**Port Authority Traffic and Violation Analysis Report**

**Variables to consider:**

**1.** The company should consider Month, Day of Week, Time of Day, Facility (FAC\_B), Vehicle Types (Autos, Small\_T, Large\_T), Payment Method (EZPASS vs. Cash), and weather conditions like Precipitation, Snow, and Temperature. These factors directly impact daily traffic volume and flow. The dependent variable used is **Total Vehicle Count**, as it measures the overall usage of the infrastructure and is essential for capacity planning and traffic forecasting.

**2.** Important variables include Time, Facility, Vehicle Type, Precipitation, and Snow, as they significantly affect the likelihood of toll violations. The dependent variable used is **Violation\_Binary**, a binary indicator representing whether a toll violation occurred, chosen for its clarity in classification and usefulness in enforcement prediction.

**3.** The most impactful variables are Month, Day of Week, Hour, Precipitation, Snow, Temperature, and the presence of NYC events such as holidays and parades. These influence seasonal patterns and traffic spikes. The dependent variable is **Total Traffic Volume**, selected to capture shifts in demand across time and conditions.

**4.** Key variables to monitor include Traffic Volume, Violation Count, Time (Month, Day, Hour), Facility, Vehicle Type, and Weather. These offer a complete operational view. There is **no dependent variable**, as the dashboard is built for monitoring key performance indicators rather than predicting a single outcome.

**Recommendations from our end:**

**Critical Factors to Monitor:**

**Weather:**

**Action:** Proactively monitor forecasted adverse weather conditions, particularly snowstorms, heavy rain, or extreme temperature changes, as these can drastically affect traffic patterns and road safety**.**

**Implementation**: Install dynamic signage that can warn or divert drivers ahead of time during such conditions. This could involve showing real-time alerts about weather conditions or suggesting alternative routes to minimize congestion.

**Impact:** Proactive management of weather-related risks can reduce accident rates, smooth traffic flow, and reduce the need for emergency interventions during peak conditions.

**Time-based Management:**

**Action**: Identify and allocate resources during the most congested times—Friday afternoons and Sunday evenings, as well as peak summer holiday weekends when traffic volumes are highest.

**Implementation:** Deploy additional traffic management personnel, including toll operators and enforcement officers, during these high-traffic periods. This could also involve staffing more personnel at toll booths or ensuring more efficient traffic flow through dedicated lanes.

**Impact:** Timely management will improve traffic flow, reduce wait times, and enhance the overall user experience during peak travel times, particularly during weekends and holidays.

**Toll Payment Enforcement:**

**Action:** Increase toll payment enforcement during peak hours to address toll violations and improve revenue collection.

**Implementation**: Enhance detection mechanisms such as automated license plate recognition (ALPR) cameras or other monitoring systems. Pair these with targeted patrols to focus on locations with high violation rates.

**Impact**: Efficient toll enforcement will ensure higher compliance, generate more revenue, and deter violation practices, improving operational efficiency.

**Operational Improvements**

**Expand EZPASS Usage:**

**Action**: Encourage broader use of the EZPASS system, particularly in high-volume traffic zones.

**Implementation:** Introduce campaigns to educate the public on the benefits of EZPASS (such as avoiding traffic delays and faster passage through tolls). Implement promotions or discounts for early adoption in targeted regions.

**Impact:** Locations with higher EZPASS usage tend to experience smoother traffic flow and less congestion, as vehicles can pass through tolls more quickly, reducing bottlenecks at manual toll booths.

**Dynamic Toll Adjustments:**

**Action**: Implement dynamic pricing strategies that adjust toll rates based on demand during peak travel times (e.g., holidays or weekends).

**Implementation:** Use real-time data and predictive models to adjust toll rates during high-demand periods. For example, increase rates during peak summer weekends or long holiday periods to balance traffic flow and spread demand more evenly.

**Impact:** Dynamic toll adjustments can help manage traffic volume, ensuring that high-traffic periods don’t become overwhelming, while also optimizing revenue for the Port Authority**.**

**Future Data Collection Suggestions**

**Special Event Tagging:**

**Action:** Introduce data flags that can mark the occurrence of major events such as marathons, concerts, or road construction closures that typically lead to traffic surges.

