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OREGON ROAD USER FEE PILOT PROJECT

PUGET SOUND REGIONAL COUNCIL TRAFFIC CHOICES STUDY

UNIVERSITY OF IOWA NATIONAL ROAD USER CHARGE STUDY

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Jim Whitty
Manager, Office of Innovative Partnerships,
Oregon Department of Transportation

My presentations tend to be a mini-symposium covering every topic I can think of. This whole vehicle miles traveled (VMT) charging thing began, as I mentioned, with Professor Dave Forkenbrock and then the University of Iowa research. Oregon was one of the fifteen states in the consortium. Then all of a sudden during the 2001 Oregon legislature, a couple of legislators decided that maybe the state should begin to move away from the gas tax. Early during the session, they held an informational hearing where they heard about all these new vehicles coming along; the hybrid electric vehicle was new back then. They looked at natural gas vehicles and at hydrogen fuel cell vehicles. One of them started worrying, "What happens if people start buying these vehicles?" Well, now the public is starting to buy them, but back then nobody thought they would, but they thought maybe we should prepare for that day. These legislators sponsored a bill that went completely off the radar; nobody saw it coming, and it passed into law. The legislation created the Road User Fee Task Force, and the legislators actually put it together quite well. They created a 12-member task force that was appointed by the governor, the Senate president and the speaker of the House. The best decision was to put four members of the legislature on the task force, one from each caucus, a Republican and Democrat from the House and also from the Senate. That became very helpful later on when the whole topic became controversial. To have somebody from each caucus who knew what was going on was very helpful.

The task force was given a mandate to develop a new road funding system to replace the old. In Oregon, that means replacing the gas tax. The state is highly dependent upon the gas tax for our road revenues. Gas tax revenues have recently dropped in Oregon, though not so seriously as at the federal level where there was a three percent drop. Oregon has experienced a drop of a half percent this last year and a half percent the year before that. But if you look at what is happening with the differential between what the state expected the gas tax to cover with inflation and what the state actually got, the difference is more like four or five percent.

The task force examined 28 different revenue mechanisms, and they came up with just a few to make up the new system. The principal new revenue source was the mileage charge because a broad base charge would be needed to replace the broad base of the gas tax system.

They also chose congestion pricing as one of the alternatives, so we tested it as well in our pilot project. The challenge for the mileage charge is this: what kind of a system and how do you collect it? Oregon Department of Transportation (ODOT) had the obligation under statute to do a pilot project based on the recommendation of the task force. But ODOT needed to determine what we wanted to test. I decided that I wanted to develop and test an actual system that could function and be successful if fully implemented. So that meant ODOT needed to think through all of the processes that would be required to collect the charge.

So you develop a concept first and then you test it. But when developing a concept you have to think that you are replacing the gas tax. Now, you could use the mileage charge also to augment the gas tax, and that is an interesting discussion, but in Oregon, the project was to replace the gas tax. That was the purpose. You look at the gas tax, and to replace it becomes a daunting challenge because the gas tax operates so well.

The gas tax is failing right now, but for 90 years it was great. In fact, Oregon was the first state to implement the gas tax back in 1919. The gas tax covers every motorist and is easy to pay in that it is paid by the distributor, who is then reimbursed by the retailer and then the motorist. The gas tax raises a lot of revenue and is very inexpensive to operate. In Oregon, it costs around $1 million a year operationally to get $400 million in revenue. Think about that. The gas tax has about a quarter of a percent operational cost. Of course, it is already in place, so it doesn't require any new capital expenditures.

The gas tax has no privacy invasion whatsoever. You don't have to report where you go to the pump. Now people use credit these days, so there is the possibility for invasion of privacy for court actions or things like that, but basically there is no government mandate for using credit. There are only a few payers—I think in Oregon there are 157 distributors who pay—and nationally there are 10 or 12 times that, so there are not that many. With very few payers nationally, the gas tax is very simple to manage. There is also only a small burden on the private sector.

But of course the gas tax is failing because of the market. The gas tax is failing because it is no longer directly connected to road use, even though years ago it was connected to road use. We have different kinds of vehicles on the road now. Gas tax revenues are eroding because of fuel efficiency improvements, and that has been like a hammer to the gas tax. This is the motivating factor to find something new.

The task force decided to give us two directives that were easy to follow: cover all motorists and do not charge out-of-state mileage. At the time it was an issue whether we would charge all mileage or just state mileage. The task force also wanted protection for motorist privacy. They wanted a gas tax credit for those who would normally pay at the

pump the gas tax and the mileage charge. They wanted a low capital cost; they didn't want it to be expensive to employ. They wanted a low relative operations cost like the gas tax. The new system had to be enforceable. They didn't want any lost revenue; everybody pays the gas tax—everybody—so they didn't want any loss under the new system. And the system must be reliable. They decided it would be best if the mileage charge was collected electronically. They also wanted a seamless transition; they didn't want to lose revenue switching from the old system to the new one. They wanted a minimum burden on the private sector, which was primarily a Republican-driven idea, although Democrats supported it as well. Then they added congestion pricing. Sounds simple, but it wasn't that simple. It took over a year and a half to design the new system to meet these criteria.

Fundamentally, we needed to create zones. We looked at it a number of different ways, such as putting switches at borders and things like that. I think some of those ideas were still on the table for exploration. We basically settled on access to the global positioning system (GPS), and that seems the more viable and inexpensive way to identify zones, rather than putting gantries all over the place. But we took the gantry system pretty seriously. We ended up, after starting with what I call "central billing" as the fundamental way to collect the charge, with collection at the fuel pump. This seemed to solve most of the problems and met most of the directives of the task force. Central billing has difficulty with giving a gas tax credit, at least we thought at that time. It is very easy to get a gas tax credit at the pump.

