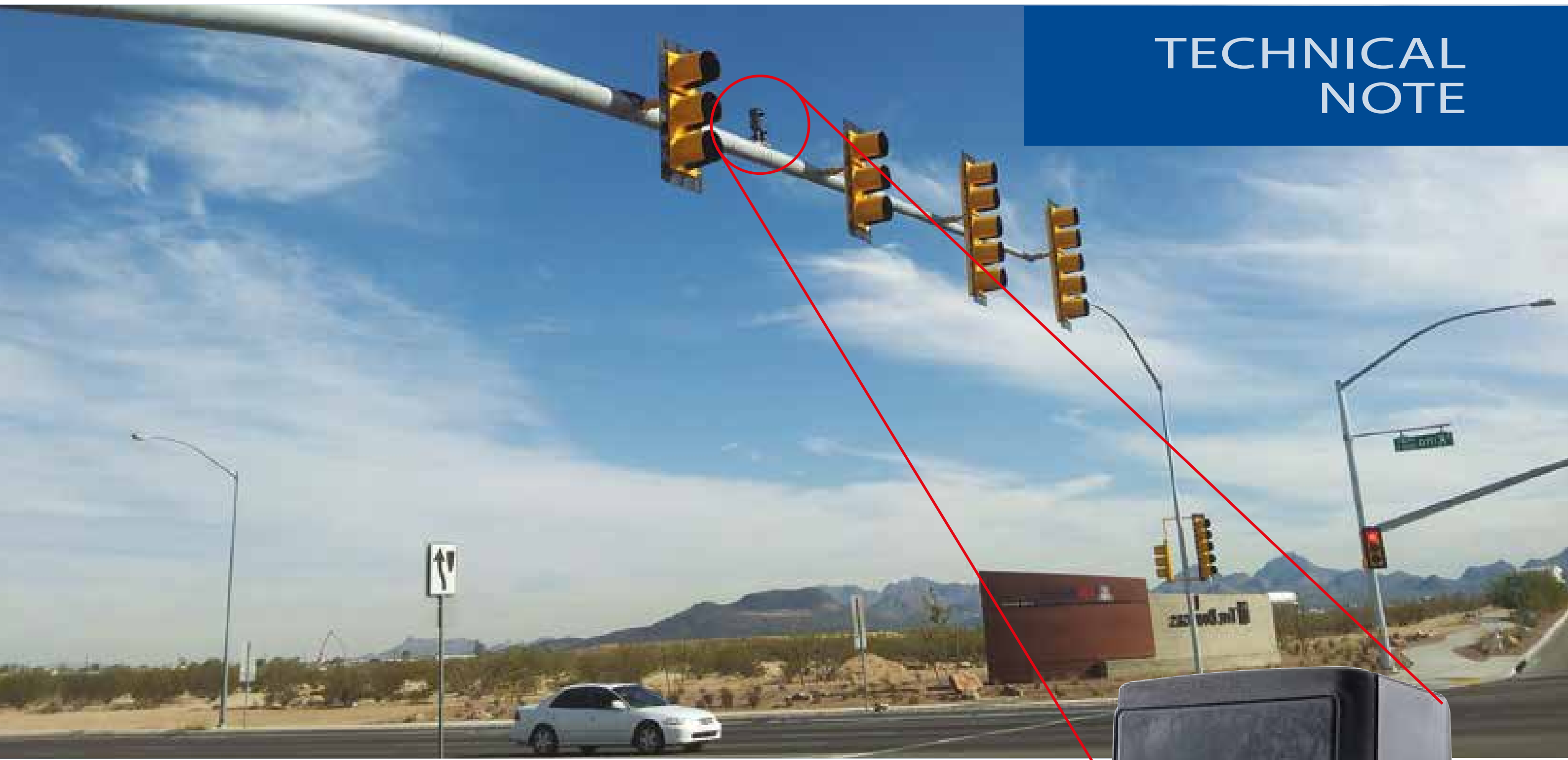
TECHNICAL NOTE



Combined video and radar detection improves safety and efficiency at intersections.

Accurate vehicle presence detection allows traffic authorities to manage and control traffic lights at intersections based on actual traffic demand. In order to do this efficiently, it should be possible to detect vehicles at various distances, on multiple lanes and in multiple directions at the same time. Although various technologies are able to detect vehicles at a certain distance, none of them can efficiently detect vehicles with such a broad range and field of view. By combining video and radar, FLIR has developed a product that actually has that field of view and is therefore able to significantly enhance the safety and efficiency at intersections.

