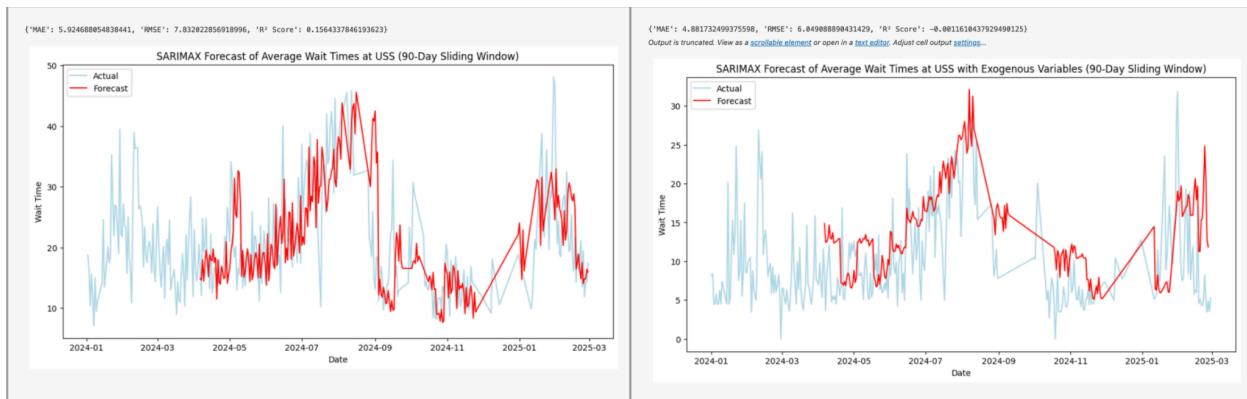


Figure 22: SARIMAX Forecast Of Average Wait Times At USS

(D) Demand Prediction for Eateries:

After testing the models for wait times, XGBoost was selected as the model to predict visitor hourly visitor count for eateries by zone. XGBoost effectively captured the trends in visitor count, accurately identifying peak hours and predicting visitor flow patterns.

Generally, the model has a high RMSE compared to wait time predictions due to the nature of the target variable. Visitor count varies more continuously, making it challenging to predict with the same level of accuracy.

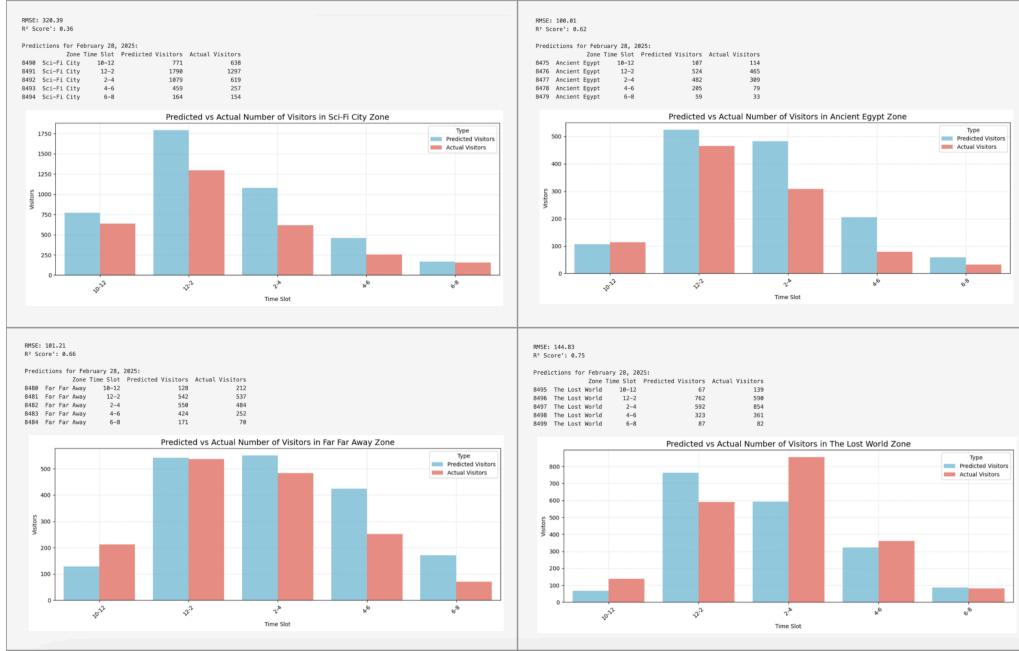


Figure 23: Predicted vs Actual Number Of Visitors In Main Eatery Zones Of USS

Accurate wait time predictions enable better staff allocation and allow visitors to plan rides more efficiently, enhancing the overall park experience. By accurately forecasting wait times, the park can optimize its resource management which reduces overcrowding during peak hours. This also ensures that staff are deployed optimally. This not only improves operational efficiency but also leads to increased visitor satisfaction, as guests can make more informed decisions about when to visit attractions. Additionally, many survey respondents have expressed dissatisfaction with USS due to the long wait times. By anticipating demand more effectively, the park can minimize wait times which will improve customer experience and potentially increase revenue through enhanced guest flow.

7. Optimization of Attraction Layouts and Schedules

Business Question: How can we optimize attraction layouts and schedules to enhance guest satisfaction at USS?

We utilized ABM to simulate visitor distributions for an average day. We adjusted ride capacities(1- increase of capacity by 10%), reduced buffer times between rides(2- from an accounted buffer of 7 minutes to 5 minutes) and rotated zones(3- rotating the zones clockwise).

Model's Results:

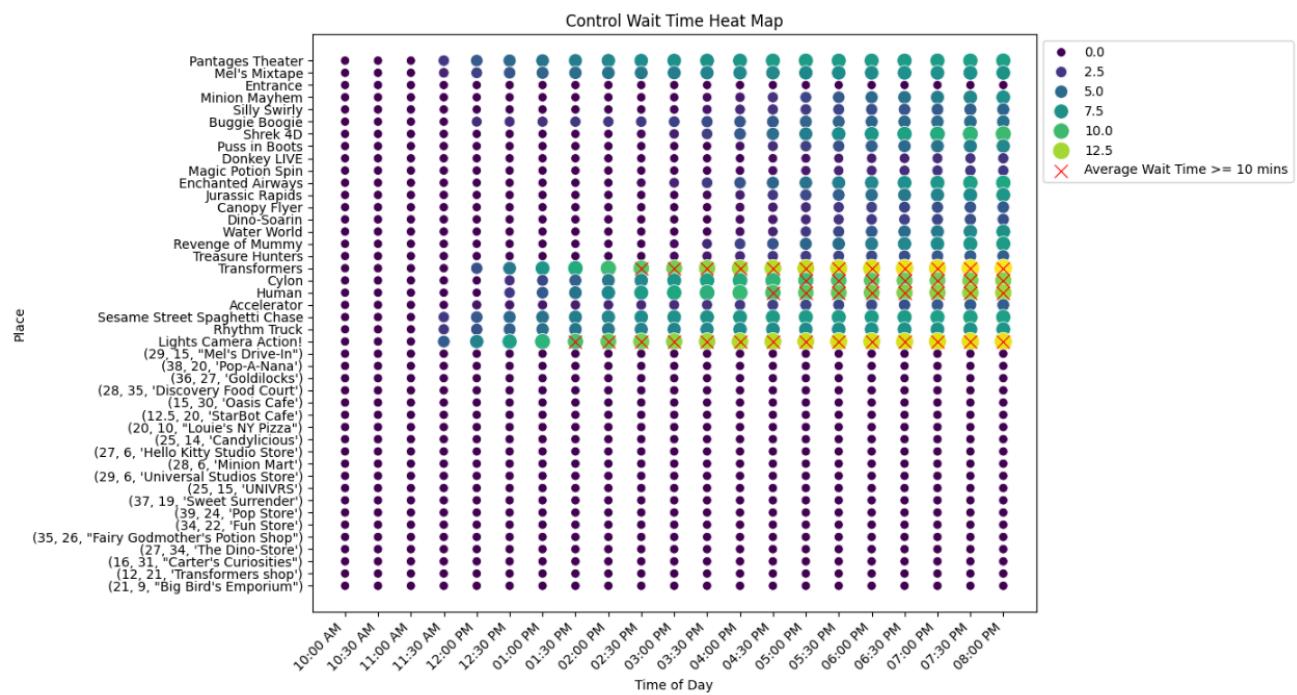


Figure 24 - Plot Of Average Wait Time Per Place At Each Time Slot (Control)

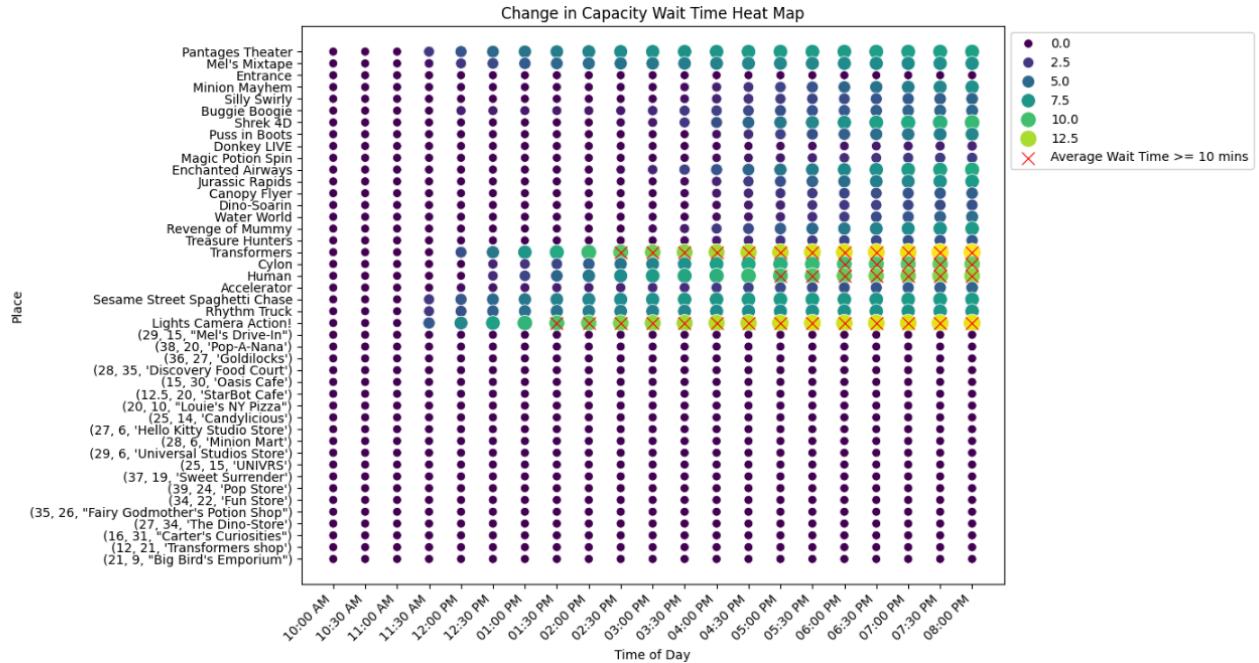


Figure 25 - Plot Of Average Wait Time Per Place At Each Time Slot (Change 1: +10% Capacity)