We also tallied the cost of collection of the central billing model and realized that because mailing costs and enforcement costs are high and add up quite quickly, central billing would be fairly expensive. However, I think there are ways to reduce that cost because you can have people pay either by automatic payment, like they do at toll roads, or maybe e-mail based billing and Internet payment, which would not require mail. There would be a significant number of people that would actually require a bill to be mailed to their home, and of those people a large percentage will not pay that bill. You will, therefore, need to have enforcement actions. That adds to the cost. However, at the pump, if you don't pay, you don't get your gasoline (or whatever the fuel).

We are going to start to see more electrical vehicles very soon, perhaps in 2010. But in 2003, the electrical vehicle was declared dead. It wasn't an option at the time, so payment at the pump seemed the way to go. There are a lot of advantages and also a lot of disadvantages for systems that do not cover electrical vehicles. That is a problem that the gas tax collection system has that needs to be resolved.

Basically, there is a receiver of the satellite signals from the global positioning system in the car. The device identifies zones by latitude and longitude and counts miles within the zones. That data is read by a mileage reader wirelessly at the pump. The mileage totals within each zone go to the point of sales system at the fueling station, which is then shared with the central computer. The data transferred includes the vehicle identification number, the mileage totals for each zone and the fuel purchase amount. This allows a minimal ability to audit and to identify anomalies in the system. One privacy issue that most people have picked up on is that the department would know the make, model and

year of every vehicle on the road and who owns the vehicle. But with that information we can look for anomalies in the system and determine who might be tampering with the vehicle and the device. Then, the mileage fee rates are applied to the mileage data, which goes back to the point of sale system where the motorist is presented with the billing and pays the charge.

One of the central features of the Oregon model was to make it really simple and easy for motorists to comply with the system. There are other models. I know people from Minnesota have been looking at something that doesn't require a mileage charge payment at the fuel pump; they are looking at a way to minimize the capital cost of collection. There are ways to do that, but when you do that you have to increase the burden on the motorists. It is almost like if you push up one, you push down the other. It is a different focus. It is a legitimate focus to have, let's say, less capital cost for a collection system at the pump and greater responsibility for the motorists. That is legitimate. Our view is also legitimate: to minimize the burden on motorists by increasing the use of electronics at the pump. Both are legitimate and open to discussion. Our view of minimizing the burden on the motorists involves thinking about public acceptance. We will see how that goes, but the public didn't seem to like our model anyway. There are reasons for that, but I don't think it was the actual model. It is more the idea of mileage charging that they opposed.

We actually tested non-equipped cars in our pilot program. They were identified as non-mileage fee payers at the pump, and they paid the gas tax. Heavy trucks were not part of our test or of our model. There are ideas about how to charge heavy trucks a distance- and weight-based charge. In fact, Oregon already does it but under the paper-and-pencil method. A weight-distance tax is the fundamental way that trucks pay their road obligation in Oregon. But to make it efficient, it might have to be electronic. This is a little bit more difficult because you not only deal with distance but also with declared weight and number of axles as well as configuration.

The cost of the system, we thought, was affordable. There was no mandate on retrofitting components on new vehicles prior to sale, which was an alternative at the time. Now people are exploring plug-in possibilities, and I think that is worth the exploration. The devices are getting inexpensive. The service stations' capital costs were figured out back in 2003 and was $35 million for a one-time capital cost. That cost might come down with time because we are basically talking about computers and mileage-reading equipment, so the capital costs may become less than that. The annual operating costs would be about $2 million a year, a bit over the gas tax but still quite efficient.

Privacy—there are more recent approaches to privacy. We basically eliminated the creation of certain kinds of data. We made sure that only the mileage totals, not the travel specifics, were transferred by short-range radio frequency. There was no travel history retained in the vehicle. But a lot of people think that the signal is coming down and is picked up by the on-vehicle device and that the on-vehicle device sends a signal back up to the satellite. This is a very common misunderstanding, as not even the military system works that way. It simply is not part of GPS whatsoever. Navigation units do have a signal going out from the device that the provider uses to enable contact with the device

and motorists, but that is something people contract for. We eliminated the signal for anybody else to pick up and follow. The device can track itself, but no one can track the device. This is largely misunderstood by the public.

In a navigation unit you have a geographical information system (GIS) digital map; we eliminated that. All that is in the device are coordinates identifying the borders of the zones. In the state of Oregon, these coordinates outline the state of Oregon, and this is where the device starts tracking miles. Miles can be counted either by the GPS receiving device or by the odometer. We captured it both ways in our system, primarily with the odometer, but not every car would work that way, so we had some working with the GPS receiver.

A navigation unit develops a travel history. We simply eliminated that. The only data in the device were mileage totals by zone. There was a "no signal" zone, basically for driving underground or in parking garages. This is all we ever learned about travel history.

Oregon's pilot program started three years ago. The objectives were to prove the concept of a per-mile base charge, as well as to test congestion pricing, but also to define a development pathway using prototype equipment that had never been put together. We wanted to find what the problems were and also to identify technology issues for further refinement.

