2022

VISION ZERO & TECHNOLOGY ROUNDTABLE

ROUNDTABLE REPORT

January 11, 2022

ITE Headquarters
1627 Eye Street NW,
12th Floor Salon
Washington, D.C. 20006

ONE CITY TOWARDS SAFE STREETS

CITY OF BELLEVUE WASHINGTON

▸ INTRODUCTION

This report summarizes feedback received during the City of Bellevue's Vision Zero & Technology Roundtable in Washington, D.C. The event was held on January 11, 2022, at the Institute of Transportation Engineers Headquarters (*see Figure 1*).

As a recipient of a 2021 National Roadway Safety Award, presented by the Federal Highway Administration and the Roadway Safety Foundation, there's an awareness within the City that building safer streets starts with generating the right data, understanding risk factors, and testing mitigation strategies. That's why Bellevue brought together public and private sector leaders to share the latest technological developments, identify problems, develop strategies, and pursue the most effective set of actions. Forming safety partnerships is an important component of Bellevue's Safe Systems approach towards Vision Zero (see Bellevue Vision Zero Strategic Plan).

The Roundtable opened with Bellevue City Councilmember Janice Zahn acknowledging that crash statistics fall short of conveying the tragedy of traffic violence in our communities (*Figure 2*). "We know that behind each collision statistic there is a story of a father or mother, son or daughter, brother or sister, grandchild, colleague, classmate or friend whose life was instantly transformed by a road crash," Zahn said. "Bellevue is taking a safe systems approach that includes better collaboration, improved street design, safe speeds, a culture of safety, and enhanced data collection and analysis. Together, we will save lives."

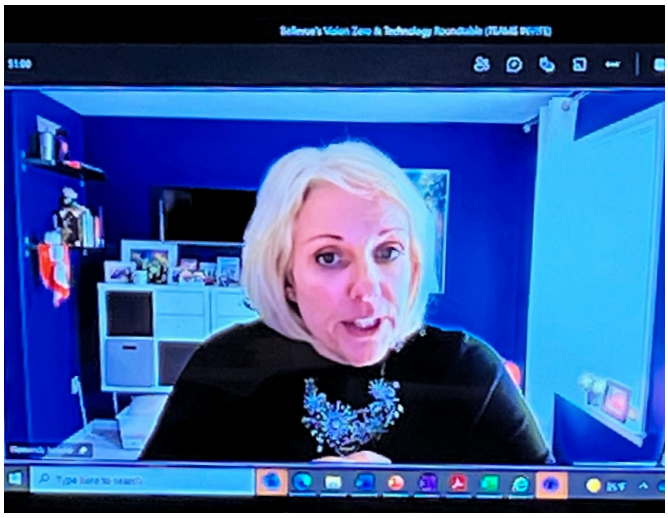
▸ **Figure 1:** Roundtable agenda

▸ **Figure 2:** Janice Zahn, Bellevue Council, providing opening remarks

Jennifer Homendy, Chairperson of the National Transportation Safety Board (NTSB), provided the welcome address to attendees and commended Bellevue for its work (*Figure 3*). "What you're doing in Bellevue is phenomenal, and I hope your efforts serve as a model to improve safety in other cities across the U.S.," she said. "All too often, we have to talk about what went wrong, but I think it's just as critical to recognize when safety is heading in the right direction." Homendy noted that a "paradigm shift" is required in how road safety is addressed. "It's critical that we aren't just relying on existing crash data to improve safety, that we're proactively identifying locations that have a high risk of crashes, but that may not yet have resulted in actual crashes" (see Transcript, Appendix A).

Franz Loewenherz, Mobility Planning and Solutions Manager, City of Bellevue, thanked roundtable attendees sharing their expertise (*Figure 4*). "Although Bellevue convened this Roundtable, the spirit of this gathering transcends our community," Loewenherz said. "As an active member in the National League of Cities, ITE, ITS America, and NACTO we're constantly learning and sharing with others. A priority in our Safe Systems approach to is to share our successes with other communities so that we're moving towards zero together."

Attendees collaborated to address six problem statements based on transportation safety challenges in Bellevue and prevalent in other cities (*Figure 5*). Detailed notes from the sessions are presented in Appendix B. The following are representative infrastructure, policy, and planning themes identified:



▶ **Figure 3:** Jennifer Homendy, NTSB Chair, providing the welcome address

▶ **Figure 4:** Franz Loewenherz, Bellevue staff, provides roundtable overview

Infrastructure Themes:

- *Build connected and comfortable pedestrian and bicycle networks to increase the number of people walking and bicycling and decrease the number of vulnerable road user fatalities and serious injuries in cities. Active transportation infrastructure build-out should incorporate before-after assessments to facilitate knowledge transfer to other communities.*

- *Pilot demonstration pedestrian-bicycle projects, gather community input, and analyze outcomes. Seek public input at the design stage about how, not whether, to add bike lanes and other active transportation infrastructure.*
- *Leverage mobile LIDAR and other road infrastructure and asset management analysis systems to collect data and inform implementation of proactive countermeasure projects at locations that represent a safety risk rather than waiting for crashes.*
- *Explore partnership opportunities with insurance companies – using telematics systems – to reward road users for desired characteristics (e.g., speed limit compliance). However, behavioral tools should not replace actions by planners and engineers to develop roadways that operate in a safe, predictable manner.*
- *Facilitate safe crossings at intersections for seniors and people with disabilities using detection technologies paired with signal controller systems to account for the variability of pedestrian crossing speeds.*

Policy Themes:

- *Transportation equity is a key factor in the conversation because of the disproportionate, adverse safety impacts that affect certain groups on our roadways. Public officials should convene key stakeholders to develop a better understanding of the relationship between equity and roadway safety and develop a comprehensive approach to incorporate equity into all efforts to achieve zero roadway fatalities and serious injuries.*
- *Observe people, in addition to cars, so we can assess impacts and benefits across various*

