A DEEPER LOOK AT THE TRUE COST OF TRAFFIC DETECTION

Traffic detection technologies are the backbone of traffic management systems, providing real-time signal actuation and rich data. In turn, these systems improve traffic flow and safety in our cities, and increase quality of life for all citizens. Given the importance of these base technologies in easing congestion, it's no surprise that researchers around the world have examined the life expectancy and life cycle costs of various detection options.

Armed with relevant research data, agencies can make informed decisions for choosing the appropriate traffic detection solution for their local intersections and roadways. Here, we'll delve into some of the most recent studies, consider the methodology used, and combine the various data they've provided to paint a clearer overall picture of the traffic detection life cycle landscape - or streetscape, if you will.

First, let's consider the importance of life expectancy, or durability, of traffic detection systems. Durability dictates how long until replacement is required, and how many detection locations are fully functional at any given time, affecting the overall reliability of the system. Failure to detect vehicles due to broken components can cause extra delay, unnecessary congestion, or misallocation of budget.

In addition, because capital and labor budget limitations can affect the ability to keep detection systems up and running consistently, it's critical to account for the life cycle costs of these technologies. This includes the upfront price of the system, installation cost, maintenance costs, lifespan of the components, and the cost of replacement.

Comparing life expectancy data

Unfortunately, there is a lack of hard data on the lifespan of radar and video detection systems. In a 2017 study by the Oregon Department of Transportation (ODOT)1, a lifespan of 10 years is assumed for radar, video, and loops but that timeframe is unsubstantiated by empirical data.

The most recent comprehensive study on loop life is from the Korea Institute of Civil Engineering and Building Technology (KICT).2 This 2017 paper studied 1,219 loops over five years in a relatively mild climate (i.e., no freeze or thaw cycles). They observed the loops had a 28% failure rate within five years. Then they projected half the loops would fail in 6.5 years (78 months) and 80% would fail in about 8.5 years, yielding an average loop life expectancy of 6.67 years.

Next, using return rate figures for magnetometer sensors (i.e. Sensys Networks' FlexMag)3 across a variety of climates, we see a failure rate of <4% within five years. In Figure 1 we see both sets of empirical data and projections for comparison. The red squares illustrate observed failure data for inductive loops and the red line projects failure rate into the future. This is compared to orange circles for observed failure data for magnetometers and an orange line for projected failures over the same time period.

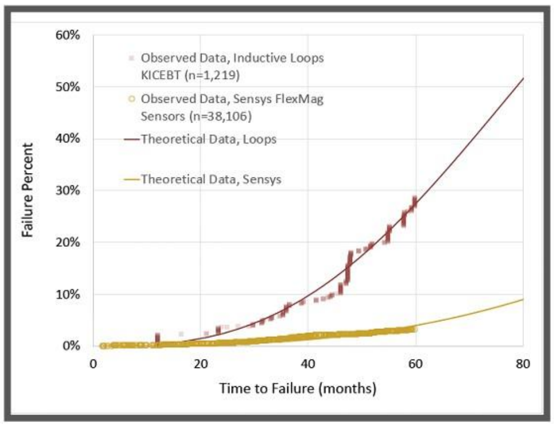

Figure 1. Observed and projected failure rates for inductive loops and magnetometer sensors

The loop failure numbers found in the 2017 study are in line with earlier studies done in Alberta, Canada (>50% failed within 7 years) and Minnesota (> 40% failed year 1).4 The Texas Transportation Institute and Georgia Institute of Technologies also reported high rates of data loss due to loop failures.5

Digging deeper into the data portions of the cumulative distribution function (CDF) (first 5 years) for loops and magnetometers we see that loops fail in groups and magnetometers fail more randomly. This makes sense because loop failures are often due to utility or other road work cutting a lead-in wire that feeds multiple loops. In general, the inherent design of inductive loops - wires installed across the roadway - cause them to be susceptible to breakage as the pavement degrades due to traffic, rain runoff, freezing/thawing cycles. Or, as a traffic engineer in London phrased it on Quora in response to a question about average lifetime of a loop detector, "an induction loop lasts as long as the road surface it's put into."6

Like loops, magnetometers can also be destroyed by road resurfacing (though some models can be installed below grade). However, because they're wireless and encased in a hardened epoxy plug in the middle of the lanes, there are no wires that can be severed so they are much less susceptible to damage caused by utility work, weather cycles, and traffic.

