Monitoring conditions in a harsh environment

Imagine a place where the temperature can vary between 14°F (-10°C) and 131°F (55°C) in the same month, and the temperature in the morning can rise nearly 1.5°F (1°C) every 10 minutes. Water, ice and snow can all occur here, and you pass through the freeze-thaw process more frequently than most places on Earth.

Now imagine objects passing over you weighing upward of 80,000 lb (36,000kg) and vibrations similar to a minor earthquake occurring on a nearly continuous basis. Does this sound like somewhere you would like to live? Probably not – but this place could be closer than you think. The road surface outside your home or place of work may be subject to many, if not all, of the conditions described above.

The surface of the road is a harsh place. You would not leave your smartphone out there because you know what condition it would come back in. But we do put electronic devices on the road and expect them to work. Road sensors that measure traffic or road weather conditions have to live in this environment.

Trial and error

Over the past 40 years, Vaisala has designed, tested and manufactured numerous types of embedded road-weather sensors, and over that time the company has learned that the road surface is an unforgiving environment. It has a low tolerance for equipment with sophisticated designs and features. It is a place where simple design means a long life.

For example, a sensor with a removable lid might sound like a good idea because it would give you the ability to service the sensor. However, removable lids can let in water.

(Left) **The remote sensor measures surface temperature via emitted infrared radiation and lasers**

(Below) **The thermally passive sensor measures road surface and subsurface temperatures, as well as water layer thickness, black ice and chemical levels**

Need to know

With road sensors subject to the extremes, a simple design is key to longevity

- Vaisala's Remote Surface Condition Sensor DSC111 is pole-mounted at the roadside to provide accurate readings of surface conditions including water, ice and snow, as well as grip level
- The company's DRS511 and FP2000 passive, embedded sensor provides information about all road weather conditions, including chemical applications

Often the sensor will remain watertight until the first time it is serviced. Then, due to temperature changes and forces from vehicles, the lid no longer fits the housing. Vaisala's experience has shown that only a completely sealed sensor remains watertight.

Another design idea is a completely wireless sensor with batteries. This concept is cheaper to install with less hassle, but the batteries struggle to last as long as expected. Though batteries have improved greatly over the past 20 years, nearly all types still struggle to cope with extreme heat and cold, which lessen their life, and as described above, very few places on earth experience more extremes than our roads.

Embedded road sensors work most effectively if they are passive, i.e., they do not attempt to change their environment. Active heating and cooling to detect the freezing point of the surface liquid is not a simple process and makes the entire sensor more complicated. A passive sensor simply measures its environment and does not try to change it. Through Vaisala's experience with sensor technologies and road physics, it has learned that embedded sensors work best if they are completely sealed, have hard-wired power and are passive in their measurements.

Non-intrusive investment

Over the past 20 years, as road weather networks grew, road authorities began to come to terms with maintaining an increasing infrastructure of road-weather ITS. Costs to repair and replace road sensors became more important, and thus agencies wanted a solution to prevent frequent replacement of embedded sensors following road resurfacing. Solutions such as lids and batteries appeared on the market to lessen costs, but they also reduced reliability. The only real solution was to remove sensors from roads altogether.

Nowadays, sensors that use lasers and infrared technology can be mounted on the side of the roadway. They are referred to as remote or non-intrusive sensors. They typically cost more than their embedded counterparts, but non-intrusive technology has proven

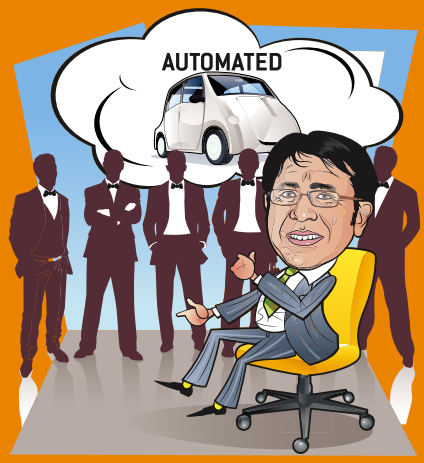
to be much more cost effective in the long run.

Non-intrusive sensors are easier to maintain and do not require any lane closures. They also offer an advantage to the decision maker. As they use lasers to detect water, snow and ice on the road surface, the grip, or road friction, of the road condition is measured. When the road authority knows the grip value, it can make better decisions.

Furthermore, a quantitative measurement of conditions means that agencies can use a performance index to monitor maintenance crews during an event, or as an evaluation of success after the event is over. Authorities using this method have seen a notable decrease in chemical use by using an index that measures performance.

The grip reading can be used for automated ITS applications, such as activating signs or controlling signal timing. This attribute takes road weather monitoring beyond maintenance and increases the return on investment by keeping drivers aware of changing road conditions.

The key to the future of road weather technology is that it must offer the most return for the least hassle and cost. Solutions with short-term gains or overly complicated designs will not survive in the long term. Vaisala has learned that reliability and accuracy are the cornerstones to a successful road weather management program. ○



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Excitement is in the air, or more accurately, on the ground. These days I often write about happenings and hype with what some call self-driving cars and what others call automated vehicles. On this occasion, I write about a group of researchers, usually level-headed but sometimes prone to break out in song. This July, venerable National Academies of Science Transportation Research Board will team with the Association for Unmanned Vehicles International to host the Automated Vehicles Symposium near San Francisco.

So what's the big deal, you ask? An underlying theme will be deployment, considered from virtually any perspective you could imagine except the unabashed PR perspective. Perhaps 500 to 600 informed, possibly bow-tied academics and a heavy dose of industry and government experts will gather in the hallowed halls of a business hotel to debate issues such as deployment in breakout sessions with working titles such as below (replete with my made-up but assuredly representative questions to consider):

Human factors: Will transition of control from relaxed driver to one that needs to intervene in an emergency be the bugaboo?

Freight and trucks: Given the economics of goods movement, will these applications be the earliest deployed?

Transit and shared mobility: Will 'transportation as a service' with nearly ubiquitous, demand-responsive automated and shared trips be enabled by automated transportation?

Active traffic management: Will automated cars deterministically behave such that centralized systems can manage traffic flows? Are traffic jams to be a vestige of the 20th and early 21st centuries?

Long-range regional planning: What about sprawl? Automated vehicles could ease the pain and inconvenience of long commutes, resulting in wide metropolitan areas and in the worst case, even reverse or suburbanize that trend to urbanization.

Traffic control devices: Will these be quaint reminders of the past, or will they become ultra-modern roadside modems that communicate by wireless link to your car's throttle and braking systems?

The prospect of like-minded folks clustered by skill and interest, and with an overall mix of disciplines, applications and technology topics is a necessary microcosm of the larger societal debate that needs to occur. And this debate won't be just about your garaged car: commercial heavy vehicles and city buses will be considered, as will be shared-use vehicles, new forms of transit and maybe even robot bicycles.

In short, the transportation future, with its messy mix and full breadth of problems and possibilities will be considered and debated. The perspectives will likely include strong doses of utopian, dystopian and "heck, I don't know" points of view, engendering lively, informed debate and even-handed consideration. It will be compactly delivered in a span of less than three days. And it will portend automated vehicles for our future. I'm so excited.

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Jim Misener, transportation and technology consultant, USA