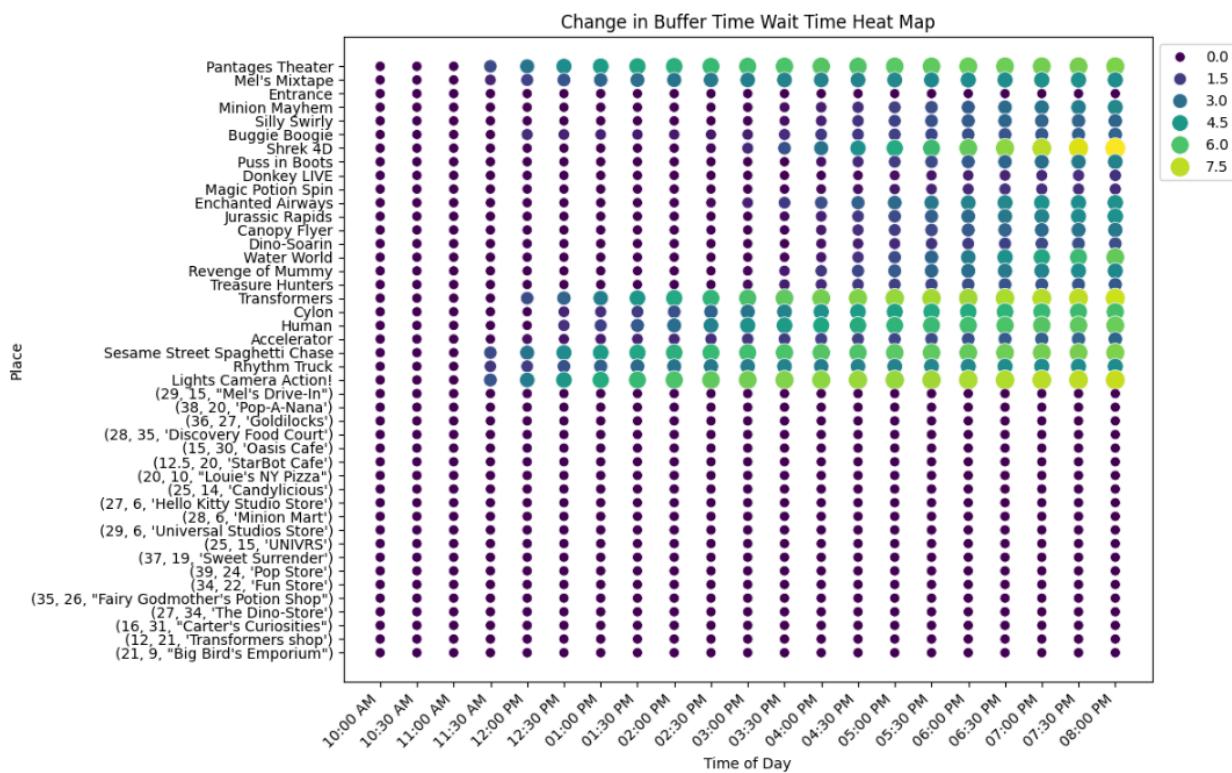


Figure 26 - Plot Of Average Wait Time Per Place At Each Time Slot (Change 2: Reduced Buffer Time From 7 Minutes To 5 Minutes)

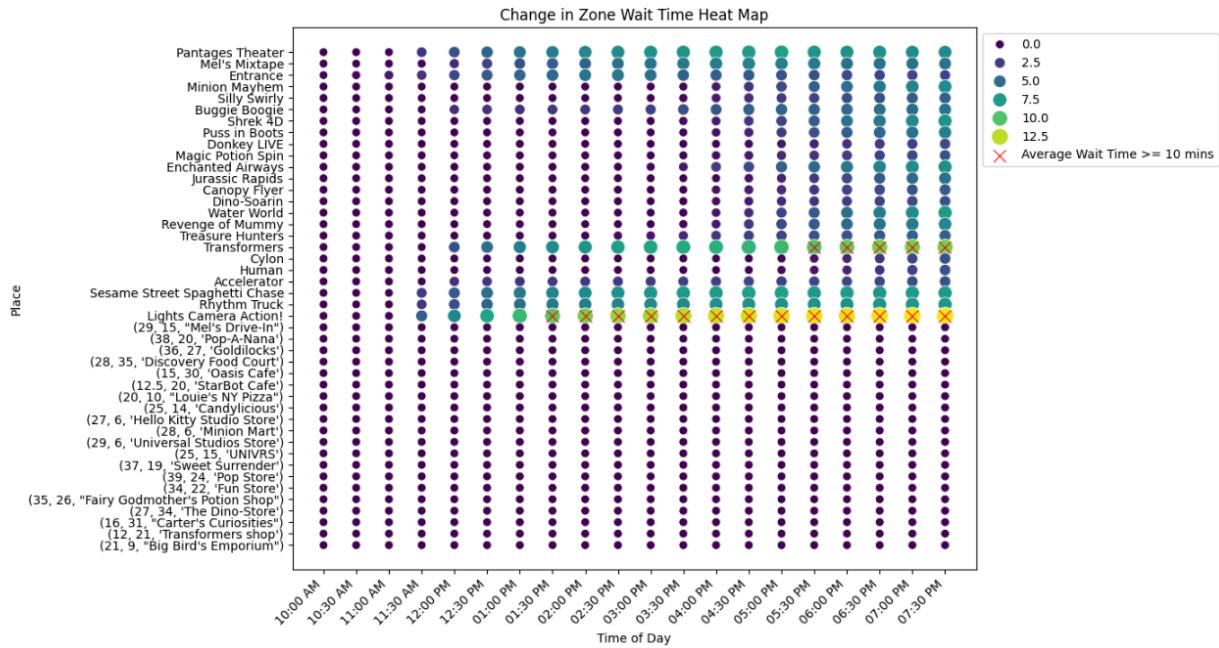


Figure 27 - Plot Of Average Wait Time Per Place At Each Time Slot (Change 3: Rotating The Zones Clockwise)

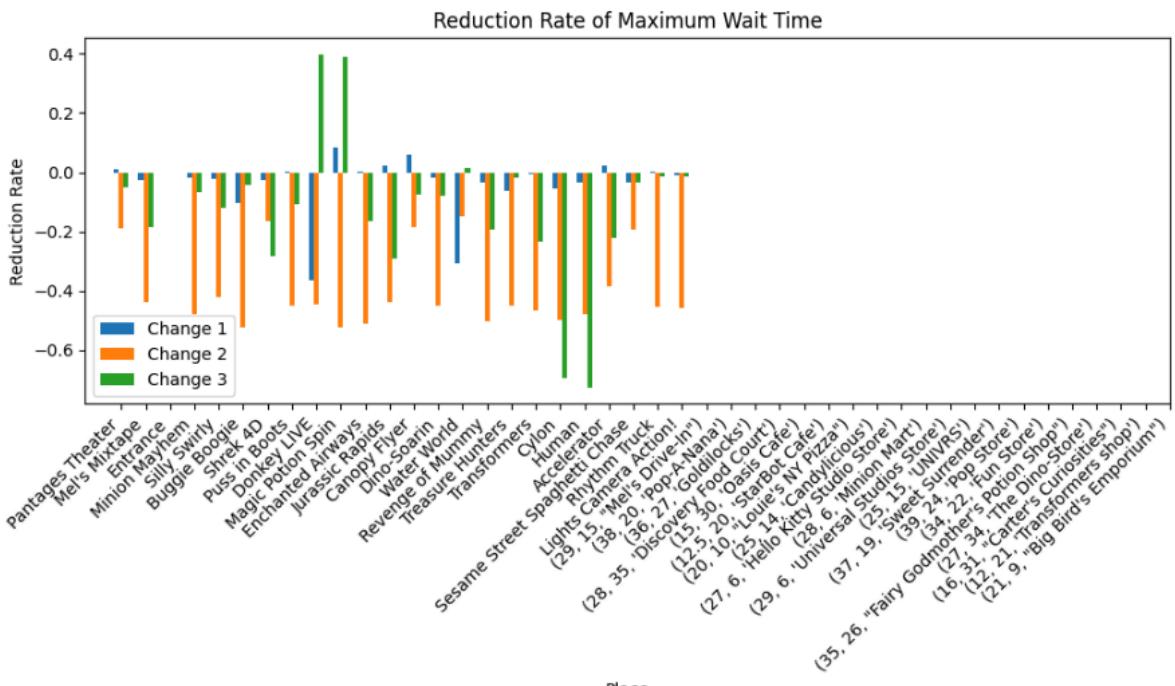


Figure 28 - Plot Of Reduction Rate Of Average Wait Time (Control Set-up vs Changes 1, 2 And 3)

We can tell that Change 2- Reduction of Buffer Time is the most effective in reducing wait time for all ride attractions. Ranked second would be Change 1- Increase in Capacity where reduction in wait time is seen throughout for the rides, except for slight increase for 'Magic Potion Spin', 'Enchanted Airways', 'Jurassic Rapids' and 'Accelerator'. While the rotating of zone is ranked last, reducing average wait time for most attractions, but with the steep increase for "Donkey Live" and 'Magic Potion Spin', which makes this adjustment unsuitable.

Change 2- Reduction in Buffer Time:

- Buffer time refers to idle time between ride cycles (e.g., time taken to unload/load passengers, dispatch intervals, or operational delays).
- Reducing this buffer time increases ride throughput, meaning more guests can board within the same timeframe.
- Since ABM models guest behavior dynamically, a faster throughput directly leads to shorter wait times because the queue is being processed more efficiently.
- This change is universally beneficial across all rides because it does not alter guest movement patterns but instead improves efficiency at the attraction level.
- Unlike capacity increases (which may only help during peak congestion), buffer time reduction has an immediate and consistent impact on wait times throughout the day.
- Every attraction benefits since each cycle processes more guests without fundamentally changing the distribution of people in the park.

Change 1- Increase in Capacity by 10%:

- Increasing ride capacity allows each cycle to accommodate more guests, reducing queue length over time.
- ABM simulations show that this benefits most rides by alleviating bottlenecks.
- Attractions like 'Magic Potion Spin', 'Enchanted Airways', 'Jurassic Rapids', and 'Accelerator' see slight increases in wait time. This can be explained by shifts in visitor preferences:
 - More guests may be drawn to these attractions due to their improved capacity, leading to higher foot traffic in these areas.
 - If the increased capacity is not perfectly balanced with increased demand, certain rides may experience unexpected congestion.
- ABM captures adaptive behavior, meaning guests might switch from other rides to those with increased capacity, redistributing congestion rather than eliminating it.