ROUNDTABLE STRATEGY SESSION: PROBLEM STATEMENTS

1. **Reactive Decision Making:** Building safer streets starts with generating the right data, understanding risk factors, and testing mitigation strategies, There is a growing recognition among safety practitioners that a reliance on crash data alone does not provide a complete picture of road risks and has well-documented limitations. To achieve Vision Zero, a systemic approach is needed to proactively identify locations that have a high risk of crashes but where the risk has not yet resulted in actual crashes.
2. **Safety for Seniors:** Intersections are challenging locations for all road users, but they can be especially difficult for senior populations. People aged 70 years and older are the fastest growing segment of the population in Washington State and tend to be more active than previous generations. Older adults are also disproportionately represented in fatal crashes involving people walking—even after controlling for differences in population size and walking rates (Smart Growth America, Dangerous By Design 2021). Of particular concern for the safety of seniors in crosswalks at signalized intersections is accounting for their walking speed vis-à-vis the pedestrian clearance interval.
3. **Project Delivery Delays:** Implementation of active transportation projects is often time consuming and costly in crowded urban streets where it is necessary to reallocate road space from cars to create safer crossings for pedestrians or a protected lane for people on bikes. In response to the increasing demand for walking and bicycling facilities in cities across the country, many jurisdictions are exploring new approaches to project implementation. Even though quick-build projects (Alta, Quick Build Guide) can accelerate change they are still subject to protracted community consultations and approval processes paired with new funding commitments (see Bellevue Demonstration Bikeway Assessment).
4. **Distracted Driving:** In Bellevue, distracted driving is one of the top 3 contributors for serious and fatal crashes. Over 15% of serious and fatal crashes in Bellevue are attributed to distracted driving. NHTSA estimates that approximately 3,142 people were killed as a resulted of roadway distraction in 2019. To achieve Vision Zero, removing the opportunity for visual, manual and cognitive distraction is key to reversing the statistics. Both the private and public sector have introduced ways to curtail distraction (i,e, cell phone blocking technologies, insurance incentive programs, new laws, and public awareness campaigns) but distraction still remains as one of the leading contributors working against Vision Zero.
5. **Safe Speeds:** Exceeding safe speeds is the top contributor for serious and fatal collisions in Bellevue. Unsafe speeds impair a driver's ability to make safe maneuvers and stop safely when needed. When a pedestrian is hit by a vehicle at 30 mph, the fatality rate is 40%. The fatality rate increases to 80% at 40mph. During the COVID-19 pandemic, vehicular speeds increased significantly, leading to more serious collisions. Geometric roadway design, enforcement, and policy can help to promote and regulate safe speeds. However, a systemic approach is needed to ensure that all roadway users are travelling at safe speeds and at all times.
6. **Vulnerable Road Users:** Pedestrians and cyclists make up for over 50% of the serious and fatal collisions in Bellevue. Collisions involving pedestrians and cyclists are system-wide and occur at both signalized and unsignalized intersections. According to NHTSA data, pedestrian and cyclists traffic deaths are on the rise while deaths involving people inside vehicles are declining as cabin protection on vehicles improve. Increased safety to protect the most vulnerable users on the roadway is paramount towards making a significant impact in lowering serious and fatal collisions.

▶ **Figure 5:** Problem statements

modes. Technology that can better measure how people walking and bicycling use the transportation system would help us make improvements.

- *To build community trust, public agencies must be transparent and clearly convey the benefits and risks of technologies. Many people support the use of technology to advance goals such as safety and mobility but are concerned about their personal privacy.*

Planning Themes:

- *In the near-term, planners and engineers should leverage existing traffic conflict analytics and video intelligence systems that detect near-crashes and excessive speeding to proactively identify where vulnerable road users – people walking and bicycling – are most at risk.*
- *In the mid- to long-term, the data collected for and by connected vehicles and the evolution of public/*

private data collaboratives offer the potential to cost-effectively scale conflict analytics practices beyond cities that have invested in smart technologies at intersections.

- *Planners should collaborate with industry to develop new community engagement tools that create equitable and accessible gathering spaces – using digital twins and metaverse – so anyone can participate at any time that is convenient. These new technologies could support more rapid evaluation, approval, and implementation of transformative complete streets projects.*

Partnerships between the public, private, and academic sectors can help surmount the challenges of advancing transportation safety projects, namely determining research questions, obtaining data, and funding pilots and full-scale programs. The City of Bellevue looks forward to follow-up conversations and collaborations with transportation industry leaders using technology solutions to improve safety (*Figure 6*).

Figure 6: Participants in the City of Bellevue's Vision Zero and Technology Roundtable (in alphabetical order): *Ali Mortazavi (DAVTEQ Inc.), Andrew Ceifetz (WSP), Anita Vandervalk-Ostrander (Iteris), Barbara McCann (Federal Highway Administration), Brad Stertz (Audi of America), Brittney Kohler (National League of Cities), Brooke Struve (Federal Highway Administration), Chris Breiland (Fehr & Peers), Craig Lyon (Advanced Mobility Analytics Group), Daniel Lai (City of Bellevue), Dennis Mitchell (DKS Associates), Franz Loewenherz (City of Bellevue), James Bradford (International Road Assessment Programme), Jamie Sullivan (DERQ), Janice Zahn (City of Bellevue), Jason Whittet (Amazon Web Services), Jennifer Foote (BEEP), Jennifer Homendy (National Transportation Safety Board), Jim Hanson (HDR), Jim Misener (Qualcomm), John Weathersby (Teradata), Kathi Driggs (Institute of Transportation Engineers), Katie Kuciemba Halse (City of Bellevue), Keith Sinclair (Federal Highway Administration), Kristin White (ITS America), Kyle Miller (Washington State Department of Transportation), Laura Chace (ITS America), Mark Bandy (Jacobs), Mark Hallenbeck (Washington State Transportation Center), Matthew Enders (Washington State Department of Transportation), Ramin Massoumi (Iteris), Randy Iwasaki (Amazon Web Services), Ray Akkawi (Advanced Mobility Group), Robert Hoyler (TomTom), Roger Brook (Sighthound), Roger Millar (Washington State Department of Transportation), Sarah Abel (Toole Design), Steven Sheffield (Ouster), Ted Trepanier (Inrix), Yinhai Wang (University of Washington), Zach Gossett (National League of Cities)*

▶ APPENDIX A

REMARKS OF THE HONORABLE JENNIFER HOMENDY
Chair, National Transportation Safety Board
CITY OF BELLEVUE, WASHINGTON:
VISION ZERO AND TECHNOLOGY ROUNDTABLE LUNCHEON

JANUARY 11, 2022

Thank you so much, Franz, for inviting me to participate in your Vision Zero and Technology Roundtable.

