



# THE FUNDAMENTALS OF ROAD USAGE CHARGING SUCCESS: A COMPARATIVE LOOK AT SMARTPHONE, DONGLE, AND IN- VEHICLE TELEMATICS

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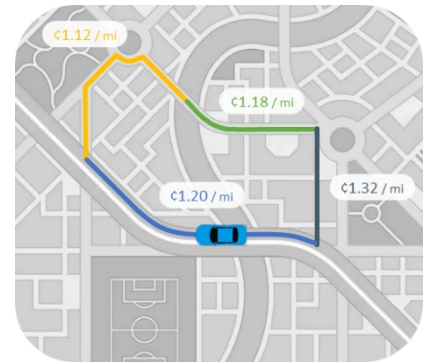
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## I. The What & Why of Road Usage Charging in the USA

Road Usage Charging (RUC) is a system of charging drivers for the miles they drive on a particular road network. This contrasts with the traditional gas tax, which charges drivers based on the amount of fuel they purchase. RUC systems can be implemented at the state or national level and used to fund the maintenance and construction of roads, bridges, and other transportation infrastructure.

Why we need RUC is clear. As the population and economy grow, and the demand for highway infrastructure increases, there is a rising concern that traditional funding methods like the gas tax will not be sufficient to meet this demand. The growth of electric vehicles that burn no gas, and an unwillingness by politicians to raise the gas tax, are two factors contributing to this concern. EV drivers pay no fuel taxes, but they still use roads and contribute to wear and tear. Additionally, Congress has not raised the 18.4 cents / gallon federal gas tax since 1993. And while states have increased their gas taxes, many are not doing so in a way that matches the inflation in construction costs or offsets the impact of EV's and high-mileage vehicles.



## II. The Substrate

A substrate is a base material or surface that supports the growth or function of something else. In the business context, a substrate is any physical or digital device or system that is used to, among other things, track and record data. In the context of a RUC, the substrate is the device or system used to count the miles driven. It can be a device installed in the vehicle, like a 'dongle' or telematics unit, or something carried-in by the driver, like a smartphone. The choice depends on the specific requirements of the system, including cost, ease of use, and accuracy. The substrate is an essential component of any RUC system because it is responsible for collecting and transmitting the data - accurately, efficiently, and fairly - that is used to calculate the charges.

The smartphone is an attractive substrate for a RUC system for reasons that ultimately contribute to the success of a RUC program.

- It is easily carried in by the driver and requires no special installation instructions or, in the case of vehicle telematics, partnerships with OEMS or other third parties.
- Smartphone GPS can be used to accurately know location and count miles driven.
- The 'smartness' of the smartphone can be leveraged to inform the driver, manage the driver's RUC account and even pay their individual charges.
- The smartphone is a computer and can uniquely be leveraged to efficiently manage RUC overlays and transmit information about charges to the RUC program manager. This last benefit cannot be understated because, if the cost to collect RUC charges is too high, the program will never be implemented.

## II. Options for Counting & Reporting Miles Driven

One of the most important aspects of Road Usage Charging (RUC) is the ability to count and report the miles driven by a vehicle accurately and securely. What mileage reporting option (MRO) used plays a large role in that.

There are several ways to do this, including reading the odometer (typically at an annual inspection or by taking a picture of the odometer), via 'dongles' that plug into the car's OBD-II port, in-vehicle telematics systems, and smartphones.

The most efficient way to count miles driven is to use GPS technology, a satellite-based navigation system that can provide location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. When used in a RUC system, GPS can determine the location of the vehicle and count the miles driven.

The use of smartphone as the MRO in RUC system makes the reporting of miles driven very efficient. Smartphones have integrated GPS technology which can be used to count miles and identify where the vehicle drove (important in the case of RUC systems with different rates depending on where and when you drive).

### Collecting RUC data via a smartphone has several benefits compared to odometers, dongles and in-vehicle telematics:

- **Convenience:** Smartphones are widely used and carried by many people, so using a smartphone app to collect RUC data can be more convenient for users than installing a separate device or dongle in their vehicle.
- **Cost-effectiveness:** Smartphones can be less expensive than other data collection methods, as users may already own a smartphone and would not need to purchase additional equipment or data plans.
- **Greater accuracy:** Smartphones can use GPS to determine vehicle location and use other sensors to know speed and other characteristics that can yield more accurate data than other methods. And, where a toll or express lane sits right next to a general-purpose lane, GeoToll Enhanced-GPS™ ensures no double charges.

### Collecting RUC data using the odometer is simple and cheap, but has disadvantages:

- Odometer readings are subject to human error, which can lead to inaccuracies in the data collected and the charges paid.
- Odometer data is limited to vehicle mileage and cannot provide other useful insights such as fuel consumption or direction - information that can improve planning efforts and lead to more effective transportation networks.
- Odometer data does not allow different price tiers, so a RUC program cannot exact a different layered fee for, say, driving in an urban area or at a certain time of day.