Change 3 - Rotating Zones Clockwise:

- Rotating zone entry changes how guests enter and explore the park.
- While this can reduce average wait times for many attractions, it disrupts guest flow in ways that negatively impact certain rides.
- Some attractions, particularly 'Donkey Live' and 'Magic Potion Spin', experience steep increases in wait times.
- Why Donkey Live & Magic Potion Spin are impacted negatively:

- Guest clustering issue: If certain zones receive an influx of guests earlier in the day, shows like 'Donkey Live' (which has a fixed schedule) may experience overcrowding at specific times.
- Mismatch between demand and supply: 'Magic Potion Spin' may not have a high enough throughput to handle concentrated guest flow from zone rotations, leading to increased wait times.
- Guest movement bottlenecks: ABM may show that guests who start in different zones take longer to disperse evenly throughout the park, creating localized congestion in areas that are not designed for sudden surges of visitors.

Overall Conclusion of Findings:

- ★ Reduction of Buffer Time is the best because it improves efficiency without affecting guest movement.
- ★ Increase in Capacity is effective but can lead to unintended shifts in visitor flow, causing slight wait time increases for some rides.
- ★ Rotating Zone Entry creates localized congestion problems, making it the least effective overall.

Analysis of the dissatisfaction factors from survey responses:

We identified that a reduction in wait time can boost guest satisfaction, especially for rides.

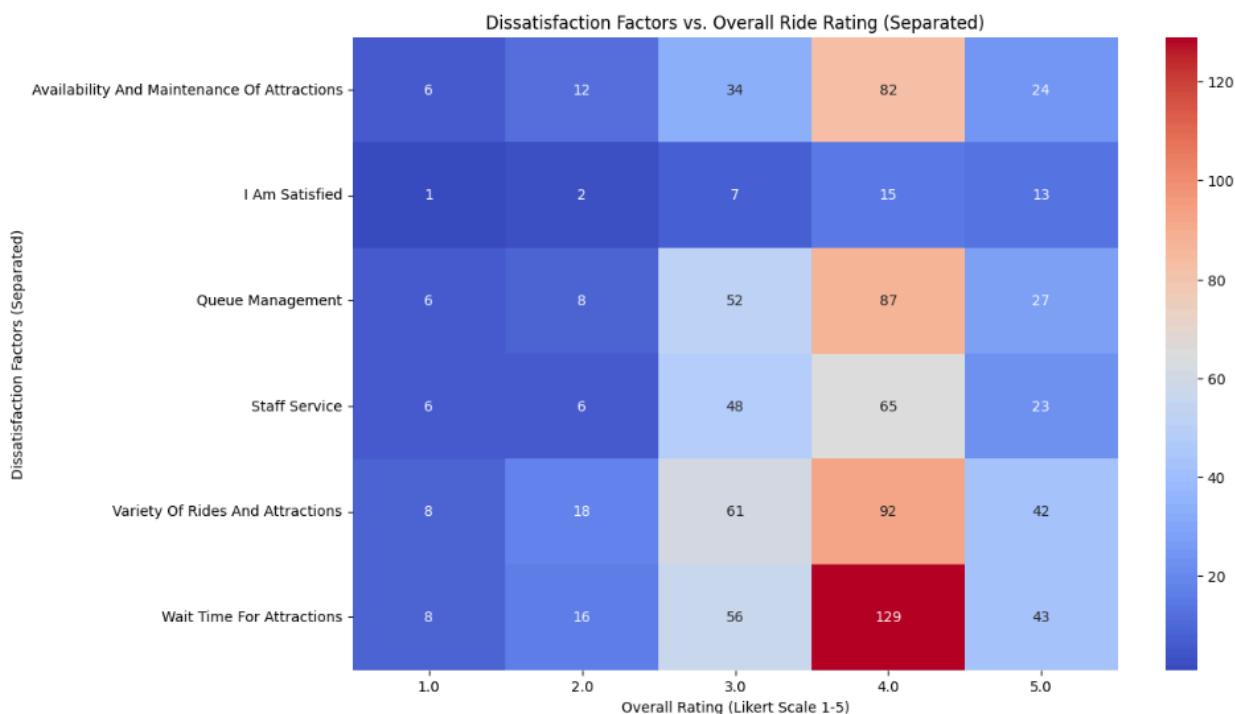


Figure 29: Heatmap Of Dissatisfaction Factors vs Overall Ride Rating

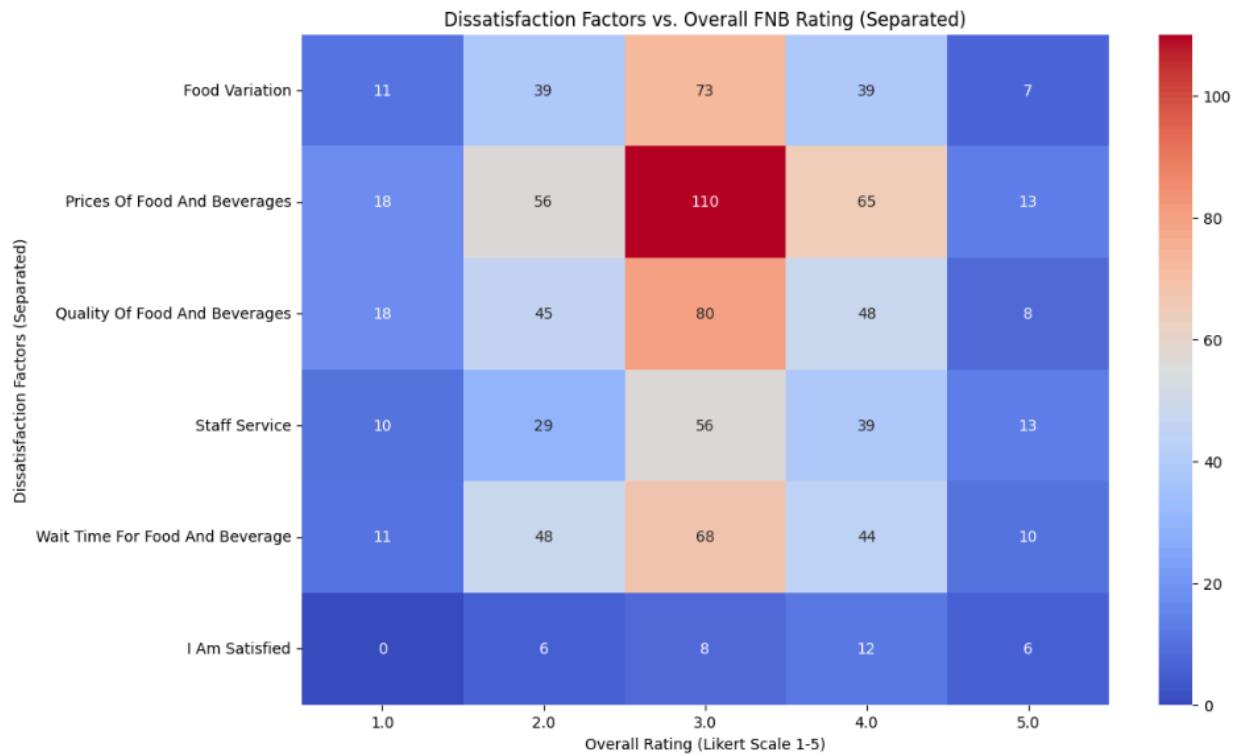


Figure 30: Heatmap Of Dissatisfaction Factors vs Overall FNB Rating

There were no useful results to evaluate for the shops and food stalls though it was shown that the changes did impact the overall wait time for ride attractions. This may be due to the limited information available to map the flow for eateries and souvenir shops accurately as there is no available wait time data on these categories of places available online. However, if there is more information about the queue or popularity of these places, the model can be easily modified to take into account such information and reassess the impact of these changes on the overall wait time for the visitors.

While limited changes can be made to attraction capacities (Change in Capacity/Zoning can only be used to determine capacity during planning phase), USS could consider a more efficient transition between each cycle of rides, allowing higher throughputs at popular attractions and increasing ride efficiency for a seamless visitor experience.

8. Resource Allocation for Demand Variability

Business Question: How can we allocate staff dynamically to meet the variability in demand of visitors throughout the day to ensure a pleasant visitor experience?

Using Agent-Based Modeling(ABM) in 30-minute intervals from 10am to 8pm, we visualised guest flows based on the popularity of the attractions. This was obtained from our predictive

model in subgroup B question 1, to guide simultaneous staff generation in the model when necessary. By identifying high-traffic areas and potential bottlenecks, we can proactively adjust staffing levels to optimize operations.

Model results:

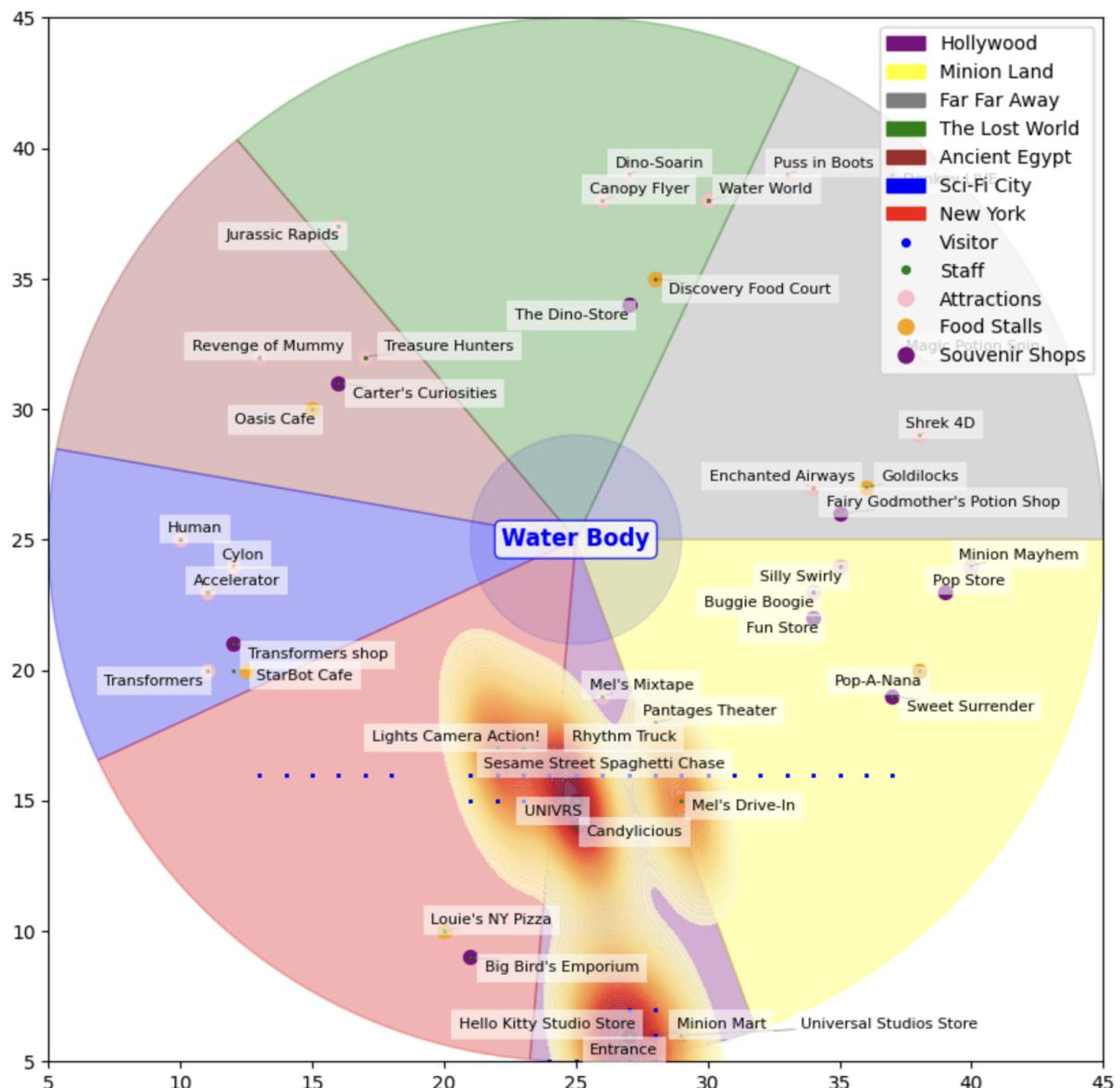


Figure 31 - Plot of USS From 10am To 10.30am Generated From ABM

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Time: 10:00 AM

Ride operating staff at each ride per zone:
Zone: Hollywood
  Ride: Pantages Theater, Number of Staff: 3
  Ride: Mel's Mixtape, Number of Staff: 3
  Ride: Entrance, Number of Staff: 4
Zone: Minion Land
  Ride: Minion Mayhem, Number of Staff: 3
  Ride: Silly Swirly, Number of Staff: 3
  Ride: Buggie Boogie, Number of Staff: 3
Zone: Far Far Away
  Ride: Shrek 4D, Number of Staff: 3
  Ride: Puss in Boots, Number of Staff: 3
  Ride: Donkey LIVE, Number of Staff: 3
  Ride: Magic Potion Spin, Number of Staff: 3
  Ride: Enchanted Airways, Number of Staff: 3
Zone: The Lost World
  Ride: Jurassic Rapids, Number of Staff: 3
  Ride: Canopy Flyer, Number of Staff: 3
  Ride: Dino-Soarin, Number of Staff: 3
  Ride: Water World, Number of Staff: 3
Zone: Ancient Egypt
  Ride: Revenge of Mummy, Number of Staff: 3
  Ride: Treasure Hunters, Number of Staff: 3
Zone: Sci-Fi City
  Ride: Transformers, Number of Staff: 3
  Ride: Cylon, Number of Staff: 3
  Ride: Human, Number of Staff: 3
  Ride: Accelerator, Number of Staff: 3
Zone: New York
  Ride: Sesame Street Spaghetti Chase, Number of Staff: 3
  Ride: Rhythm Truck, Number of Staff: 3
  Ride: Lights Camera Action!, Number of Staff: 3

Food stall staff at each zone:
Zone: Hollywood
  Food Stall: Mel's Drive-In, Number of Staff: 1
Zone: Minion Land
  Food Stall: Pop-A-Nana, Number of Staff: 1
Zone: Far Far Away
  Food Stall: Goldilocks, Number of Staff: 1
Zone: The Lost World
  Food Stall: Discovery Food Court, Number of Staff: 1
Zone: Ancient Egypt
  Food Stall: Oasis Cafe, Number of Staff: 1
Zone: Sci-Fi City
  Food Stall: StarBot Cafe, Number of Staff: 1
Zone: New York
  Food Stall: Louie's NY Pizza, Number of Staff: 1

Souvenir shop staff at each zone:
Zone: Hollywood
  Souvenir Shop: Candylicious, Number of Staff: 1
  Souvenir Shop: Hello Kitty Studio Store, Number of Staff: 3
  Souvenir Shop: Minion Mart, Number of Staff: 1
  Souvenir Shop: Universal Studios Store, Number of Staff: 1
  Souvenir Shop: UNIVRS, Number of Staff: 1
Zone: Minion Land
  Souvenir Shop: Sweet Surrender, Number of Staff: 1
  Souvenir Shop: Pop Store, Number of Staff: 1
  Souvenir Shop: Fun Store, Number of Staff: 1
Zone: Far Far Away
  Souvenir Shop: Fairy Godmother's Potion Shop, Number of Staff: 1
Zone: The Lost World
  Souvenir Shop: The Dino-Store, Number of Staff: 1
Zone: Ancient Egypt
  Souvenir Shop: Carter's Curiosities, Number of Staff: 1
Zone: Sci-Fi City
  Souvenir Shop: Transformers shop, Number of Staff: 1
Zone: New York
  Souvenir Shop: Big Bird's Emporium, Number of Staff: 1

Cleaning staff at each zone:
Zone: Hollywood, Number of Cleaning Staff: 4
Zone: Minion Land, Number of Cleaning Staff: 4
Zone: Far Far Away, Number of Cleaning Staff: 1
Zone: The Lost World, Number of Cleaning Staff: 1
Zone: Ancient Egypt, Number of Cleaning Staff: 1
Zone: Sci-Fi City, Number of Cleaning Staff: 1
Zone: New York, Number of Cleaning Staff: 4

Security staff at each zone:
Zone: Hollywood, Number of Security Staff: 6
Zone: Minion Land, Number of Security Staff: 6
Zone: Far Far Away, Number of Security Staff: 1
Zone: The Lost World, Number of Security Staff: 1
Zone: Ancient Egypt, Number of Security Staff: 1
Zone: Sci-Fi City, Number of Security Staff: 1
Zone: New York, Number of Security Staff: 6

```

Figure 32 - Staffing Roster Generated For Time 10am To 10.30am By ABM

During opening hours, we expect a large crowd to be entering the USS and consequently we see 4 staff being allocated to the entrance instead of 2 staff being allocated during non-peak hours. With the heat map overlaid on top of the USS map, we expect a majority of the crowd to be within 3 zones closest to the entrance, namely Hollywood, Minion Land and New York. As such, more security and cleaning staff have been allocated to these zones for safety and cleanliness management. As visitors begin streaming in, many of them begin visiting souvenir shops like Hello Kitty Studio Store in the Hollywood zone. This increase in the number of visitors in the shop meant an increase in demand for the shop staff to aid them in their purchases or recommending them merchandise, which can be seen from the addition of 2 shop staff to this shop as opposed to others. Similarly, visitors also begin taking rides but since the rate at which visitors are entering rides are comparable to the ride cycle times, no significant queues have formed and as such, no additional staff is needed to be mobilised yet.

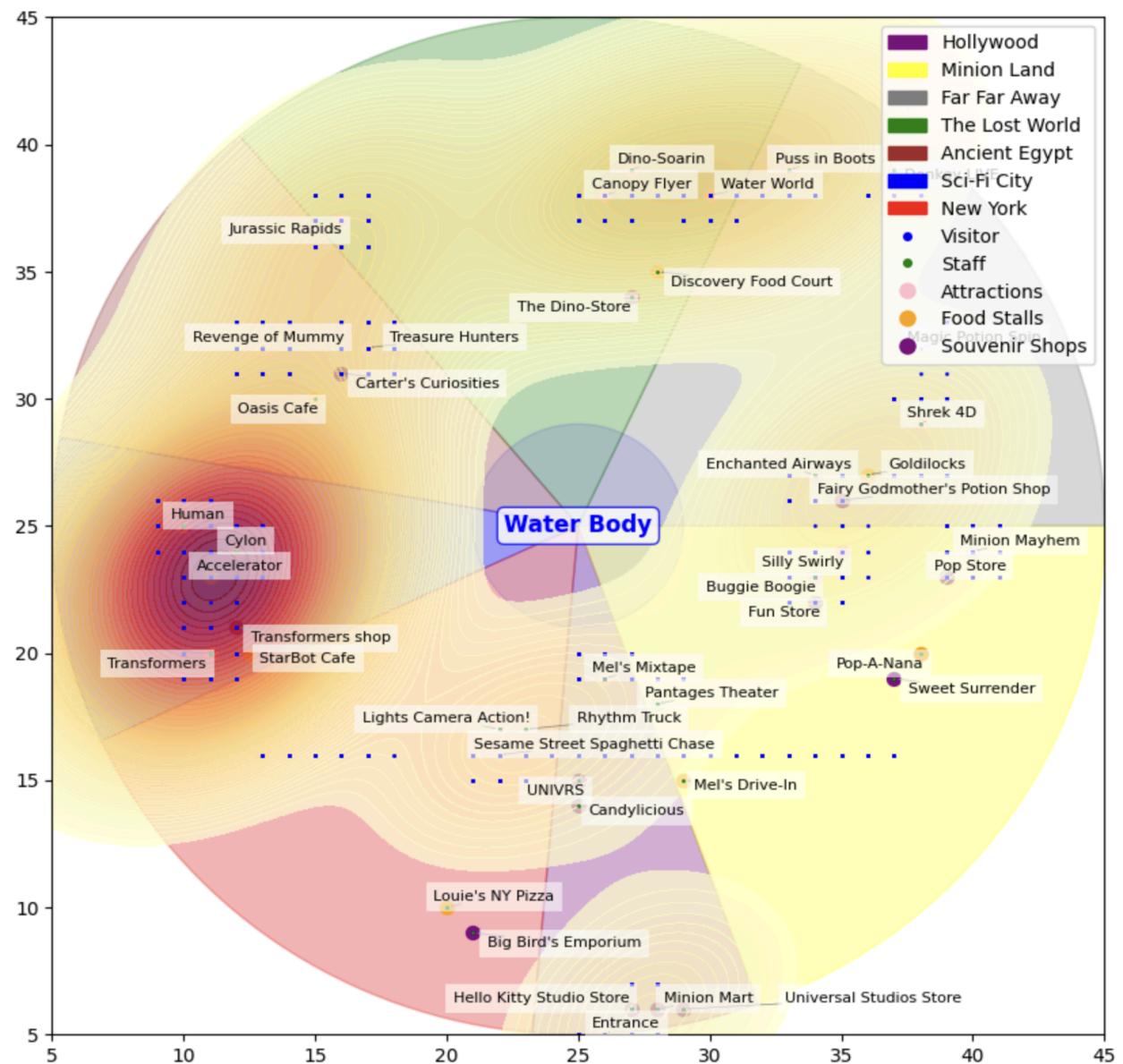


Figure 33 - Plot Of USS Map From 12pm To 12.30am Generated From ABM

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Time: 12:00 PM

Ride operating staff at each ride per zone:
Zone: Hollywood
  Ride: Pantages Theater, Number of Staff: 4
  Ride: Mel's Mixtape, Number of Staff: 4
  Ride: Entrance, Number of Staff: 2
Zone: Minion Land
  Ride: Minion Mayhem, Number of Staff: 3
  Ride: Silly Swirly, Number of Staff: 3
  Ride: Buggie Boogie, Number of Staff: 5
Zone: Far Far Away
  Ride: Shrek 4D, Number of Staff: 6
  Ride: Puss in Boots, Number of Staff: 6
  Ride: Donkey LIVE, Number of Staff: 3
  Ride: Magic Potion Spin, Number of Staff: 3
  Ride: Enchanted Airways, Number of Staff: 6
Zone: The Lost World
  Ride: Jurassic Rapids, Number of Staff: 6
  Ride: Canopy Flyer, Number of Staff: 6
  Ride: Dino-Scarin, Number of Staff: 6
  Ride: Water World, Number of Staff: 4
Zone: Ancient Egypt
  Ride: Revenge of Mummy, Number of Staff: 6
  Ride: Treasure Hunters, Number of Staff: 6
Zone: Sci-Fi City
  Ride: Transformers, Number of Staff: 6
  Ride: Cylon, Number of Staff: 6
  Ride: Human, Number of Staff: 6
  Ride: Accelerator, Number of Staff: 3
Zone: New York
  Ride: Sesame Street Spaghetti Chase, Number of Staff: 3
  Ride: Rhythm Truck, Number of Staff: 3
  Ride: Lights Camera Action!, Number of Staff: 6

Food stall staff at each zone:
Zone: Hollywood
  Food Stall: Mel's Drive-In, Number of Staff: 2
Zone: Minion Land
  Food Stall: Pop-A-Nana, Number of Staff: 3
Zone: Far Far Away
  Food Stall: Goldilocks, Number of Staff: 3
Zone: The Lost World
  Food Stall: Discovery Food Court, Number of Staff: 3
Zone: Ancient Egypt
  Food Stall: Oasis Cafe, Number of Staff: 3
Zone: Sci-Fi City
  Food Stall: StarBot Cafe, Number of Staff: 1
Zone: New York
  Food Stall: Louie's NY Pizza, Number of Staff: 3

Souvenir shop staff at each zone:
Zone: Hollywood
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  Souvenir Shop: Universal Studios Store, Number of Staff: 3
  Souvenir Shop: UNIVRS, Number of Staff: 1
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  Souvenir Shop: Sweet Surrender, Number of Staff: 1
  Souvenir Shop: Pop Store, Number of Staff: 1
  Souvenir Shop: Fun Store, Number of Staff: 1
Zone: Far Far Away
  Souvenir Shop: Fairy Godmother's Potion Shop, Number of Staff: 1
Zone: The Lost World
  Souvenir Shop: The Dino-Store, Number of Staff: 1
Zone: Ancient Egypt
  Souvenir Shop: Carter's Curiosities, Number of Staff: 1
Zone: Sci-Fi City
  Souvenir Shop: Transformers shop, Number of Staff: 1
Zone: New York
  Souvenir Shop: Big Bird's Emporium, Number of Staff: 1

Cleaning staff at each zone:
Zone: Hollywood, Number of Cleaning Staff: 4
Zone: Minion Land, Number of Cleaning Staff: 3
Zone: Far Far Away, Number of Cleaning Staff: 4
Zone: The Lost World, Number of Cleaning Staff: 4
Zone: Ancient Egypt, Number of Cleaning Staff: 4
Zone: Sci-Fi City, Number of Cleaning Staff: 4
Zone: New York, Number of Cleaning Staff: 4

Security staff at each zone:
Zone: Hollywood, Number of Security Staff: 6
Zone: Minion Land, Number of Security Staff: 6
Zone: Far Far Away, Number of Security Staff: 6
Zone: The Lost World, Number of Security Staff: 6
Zone: Ancient Egypt, Number of Security Staff: 6
Zone: Sci-Fi City, Number of Security Staff: 6
Zone: New York, Number of Security Staff: 6