I'm so sorry that I'm unable to meet with you all in person today. Once we get past this uptick in COVID-19 cases and hospitalizations I plan to visit the City of Bellevue in person. I'd even love to join you for a walking audit during one of your Road Safety Assessments.

All of you are familiar with the NTSB. We investigate crashes and other significant events in all modes of transportation, determine the probable cause and contributing factors that led to that crash, and then issue safety recommendations that are aimed at preventing fatalities and injuries and saving lives.

All-too-often we have to talk about "what went wrong" but I think it's just as critical to recognize when safety is heading in the right direction. That's why I'm so excited to see all that you are accomplishing. What you're doing in Bellevue is phenomenal, and I hope your efforts serve as a model to improve safety in other cities across the U.S.

You aren't just implementing a Safe System Approach, which is on the NTSB's Most Wanted List of Transportation Safety Improvements, you understand the need to establish and achieve a shared goal: zero by 2030.

You have the commitment from state and city leaders to support your efforts. You've identified champions to help implement your vision and you're engaging with a diverse group of stakeholders and partners to improve safety. You've developed and are implementing a strategic plan. And you are looking at data…where, when, and what type of collisions are occurring so you can take action to eliminate them.

These are the actions that are needed to address a growing public health crisis on our roads. Nearly 40,000 people are dying annually. Millions more are injured. Anything above zero is unacceptable, and we're trending in the wrong direction.

That's why I've called for a new direction, a paradigm shift in how we're addressing road safety. The conventional approach to road safety which the U.S. has relied on for decades for driving down fatalities and injuries is failing road users.

Now I often hear that Vision Zero isn't achievable. It is, and we need leaders like each of you to demonstrate that it is, in fact, achievable. Now today you're going to talk through some problem statements: reactive vs. proactive decision making, for example.

It's critical that we aren't just relying on existing crash data to improve safety. That we're proactively identifying locations that have a high risk of crashes that may not have resulted yet in actual crashes.

That's similar to how safety management systems (SMS) work in aviation. The aviation industry is constantly identifying risk, not just based on accident and incident data, but on a host of valuable information, and then they take that information and implementing measures to address that risk. Then they evaluate and constantly reevaluate safety outcomes to see if those measures are working or whether they need to take a different approach. SMS is a big reason why we've gone from hundreds of fatal aviation accidents among the major airlines annually to none in seven of the past 10 years, and we've recommended SMS in all modes of transportation.

I could go on about your other problem statements, which I think are phenomenal, but I don't want to influence your discussions. I'm looking forward to hearing the outcomes of your strategy session.

But I will comment briefly about the importance of harnessing technology to improve safety. The NTSB has long recommended utilizing technology to help save lives in **all** modes of transportation.

From technology in the cockpit of aircraft to support the flight crew, to technology like positive train control to prevent train-to-train collisions and derailments, and technology to detect defects in pipelines to ensure the safe transportation of oil and gas.

So, when it comes to our roads, we support the safe implementation of technology because we know from our investigations that – when safely tested and deployed – technology can help prevent crashes, eliminate fatalities and mitigate the severity of injuries. These include collision avoidance technologies: automatic emergency braking, forward collision warning, lane departure warning, lane assist, blind spot awareness.

I noticed a discussion in your strategic plan about the importance of ensuring citywide fleets have these new safety technologies. That's critical, but you could also educate your personnel about the safety benefits of these technologies in their own vehicles. Research shows that the average car ownership is about 11 years so it will take some time for these technologies to get into all cars, but in the meantime we should talk about their benefits with our workforce.

Technology is also critical when we start looking at the operation of automated vehicles on our roads. I'd encourage you all to look at our Tempe, Arizona, investigation report and read through our recommendations to states on how they can ensure the safe operation of these vehicles on their roads.

The role of technology in our infrastructure can also improve safety, including the use of safety cameras to help address speeding in school zones and on local roads. I had a great discussion with Franz yesterday about how other countries have been able to demonstrate the use of cameras to improve safety rather then revenue generation. I hope we can share ideas on that in the future.

With that, I'm sure I am well over my 5 to 7 minutes but I'm incredibly excited at all that you are accomplishing in Bellevue and I look forward to seeing your vision becoming a reality. I will see you in person in 2022!

Thank you.

▶ APPENDIX B

REACTIVE DECISION-MAKING: Building safer streets starts with generating the right data, understanding risk factors, and testing mitigation strategies. There is a growing recognition among safety practitioners that a reliance on crash data alone does not provide a complete picture of road risks and has well-documented limitations. To achieve Vision Zero, a systemic approach is needed to proactively identify locations that have a high risk of crashes but where the risk has not yet resulted in actual crashes (*Figure 7*).

- **Framing of topic is important.** The City of Bellevue has a successful track record of leveraging its extensive traffic camera network at signalized intersections to identify near-crash conflicts and speeding risks and evaluate safety countermeasures outcomes. FHWA has been promoting the systemic safety approach for many years; it is now being recognized as a key element in the Safe System toolbox (see link). In addition, several of the new programs funded under the Bipartisan Infrastructure Law will encourage a systemic approach.
- **CV data from sources such as Wejo can provide meaningful insights regarding areas to better understand what is contributing to safety issues; that said, this data will take time to fully integrate in planning for and operating transportation infrastructure.** Fast evolving C-V2X technologies and the development of public/private data collaboratives offer the potential to cost-effectively scale conflict analytics practices beyond cities that have invested in smart technologies at intersections. In the mid to long-term, the data collected for and by connected vehicles will allow for real-time safety management on the entire road network, not just at locations such as intersections where sensors such as video cameras or lidar is in place. These data are much more than that provided by vehicle manufacturers that can provide information on hard decelerations for example. Waymo for example can provide data using cameras and lidar that can track the trajectories of all road users in the vicinity, not just the vehicle itself. As such, it's estimated that even at 40% of the

▶ **Figure 7:** Franz Loewenherz facilitating the reactive decision-making session

vehicle fleet the data from these vehicles will be able to provide full coverage of all road users, including pedestrians etc., across the entire road network. Advances in edge processing allow these massive amounts of data to be pre-processed 'on-site' and only the information needed for actionable insights sent to the cloud for further analytics. Even so, the volumes are not yet consistent enough to rely upon as a sole solution. As such, particularly in the interim, it will be important to promote collaborative relationships between local governments which are planning to implement road safety initiatives, and location technology companies to leverage existing data and ensure that any road safety improvements are correctly and timely reflected in the products which are being utilized by the public.

