# MODERNIZE CENSUS INFRASTRUCTURE TECHNOLOGY

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## Project Objective

The project aims to perform extensive survey and stakeholder engagement to identify the most effective traffic sensing technologies for California by comparing both traditional and modern systems to support more intelligent and reliable traffic sensing solutions.

## Problem Statement

The key research problem is that existing traffic census systems fail to provide network-wide high-resolution, real-time data needed for effective traffic management, especially in complex urban and multimodal environments.

## Research Methodology

This study applies a structured evaluation matrix and 10-year lifecycle cost analysis to systematically compare traditional and modern traffic sensing technologies across key performance criteria. Insights from field pilot deployments across diverse roadway contexts based on extensive survey and interviews further validate sensor effectiveness under various use case scenarios.

## Results

This study presents a comparative assessment of traditional and modern traffic sensing technologies based on multiple performance dimensions. Traditional systems such as inductive loops, magnetometers, and infrared sensors are durable and cost-effective but provide limited data resolution and adaptability. In contrast, modern technologies, including video detection, radar, and LiDAR, offer higher accuracy and enable real-time, high-resolution data collection suited to complex, multimodal environments. A summary of these findings is provided in a performance evaluation matrix that includes criteria such as accuracy, environmental resilience, implementation complexity, and future applicability.

A detailed lifecycle cost analysis was conducted to quantify the financial implications of deploying each sensing technology over a ten-year period. As presented in Table 1 and Table 2, traditional sensors maintain relatively low total costs, whereas the life cycle expenditures associated with modern technologies are considerably higher. These elevated costs are primarily attributed to increased maintenance frequency, calibration demands, and complex installation procedures. Nevertheless, the advanced functional capabilities provided by modern systems justify their financial investment in environments that demand granular, real-time data for traffic optimization, safety interventions, and multimodal integration. The analysis underscores the importance of evaluating sensing technologies not only through the lens of economic feasibility but also in terms of strategic alignment with long-term mobility and infrastructure goals.

Table 1. Summary of Estimated Initial, Maintenance, Replacement, and Total Lifecycle Costs for Traditional Traffic Sensing Technologies Over a 10-Year Period

| Technology | Initial Cost (USD) | Maintenance Frequency | Maintenance Cost (USD, 10 years) | Replacement Cycle | Replacement Cost (USD) | Total Lifecycle Cost (USD) |
|---|---|---|---|---|---|---|
| Inductive Loop | 500 | 3 years | 450 | 10 years | 500 | 1950 |
| Magnetometer | 800 | 4 years | 500 | 10 years | 800 | 2100 |
| Infrared Sensor | 1500 | Annually | 1000 | 10 years | 1500 | 4000 |

Table 2. Consolidated Lifecycle Characteristics and Costs of Modern Traffic Sensing Technologies

| Technology | Initial Cost (USD) | Maintenance Frequency | Maintenance Cost (USD, 10 years) | Replacement Cycle | Replacement Cost (USD) | Total Lifecycle Cost (USD) |
|---|---|---|---|---|---|---|
| Video Detection | 7,500 | Monthly | 9,600 | 10 years | 7,500 | 24,600 |
| Radar | 4,000 | 2 years | 2,500 | 10 years | 4,000 | 10,500 |
| LiDAR | 30,000 | Annually | 15,000 | 10 years | 30,000 | 75,000 |

Based on the evaluation matrix and cost analysis, the study recommends sensor deployments tailored to specific roadway contexts, as shown in Table 3. Inductive loops, radar, and magnetometers are appropriate for freeway mainlines, while ramps and merging zones require higher-resolution technologies such as LiDAR and video detection. Arterials benefit from combining magnetometers and video systems for balanced performance and cost. Urban intersections demand integrated platforms with LiDAR, video, and infrared sensors to address multimodal complexity and support real-time coordination. These findings support a context-sensitive, hybrid deployment strategy for scalable and resilient traffic sensing.

Table 3. Summary of Operational Characteristics by Roadway Type

| Roadway Type | Key Characteristics | Operational Priorities |
|---|---|---|
| **Freeways (mainline and ramp)** | High-speed segments, merging behavior, weather sensitivity | Speed detection, queue monitoring, environmental resilience, and advanced traffic control (ramp segment) |
| **Arterials** | Moderate speed and volume, mixed access, moderate complexity | Flexible installation, flow efficiency |
| **Intersections** | High complexity, multimodal conflicts, diverse road users | High-resolution detection, safety analytics |