```

Figure 34 - Staffing Roster Generated For 12pm To 12.30pm By ABM

From 12pm to 12.30pm, the visitors have already entered the park and started taking rides, the queues have started to form for rides, especially the popular ones. From the heatmap, we see most visitors are in the Sci-fi zone for the most popular rides in USS: Human, Cylon and Transformers ride. These rides have very high wait times deemed unacceptable from our survey responses. As such, a maximum number of staff have been dynamically allocated to these rides to help manage the queue situation and ensure smooth operations to reduce wait times. Other popular rides also see an increase in staff allocation, with higher wait times commanding greater staffing levels. This is also a time where visitors start getting hungry and the increase in number of visitors to food stalls meant a greater number of staff being mobilised to these stalls to better attend to the visitors, with greater number of visitors commanding greater staffing levels.

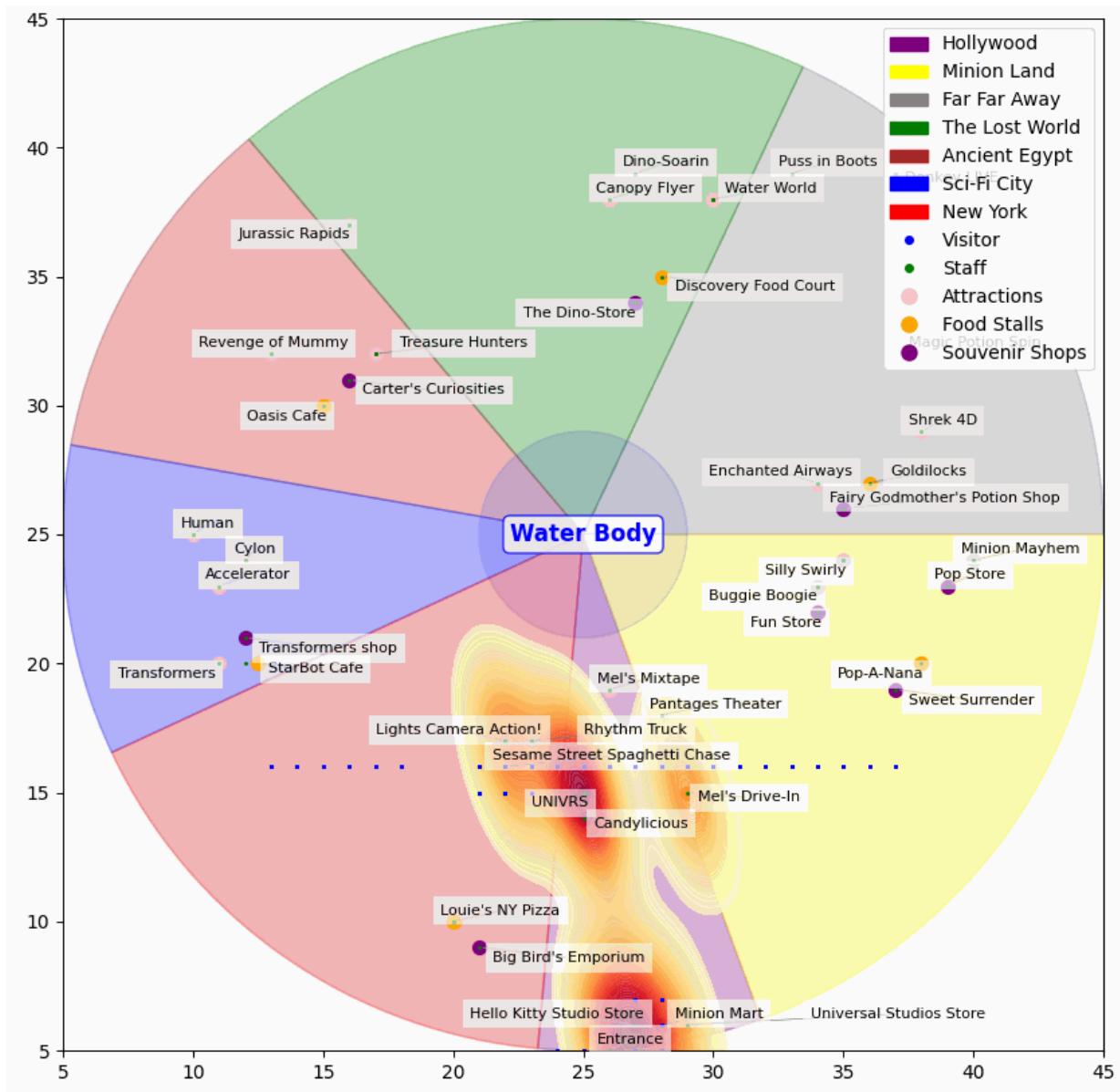


Figure 35: Gif Showing Changes In Visitor Traffic And Concentration Throughout The Day

With the help of the heatmap, we observe that visitor traffic is highest in popular attractions and zones, requiring more staff to be dynamically mobilised to address crowd surges, maintain cleanliness, and enhance guest experiences. Thus, as the day progresses, staff should be allocated to the various areas with higher demand as suggested by the staff roster produced.

By deploying more staff to high-traffic areas, we improve guest experience through faster service and ensure better cleanliness and safety management with timely interventions.

9. Predicting Guest Complaints and Service Recovery

Business Question: How can USS leverage historical review data to proactively detect and address guest complaints, improving satisfaction, protecting its online reputation, and driving repeat visits?

- Dataset: 50,000+ USS TripAdvisor reviews
- Variables: Combined Review Text + Title
- Star Rating: 1-2 = "complaint", 3-5 = "non complaint".
- Approach:
 1. Built a TF-IDF + SVM model to classify complaints across all branches.
 2. Applied Latent Dirichlet Allocation topic modeling to uncover recurring complaint themes

Using our trained machine learning model on responses collected from exit surveys, we can automatically analyze responses and flag potential complaints early on. This enables the team to address issues proactively, before they turn into negative public reviews. Despite the natural class imbalance in reviews, our model performs strongly—with an overall accuracy of 94%. It achieves a precision of 0.62 and recall of 0.64 for complaint detection, meaning it can reliably identify a significant portion of potentially dissatisfied guests. For non-complaints, the model is highly accurate with a 97% precision and recall. This predictive capability is especially valuable given that online ratings on platforms like TripAdvisor heavily influence guest decisions. By acting on flagged complaints quickly, we can help maintain a strong reputation for USS and continue attracting new visitors.

	precision	recall	f1-score	support
complaint	0.62	0.64	0.63	792
non-complaint	0.97	0.97	0.97	9389
accuracy			0.94	10181
macro avg	0.79	0.80	0.80	10181
weighted avg	0.94	0.94	0.94	10181

Figure 36: Classification report of TF-IDF + SVM model

To better understand the key pain points raised in low-rated reviews, we applied topic modeling using Latent Dirichlet Allocation (LDA) on reviews rated below 3 stars. By combining the title and text of each review, we enriched the context and used TF-IDF vectorization (with unigrams, bigrams, and trigrams) to capture detailed patterns in the language. LDA then helped uncover five distinct themes commonly mentioned in complaints, such as crowding, long wait times, and pricing concerns. These topics were manually labeled based on the top key phrases associated with each. Additionally, a

word cloud was generated to visually highlight the most frequent terms, offering a quick overview of recurring issues in guest feedback.