(Referring to presentation)
This is the technology pathway on the right. It looks complex, but it was just as fast as a credit card transaction. We used a congestion pricing strategy called "area pricing." Since we were not using a GIS map, we simply identified the borders of each zone, for motorists entering that zone, both geographically as well as temporarily. Miles driven within that zone are identified as rush-hour miles, with a different rate. The rush-hour zone was from 7:00 to 9:00 in the morning and 4:00 to 6:00 in the evening during workdays.

We had 285 passenger vehicles involved and 299 actual drivers involved. There was a control phase where we determined what your travel history was and then the experiment phase was in the second half. There were three zones and three motorist groups, a control group who paid the gas tax, a mileage-charge-only group who paid 1.2 cents per mile, and a rush-hour group. (By the way, 1.2 cents per mile was equivalent to the gas tax rate in Oregon, as at that time the average motor vehicle got 20 miles per gallon.) The rush-hour group paid 10 cents per mile for driving during peak periods. We dropped the basic charge to 0.43 cents per mile because we promised the legislature we were not going to raise any additional money from the pilot project.

The devices were very simple: the GPS receiver antenna, the white box which is the mileage counter, and the antenna on the top was the antenna that transferred the data to the fuel pump through the white box on the bottom. We had a screen on the upper right, which was important for motorists to know when and where they were driving and what

zones they were in. That proved to be an important decision, although it did tend to add power consumption. That was challenging for vehicles with a weak battery, and we lost a few batteries along the way.

The results were positive. Zone differentiation and mileage counting worked perfectly as well as transmission accuracy and administration. We had a little trouble with the vehicle identification at the fuel pump. We had Car Toys install the equipment wherever they thought it would work. They had to go from large vans down to sports cars, and the antenna was not located properly on all of those. There was a very quick turnaround on the technology development from a local manufacturer.

The grant term limits proved very problematic for this pilot project. We had three years to do everything. That means you have to cut off…guess what? Quality assurance. This was a problem for vehicle identification at the fuel pump. But we now know how to solve this problem.

Peak period driving was reduced 22 percent, and acceptance by the participants was surprising. Ninety-one percent of the motorists said they were willing to keep the device on their cars if the system was extended to every fuel station statewide.

Mandating retrofitting is extremely difficult. Cars are not created the same. It's like every car model is created from scratch. They do not have standardized ports, and they don't have standardized power systems. It's a weird thing to try to equip technology into vehicles. You have to be very creative. Some vehicles had to be excluded from the pilot project because they couldn't accept the technology. Mandated retrofitting is, therefore, extremely difficult at this time.

I want to talk about public concerns and the issues that came up in our pilot project. Actually, you can find all of these issues by going to one place: *The Washington Post*. It has a couple of great editorials from earlier this year. I think it was mid-February or early March, specifically. If you look at the comments you will see all of this. It is a great spot to go to get all of them. People are worried about the efficiency of the system. Is it going to be easy to pay? Is it going to be difficult? They don't know. Is everybody going to pay? Will some people get out of it? Are they going to scam the system? Are they going to unplug the technology? They are worried about all this. Of course, privacy is the number one issue. Fear of technology affects parts of the public that tend to be older. Younger people don't tend to be afraid of technology.

The rate structure is an issue. I had an interesting discussion with one of my old friends. I told him all about this, and I asked him what his concerns were. He ticked them off, and I resolved every one. He said, "OK, I get that, but I still hate it. I don't know how much I am going to pay." That is important: rate equity. Who is going to pay what?

Rural motorists want a subsidy. Road pricing is a difficult issue. You pay by the mile. People are smarter than you think. They know they may have to pay more by driving in peak period conditions, and that scares them. They perceive a large bureaucracy,

although our system is designed electronically, so it wouldn't have a large bureaucracy. That is the whole point.

Motorists' class wars. Rural versus urban. Green versus industry. Those issues come forward here as well. I used to think that flexibility of the system was a strength. Look what all these things can do. I then started to wonder about that because the public sees that as well. They see flexibility as danger; they can do all these things to me.

We identified all these issues ahead of time. We identified ways to resolve all these issues ahead of time. And people still don't get it. No matter how much I talk in the media or anywhere, no matter how much I put on the website, they still don't get it. They'll get a couple of things, and yet they know that the system is more than those couple of things. Then they fill in the blanks themselves with great fear. It is like a walk in the dark in unfamiliar territory. What do you see in the darkness? You see possible danger. So because they don't know every element of the system, they fill in the gaps with fear. And that is where there is real opposition to the system. It is not what we did or what we intend to do—it is what they don't know.

There are a number of things we have to do in Oregon to implement the system. The technology has to be refined, and the manufacturing has to develop. We have to make sure that the pay-at-the-pump model does not disadvantage the fuel distribution industry. And, of course, our system does not have a collection mechanism for electric vehicles and it has to.

We also want to investigate alternative approaches. Lately, I changed a bit of my thinking on this whole thing. We developed a closed system. Oregon's system is a closed system, not an open standard. And I changed my mind on that. I wrote a paper for the Transportation Research Board (TRB) Executive Committee in January that basically advocated that closed system. Since then, I have rewritten that paper, and now I think we should strongly investigate an open system. I think there is more likelihood of public acceptability in an open system, and I didn't want to go into that here because this is about the past and I'll talk about it in the institutional panel later today.

Thank you.