- **Leverage edge processing and cloud-based applications and storage.** Some computational alerts may be able to be done at the edge (either on the side of the road, in a vehicle, or in a phone) which could reduce latency as well as allow for these applications to occur where communication networks are inconsistent, non-existent, or overloaded (such as in a dense urban area where buildings may block line-of-sight communications or in rural areas where the communication networks may not be as robust). As an industry, we need to work together to improve our ability to detect and provide alerts to pedestrians crossing between intersections. While existing CV data (from sources like Wejo) is good, it would be beneficial to also have additional vehicle & infrastructure data to understand what occurred. Infrastructure and vehicle data need to co-exist and be shared openly and more importantly used simultaneously as redundant systems and not one or the other. This observation is offered to build upon NTSB Chair Homendy's reference of airline safety which incorporates on board and ground systems as redundant measures of safety. By way of example, Iteris is working with Spoke Safety to develop enhanced detection and alerts for bicycle fleets.

- **Data currency/relevance is important for real time decision making and effective planning.** In many jurisdictions safety data lags by months to years, and other potentially relevant data (e.g. citation data) is not available. For example, when considering speeding, many crashes do not record that speeding was a factor (MMUCC compliance), and for non-crash events there is no public record at all (note: this has to do with what police officers report to FARS, and what the standards are for that reporting, which are set by each state). Where are speeding tickets issued? How many? What is the magnitude – 5 over? 20 over? 5 over on a 45mph roadway may have different impacts compared to going 5 over on a 25mph residential street. There is a national dataset of speeds (not speeding tickets) that is publicly available, the National Performance Management Research Data Set (NPMRDS). NPMRDS is used for measuring the degree of delay, but the USDOT Safety Data Initiative did have a project to test using it for safety analysis, which showed some promise. Also, some of this data does not cross jurisdictions (e.g. Maryland and Virginia may not be sharing data about violations even as drivers frequently travel between those areas).

There is also a need to raise the comfort level of safety and traffic engineers for using real time data such as Wejo and near miss trajectories – engineers tend to be more comfortable with traditional crash data as a method for estimating risk of intersections.

- **Evaluate all modes before, during, and after improvements.** Some technologies are aiming to predict where conflicts/concerns/crashes may arise before they happen such as computing vehicle/bicycle trajectories to determine if those paths may intersect both spatially and temporally. It's important to share event data to nearby users or emergency service provides to improve response and improve health outcomes (shorter response may increase survivability). After the event the data could be used to help drivers avoid a scene (reduce congestion) or at least change lanes to avoid secondary crashes. Additionally, the data is useful to improve future predictions and better fine-tune response.

- **Define consistent strategies to apply data to measure and document benefits.** The implementation of new safety measures is a significant milestone, but it is also important to validate/measure the resulting benefits. This serves two points; first, to provide evidence in support of a success statement; and second, as evidence to provide justification for similar future initiatives. TomTom maintains a rich content of historical traffic data, and continually updated live traffic data, which can be utilized to help provide such measurements – such as pre- and post-implementation traffic statistics. The TomTom "Move Portal" product provides the feasibility to perform a wide variety of analytics including traffic statistics, origin-destination analysis, route monitoring, and the traffic index. Such analytics can distinguish details by specific dates and times, which can facilitate the illustration of more relevant trends for planning purposes.

- **Commercial navigation products can play an important role in the post-implementation phase of road safety initiatives.** Sure, physical adaptations will be obvious, but it will be the interaction with navigation devices which will provide the necessary dynamic awareness to promote the optimal effectiveness. Such awareness is evident both through appropriate map content updates, which impact navigation, and through advisories (such as a warning when a posted speed is exceeded) in the navigation device. However, for this to be possible, it is imperative that location technology companies, such as TomTom, are provided with the applicable data updates as early in the process as possible, to allow for good alignment of the new product content with the timing of the ground truth changes.

- **Proactively manage road safety by harnessing road infrastructure data.** Understanding crashes requires knowing what infrastructure was in place at the time of the crash, everything from lane width to presence of specific countermeasures. This is fundamental to the systemic approach promoted by FHWA – identifying locations that represent risk are systematically addressed (rather than waiting for crashes to occur). In many States this information is not yet collected uniformly. A system is in place for collection of this information through the Model Inventory of

Data Elements (MIRE) – a subset of these data is the Fundamental Data Elements, and States will be required to collect this information by 2026. States' ability to meet the reporting requirements are still being evaluated & processes updated (note: not everything will be universally adopted by all states, but most will comply with majority of reporting requirements). However, many elements for ped/bike safety are still not included in the inventory. Technology can be a huge help in collecting this information, and then combining its analysis with crash data.

- **Build upon existing data dictionaries (e.g., MIRE) so we can communicate consistently between agencies and within the industry.** In addition to MIRE, there is also a standardize set of data to collect and assess degree of injury called Model Minimum Uniform Crash Criteria (MMUCC) and a standardized location to report traffic volumes for both motor vehicles and non-motorized travelers called Travel Monitoring Analysis Systems (TMAS). We should build-upon these existing platforms and provide consistent requirements or definitions for what data needs to be collected or shared, as well as using standard or open formats to ensure interoperability between systems. This will include identifying standards for how performance measures are applied. This can then be built on to identify improvements that need to be made to infrastructure – iRAP Safer Roads Investment Plans provide the economic justification for them.

- **Build upon existing opportunities to expedite road infrastructure documentation.** It is an expensive, time-consuming, and sometimes dangerous endeavor to conduct manual surveys to assess the infrastructure; yet this is an important element to effectively identify safety concerns and arrive at recommended physical road safety improvements. All too often, such assessments occur following a tragic incident and are limited to a specific location, which doesn't ultimately address the root concerns given the holistic nature of the problem, which is likely to result in similar incidents in the future if not corrected. The TomTom Mobile Mapping program (MoMa) provides robust coverage of high-definition feature-rich 360° panorama images and LIDAR point cloud sensor data. This data is designed to be integrated with a customer's business applications, and includes such capabilities as: feature extraction, measurements, etc. As an accredited iRAP partner, the TomTom MoMa content is utilized to support a wide range of road safety & road asset management analysis purposes. While the most extensive coverage is upon the major road network, TomTom is actively expanding the coverage in select metro areas; for example, Seattle now has 100% coverage, with 2021 currency.

