

Best Practices: Signalized Intersection Investments

– Summary Briefing –

Prepared for:



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Overview

With Florida's population expanding rapidly due to increased migration and economic development, the strain on its transportation infrastructure is intensifying. Traditional traffic management approaches are proving increasingly insufficient, resulting in delays, safety issues, and operational inefficiencies. Furthermore, aging and suboptimal intersection infrastructure significantly contributes to the ever-increasing recurring congestion and delays on arterials in the state. Intersections are crucial points in our transportation system where vulnerable road users (VRUs) (i.e., pedestrians, cyclists) and motorists converge, creating an environment of increased safety risk. The inherent interaction complexity and need for heightened situational awareness present unique challenges to all users, especially VRUs, often leading to adverse consequences such as property damage, injuries, and even fatalities.

Intersections, whether controlled or uncontrolled, have unique mobility and safety challenges, but signalized intersections require greater infrastructural investment as they are strategically commissioned to manage higher volumes of VRUs and vehicles. This briefing provides a summary of the study undertaken to explore current and best practices for signalized intersection investments to address existing challenges and ensure future-proof solutions, aiming to provide stakeholders with guidance that enhances operational efficiency, safety, and overall benefits for all road users.

Safety and Mobility Challenges at Signalized Intersections

Safety metrics at intersections in Florida summarized (crash data from 2019 to 2023¹):

- 26.3% of crashes in Florida are related to intersections.
- 32.2% of crashes at intersections lead to an injury or death.
- 23.4% of fatal crashes at intersections involve VRUs.
- As compared to 2019, intersection-related fatal crashes were up 13.8% in 2023.
- A 20.1% reduction in crashes was observed in Florida from 2019 to 2020, however, intersection-related fatal crashes increased by 5%.
- There are 2.4 times more pedestrian fatalities at intersections than bicyclists.
- VRU-involved fatal crashes have been increasing at an annual rate of 7.4% between 2019 and 2023.
- 83.4% of crashes at intersections involving VRUs lead to an injury or death.

Mobility metrics derived from 16,694 signalized intersections analyzed in Florida²:

- The average delay per vehicle was 20.4 seconds as compared to the national average of 18.1 seconds.
- Three intersections in Florida ranked among the top ten for peak hour delays nationwide.
- The average percentage of vehicles arriving on green without stopping at the intersection was 64.7% as compared to the national average of 63.5%.
- The total daily delay per signal was 178.3 hours (national average 117.4 hours), resulting in approximately 1328 pounds of CO₂ emissions per day.
- Most of the signalized intersections are primarily designed to prioritize motor vehicle throughput efficiency, often with limited consideration for VRUs, thus resulting in the observed fatality trends.

¹ <https://signal4analytics.com/>

² <https://inrix.com/signals-scorecard/>

Current State of Signalized Intersection Infrastructure

Signalized intersection infrastructure and connectivity vary significantly across Florida and, more broadly, throughout the United States, making the “one solution for all” investment approach challenging in terms of feasibility and scalability. The following is a summary of the observed key findings:

- The most common signalized intersection layout consists of four legs with 32 vehicle-to-vehicle and 24 vehicle-to-pedestrian conflict points.
- Most of the signalized intersections are primarily designed to prioritize motor vehicle throughput efficiency, often with limited consideration for VRUs, thus resulting in the observed fatality trends.
- Signalized intersections typically consist of a central processing unit (CPU), traffic signal cabinet, backup signal plan, controller cards, phase timing hardware, signal heads, IP communications, conflict monitor, time clock, power supply, local user interface, and pre-emption hardware.
- Most existing signalized systems lack upgradeability and modularity, as well as interoperability due to limited data transfer/sharing capabilities, resulting in higher costs for complete overhauls.
- Approximately 25% to 40% of signalized intersections in the U.S. currently support adaptive traffic control systems (ATCS), indicating the presence of sensors and newer communication infrastructure. This figure is expected to exceed 70% by the year 2030.
- There is very limited guidance in the MUTCD regarding the design and implementation of traffic signals and other control devices in a mixed traffic environment (i.e., human drivers and CAVs).
- Studies have shown critical vulnerabilities within legacy signal controllers and connected infrastructure especially related to malicious control, outdated firmware, encryption, privacy, and data security.
- Short- and medium-term plans across most states of traffic signal investment involve asset management and personnel training/development.
- Long-term plans of traffic signal investment across most states involve provisions for the integration of advanced technologies and equitable access.
- There is a lack of dedicated protocols or standards towards over-the-air updates for intelligent intersection infrastructure, to ensure operational efficiency, longevity, and network security.

Emerging technologies and artificial Intelligence (AI) are bringing unprecedented improvements to safety and mobility at signalized intersections, with a focus on enhancing the utility of existing infrastructure and incorporating modular components as needed. While vehicle-to-everything (V2X) communication is advancing to address safety concerns, challenges like latency and the accuracy of real-time processing algorithms still need to be resolved. A well-rounded investment strategy in signalized intersections should prioritize streamlined infrastructure digitization, data generation, and data-driven analytics, along with connected infrastructure-based mitigation strategies.

Policy Considerations towards Best Investment Practices

Based on these findings, we derive the following phased (short-term, medium-term, long-term) policy recommendations towards best investment practices:

- **Digitize existing infrastructure (short-term):** Invest in digitizing existing signalized intersection infrastructure using a standardized approach to ensure consistent data collection across the state.
- **Foster collaborative partnerships and workforce development (short-term):** Establish and promote collaborative approaches via inter-agency coordination, public-private partnerships, and workforce development to optimize resources and accelerate technology deployment. This can be achieved through funding public-private pilot programs deploying scalable and innovative technologies across the state.
- **Develop uniform state-wide protocols and guidelines (medium-term):** Establish and fund uniform state-wide protocols for the systematic deployment, maintenance, and upgrading of signalized intersections.
- **Promote open-data initiatives for intersection management (medium-term):** Encourage adoption of open-data practices that allow for easy sharing of all non-proprietary datasets, fostering innovation and transparency. This is especially crucial for the rapid development and deployment of advanced AI-powered traffic management solutions.
- **Invest in future proof and scalable design elements (long-term):** Prioritize investments in modular, connectivity-ready, and interoperable systems/components for all upgrades and new signalized intersections, ensuring adaptability with evolving technologies.
- **Performance-driven investments (long-term):** Prioritize intersection investments by outlining standardized state-wide performance targets.



Concluding Remarks

Overall, we find that signalized intersection infrastructure and connectivity differ widely across the United States and Florida, making a universal investment approach impractical and difficult to scale. However, through the literature, we identify systematic solutions that aid decision making such as life cycle assessment and outlook on nationwide trends. From a nationwide perspective, emerging technologies and AI are making significant strides in enhancing safety and mobility at signalized intersections. While challenges such as latency and real-time processing accuracy persist with these technologies, they are being actively addressed and improved. Investment planning for future traffic signals should support their integration to fully realize the benefits and functionality.

Based on these findings, we recommend a comprehensive investment strategy for signalized intersections that prioritizes digitization, data analytics, and connected infrastructure to enhance safety and efficiency. Adopting these strategic recommendations will not only address current challenges but also position Florida's transportation infrastructure to meet future demands, ensuring safer, smarter, and more equitable intersections for all road users.

For further information please refer to the full Florida Policy Project report entitled "Best Practices: Signalized Intersection Investments"