Matthew Kitchen
Program Manager for Development, Data Systems and Analysis Department, Puget Sound Regional Council (PSRC)

Before I talk about our study and before we look forward, let's look back in history one moment. There was a time when if one were financing new roads, for the most part you got together with your neighbor and you would build a road with what resources you had available or could gather together, and then you charged someone who wasn't your neighbor to use that road. To a large extent this was the practice until the advent of the automobile. And suddenly we needed better roads, and more roads. At first,

municipalities, and then whole states, began to try and find ways to generate new revenues through taxes and fees for vehicle registration and their use.

The federal government had a role trying to maintain its federal interest in the roadway system. And one pervasive effect of this involvement is still with us: the prohibition on the tolling of interstates and federal highways. In some respects, it was this prohibition on tolling that engendered the need to institute fuel taxes. So this history began in Oregon with the fuel tax in 1919 and very quickly went to most states. Within 10 years every state had a fuel tax. It took the federal government a little longer to get there with a number of failed attempts at instituting a federal fuel tax, which finally succeeded in 1932. The fuel tax was never meant to be the way that we were going to finance this system. It was just an interim step. It was a feasible way to generate revenues but not really the best way.

Jim described very clearly the advantages of the fuel tax, and there are a lot of them. However, in addition to the fiscal weakness of the current system, there has been another issue, which is that the relatively low flat rates that are applied to all mileage simply don't address one of the fundamental issues that we have in the Seattle area: a significant amount of roadway congestion. And this congestion is related to finance in a number of important ways. Because we don't generate revenues where and when we need them, we have a very difficult time in satisfying the roadway demand that results. And we are in a sort of vicious circle.

We are very consciously trying to address not just the fiscal weakness of the fuel tax but also trying to understand better the implications of charging more directly for road use in a way that can control the congestion problem.

Our intent was to implement a behavioral study and, in order to understand behavior and do this with a rigorous research methodology, we knew we needed a very flexible toll system. We needed to implement a toll system, but not so much because we wanted to design a system that would replace the fuel tax but because we needed to have a system in place in order to measure and understand driver behavior.

We knew we weren't in the business of developing software and hardware, and we operated under a time restriction for the federal pilot program so we very quickly turned to the private market to see where there was an existing toll system that provided functionality for us. We selected Siemens, which supplied devices used in the Germany heavy vehicle tolling system. The back end is, of course, very different. Our primary purpose was to understand the implication of putting a charge on every road in our urban region, where those charges vary by time of day and by facility. So we had a road network of nearly 7,000 roadway assignments, each with a unique toll. We had to simplify this because this wasn't understandable. We ended up with the toll structure depicted here in the graphic with toll rates that were much higher in the a.m. and the p.m. peak periods. Tolls were higher on freeways than they were on the arterial network. But we were tolling both freeways and arterials. That is the basic toll structure.

How did all this work? What we did was we recruited households randomly. We recruited just under 300 households with over 450 vehicles. We told these folks that as part of this experiment they would have some equipment installed in their vehicles. We recruited participants for about 18 months of participation. Once we equipped their vehicles, we left them alone for about six months and we collected baseline information about their driving patterns. And after we had a baseline we gathered them all together and we said, "This is how the rest of the study will proceed: For the rest of the study you are going to have a bank account with real money in it. It is an electronic account. You can log in online and find out what your account balance is. But the deal is that for the next ten months, wherever you drive, we are deducting funds from that account depending on the time of day you are driving and facilities you are driving on. At the end of those ten months, whatever is left in the account, you take home."

The idea was to create an economic incentive and obviously to hold them financially harmless; otherwise we would have no volunteers. We needed to create a real economic incentive because we were looking to understanding the response to the prices.

The system itself, from a technical perspective, is a device in the vehicle which receives GPS signals. It locates the vehicle in space and matches the vehicle to an embedded map of the road network. It then looks up a table and assigns the right toll rate. It can display that toll amount in the device so that there is an immediate cue back to the user that they know they are being charged. The information is stored in the device and then sent through the cellular network to the central office. So, unlike the Oregon example where no information was stored or transferred, the very premise of our study was to have differential pricing on different facilities and necessitate essentially a record of trip making and the communication of at least some level of detail. While it doesn't have to be the exact location or the exact facilities that are being used, some detailed information about the road use must be sent back to the central system in order to generate a bill.

In essence we operated a toll system without the enforcement component, which is an important dimension of a toll system. But in all other aspects we were operating a toll system, a small scale one, for about 18 months. We had a customer service center where we received calls from participants on a regular basis. We had over 100,000 devices and central system communications, so we had an extensive task of operating the technical system. In total we collected around 750,000 individual trip records from these households. And we conducted a number of surveys as well.

The real purpose, of course, was to understand driver behavioral response, so we will spend a little time talking about this. We have an incredibly rich database of information about response to variable tolls. We have the ability to display this information in a sensible way. We have the ability to understand not only some aggregate information about response but disaggregate behavioral response across a number of important dimensions. We understand, for example, demand response as a measure of the amount of trips that folks made or the change in their total trip making. We have the ability to understand changes in start times of trips. We understand the response in terms of how much in tolls they pay, essentially the elasticity of the revenue yield from this toll policy.

And we understand something about trip chaining, the degree to which folks have combined trips in order to avoid toll conditions. We can understand all of these dimensions across a range of trip purposes, including your commute type trips and your non-commute type trips. We expect those responses to be quite different from each other, and they are.

The primary explanatory factor is, of course, the toll cost. We essentially have created models from this data where the toll costs are the key explanatory factor. We can understand other explanatory dimensions, like household composition and income, that allow us to understand how these responses would vary across household types.