Figure 37: Word Cloud Containing Top Complaint Themes At USS

	Topic	Key Phrases
0	Crowded Park & Ride Experience	park, ride, universal, rides, day, time, line, just
1	Wait Times & Food Service Issues	rides, park, day, ride, express, long, food, time
2	Value for Money Concerns	rides, updating, time money, long, money, expensive, harry potter really, potter really
3	Expensive & Poor Queuing System	rides, ride, park, expensive, queues, food, express, money
4	Cost vs. Disney Comparison	rides, money, park, long, time, disney, waste, worth

Figure 38: Output of topic modeling analysis

10. IOT Data Integration for Experience Optimization

Business Question: How willing are people to wear a digital watch and how feasible and impactful is IOT in a theme park?

Explore the use of IOT devices (e.g., wearables, smart devices) for real time data collection

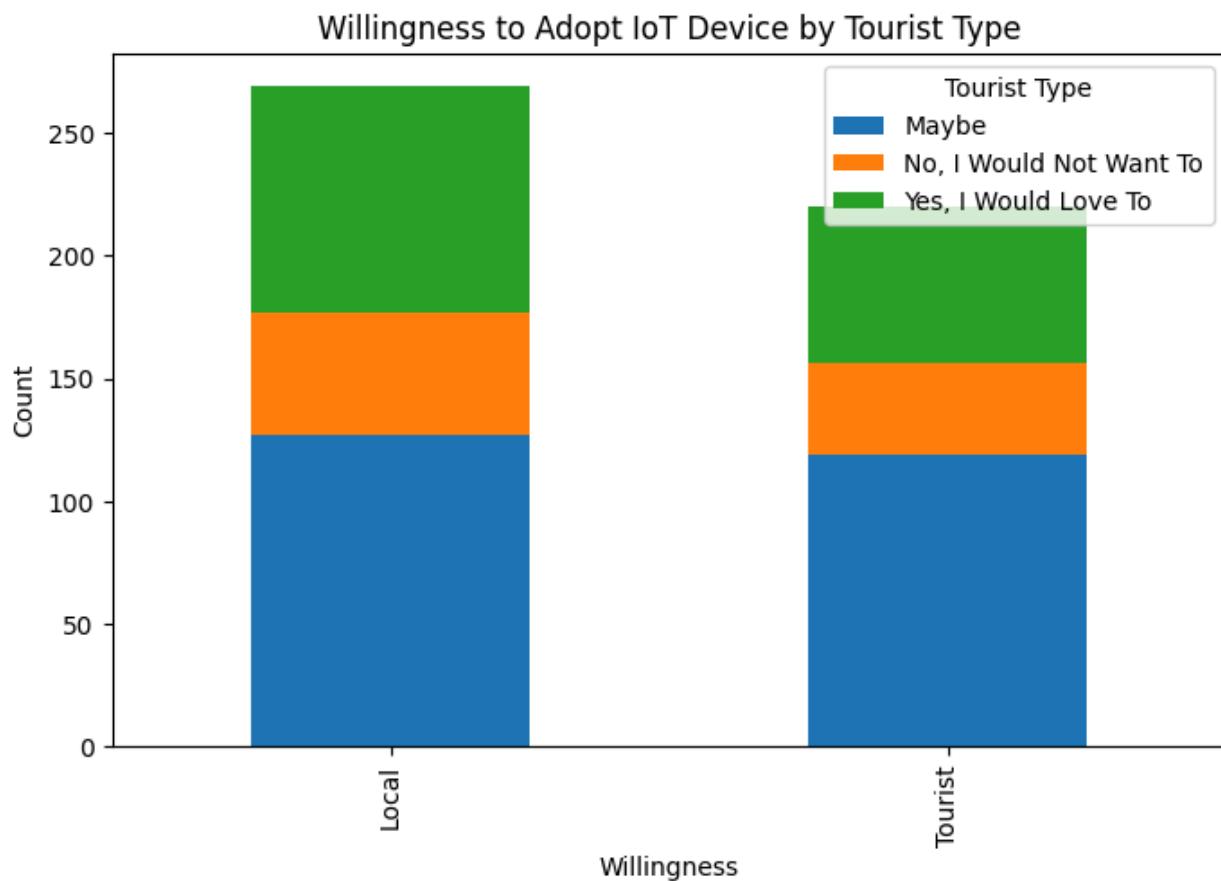


Figure 39: Willingness to Adopt IoT Device by Tourist Type

Analyzing willingness to adopt IoT based on tourist type, it is evident that both tourists and locals show varied levels of interest, with no group overwhelmingly willing to adopt IoT devices. This suggests the need for targeted communication and educational efforts to highlight the benefits of IoT enhancements.

Insights:

- Tailored marketing strategies addressing the specific concerns and expectations of both locals and tourists could improve their willingness to engage with IoT technologies.

- Special attention to addressing common misconceptions and showcasing practical benefits might convert hesitant visitors.

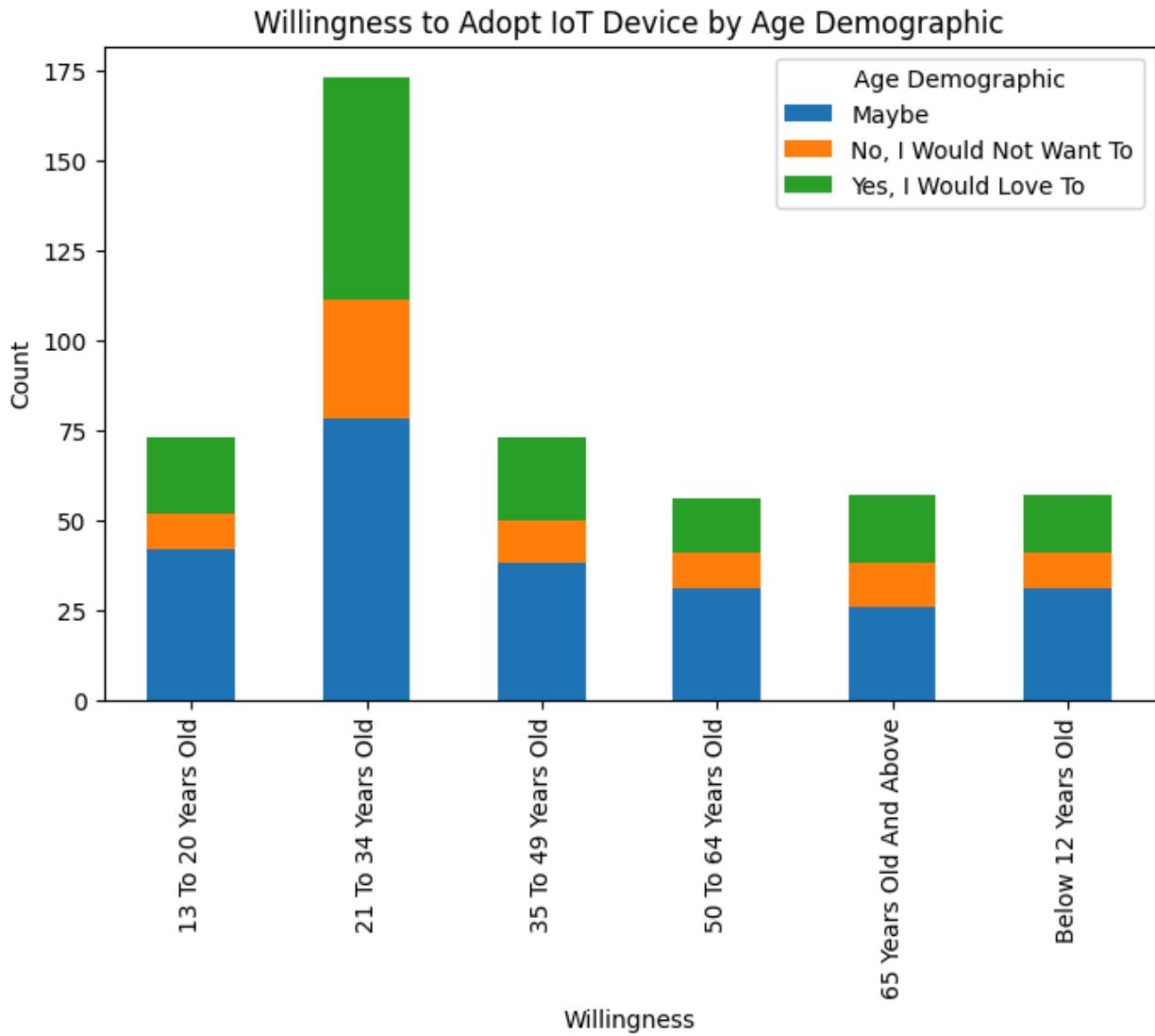


Figure 40: Willingness to Adopt IoT Device by Age Group

The willingness by age group plot reveals that younger demographics are more open to adopting IoT devices, whereas older visitors show more resistance.

Insights:

- Developing intuitive and accessible IoT solutions that appeal to all age groups can bridge the gap in technology adoption.

- Implementing user-friendly interfaces and providing additional support can increase acceptance among older visitors.