OBD-II port dongles are familiar and prevalent today for several use cases, including RUC pilot programs, but the units have disadvantages:



- A dongle is costly. This additional hardware must be purchased (\$50 and up), distributed and replaced every 2-3 years. There's also the monthly fee for the cellular data plan needed to send data.
- Installation sounds straightforward but it is not intuitive, leading to calls to the customer service centers. This reduces adoption and increases management costs.
- Dongles can be vulnerable to tampering or malfunction, which affects accuracy.
- Cars have only one data port, which may be used by other devices such as an auto-insurance dongle or DIY diagnostic app. Some EVs no longer have ports at all.
- Dongles may not be compatible with all vehicles, which can limit the number of vehicles that can participate in the RUC program.

Though advanced and part of a car, there are issues with in-vehicle telematics approaches that impact the success of a RUC program:

- Proprietary systems: In-vehicle telematics units are typically proprietary and may only be compatible with certain makes and models of vehicles. This means the driver or RUC program must have a relationship with a specific auto OEM or 3<sup>rd</sup>-party API provider to use the system. This can limit flexibility and the options available to drivers and program managers since they permit only certain vehicles.
- Data sharing: Some auto OEMs may not wish to share with third parties like RUC Program Managers the data collected by their telematics units. This can make it harder for RUC program managers to accurately track and charge for usage or analyze data critical to improving transport network efficiency and effectiveness.
- Data access: Some auto OEMs may not provide access to vehicle telematics data for free, requiring the RUC program manager to pay for it, on a recurring basis. This additional cost can increase opex and risk the program's success.



In summary, reporting miles driven is an important aspect of RUC, as it is used to calculate road charges. The most efficient way to report miles driven is via GPS which knows the location of a vehicle and can count the miles driven.

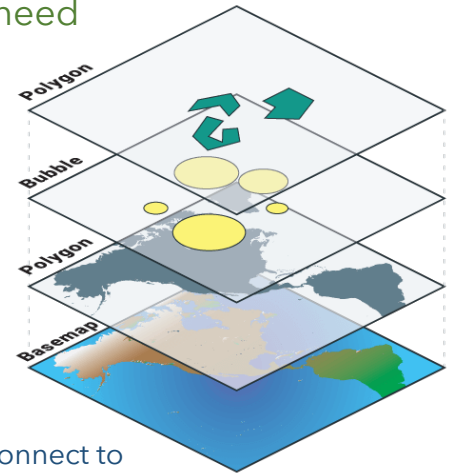
Using smartphones as the MRO in a RUC program makes reporting miles more efficient due to the built-in GPS technology, the zero cost of the unit, the ability to collect data in an unencumbered way, and calculate the charge. Lastly, there's the fact RUC Program managers will not have to pay for the data plans required to send data.

## IV. Overlays

An overlay in the context of geographic information systems refers to a method of adding additional information or data on top of a base map. In the setting of RUC, an overlay is used to differentiate between various types of roads, vehicles, and usage scenarios, and to apply different charges accordingly. For example, some roads may have higher usage charges than others, depending on factors such as congestion, traffic volume, or environmental impact.

Managing overlays, which are dynamic and in need of constant modification to meet RUC goals and objectives, can be expensive and result in the RUC program being cost-prohibitive.

**A smartphone is the best way to efficiently manage overlays**, as it provides a convenient and accessible platform for both the collection and processing of RUC data. Smartphones come with a wide range of sensors and tech, such as GPS, cameras, accelerometers and such that can be used to accurately count and report vehicle mileage and usage. Additionally, smartphones can easily connect to other systems, such as vehicle telematics or traffic management systems, to provide real-time data and insights.



One of the key advantages of using a smartphone for RUC is that it allows for a more flexible and adaptable system. Rather than relying on fixed infrastructure, such as seen in tolling with its toll booths or transponders and video cameras, a smartphone-based RUC system can be easily updated and modified as needed. For example, new roads or usage scenarios can be added, and charges adjusted based on real-time data. Also, a smartphone-based RUC system can be easily integrated with other services like car-sharing / ride-hailing, to provide a more seamless and convenient experience for users.

Another advantage of using a smartphone for RUC is that it allows for a more accurate and transparent billing system. For example, with traditional fee-based transportation facilities like toll roads, it can be difficult to accurately track and bill for usage, particularly for multi-state or multi-modal trips. A smartphone-based RUC system, on the other hand, can provide a detailed and accurate record of a vehicle's usage, including the date, time, and location of each trip. This can help to ensure that users are only charged for the actual roads and services they use which, by the way, can also help to prevent fraud or abuse.