- **The alignment and standardization of data sources through an independent data broker could provide access at a greater scale.** The AiRAP initiative (advanced and intelligent collection of RAP data) spearheaded by iRAP, aims to capture advances in artificial intelligence, machine learning, vision systems, LIDAR, telematics and other sources like operational data to deliver critical information on road safety, crash performance, and investment prioritization for all road users.

With iRAP acting as the trusted independent data broker; accrediting data suppliers and aggregators able to provide the data in the open format to the required quality; followed by aligning and connecting the data with those who can use this qualitative information to help inform infrastructure improvements needed across the road network. By way of example, Teradata worked with the State of Georgia serving as data aggregator; this case study demonstrates a data-driven approach to Variable Speed Limits measuring "zone of influence", turbulence, bottlenecks, and queue lengths.

- **Evolving from point-in-time to real-time safety assessments will reduce the response time.** Infrastructure can also be managed in real-time. Starting with base-maps, such as 3D digital twins provided by Lidar, these maps could be updated from connected vehicles. For example, if a stop sign were knocked over or concealed due to vegetation growth, this information could be captured and shared from the vehicles. An analytics platform can then receive this information and alert the DOT proactively to the issue. TomTom offers an online application, "Road Event Reporter", to government trusted partners, which allows them, as the local experts, to directly input both planned & unplanned road closure details. This is a free service, and the government-generated information is streamlined to the TomTom Live Traffic network. One of the objectives of this trusted partner program is to not only re-direct vehicles which may be stuck in congestion, but, more importantly, strive to provide advance awareness of road closures such that drivers can be navigated accordingly to avoid the situation altogether and not become a contributing factor to the existing congestion. Should drivers still need to traverse the impacted areas, then at least they would be more aware of the conditions and perhaps modify their actions accordingly.

- **Having the ability to warehouse data is important to the long-term success of a Vision Zero initiative.** The City's ability to aggregate sensor and endpoint data, co-located with other, as yet unknown data will be transformative over time. This will enable future-proofed capabilities and provide the layer to make data-driven decisions, give the ability to perform data science studies and perform analytic while creating visualizations and giving capabilities to scientists and analysts.

- **Be prepared for technology transition.** Our analytics and approaches to managing safety will need to be technology agnostic as the sensor technology will evolve over time - this includes the ability to leverage wide ranging analytics tools, technologies, visualization engines, and platforms. For example, the capability of analysts to easily access the data with BI tools of their choice, scientists to use python, r, to run modeling using a variety of tools are important to enable the widest variety of users to study and inform policy as well as inform decisions and report on status. As well, technology adoption can be a long cycle (e.g. turnover in vehicle fleet, retrofitting of sensors at intersections) so there is going to be a mix of old and new technologies on our roadways. Our approaches will need to work across all current technologies in place. Need

to know that onboarding and off-boarding vendors and endpoint solutions is a natural evolution of a healthy ecosystem. There has already been much progress, and there is much more data available than in recent years; but how can we supplement that in the short term for maximum benefit? TomTom has a Mobile Mapping program, in which vehicles specifically equipped with 360-degree panoramic cameras, survey-grade GPS, and LIDAR, drive designated routes. The typical coverage includes annual drives of major road networks.

- **We need to measure people, in addition to cars, so we can assess impacts and benefits across various modes.** This remains a challenge as little infrastructure is in place to do this (thus things like pedestrian exposure are still not known). Technology that can better measure use of transportation features by people walking and bicycling would be very helpful. Any metrics or performance measures need to focus on the human element. While it's important to understand speeding rates and how connected and autonomous (or other technologies) can mitigate those challenges, it's important to ensure that we're both designing systems around the end user's needs, as well as advancing safety technologies that address those specific challenges.

- **Consider operating speed data.** Since COVID, drivers are increasingly speeding. Another factor to consider is that speed as it relates to crashes is still a judgment call by law enforcement on the scene; perhaps agencies could find a way to secure vehicle information about actions underway at the time of a crash, including the speeds involved. When these results are combined with a more comprehensive road safety assessment of the infrastructure (e.g. utilizing available panoramic images & LIDAR content), certain locations may be identified in which the more potentially deadly combination of speeding trends and infrastructure concerns are present; thus creating a higher priority focal point for further assessment. Two existing technology solutions in this space: (1) TomTom maintains historical traffic data (based upon GPS probe inputs), which allows for the identification of locations, and time frames, whereby the actual traffic flow speeds are exceeding the designated posted speed limits. Such an analysis can identify potential problem areas for more in-depth investigation, which can then result in more effective recommendations for improvement. (2) The Iteris ClearGuide Safety Module provides insight into the distribution of individual traffic speeds and sample counts to reveal segments of the network that are high-risk with respect to the portion of samples that exceed posted speed limit. It can be used to: (i) find segments with speeds exceeding speed limit by a desired margin; (ii) rank segments based on speed violation; (iii) generate color-coded maps to identify safety hotspots; (iv) apply filters based on time of day, day of week, corridors, and regions; and (v) conduct before and after analysis. Additionally, the INRIX Safety Service will provide tools to assess factors associated with risk including: observed speed distribution; volume distribution; index of vulnerable road users; collision history; near-miss observations.

- **Ensure technology incorporates human centered design by focusing first on the end users.** Agencies have challenges with integrating data meaningfully because regional transportation centers are typically responsible for managing the operations of cities and regions and are required to integrate multiple datasets, whether it's from connected vehicles, video cameras or other traditional ITS technologies. Data dictionaries would be important to standardize the data needed to advance safety measures and to better understanding the data collected in vehicles. Standardizing a data dictionary would help harmonize this work across cities and regions and promote growth for the private sector with more predictable standards.