Normalizing life cycle cost across multiple data sets

Now, let's combine the lifespan data from KICT and system cost data to normalize life cycle costs of various detection systems. In the 2017 ODOT study mentioned earlier, researchers calculated life cycle costs for a variety of detection technologies over 10 years, as summarized in Table 1.

Alternative	Total Initial Costs	Total Present Annual Costs	Total Present Replacement Costs	Life Cycle Cost	Percent Increase in Cost Compared to Lowest
Inductive Loop	$20,400	$0	$0*	$20,400	0%
Sensys Magnetometer	$31,750	$0	$4,629*	$36,379	78%
Wavetronix Radar	$46,520	$38,949	*	$85,469	319%
Iteris VersiCam	$42,000	$35,255	*	$77,255	279%
Traficon FLIR	$51,984	$20,327	*	$72,311	255%
Iteris Vantage Vector	$31,520	$24,880	*	$56,400	177%

Table 1. ODOT life cycle cost calculations for 1 intersection over 10 years (empirical lifespan data not accounted for)*

Since these assumptions do not account for empirical data of loop failures, the results are incomplete and skewed quite a bit. However, the authors acknowledged that costs were highly dependent on the life expectancy assumptions and that, "...inductive loops may not last as long as

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expected due to construction, pavement failure, freeze thaw cycles, or vermin."

Indeed, all detection types have some probability of failing sooner and replacements have some probability of failing again in the 10 year window. This is true for any system deployed and it increases the cost and number of replacements needed. The effect is small for systems with low failure probabilities over the period but larger for systems with higher failure probabilities. Given the failure CDFs of loops and magnetometers that we examined earlier, this will have a significant impact on a loop installation and small impact on a magnetometer installation.

Correcting the numbers for loop and magnetometer life expectancy using loops' median life expectancy of 78 months, the normalized costs are shown in Table 2.

Alternative	Total Initial Costs	Total Present Annual Costs	Total Present Replacement Costs	Life Cycle Cost	Percent Increase in Cost Compared to Lowest
Inductive Loop	$20,400	$0	$10,200	$30,600	0%
Sensys Magnetometer	$31,750	$0	$1,382	$33,132	8%
Wavetronix Radar	$46,520	$26,646	*	$73,166	139%
Iteris VersiCam	$42,000	$23,515	*	$65,515	141%
Traficon FLIR	$51,984	$13,558	*	$65,542	142%
Iteris Vantage Vector	$33,520	$16,595	*	$50,115	64%

Table 2. ODOT calculations corrected for actual loop failure rates, calculated over loops median life expectancy of 78 months (Does not include costs associated with radar and video failures over the 78 month period)*

In addition, a 2010 study from the Washington State Transportation Center7 analyzed the effects of cutting loops and pavement damage on different pavement types and loop shapes over a stretch of I5 in Washington State. Results depend on loop age, shape and pavement type but generally concluded cutting loops accelerates pavement damage. At a high level, they concluded loops should be burdened by an additional 25% of the loop cost to account for the premature pavement failures that they cause. This makes sense given the extensive trenching that is required to install loops and their lead-in wires allowing vehicles and weather to further degrade the roadway, compared to the 4" epoxy plugs for magnetometers.

Accounting for the cost of pavement damage the total normalized costs are shown in Table 3.

Alternative	Total Initial Costs	Total Present Annual Costs	Total Present Replacement Costs	Life Cycle Cost	Percent Increase in Cost Compared to Lowest
Inductive Loop	$25,500	$0	$12,750	$38,250	15%
Sensys Magnetometer	$31,750	$0	$1,382	$33,132	0%
Wavetronix Radar	$46,520	$26,646	*	$73,166	121%
Iteris VersiCam	$42,000	$23,515	*	$65,515	98%
Traficon FLIR	$51,984	$13,558	*	$65,542	98%
Iteris Vantage Vector	$33,520	$16,595	*	$50,115	51%

Table 3. ODOT calculations corrected for actual loop failure rates plus pavement damage, calculated over loops' median life expectancy of 78 months
(Does not include costs associated with radar and video failures over the 78 month period)*

Conclusion

While there remain stones unturned when it comes to empirical data on the lifespan of radar and video detection systems, we now have a better understanding of the total costs of various systems when accounting for (known) failure rates, pavement damage, and maintenance costs.

Finally, recognizing that traffic professionals prioritize accuracy and reliability over price[8], it's worth noting that radar and video tend to be less consistent than in-ground detection for these metrics. While it's difficult to assign a cost value to accuracy and reliability, it is clearly still a critical consideration when choosing your detection solution.

Sources cited can be found linked in the electronic edition of the Journal.

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