**Implementation**: Integrate external event data sources into the traffic monitoring system, tagging specific times or dates with event-related information. This will allow traffic models to account for these spikes in demand.

**Impact:** Understanding event-based surges will help the Port Authority forecast traffic more accurately, allocate resources accordingly, and develop strategies to mitigate congestion during these times.

**Real-time Speed Data:**

**Action**: Incorporate IoT sensors or mobile app integrations to collect real-time speed and traffic flow data at critical points along the tunnels and bridges.

**Implementation:** Deploy sensors to gather live speed data or integrate mobile traffic apps that allow drivers to report conditions. This data could then feed directly into the Port Authority’s traffic management systems for real-time decision-making.

**Impact:** Real-time speed data will enable dynamic rerouting of traffic, improve congestion management, and provide accurate, up-to-date information to drivers, thus reducing delays and improving overall traffic flow.

**Exogenous Factors to Incorporate**

**Gas Prices:**

**Action:** Monitor fluctuations in gas prices, as these can have a direct impact on travel behavior. Higher gas prices may reduce the volume of discretionary travel, while lower prices may encourage more road usage.

**Implementation**: Incorporate gas price trends into predictive models to account for changes in traffic volume and driving patterns. This will help forecast demand more accurately, especially during price surges.

**Impact:** Understanding the relationship between fuel prices and travel behavior can enable more accurate traffic predictions and better resource allocation during high-demand periods.

**Public Transit Disruptions:**

**Action**: Monitor disruptions in public transit services (e.g., train or bus strikes, service interruptions) that could lead to an increase in vehicle usage on tunnels and bridges.

**Implementation:** Integrate public transit data into traffic models to predict surges in bridge and tunnel usage when there are transit service disruptions.

**Impact:** Factoring in these disruptions can provide more accurate traffic forecasts and allow for proactive management of surges in traffic caused by changes in public transit availability.

**Other Strategic Recommendations**

**Invest in Predictive Maintenance:**

**Action:** Prioritize maintenance efforts based on traffic volume and weather patterns. Schedule routine maintenance during periods of low traffic to minimize disruptions.

**Implementation:** Use predictive analytics to forecast the optimal times for maintenance work based on historical traffic data, weather forecasts, and usage patterns.

**Impact:** Predictive maintenance allows for more efficient use of resources, reducing downtime during peak traffic hours and minimizing disruptions to commuters.

**Public Communication:**

**Action**: Use dynamic digital boards and mobile apps to inform drivers about expected delays during weather events, high-traffic weekends, or road construction.

Implementation: Integrate real-time traffic data and event information into public communication platforms (e.g., digital road signs, apps) to keep drivers informed of delays and alternative routes.

**Impact:** Timely and accurate public communication can reduce driver frustration, improve compliance with diversion routes, and enhance overall traffic flow during peak or disrupted times.

For our **group project**, we have used **XGBoost regression** for predicting traffic volume, **Random Forest classification** for predicting toll violations, and **SARIMA time-series forecasting** for modeling traffic patterns. Additionally, we employed feature engineering, handled missing data, and integrated external variables like weather and events. To validate the performance of each model, we utilized **Azure Machine Learning** for model training, testing, and performance evaluation.

For this project, we have used Python (with libraries like Pandas and XGBoost), Azure Machine Learning for model validation, and Power BI for data visualization and reporting.

**Final Remarks**

Our analysis highlights key areas for improving traffic and toll management at the Port Authority. By using predictive models like XGBoost, Random Forest, and SARIMA, we identified that weather, events, and gas prices significantly impact traffic flow and toll violations. We recommend proactive weather monitoring, increased toll enforcement during peak times, and expanding EZPASS usage to reduce congestion. Implementing real-time speed data collection and dynamic toll adjustments will optimize traffic management. These strategies will improve traffic flow, reduce violations, and enhance operational efficiency.