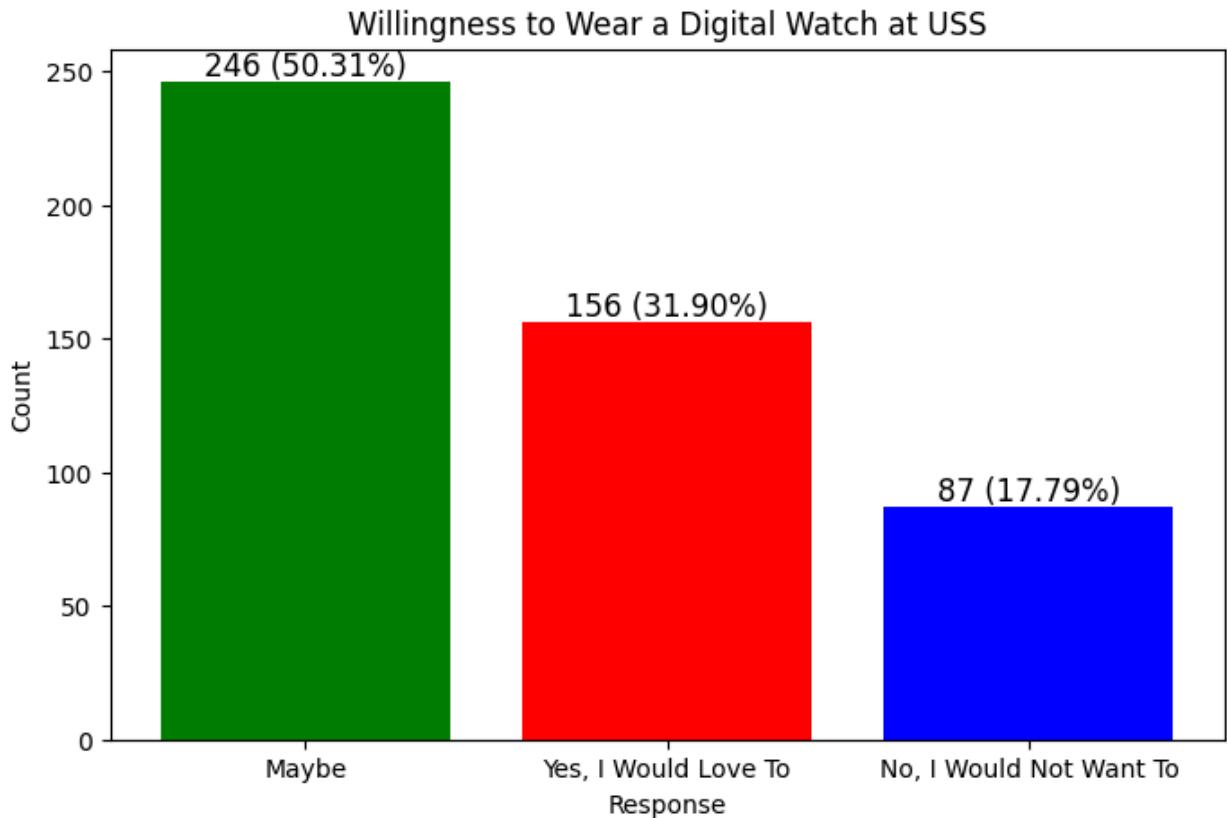


Figure 41: Willingness to Wear a Digital Watch at USS

This final visualization clearly segments visitor willingness into three categories: willing, undecided, and unwilling. Approximately half of the guests are open to using digital watches, indicating a solid base to build upon for future IoT integrations.

Insights:

- Leveraging the interested demographic by rolling out pilot IoT projects could provide valuable feedback and set a precedent for expanded use.
- Addressing the concerns of undecided and unwilling guests through demonstration kiosks or informational campaigns could further increase adoption rates.

Evaluate their impact on predictive accuracy and operational flexibility

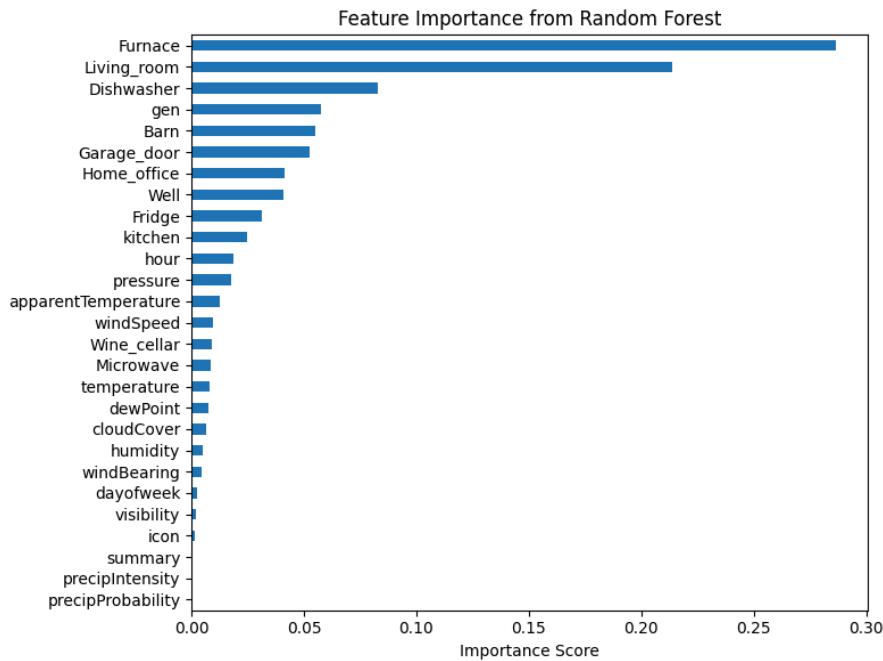


Figure 42: Feature Importance from Random Forest

The "Feature Importance from Random Forest" plot provides an insightful look into the variables that are most influential in predicting outcomes within our IoT systems at Universal Studios Singapore (USS). Notably, the features related to device-specific energy consumption such as 'Furnace', 'Living room', and 'Dishwasher' top the list, indicating that these are critical drivers in the overall energy management system. This suggests that targeted strategies to optimize energy usage in these high-impact areas could significantly enhance efficiency.

Insights:

- Optimization of energy usage for 'Furnace', 'Living room', and 'Dishwasher' could lead to significant operational efficiencies.
- Focus on these areas might yield the most substantial improvements in energy consumption reduction.

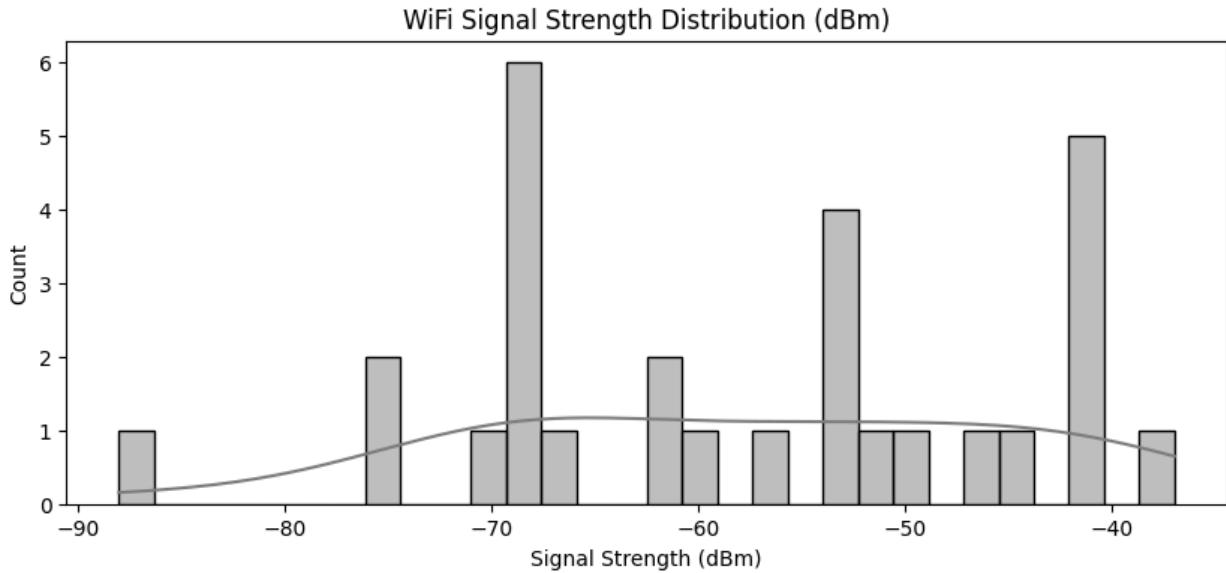


Figure 43: WiFi Signal Strength Distribution

The distribution of WiFi signal strengths shows a concentration around -60 dBm to -50 dBm, with notable peaks, suggesting areas of strong signal interspersed with zones of weaker coverage. This variability in signal strength could impact guest experiences, particularly in how they interact with IoT devices that rely on constant connectivity.

Insights:

- Areas with weaker WiFi signals might experience disruptions in IoT device functionality, impacting guest satisfaction.
- Enhancing WiFi infrastructure to reduce signal variability could improve the reliability of IoT applications.