So, in aggregate, what we found was a 12 percent reduction of total VMT and less reduction in the amount of trips or tours that folks made. This might seem small, but when you overlay this on the network, where people are avoiding certain types of travel the most, you see the opportunity for pretty significant savings and gains in terms of congestion reduction.

We also can observe something directly about people's values of time. Of course, folks were making some explicit tradeoffs at the margin between cost and time. The standard research on this has suggested that somewhere in the range of 50 percent of your wage rate is a reasonably good, average kind of assumption about values of time to use in estimating the cost of congestion or even in creating models to explain behavior.

We actually found considerably higher values of time than some earlier research, somewhere in the 75 percent range of the wage rate. This has been important for us as we develop other tools for examining toll policy in our region. We are obviously thinking about other kinds of implementation for tolling, not just this aggressive form. It is important to us to do some studies with pretty reasonable values of time. These findings are consistent with more recent research coming out of analysis of high-occupancy toll (HOT) lanes, so we feel very confident about what we are finding.

We've also observed directly shifts in time of day, in terms of trip start time. The conclusion here is really that the closer folks' originally typical departure time was to a change in a toll structure, the higher the probability of a shift in their departure time as a result of the tolls. In other words if there was a reasonably good opportunity to avoid a higher toll by making a small change in their departure time, their probability of doing that was actually quite high. This diminishes quite quickly when their typical departure time is further away from the opportunity to avoid those charges. Basically, we are seeing results that are in the right direction. We are seeing folks that are making changes that are modest but important.

So what do we think the implications of all of these arguments are for road management? First, we developed a cost model of the full implementation of such a toll system. The cost model itself tells you a couple of things. One of them is that it is true that a system like this is, of course, not without cost. We've developed a very conservative approach in order to make sure we weren't accused of underestimating the costs and particularly with

the operation side of things. We assumed that when you pay for cellular service, you would pay retail rates. That's pretty absurd but is about as conservative an assumption as you can make. We expect the cost to be quite a bit less than what we were estimating.

With some basic cost assumptions, and some ability to extend our behavioral findings to a full regional scale, we can examine costs and benefits directly. We've estimated the benefits in travel time savings over a 30-year implementation period to be in the range of about $37 billion, with a benefit cost ratio of over six. If you had any other type of transportation project that has a cost benefit ratio of six, you would implement it.

The opportunities are enormous for our region as we have a significant congestion problem. This is not true for every regional environment. We've estimated revenues from this kind of system; again this is modeling for the year 2010, so if we were to implement this next year, we will be generating somewhere around $3 billion in revenue. Compare this to the fuel tax, where our annual regional share is somewhere around half a billion dollars.

And clearly with the simplicity of the fuel tax system, the cost of implementing it is so low that a broad toll system is not going to compete in terms of administrative efficiency. So you have to count on the other gains you get. In our case the estimates of travel time savings for users are a way to justify this.

We've done some further work where we tested the implications of just a uniform per-mile tax versus one that varies by time of day and by facility. This is work we are doing right now for our planning process in our region. So we are jumping ahead; we are modeling the future, 2040. The two scenarios we tested have comparable revenues, and yet the variable charging has travel time savings benefits that are two and a half times greater than the benefits you get from a flat fee.

Two things of importance: One obviously is how much better is it to have some flexibility/variability in the toll structure or the rate structure that tries to control for congestion problems. But the other is that you still have positive travel time savings even with a flat fee. That suggests, at least for our region, that our road network is undercapitalized. So there will be great opportunities, in the future, simply from reducing congestion, even in a fairly crude manner that does not differentiate meaningfully by the facility type.

One of the most important things that you learn from a system like this, and it is something that you do not know when you levy your fuel tax and frankly would not know if you simply had a flat rate across your network, is that we know where in the road network we generate the revenues. So for the folks that were in our study, we know exactly which roads they used, which roads they were willing to pay for. We know where the revenues will be generated. And, as is frankly not surprising, you generate most of your revenues on a fairly small number of facilities, at least in our region. With our topography this is not particularly surprising.

Yet, half the revenues are generated from a fairly broad distribution of roads in the urban area. This tells us that if you toll just your high yield roads, and didn't toll other facilities (which would obviously yield considerable revenue loss), the diversion opportunities are considerable. This is undesirable. And frankly this is a primary reason why, as we move in our region to increasingly toll our highway system, we will have to find some way to solve that diversion issue.

On the issues of public opinion and public acceptance, we did some before and after survey work with our study households. We asked folks about what percentage of the revenue should come from directly charging the users. In the before experiment survey the response was somewhere in the range of about 40 percent, and in the after experiment survey it was somewhere in the range of 50 percent. So we moved people slightly as a result of their involvement.

We also asked them about how strong their concern for privacy was, where 1 was low and 7 was high. The mean response didn't change from before and after the experiment. But we drove people from the middle of the distribution to the outside. And this is, I think, revealing, because these folks spent 18 months with this toll system. They may have never really thought about this issue before, and suddenly they were spending a lot of their time in their vehicle pretty much unable to ignore the fact this system was collecting information about their travel. We drove some people out of the center and some of them decided this wasn't a big issue for them at all, while others said, "I really didn't think much about it before, but now that I've lived with this, this is a problem."

So what can we conclude? We are still doing a lot of work with the study data, making it available to other researchers, to make the best use of it as possible. Some of the conclusions are pretty simple and straightforward. We did see a real opportunity to address congestion problems through differential tolling. The technology worked, and we had no problems with the toll system. Technology is simply not a barrier in this area, but there are lots of details in terms of system design. This is not going to be a problem in implementing a system like this. But there are a lot of other things that need to be proven.

