



New Technology Drives Changes in Traffic Information Collection

According to the U.S. Department of Transportation (DOT), roads built in the peak years of new interstate construction—roughly between 1960 and 1980—are approaching the end of their design life. Frankly, they are wearing out. This is one of the principal reasons why use-fees have emerged so strongly in the U.S. transportation industry.

Transportation analyst Bob Poole, Searle Freedom Trust Transportation Fellow and director of transportation policy at the Reason Foundation, summarizes the rationale for tolling as the U.S. faces the need to address its rapidly deteriorating interstate network of highways:



- Tolls can be tailored to the costs and benefits of each section of highway and crossing.
- Tolls are fairer since users pay for what they use and not for other people's use.
- If implemented as a true user fee, toll rates will be self-limiting and dedicated via enforcing bond covenants on capital (unlike taxes) and so should be politically more acceptable.
- Tolls are implementable as needed by road conditions and traffic.
- Tolls on urban expressways can help manage traffic via variable toll rates for freer traffic flow, and more efficient and predictable travel.

To this list we would add another important reason, the technology is available to enable viable electronic open road tolling on a nationwide basis.

With an increase in toll roads comes the need for better toll enforcement, traffic management, and information collection. Moreover, accurate, reliable, and cost-effective solutions are required as the demand for more free-flowing traffic tolling on crowded highways increases. Electronic equipment to identify and store large amounts of vehicle data is more common and represents a technology shift that is

transforming the way industry experts think about vehicle classification and toll collection. This white paper explores a new, above-ground technology that improves traffic information management when compared to existing technology options.

Applications

From pneumatic tubes and physical gates to video camera analytics and radio frequency identification, a variety of technologies have been used over time to achieve varying degrees of results in toll road applications. In this paper, we discuss two technologies used frequently together or independently, for free flow tolling: inductive loop systems and LIDAR (Light Detection and Ranging) devices.

Inductive Loop Technology

An induction loop is a detection system that uses a charged wire loop to create a magnetic field and an electrical current in a nearby wire. When a vehicle approaches, the magnetic field's eddy currents are altered and the nearby wire's electrical current changes. The change in electrical current is sensed by a relay in the circuit. This change in eddy currents can also be called a change in circuit's inductance and has been used for years in toll road and traffic light management systems. Inductive loops are effective in both fast and slow moving traffic. The measurements from the inductive loops are inferred and not direct measurements of an object's dimensions or shape. Specifically, inductive loops do not directly measure vehicle height, width and length. Loop systems also have a difficult time recognizing vehicles that straddle lanes and vehicles that change lanes in the middle of the tolling system. These events will often require a manual check of the transaction, which creates an instance in an exception report.

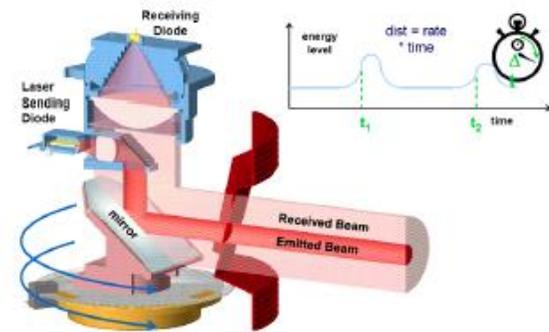
The loop's structure also means that only metal masses above a certain size are capable of triggering the relay. This is done to limit false triggers caused by environmental conditions, but it also means that smaller objects such as motorcycles and other smaller objects are missed by the inductive loop and corresponding switch. Historically, inductive loops were good at counting axles when traffic was moving, but had difficulty in stop-and-go traffic situations. When there was no change in the magnetic field, there was no change in the magnetic field. Rather than relying solely on the loop's relay, a timing feature was added to the inductive loop sensor that was able to determine a vehicle's dwell time and speed.

Inductive loops work very well in different weather conditions but must be properly placed and sealed for them to have no effect on the roadway or the technology. Installing loops in freezing and thawing climates creates unintended circumstances. The pavement breaks caused by the initial installation create new fractures in the roadway, which leads to increased road maintenance. Cutting into the roadway has long been known to reduce the effective life of roadways; the extent of this effect is a matter of ongoing debate. Once the inductive loops are installed, the maintenance costs are not limited to the device. An extended lane shutdown time is required, which is costly and hazardous to workers and travelers in the roadway.

LIDAR Technology

Overhead sensing solutions that can be accessed from a tolling gantry from above can allow traffic to move freely, therefore, providing a maintenance routine without causing lane shutdowns and creating congestion. LIDAR is an overhead sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. Most LIDARS are time-of-flight devices. A single concentrated beam of light is emitted and the sensor's internal clock calculates the time for that emitted beam to hit an object and reflect the emitted beam back towards the scanner. The speed of light is constant. Therefore, it becomes easy to calculate the distance of an object from the sensor.

LIDARs with a 360° rotating mirror assembly are called LIDAR or laser scanners. The scanner's field of view and angular resolution can be configured and optimized for a particular application. The field of view is measured in radial degrees and is the scanner's viewing area. The angular resolution is the difference between each individual laser's shot and is usually measured in fractions of degrees. As an example, a laser scanner with a 90° field of view and a half-degree angular resolution has 180 measurement points. Increasingly, it is the technology of choice for traffic information collection used on many occasions to detect vehicle over height, vehicle separation and vehicle profile in tolling applications.