- **Many people support the use and integration of technology to advance goals like safety and mobility, but many are afraid of how companies are protecting their personal privacy** and are wary of being tracked. It is important to understand that we must clearly convey both the benefits and the risks to the public of the technologies that we're discussing today so that we are transparent and build public trust. Collaboration is needed to help people understand how these types of ITS and other technologies could be used, what the public and private sector are doing to protect personal privacy, and how this data could address our policy goals like saving lives. Privacy, security and cybersecurity is of great concern to many. Data must be anonymized, and it needs to be understood that it is being used for societal benefits.

- **Human behavior is always factor.** Audible and/or visual warnings within vehicular navigation applications provide relevant reminders to drivers in situations where the designated speed limit is exceeded. Of course, due to human behavior, such warnings can still be disregarded, but with these capabilities available, there is likely to be a greater volume of benefit than not. Again, the key is that the navigation devices contain the most up to date details possible – this is something that needs to be initiated by the authoritative data owners (i.e. local governments) and made available to the commercial mapping providers. Just because changes have been made on the ground does not mean that they will automatically be reflected in the navigation devices.

- **We should focus on CV applications to enhance safety and efficiency is incentivized, such as use of phone telematics.** When new technology is added to vehicles it generally starts with high-end vehicles and then will make its way down to the broader fleet (unless federal mandates require a feature to be installed – e.g. backup cameras). This has several ramifications: many people when shopping for a vehicle may not be looking for the top-of-the-line model, and as Secretary Homendy reminded us during her call the average age of the U.S. vehicle fleet is about 11 years old and getting older, so not only will new technology take awhile to become present in the overall vehicle fleet there will still be a long period of time where older and newer vehicles need to co-exist on the roadways. There will always be a portion of vehicles that will not comply – It may not be possible to add

a dongle or widget to a '65 Mustang. Phones have a shorter lifecycle and are more likely to be in someone's possession regardless of their mode of travel so privacy implications aside these devices may be easier to provide alerts or telematics information to the overall network. Even so, based on Derq's experience, telcos may not want to be liable for this type of safety applications.

- **We should focus on who to improve safety culture**. All too often, we hear such perspectives as: "It can't happen to me", or "I don't want to change my activities or make additional investments just because other people are (perceived to be) more careless." In such cases, people tend to downplay the potential impact of change, and/or simply not want to get involved with the support of safety improvement activities. Perhaps the inclusion of more relevant, evidence-based examples of success stories incorporated into advocacy campaigns might help change some of these perspectives.

- **Nudge theory can be used effectively as a means of improving road user behavior.** This speaks to Safe System, where there is shared responsibility. Planners, engineers, and operators of the transportation system have a responsibility to help improve the system (develop roadways which operate in a controlled and predictable manner) and users have a responsibility to make safe choices when utilizing the system (e.g., operating their vehicle in accordance with the context). In terms of achieving better compliance with legal speed limits nudge theory - a choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives - can be effective. By way of example, insurance companies could use telematics and reward road users through points generated for each trip driven according to desired characteristics (speed limit compliance, cornering speed, rate of acceleration, and/or rate of braking). These points could then be used through incentives (e.g., discounts, rewards, or premium adjustments). Insurance companies could also penalize repeat offenders or for particularly egregious behaviors.

- **Reliable improvements need to be developed that provide positive guidance.** Positive guidance such as a shared lane marking which helps cyclists determine where they should ride provides better information than negative guidance (e.g. restrictions). While restrictions may disincentivize behavior they do not share information about where that activity may be allowed ("Great, I can't ride here. So where can I ride?"). These can include urban design elements such as landscaping that provides guidance to pedestrians to crossing areas.

- **Policy factors need to be considered.** In addition to technologies, much of these challenges can also be solved by policy or otherwise require policy debates on how we balance safety and technology. For example, one of the participants noted how pedestrians may illegally jaywalk causing safety issues for vehicles; however, policy decisions around land use and safe access to trails so it's important to ensure technology, design, land use and urban planning are all parts of the conversation when addressing safety challenges.

SAFETY FOR SENIORS: Intersections are challenging locations for all road users, but they can be especially difficult for senior populations. People aged 70 years and older are the fastest growing segment of the population in Washington State and tend to be more active than previous generations. Older adults are also disproportionately represented in fatal crashes involving people walking—even after controlling for differences in population size and walking rates (Smart Growth America, Dangerous By Design 2021). Of particular concern for the safety of seniors in crosswalks at signalized intersections is accounting for their walking speed vis-à-vis the pedestrian clearance interval (*Figure 8*).

- **Advancements in detection technology provides great potential.** Recent advancements in detection technology allow systems to look at the gait of the person to see if they are elderly or impaired to change the traffic signal time. In addition to the gait systems may be able to evaluate crossing speed, to detect and benefit other users (e.g. a child, or someone who has other physical concerns slowing their crossing that may not be a senior). Some systems also implement machine learning capabilities which are capable of detecting and classifying senior citizens by identify walking gaits of pedestrians and classifying those with slower than average gaits as elderly. Models could also be trained to classify wheelchairs and similar assisted low-powered vehicles and classify them as a distinct class of VRU.

- **Integrate advanced detection with other traffic signal and ITS systems.** If the detection technology can communicate directly with controllers and/or blank-out signs, for example, safety measures such as extending crossing times for elderly could be a useful way to protect the elderly. Advanced pedestrian detection system that can classify the elderly can override existing pedestrian pushbuttons to provide more walking time. Dr. Yinhai Wang from the University of Washington is developing a detector capable of providing pedestrian signal extensions which could be implemented in Bellevue. Integration of detection systems with adaptive lighting is a potential solution to provide more visibility when seniors and other vulnerable road users are detected.

Figure 8: Daniel Lai facilitating the safety for seniors sessions.

- **Probe-based data sources can help provide better understanding of vulnerable road users.** Obtaining data on vulnerable road users can

be challenging. Mobile phone data attempts to determine the mode but cannot determine the elderly. Data providers such as INRIX are working to build a portal to better understand areas of concentration of vulnerable users from mobile/LBS data.

- **Vehicle-to-Network (V2N) technology can provide near-term promise -** Signaling to the car or the senior is aspirational, but to get benefits sooner would require V2N/N2V. We'd have to use current cellular networks, perhaps to obtain proximity but not exact location of pedestrians. Once short-range technologies such as V2X become widespread, particularly in handhelds, then direct messaging to cars and seniors can be used. That will take some time.
- **Need for more collaboration with motor vehicle manufacturing.** Crash testing for motor vehicles may not be appropriate for helping seniors since the dummy is not a senior. This is important to consider. A younger/more able person may be more physically able to heal from an injury that could prove life altering or fatal to seniors, as people generally get more frail with age. As an industry, we also need data from car manufactures, NHTSA, NTSB to get data to see if certain car designs are more dangerous for seniors in or out of a car.