An assumption that the public sector is going to be in the business of hardware development, of software development, billing, all those other things—this strikes me as probably not likely. The public sector should probably do the things that we do well, and all those things are not the things that we do well. So there is a lot to think about in terms of how, if ever, we would structure such an approach to implementing this approach to tolling.

Ultimately, public acceptance of the underlying concept is really going to be what is important. We tend to think of public opinion as sort of static. I am not sure that is particularly meaningful. I think we are in an evolutionary phase here in communication with folks. We are going to learn a lot of things, they are going to learn a lot of things, and we will see where we go.

Thanks. We have our summary report available on our website, or if you want hard copies we can mail you hard copies. Thanks.

Dr. John Kuhl
Professor of Electrical and Computer Engineering, Professor of Public Policy, University of Iowa

Wherever I go and talk about this, I always follow Jim Whitty on the program. He always says all the important things and I end up just adding some incremental differences about what we are doing in the Iowa Study. I am going to start today by pointing out the most fundamental difference between our study and Jim's study. Our black box truly is black. That's critical. Actually, I think probably the biggest difference between the perspective we have and the perspective that we heard in both of the previous talks is that we are fundamentally focused on looking at those issues that are the basis of a national implementation. By that we want to potentially encompass not only collection of federal fees but also state level fees in an integrated basis.

Much of the genesis of this study is definitely due to David Forkenbrock's leadership. I also want to acknowledge my co-investigator, who unfortunately was not able to be here today.

So I am going to start by telling you some things that you already know, and that is the fact that the motor fuel tax has been the primary bedrock funding source for US routes for 70 or 80 years. In some cases it has provided 90 percent of the revenue to the Highway Trust Fund and provides a large percentage of the revenue for state and local levels in very different ways. Now, the reason I point out the state and local issue is because, as you all know, the states take very different approaches to how they collect motor fuel tax and how they use motor fuel tax revenues. State motor fuel taxes vary from nothing in the state of Alaska to approximately 40 cents per gallon in the state of California. There are also a number of local jurisdictions, counties, and city jurisdictions around the country that impose additional levels of motor fuel tax. For instance, in the Chicago metro area they impose a county motor fuel tax as well as a city of Chicago motor fuel tax.

States are also different in the way that they calculate the rates. Some states use flat per-gallon fees like federal tax. Some use percentage-based fees, and some use a combination. So there is a great deal of variability, and this picture certainly points that out.

The reason I make that point is because any system which is going to function on a national level and is going to have the participation of the states, is certainly going to have to deal with (and certainly have the flexibility to deal with) these state level differences. We should expect the states will want to continue to assess differential fee rates, and we can assume the states will continue to want to calculate those rates or base those rates on different factors. And we can assume that a federal system or a national

system meets the capability to calculate and portion those fees back to the state as well as county local jurisdictions in a fair and equitable manner.

Some additional factual constraints that we need to help frame the discussion about implementing a national-based system and the scale that is involved in implementing something like this are that there are over 250 million registered vehicles in the US, and the average age of these vehicles is approaching 10 years. This means there are a lot of old vehicles out there, which means that it takes a long time to flush old vehicles out of the system. There will continue to be vehicles from substantial ages of more than 10 years old in the system for a long time. That adds a very important implication facing a mileage-based system, if that mileage-based system is going to involve new manufactured technology. This is something that we have to think about and hopefully we will discuss in greater detail later today.

Remember that 250 million vehicles travel over 3 trillion miles a year, and I'll come back to talk about this in a second. But the average driver pays amazingly little in motor fuel tax. In fact, the typical driver pays only about $20 a month in motor fuel tax, and most people don't have any idea of how much they pay in motor fuel taxes. If you ask people, the average citizen will give you wildly varying figures which are usually much closer to a quarter of magnitude higher than reality. The fact is it is a very effectively hidden tax, but it is actually a relatively modest tax. And that adds implications for efficiency, and both the earlier speakers talked about it. If a pump is collecting $20 a month in fees or something on that order from an individual, then the cost involved in the transaction on an individual basis obviously has to be quite small. It better be an efficient transaction.

On the other hand, if you look at the aggregate problem, the total added revenues that are generated by the motor fuel tax at the federal, state and local level, then there is a billion dollars a year. So there is a huge amount of revenue being generated, and that, of course, has implications for robustness, reliability, security of the overall collection system and the infrastructure associated with it. If we are going to do this on a national basis, then that mileage-based system must work everywhere, it must work for everybody and it must work all the time. There are over 160 thousand miles of just federal highways in the US, the vast majority of which are rural two-lane roads. If you expand that to state and local level, there are over 4 million miles of public roadway in the country. Then of course a national system needs to operate effectively on all 4 million miles of that roadway and serve everyone or address everyone who rides on those roads.

Numerous federally chartered commissions have come to the unanimous opinion that the highway trust fund is on a path to insolvency and that something pretty drastic needs to be done both in a near term and even more so in the long term. These federal studies have all unanimously recommended that in the long term the best answer seems to be switching to some form of mileage-based charging system. So that sort of lays the context for our national evaluation study.