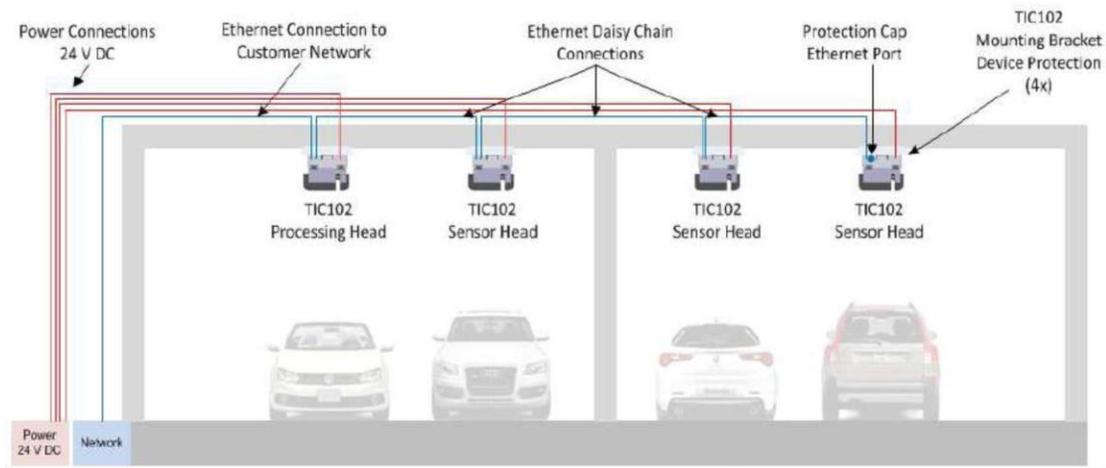
LIDAR technology has been tested in a variety of weather conditions such as fog, snow and rain. Through specific toll road experience and sensor testing, incorrect measurement values caused by varying weather conditions can be eliminated.

A Breakthrough in Traffic Information Collection

SICK provides the TIC102 traffic information collection system that uses LIDAR technology from multiple scanners to classify vehicles and detect and identify lane straddlers and lane changers. When used in multiple lane environments, adjacent lane TIC systems provide vehicle classification redundancy in both free-flow and stop-and-go traffic situations. SICK's previous experience in toll road applications has been incorporated into the TIC102 system's filtering algorithms to provide a reliable output with a corresponding confidence value for each measured and calculated value. Further, SICK has combined multiple LIDAR-based devices to classify vehicles. Through this technique, the system is able to calculate speed and accurately classify up to 30 categories of vehicles.

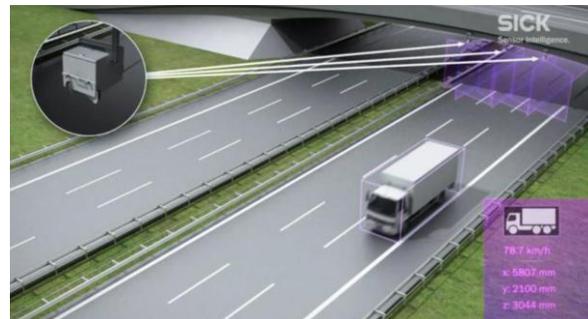
Each TIC102 system contains two scanners. One scanner is mounted parallel to traffic flow and is used for speed and length measurement. The orthogonal scanner

measures a vehicle's width and height, and the combined approximate dimensional information is used to determine the vehicle's class. The TIC102 system is not a per-lane system. Up to four TIC102 systems communicate together on the same gantry and provide classification data outside of their dedicated lane. Individual TIC102 heads can be removed from the gantry without an interruption in fee collection. Below is a typical four-lane mechanical and electrical wiring setup for the TIC102 system.



The TIC meets the key functional requirements of today's traffic information demands. Primarily, it works more reliably in real-world conditions:

- Provides functionality across multiple lanes.
- Classifies lane straddlers and lane changers.
- Works in stop-and-go traffic.
- Works in all weather conditions.
- Meets the demands of site requirements through scalability.
 - Customizable to fit user requirements
 - Easily modifiable configuration to meet roadway changes
- Facilitates scheduled maintenance by providing advanced diagnostics before involuntary shutdowns.
- Provides extremely high detection rates.
- Reduces classification errors by providing confidence values of measured values.



What's different about the TIC is its method of applying time of flight technology with the multi-echo technique. Rather than simply pulsing the light and getting a return at

a specific angle, it captures multiple echoes. This improves accuracy while helping to filter out environmental noise and weather elements, such as rain, sleet, snow, fog, etc.

By looking at the data provided through the multi-echo technique, and then manipulating it for analytical purposes, the TIC102 meets virtually any traffic information collection need an application may require.

Into the Future, Efficiently

As tolls become an increasingly viable solution to the problem of the nation's aging highway systems, new uses of LIDAR technology create opportunities to improve revenues and lower costs on any toll road.

The transportation industry is looking to the future with many considerations to reduce the CO emissions generated on our congested highways. In free flowing tolling applications, a system that allows for maintenance from above the toll lane — and not in the lane — makes for a more environmentally sensitive system. Congestion can have a negative impact on the environment by increasing the greenhouse gases associated with driving. It makes good and healthy sense... as well as cents.

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