PROJECT DELIVERY DELAYS: Implementation of active transportation projects is often time consuming and costly in crowded urban streets where it is necessary to reallocate road space from cars to create safer crossings for pedestrians or a protected lane for people on bikes. In response to the increasing demand for walking and bicycling facilities in cities across the country, many jurisdictions are exploring new approaches to project implementation. Even though quick-build projects (Alta, Quick Build Guide) can accelerate change they are still subject to protracted community consultations and approval processes paired with new funding commitments (see Bellevue Demonstration Bikeway Assessment).

- **Advancing transformative Complete Streets projects is challenging.** Walking and cycling are the cleanest ways to get around a city, and both can have enormous benefits for health, greenhouse gas emissions, air quality, road safety and equity. To make walking and cycling attractive options cities must focus on safety and comfort for people on bike and foot. This is relatively straightforward in engineering terms but can be politically challenging due to opposition from groups that expect to be negatively impacted. The FHWA is developing resources to help agencies focus on transforming arterials, and projects underway to move FHWA's practices to support a Complete Streets design model in its work with State, Tribal, and local agencies.
- **Ensure participatory and flexible infrastructure design.** At the local level, ensure that the

design process for new cycling and pedestrian infrastructure is participatory. Be prepared to be flexible with the details to address concerns and maintain popular support. Usually, people who live on a street are in favor of improving walking and cycling infrastructure, and the opposition comes from those who drive through. Seek public input at the local design stage about how, not whether, to add bike lanes and other key infrastructure. If people have a hands-on experience with concepts, they may have fewer concerns with the impacts and will better understand the benefits

- **Equity needs to be part of the conversation**. An important area for focus is the disproportionate, adverse safety impacts that affect certain groups on our roadways. To achieve zero roadway fatalities and a transportation system that is safe for all users. Government needs to advance equity as an instrumental component of transportation safety and convene key stakeholders to develop both a better understanding of the intersection of equity and roadway safety, and a comprehensive approach to incorporating equity into all efforts to achieve zero roadway fatalities and serious injuries. When it comes to working with community groups it is critical to engage with them at the beginning of project development if we're to foster trust in the process and outcomes. Instead of making people come to us, it's time for us to go to where they congregate.

- **Develop new technologies for community engagement to support evaluation/approval of roadway design options.** Singapore, London, and several Texas Gulf Coast cities have created digital twins of their communities to tackle facets of city management, including modeling traffic patterns on city streets, analyzing building trends, and predicting the impact of climate change. Digital twinning of a transportation system in the metaverse – such as Seoul's ambitious plans to develop a metaverse ecosystem – could allow for immersive scenario testing of roadway design solutions. Real-world data paired with digital simulations of roadway options could provide valuable insights that could help cities identify and resolve problems before designs are implemented in the right-of-way. Long used for construction and manufacturing, digital twins of an urban street has the potential to accelerate community consultations and approval processes for project implementation of transformative active transportation projects. Additionally, the use of digital twins, and the metaverse as a platform, has the potential – so long as barriers to access (bridging the digital divide) can be addressed – to create a gathering space where anyone can participate at any time that is convenient for them. It's time to for us to figure out how to show up differently and learn new ways of communicating about our work. Experiential engagement in the metaverse – to share and explain expected outcomes – should be explored.

- **Stay focused on long-term goals.** It's important to remember that some of the most notable world-class bicycle cities (Amsterdam, Copenhagen, etc) were not always bike friendly. As in many other cities, cyclists came under pressure due to the rapid rise of motor traffic. But through a combination of grassroots activism and municipal policy, the active transportation managed to make an astounding comeback.

DISTRACTED DRIVING: In Bellevue, distracted driving is one of the top 3 contributors for serious and fatal crashes. Over 15% of serious and fatal crashes in Bellevue are attributed to distracted driving. NHTSA estimates that approximately 3,142 people were killed as a resulted of roadway distraction in 2019. To achieve Vision Zero, removing the opportunity for visual, manual and cognitive distraction is key to reversing the statistics. Both the private and public sector have introduced ways to curtail distraction (i.e. cell phone blocking technologies, insurance incentive programs, new laws, and public awareness campaigns) but distraction still remains as one of the leading contributors working against Vision Zero (*Figure 9*).

- **Defining distracted driving.** The Center for Disease Control define distracted driving as driving while doing another activity that takes your attention away from driving. Distracted driving can increase the chance of a motor vehicle crash. The CDC has three categories of distractions: visual (taking your eyes off the road); manual (taking your hands off the wheel); and cognitive (taking your mind off driving).

  The most common distraction is from cell phone with calls, texting, and social media. Other common distractions can include vehicle occupants (especially young children in rear seats), navigation systems and in vehicle displays, eating (taking hands off the wheel to eat), weather (rain, glare, snow), things that impeded vision and hearing, and physical and mental conditions (drowsiness, neck and back limitations).

- **Actions/candidate solutions.** The group discussion focused on changing the culture that driving distracted is somehow acceptable. Given the number of distractions the group thought there might be a number of required solutions working together to have an impact.

▶ **Figure 9:** Randy Iwasaki facilitating the distracted driving session.

One primary objective is to change the social expectation that is ok to operate under the influence, w hile using phones and/or other distractions. The discussion focused on what can be done to change distracted driving from being ok to something you just don't do. The favored solutions, included an outreach campaign, engaging insurance companies to provide good driver incentives, exploring technologies to limit distractions and driver modelling to better understand driver behavior to influence solutioning.

- **Partnerships.** Partnerships are key to designing and implementing successful solutions to reduce driver distraction. Different partners bring different resources to the table and part of the work is to figure out the right roles and responsibilities, how to coordinate partners and how everyone should work together and govern the work. Current and potential partners include: technologists, insurance companies, vehicle manufacturers, fleet operators, regulators and advocacy and researchers.