The national evaluation study that we are conducting at the Public Policy Center of The University of Iowa—over this two-year span we have involved 12 test sites around the

country with around 2700 participants. The goals of the study are two-fold. First, we want to provide a preliminary feasibility assessment, and that is primarily looking at the technology and techniques involved. Is a system like this robust enough and reliable enough? Do the basic technologies involved work? Does it give enough confidence that we would want to go forward with this on a large-scale basis? But I think more importantly, what we want to do in this study is to assess public attitude and acceptance. Look at the public issues, political issues and policy issues that are involved in a system like this. It kills me to say this, as an electrical engineer, but in the long run, the political argument shapes up here. Whether or not we move into a mileage-based charging system is ultimately not going to depend upon the technology. The technology would be there. We still have very different discussions about what is the right technology, but I think most of us have confidence that we can solve the technology problems. Ultimately, the real hard issues are going to be the public acceptance issues, the public policy issues, and the political issues. So we've tried to provide some basic evidence for some basic understanding that helps frame that very important debate and argument that has to go forward.

This study actually started more than a decade ago, and Jim briefly mentioned the pooled fund study done by 15 state departments of transportation in the Federal Highway Administration that actually started back in 1999. In fact, Minnesota Department of Transportation (MnDOT) was the lead DOT. That study resulted in a document that was produced which outlines sort of the basic architecture and idea concept for a mileage-based charging system. And based upon that we went forward with funding, in 2005, the authorization act for national evaluation study, which is what we are conducting right now. Now, this study is looking both at technology issues as well as public acceptance issues. So in addition to looking to fundamental technology we are looking at robustness issues of the system. Privacy and security have been discussed already, and I'll come back and say a little bit about this.

The transitional phase is a very interesting issue. We have a relatively old vehicle fleet on the road, if you look at the average age of cars. And if you want to transition into new technology in vehicles, exactly how are we going to do that? Are we going to be able to have a transition period where we are running both the old system and the new system simultaneously?

The public policy ramifications are, of course, public acceptance issues. Now let me just real briefly run through each of these and talk about them. In terms of the robustness issues, if you are talking about a system which is going to collect $80 billion in user charges a year, then it better be robust in the sense that first and foremost it better be accurate and reliable. It better function everywhere effectively including all different environmental conditions, urban canyons, rural areas, etc.

It better be secure because it will be a target for fraud and evasion, both on the individual level as well as more coordinated attacks, and hacking as well as even cyber terrorism as it would be a very fundamental piece of the country's public infrastructure and, therefore, vulnerable. So that has to be a primary consideration in designing a system like this. I

always tell people that I think it would be about five minutes after a system like this is developed before there would be an ad on a popular mechanics magazine that says, "How to beat the gas tax."

Privacy and public acceptance—we all know that privacy is the key issue here. I don't think there is any doubt about that. That is the most explosive issue. The immediate reaction you get from people when you talk about this concept, and rightfully so, is concern about privacy, and that is nothing new. I mean, we started to see this a decade ago when we first started to form this concept. We knew that this was going to be an important, upfront issue. Many people fear that the primary intent of this system is somehow rooted in the government desiring to track them, and it is very difficult to sway people of that fear. As Jim pointed out, the public does not understand the technologies involved. In fact, people have a very limited understanding of technologies like GPS, and the media often fuels these misunderstandings by misrepresenting the technologies.

There is a fundamental tension between protecting privacy and providing auditability. On the one hand, you want to protect people's privacy and collect as little information as necessary and to send as little information as necessary. But on the other hand, people want to know that the charges being assessed are actually correct. In order to do that you need to provide them some evidence about how those charges were collected. So we have this fundamental tension between how much information you collect, how much information you provide to the individual and can it be associated with other auditability issues.

Next to privacy, I think cost and overheads may be the second most important issue over a system like this. Can it be made efficient enough and can the overhead cost be kept low enough that in fact it generates revenue without excessive cost? And the big part of that is the basis of enforcement basis. I think my comments on this will be discussed on the panel later today.

Phasing is a huge issue. I think both Jim and I, having thought about installing all this technology in existing vehicles, would argue that it would be difficult but maybe not impossible. The difficulty is to retrofit this technology to all distinct vehicles, and the best path forward may be to, at some point, mandate the manufacture or the inclusion of this technology in new vehicles. If that is the case then we have to deal with a long phasing period during which we have some vehicles on the road with the technology and some without, and we may run some under a dual system, which is an interesting technology challenge.

Defining the charging policy—I think Ginger said that once people get past the privacy issues, the second big concern the public has about this concept is fairness: "I bought my Prius because I thought I was going to have to pay less gas tax; now you are telling me I am going to pay the same as the environmentally irresponsible person that drives a Hummer." In fact, there is a great deal of flexibility on the mileage-based system in allowing social scales for charging. That is one particular reason why our study happens to be in approximate neutrality with the gas tax.

Let me talk to you about the architecture that we are using in our study. It is not so different than what has been described in the previous studies. It's comprised of an onboard computer system, which itself consists of a global positioning system receiver, a GIS database that simply identifies the boundaries of all road use charge jurisdictions, and an associated rate table. All charges are computed on the vehicle, and there is a cellular wireless transmitting receiver for purposes of uploading charge information to the collection center as well as downloading updates to the GIS database and to the rate tables located in the vehicles. So the picture here is pretty much the same as what we saw previously: the vehicle is able to derive its location from the GPS system. We do not use the GPS system as the primary means of measuring distance traveled except in cases where it is necessary due to the limitations of the vehicle. In most cases computing distance traveled is recommended by using the odometer, but even then it is validated by the GPS system. The GPS system is used for validation purposes as well as placement of the vehicle within different charging jurisdictions. All charge rates are computed on the vehicle, and the vehicle-mile charge data is transmitted by a cellular data link to a collection point and network operation center. From there it is transferred by secure terrestrial link to a collection center. The office prepares bills, which are sent to the vehicle owner, who then pays those charges. Those charges then would be allocated back to the appropriate charging jurisdictions.