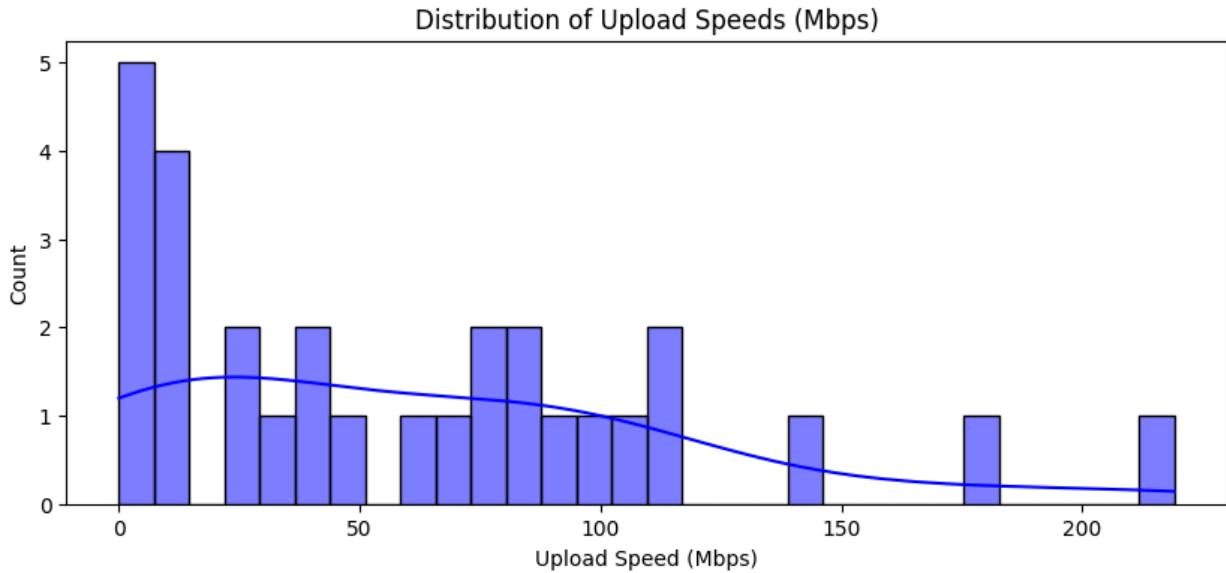


Figure 44: Distribution of Upload Speeds

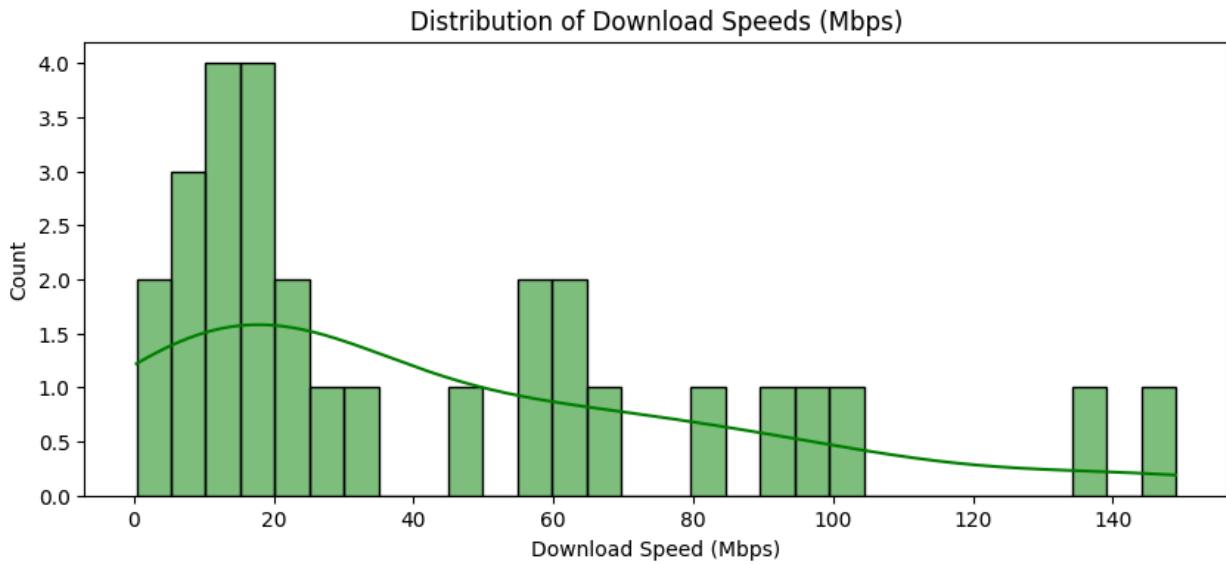


Figure 45: Distribution of Download Speeds

The plots for both upload and download speeds reveal a wide range of connectivity speeds across the park. While there are peaks at higher speeds for both uploads and downloads, there is a noticeable number of connections at the lower end of the spectrum.

Insights:

- The variability in internet speeds could affect the performance of real-time data-driven applications and guest services.
- Investment in network infrastructure to stabilize and increase internet speeds could improve both guest satisfaction and system performance.

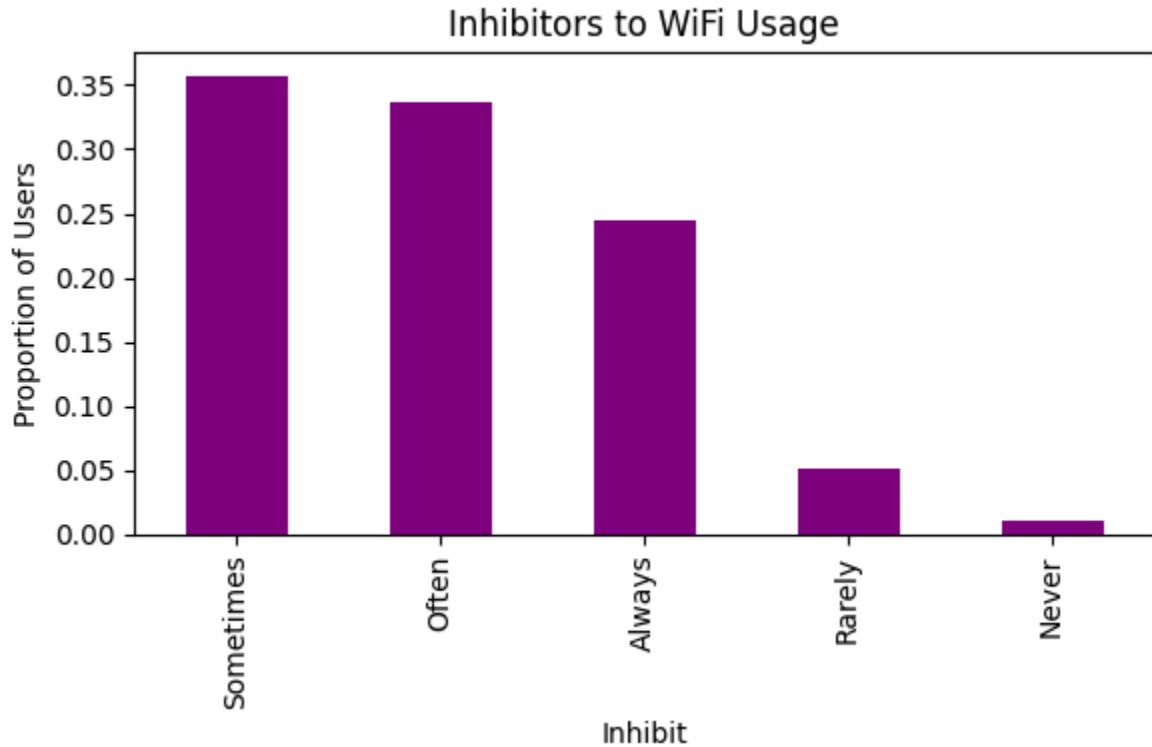


Figure 46: Inhibitors to Wifi Usage

The "Inhibitors to WiFi Usage" plot shows that issues like signal strength, speed, and accessibility frequently inhibit guest usage of WiFi. The majority of users report experiencing problems 'Often' and 'Sometimes', which could hinder their engagement with IoT-driven experiences.

Insights:

- Addressing WiFi reliability and accessibility issues is crucial for enhancing guest experiences and ensuring the successful deployment of IoT solutions.
- Direct feedback from guests on their WiFi experiences could provide targeted insights for improvements.

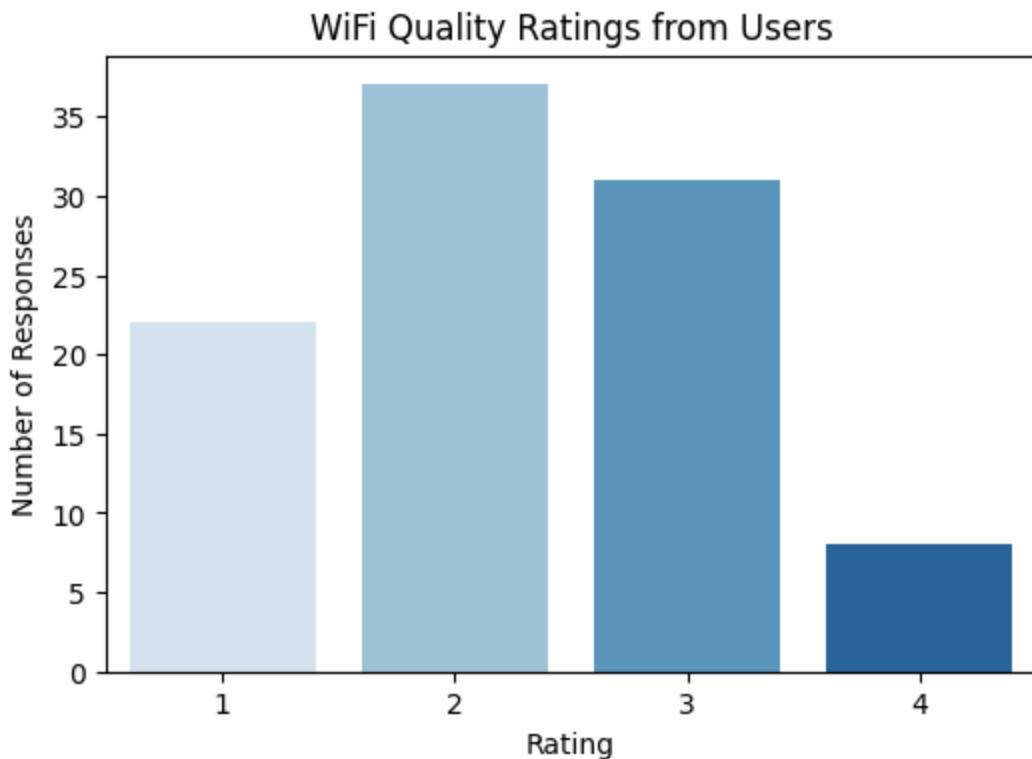


Figure 47 : WiFi Quality Ratings from Users

The third plot shows user ratings for WiFi quality, which skew towards the lower end of the satisfaction scale. This indicates room for significant improvement in the network services provided in the park.

Insights:

- Immediate efforts to upgrade WiFi infrastructure to elevate user ratings are essential. Higher satisfaction with WiFi quality can directly enhance the guest experience and the effectiveness of real-time IoT applications.

Insights and Business Impact

High visitor traffic at popular attractions often results in longer wait times, which remain the primary source of visitor dissatisfaction with rides and attractions. In addition to increasing staff deployment, optimizing ride capacities and minimizing buffer times can effectively reduce overall wait times, thereby enhancing the visitor experience.

A seamless guest experience is strongly correlated with higher levels of satisfaction, increasing the likelihood of both positive recommendations and repeat visits. Furthermore, improving guest experience can amplify the effectiveness of marketing initiatives by attracting a broader audience, particularly during special events. USS stands to benefit from increased ticket sales and higher in-park spending. The expansion of USS's visitor base also creates opportunities for premium experiences and exclusive offerings, further driving business revenue and long-term growth. Sustained guest satisfaction and long-term revenue growth will reinforce USS's position as a premier entertainment destination, ensuring its continued success and competitiveness in the industry.

Recommendations

USS can explore the implementation of wearable technology for visitors to monitor real-time ride popularity and queue dynamics. This system would enable the collection of live and historical data, facilitating data-driven decision-making in areas such as staff allocation and operational efficiency.

Furthermore, integrating demand forecasting and resource optimization strategies can enhance its ability to dynamically adjust staffing levels and attraction schedules based on visitor flow patterns. By strategically deploying staff to high-traffic areas, USS can ensure that guest needs such as queue management, on-site assistance and cleanliness are effectively met, ultimately enhancing the overall visitor experience.

Additionally, leveraging predictive analytics for proactive service recovery can help identify and address potential guest concerns before they escalate. By analyzing historical complaint patterns, USS can implement preemptive measures to resolve issues efficiently, thereby improving customer satisfaction, fostering brand loyalty, and reinforcing its reputation as a premier entertainment destination.

Conclusion and Next Steps

Guest satisfaction at USS is primarily influenced by factors like extended wait times, high prices and crowd management challenges. To address these concerns, segmentation analysis can be leveraged to market personalised guest experiences and enhance visitor engagement, while predictive models ensure resource optimisation. Enhancing demand forecasting, improving operational efficiency, and investing in IoT infrastructure further refines visitor management. Additionally, AI-driven staff allocation and real-time data tracking can streamline guest experiences, seamlessly reducing service bottlenecks.

USS should continuously monitor evolving guest satisfaction trends and adapt strategies accordingly. Future initiatives could include expanding digital engagement for real-time guest navigation or integrating virtual queuing systems to minimize wait times. By implementing these forward-looking strategies, USS can elevate visitor satisfaction and drive repeat visits, reinforcing its position as a globally popular theme park.