SAFE SPEEDS: Exceeding safe speeds is the top contributor for serious and fatal collisions in Bellevue. Unsafe speeds impair a driver's ability to make safe maneuvers and stop safely when needed. When a pedestrian is hit by a vehicle at 30 mph, the fatality rate is 40%. The fatality rate increases to 80% at 40mph. During the COVID-19 pandemic, vehicular speeds increased significantly, leading to more serious collisions. Geometric roadway design, enforcement, and policy can help to promote and regulate safe speeds. However, a systemic approach is needed to ensure that all roadway users are travelling at safe speeds and at all times.

- **Defining safe speeds.** The group spent considerable time discussing how best to define safe speeds. The World Health Organization defines excess speed as exceeding the speed limit and inappropriate speed as driving at a speed unsuitable for the prevailing road and traffic conditions. Safe speeds are ultimately appropriate to the environment, which can change with conditions, including weather, use, and density. One of the challenges of Vision Zero programs is to align safe speeds with credible speeds and actual speeds. The group though those interests should align, but mostly do not. Safe speeds are greatly impacted by intersection of infrastructure, human and environmental conditions. The correlation of these can change greater – poor roads can be worse in inclement weather than newer roads. The lack of data on speeds and the various impacts and conditions impact the ability effectively define safe speeds.

- **Solutions for reducing speeds.** Reducing speeds is essential to realizing Vision Zero. There are different names for solutions - management, calming, smoothing, but they all aim to get drivers to operate at safer speeds. The group discussed options that could be deployed in Bellevue. One idea comes from Danville, California where the speed reduction program uses technology-based solutions. Danville was named the safest city in California. Danville uses Artificial Intelligence speed smoothing on I-680.

  Insurance companies are key stakeholders in realizing vision zero. A 2015 National Highway Traffic Safety Administration calculated that in

2010 24 million cars in the US were damaged in crashes, 3.9 million people were injured of killed with a total economic impact of $242B. Insurance companies can play a role in influencing behavior through incentives, education campaigns and telematics (the use of data from vehicle-borne devices. The group discussed that a city-wide initiative in collaboration with insurance companies to increase the use of telematics would make an important project.

Data collection from automotive communication systems (ASC) + mobile phones was discussed a way to increase available data on driver behavior on a trip basis. Enforcement cameras capture data from a specific location at a specific point in time – usually areas where speeding is known to occur. Data from ACS could provide a better understanding of behavior over an entire trip. Do the same drivers speed consistently or are there areas in Bellevue that encourage or facilitate higher speeds.

The group also discussed an incentive-based system for good behavior. (*We also talked about a rating system using technology in the car, but probably more readily available data from your phone. For example, the phone provides you with feedback such as "Franz your driving score today is 92"*)

- **City of Bellevue.** Looking specifically at the City – what are some solutions that leverage existing resources and knowledge – especially anecdotal/qualitative data and can build on that data to develop a deeper understanding of speeding in Bellevue. The existing Bellevue report identifies the top speeds zones across the City. What additional data is available or needed to better understand who is speeding and why? The group thought Bellevue police engaged in enforcement likely have good insights on speeding from their work in the field. How best can these insights be captured and used to better understand speeding? Another idea is to use local Bellevue traffic offenders in a POC for data, ACS, insurance solution. Could offenders be offered leniency for participating in a monitoring project? Perhaps a project could coordinate with TomTom, Waze and car manufacturers on different types of alerts, notifications to drivers when they are over posted speeds or driving fast for conditions.

VULNERABLE ROAD USERS: Pedestrians and cyclists make up for over 50% of the serious and fatal collisions in Bellevue. Collisions involving pedestrians and cyclists are system-wide and occur at both signalized and unsignalized intersections. According to NHTSA data, pedestrian and cyclists traffic deaths are on the rise while deaths involving people inside vehicles are declining as cabin protection on vehicles improve. Increased safety to protect the most vulnerable users on the roadway is paramount towards making a significant impact in lowering serious and fatal collisions.

- Understand technology lifecycle and target those that make the most impact. It is easier to get technology to vulnerable users than to equip newer technology in cars (i.e turnover of handheld devices is much sooner than fleet turnover for vehicles). Mobile phones, which are ubiquitous are much more affordable than vehicles and are less complex, which supports wider adoption in society. However, getting people to use the available tools on a mobile platform can be a challenge. There also needs to be consideration for privacy concerns with smart phones though, so the need and benefits will need to be balanced.

- Focus on the VRU risks that are easiest to tackle first. Better to pick off problems and solve those that are a bit easier to tackle. Providing solutions for VRUs in work zones and protecting road workers is an example of a smaller population and scope that can be tackled first. You can equip the workers with technology that can save their lives. Ideas like this may also have the most immediate impact and highlight the benefits of the various technologies, making buy-in easier for other parts of the system.

- Use technology to better understand VRU challenges. Detection technologies can help to classify the vulnerable users and see what is easier to address - however, we can't lose sight of the main concern by chasing what technology can do.

- Providing real-time information to VRUs. There are potentially multiple ways of communicating messages to users including in-vehicle, on-phone, dynamic messaging on the roadside, activated signage, etc. Consider implementing messaging redundancies. If the one system fails then having more than one way of communicating information (whether static signs/markings, in-vehicle and roadside messaging, etc.) may still help communicate safety-critical information.

- Advancements in detection technology provides great potential. Using machine learning models, detection technology companies could use pedestrian direction and trajectory data to predict likely crossing intent for the elderly in order to provide advance notification to controllers of potential safety countermeasures (e.g. extend the crossing phase, notify blank out sign to hold left turn traffic). Using Pedestrian Safety Messages, Infrastructure such as AI video detection technologies could communicate with Roadside Units (RSUs) to inform Connected and Autonomous Vehicles/ Platforms on VRUs at risk at locations out--of-line of site of vehicle sensors, but potentially on vehicle planned routes.

- Integrate advanced detection with other traffic signal and ITS systems. Blank out or dynamic messaging signs connected to AI video detection technologies could be programmed to notify drivers to change speed limits based on on-the-ground VRU activity that they may not be able to see or normally slow down to avoid conflicts. Advanced detection technologies could also help improve traffic signals to "perceive" VRU danger situations better. When integrated with other traffic signal and ITS systems, there is opportunity to manage corridor operations using speed moderation to increase safety for VRUs which may also heighten awareness of VRUs.

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