It is very important to know that, as in Jim's study, in our concept no GPS data ever leaves the vehicle. In fact, no GPS data is ever retained on the vehicle. Specific point data is maintained only long enough to compute the incremental charge updates. The only data that ever leaves the vehicle is aggregate charging data. So it is impossible in our system to specifically track the vehicle or to place the vehicle in any specific location.

We also charged refueling events, and this is interesting. We have to worry about how you run a system where people are still paying by the pump. Those people who are in the new system are paying by the mile and shouldn't have to pay the tax twice. So we are actually investigating the potential to capture refueling events and refueling amounts off of the vehicle diagnostic bus, which is available in most new vehicles, and using that as a basis for rebating the amount of motor fuel tax which is paid at the pump in most situations.

Charges are uploaded on an opportunistic basis, so it's not necessary for the vehicle to be in range of the cellular data service. In fact, we can retain information on the vehicle for as long as several months in case the vehicle has to be out of range for an extended period of time.

The particular simulated payment service which we are using in our study is billing, but it is certainly by no means the only way in which you can implement the payment.

We also regularly download updates from the GIS database into the rate table to the vehicle over the wireless link. That's necessary because, particularly at the state level,

charges change on literally a monthly basis. Particularly on those states which assess their taxes on a percentage of the price of fuel as opposed to a fixed rate.

We use quite sophisticated data encryption techniques to make sure that system privacy is protected during all the wireless transmissions. Even though this is a concern, there's no rocket science here because, of course, we are currently using these same network technologies for all sorts of secured transactions, such as banking services and other types of applications.

In our particular study we chose a charging policy which is in neutrality with the gas tax or approximate neutrality with the gas tax. People will be paying about the same amount of charges in the current day. In order to do that, we established 20 different charge classes. Each vehicle is assigned to a charge class, based upon its fuel efficiency. Then the mileage charge rates for that particular fuel class are set to provide neutrality with the amount of fuel tax that a vehicle in that class would pay.

We do have the capability to handle multiple levels of charge jurisdictions. In fact, we will actually be operating in the metropolitan Chicago area where there is both a state, county and city tax assessed on top of the federal tax. It would be quite easy to integrate this system to other road financing and management options like congestion pricing or electronic tolling. We haven't done that in our study, but it is a relatively straightforward thing to do. Of course, the technology is independent of the type of vehicle propulsion system or fuel type, so it is certainly compatible with the expected nature of the future in which we will have different types of systems on the road.

A little more detail about the study—this is a two-year study. We kicked it off in the fall of 2008 with 12 sites nationwide—six sites in year one and six in year two. We are currently in the field in year one. Between the two years we are going to have a total of 2700 participants among the sites. Each participant will have a mileage-based charge system installed in his or her vehicle for approximately 10 months.

The billing system here is actually simulated in the sense that there is not a real financial transaction involved with the participant. Instead, we send them simulated billing statements on a monthly basis. In return we ask them to fill out questionnaires. The questionnaires have information related to the overall acceptance of the system and quite specific questions about how they like different levels of detail on their billing statements, etc.

The six sites for the year one of our study are here in Austin, San Diego, Boise, Eastern Iowa, North Carolina area and Baltimore. These sites were selected for a number of demographic considerations to provide an appropriate mix of urban and rural areas, city sizes, population sizes, age demographics, income demographics, etc.

During year two we will go to six different sites. Tentatively, four sites that are selected for year two are Portland, Miami, Chicago, and Wichita.

Some of the demographics that are new to the study design are participant age, sex, level of education, income, driving habits and a number of other things. The subjects are compensated for participation in the study, and that compensation is tied to their faithfulness in filling out the surveys and doing other things that they are supposed to do.

I will mention that the onboard units are professionally installed under the dashboard as they would be in the real system. There is no black box or white box sitting on there or anywhere that they could see it. We are not quite to the point where we can give you any actual and carefully analyzed data. But where we are right now is we have 1200 participants in the field. These participants were selected from over 40,000 people who applied to be in the study. I was amazed at the level of interest among participants. We started to install units in October 2008 and completed installation in December 2008. Today, we have over 5 million miles reported, which would account for approximately $120,000 in collected user fees. This summer we will recruit 1500 new participants and train them. We will begin year two installation in August 2009 and complete our operation in early fall of 2010. We expect that over the two years of the study that the total report of mileage will be in the order of 25 million miles.

Let me give you some preliminary observations. These are not scientific and are not based on careful analysis, so please take them in the appropriate manner at this point. But at least they are very strong indications that, as we previously saw in both previous reported results, the principal level of acceptance of mileage-based charging appears to increase the longer they live with the system. Participants appear to like the openness of the system. The fact that they get a statement at the end of the month saying how much they are paying gives them some indication on why they are paying this charge. On the technology side, we have some real concerns about the accuracy of GPS as a means of calculating vehicle miles traveled. There may be some technological solutions to that issue, but at least for now we found that the vehicle odometer is substantially more accurate. As Jim pointed out, retrofitting the onboard unit to a wide variety of vehicles has proved to be a very daunting process. We've definitely learned that bus standards are not standard by any means and that modern vehicle electronic systems are very fragile. It is certainly a difficult challenge to take a piece of technology like this and sort of deeply integrate it into an existing vehicle.

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