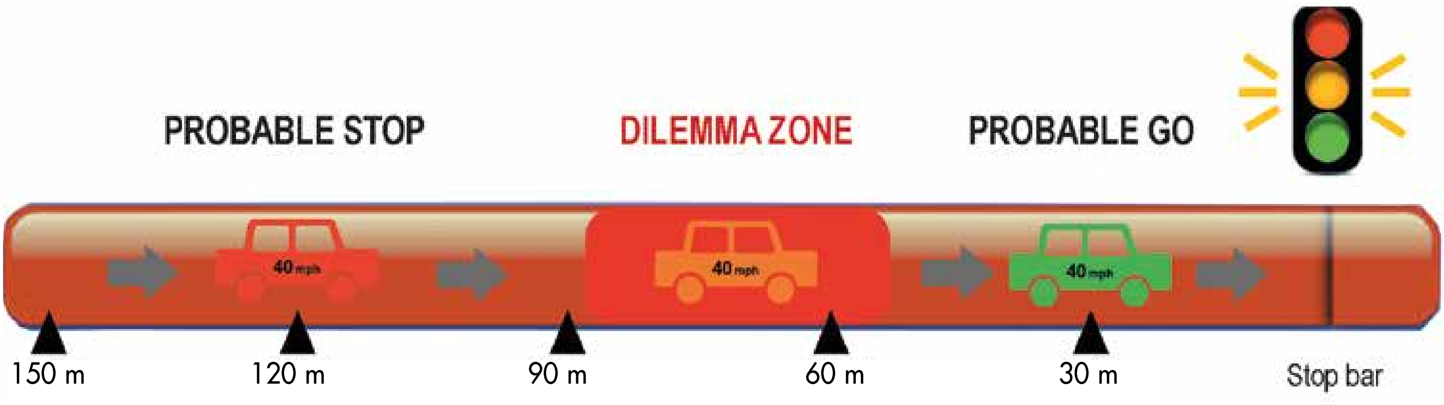
FLIR developed a cost-effective combination of video- and radar-based vehicle presence detection.

To meet the needs of today's traffic management authorities, FLIR Intelligent Transportation Systems has developed a cost-effective combination of video and radar-based vehicle presence detection in a single, integrated unit that is able to detect vehicles at various distances, for multiple lanes and multiple directions at the same time. The hybrid video/radar sensor can be used for traffic adaptive systems and dilemma zone protection applications.

Traffic light efficiency

Accurate vehicle presence detection for multiple distances, for multiple lanes and directions, next to presence detection of stopped vehicles at the stop bar: all of this is of crucial importance when traffic lights need to be controlled proactively. By combining all this detection information, a traffic control system is able to take into account the current and oncoming traffic and as a result, take better decisions for current and future green times. Not only can a traffic control system manage a local intersection, but also multiple neighboring intersections. This is called a "traffic adaptive" system.

Traffic (light) efficiency here means reducing waiting and/or traveling times. This results in reduced costs: purely economical (idling vehicles cost



The dilemma zone

money), ecological (CO_2 emissions) and psychological cost (frustration, stress).

Today, less than 1% of the intersections in the United States have traffic lights that are equipped with a traffic adaptive system. And yet, "adaptive traffic control systems" are widely regarded within the ITS community as the solution par excellence with the highest benefit/cost ratio. In addition, the enormous social and political pressure to keep vehicle emissions under control calls for an increase in systems that take into account the actual traffic demand.

Safety in the dilemma zone

When it comes to traffic safety, a detection system that combines several distances could easily warn the traffic light controller whenever a vehicle is present in the dilemma zone. In that area, motorists might hesitate whether to continue driving or stop in case the traffic light switches from green to amber. In the first case, motorists might choose to accelerate with a risk of overspeed and collision at the intersection. In the latter case, an emergency stop might cause a head-tail collision.

Dilemma zone protection is a method that minimizes the probability that the amber light will be activated while vehicles are in the dilemma zone. In order to do this one must calculate when a vehicle is in the dilemma zone or not. By detecting a vehicle in the dilemma zone, a traffic control system can use this information to decide to postpone the activation of amber until the vehicle in question has made it across the intersection safely. The controller could also decide to make the red time of the conflicting direction longer, so that a potential red light runner will not cause an accident. An additional prerequisite for efficient dilemma zone protection is the ability to make a distinction between a small and a large vehicle, since both have completely different braking distances.

The following statistics illustrate the importance of dilemma zone protection.

- In the city of Damascus, Syria, 38% of 226 vehicles in the dilemma zone stopped for red, 56% disobeyed the amber light and 6% disobeyed the red light. In total, some 47% (96 vehicles) conflicted with the dilemma zone. From that number, 51% accelerated during the amber light, 43% braked in an uncomfortable and dangerous way and 6% disobeyed the red light.
- Similar research in Malaysia showed

Electro-magnetic sensors

Inductive loops

Radar detection

Video detection

that 62% of the motorists were influenced by a sudden change into amber. 56% of those "influenced motorists" accelerated during orange, 13% stopped abruptly and 31% ignored the red light and drove passed.

Large differences may be explained by local driving habits, driving education and local traffic legislation. However, the dilemma zone problem is clearly there, worldwide, and on every signalized intersection.

Available technologies

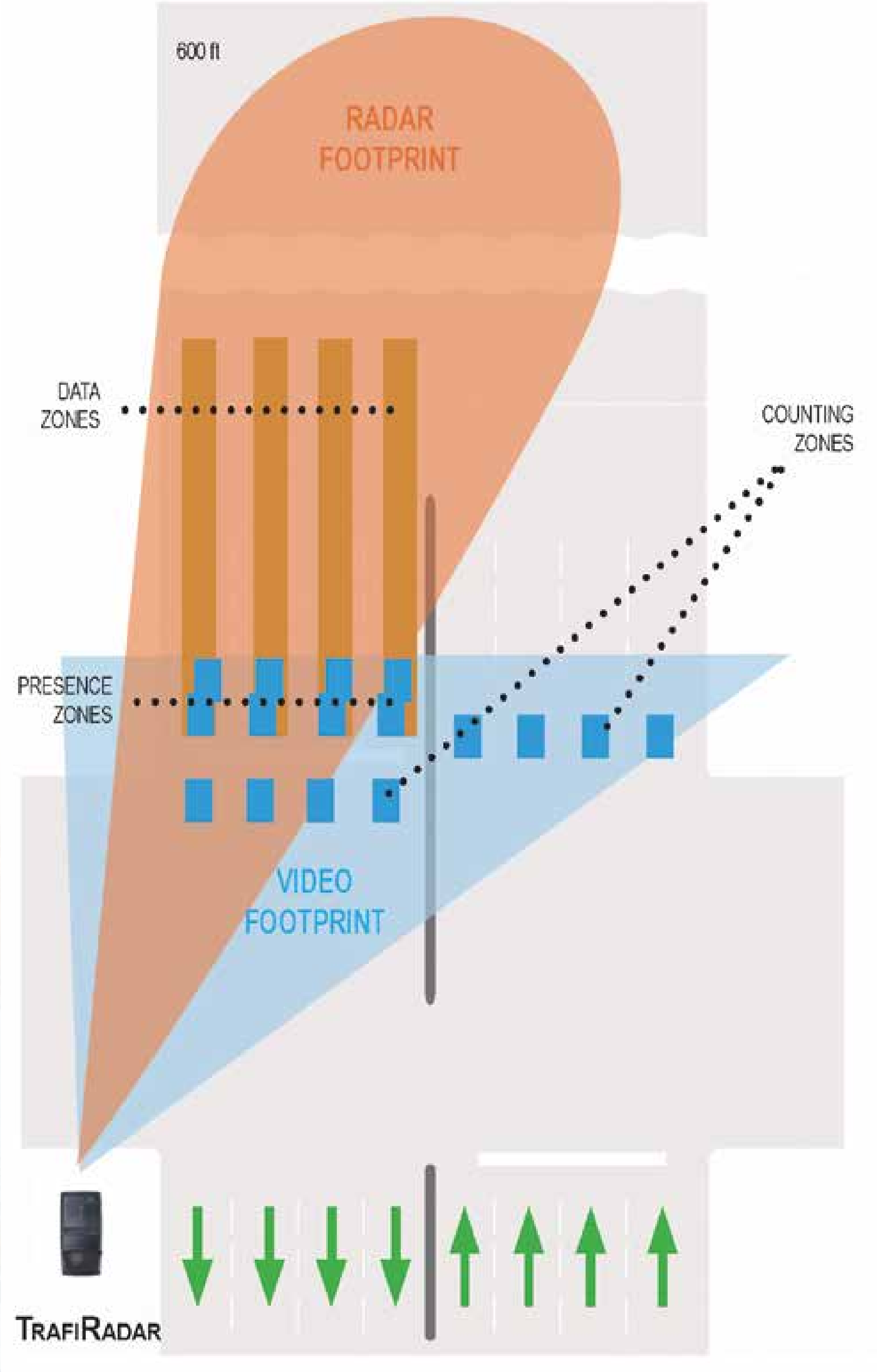
Current systems for traffic adaptive applications and dilemma zone protection are very expensive and demand significant installation and configuration efforts.

Electro-magnetic sensors

On-road electromagnetic sensors use wireless communication to repeaters and send detection information to the traffic controller via access points. An electromagnetic sensor allows vehicles to be detected on one point of the road, which makes installation cumbersome and expensive.

Inductive loops

Inductive loop systems have been around for half a century and still take a large portion of the market, but here installation costs are high and require extensive road works. Loop detectors are placed in the subsurface of the roadway and when utilized, they can provide real-time traffic information on that point of the road. Installation usually means disrupting traffic flows. Another problem with loops is that they have a high failure rate.



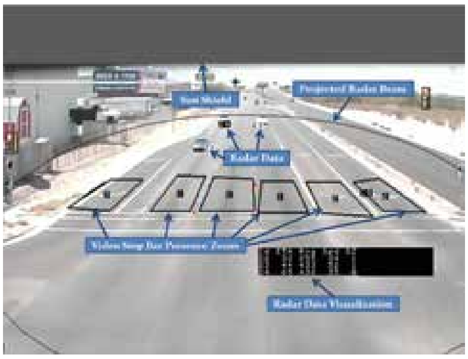
TrafiRadar's combined video and radar detection footprint

Radar detection

Doppler Radar transmits a continuous wave of a constant frequency. When this frequency strikes a moving object the frequency is changed and the new frequency returning to the radar is used to determine the speed of the moving target. Radar-only systems require multiple units to be installed, e.g. a radar detector is installed at the stop bar and one at an advanced position.

Video detection

Video detection has proven to be very accurate and reliable for traffic light management. The combination of both numerical data and visual image control sets video detection apart from other systems. The immediate visual feedback received from video systems allows fast incident response, which is a huge bonus for managers needing to make rapid-fire decisions. However, when detection at the stop bar and at the same time at a 100-150m distance is required, then two video detection systems are needed to realize efficient detection, which increases the cost of installation.



TrafiRadar's radar unit provides accurate information on the vehicle's lane position and speed in a specific area of interest.

In this example, TrafiRadar detects vehicle with ID 27 and 28 to be in the dilemma zone.

TrafiRadar provides accurate data on position per lane, distance and speed, making it an ideal tool for traffic adaptive systems.

The FLIR solution: accurate and cost-effective detection for safe and efficient intersections

FLIR Intelligent Transportation Systems, formerly Traficon, has developed a combined video and radar sensor, called TrafiRadar, which has been designed to accurately detect vehicles at signalized intersections. TrafiRadar is a compact and integrated sensor that is easy to install and configure and very price-competitive.

TrafiRadar uses video and radar detection for different purposes:

- Video for detection at short range, for system configuration and for operator visualization
- Radar for detection at medium and long range

This approach allows detecting:

- Approaching vehicles at 150 - 200m distance of the intersection (advance detection)
- Approaching vehicles at 25 - 150m distance of the intersection (dilemma zone detection)
- Approaching and stopped vehicles at 0 - 25m distance of the intersection (stop bar detection)
- Vehicles leaving the intersection (intersection check-out)

Several aspects of the TrafiRadar product, which are unique in the world of ITS, make it ideal for use in traffic adaptive systems. The TrafiRadar sensor:

- Presents radar information on the video image.
- Sees clearly from the stop bar up to 150-200m
- Makes a distinction between medium and large-size vehicles
- Distinguishes multiple lanes.
- Features two technologies that interact and complement each other
- Is an integrated solution, in one hardware unit
- Is significantly less expensive than other current systems and technologies.
- Can be installed within 30 minutes' time.

Conclusion

A combination of video and radar-based vehicle presence allows for accurate detection of vehicles at various distances from an intersection. This capability makes it possible to deploy so-called traffic adaptive systems or provide for dilemma zone protection.

The combination of video and radar-based vehicle presence detection in one single product makes it possible to detect speed and location between 0 and 200 m from the stop bar. The integration of both video and radar detection technology into a single unit makes this solution very cost-efficient in contrast to single-technology solutions.

FLIR's TrafiRadar sensor

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