To summarize, a smartphone is the best way to efficiently manage overlays in Road Usage Charging system due to its flexibility, accuracy, and convenience. The use of smartphones in RUC can provide more accurate tracking of a vehicle's usage and a more transparent billing system, as well as allowing for a more flexible and adaptable system. And moreover, the integration of RUC with other transportation-related

services can provide a more seamless and convenient experience for users. All these contribute to efficiency and higher adoption.

## V. Data Management

A national RUC system for the 290 million US light-duty vehicles and 4M interstate trucks in the USA will generate a tremendously large amount of data.

The amount of data depends on the type of data being collected (in a RUC system that can include, at a minimum, vehicle account holder identification data, vehicle type, GPS location points, etc.), the frequency at which that data is collected, and the size of each data transmission. Further, the amount of data sent may be affected by data compression and data encryption requirements placed on the vehicles and servers. Talking about “big data,” for just 1M drivers, sending basic location and other data from the vehicle to the RUC program manager the standard number of times per hour to ensure all miles are captured, would generate 32,000 terabytes of data.



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To help relate to that number, a terabyte (TB) is a unit of data storage equal to 1,000 gigabytes (GB) or 1,000,000 megabytes (MB). 32,000 terabytes is equal to 32,000,000 gigabytes or 32,000,000,000 megabytes.

To put that in perspective, a single terabyte can store around 250,000 songs or about 330 hours of high-definition video. Therefore, 32,000 terabytes would be able to store 8 billion songs or around 10,560 years of HD video. And this is just for 1M vehicles.

This is truly “big data,” a term that refers to data sets so large and complex that traditional data processing methods are inadequate. 32,000 terabytes would certainly be considered big data and would require specialized software and hardware to process and analyze.

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In the RUC context, this data must be collected, stored, and analyzed to accurately calculate charges and ensure the system is functioning properly and fairly. Effective data management is crucial to the success of a RUC system because if you cannot collect, analyze and calculate it efficiently, then the program may become quite cost-prohibitive compared to the cost of collecting fuel taxes at the pump (which on average is less than 2 cents for each dollar collected).

Smartphones, which GeoToll proposes as the best foundation for a RUC program, can be used to efficiently manage the huge amounts of data generated by the millions of vehicles in the program. Smartphones are equipped with powerful processors and



large storage capacities which allow them to handle large data loads. Furthermore, smartphones can also be used to work in RUC programs with multiple overlays, easily calculating the actual fee and then transmitting ONLY THAT data to the RUC program manager. They can do this in real-time, resulting in accurate and up-to-date charges.

### Data management also includes the security of the data.

A RUC system collects sensitive information such as location data, vehicle identification numbers and personal information. The system must therefore be designed with security in mind to protect this information from unauthorized access and to prevent fraud. This can include encryption and secure data storage practices.

Another important aspect of data management is the ability to analyze the data to identify patterns and trends. This can be used to improve the efficiency of the RUC program and to identify potential issues. For example, if a high number of vehicles are traveling on a certain road during peak hours, it may indicate a need for additional infrastructure or a different pricing structure for that road.

In summary, effective data management is crucial for the success of a national RUC system for 290 million vehicles. Smartphones can be used to efficiently manage the large amount of data being generated, including real-time data transmission. Data security must be a priority to protect sensitive information from unauthorized access and prevent fraud. Lastly, the ability to collect, analyze data and then calculate charges 'on the edge' can greatly improve the efficiency of the RUC system as well as identify and isolate potential issues.

## VI. Privacy & Security

RUC programs collect fees from drivers based on the miles they travel. The programs require the collection of sensitive data such as odometer readings, payment data/ credit card information, and personally identifiable information (PII) such as the driver's name, address, etc. It's important to the success of a RUC program to ensure the security of this data because:



- Vehicle data can be used to track an individual's movements, compromising their privacy and creating potential security risks.
- Payment data such as credit card information is valuable to hackers and can be used for fraudulent purposes if it falls into the wrong hands.
- PII can be used for identity theft and other forms of fraud, which can have severe financial and personal consequences for the individual.

Therefore, it's crucial for RUC programs to implement strong security measures to protect the data they collect, such as encryption, firewalls, and access controls, to ensure that this data is not disclosed, lost, or misused.

## Privacy is perhaps the strongest argument in support of using smartphones instead of dongles or in-vehicle telematics units:

- Greater control over personal data: Smartphones are personal devices, and users have greater control over data that is collected and shared. This can provide drivers with more transparency and choice when it comes to their PII data.
- Less data collection: Smartphones can collect *only* the data needed for the RUC program, whereas dongles and telematics units may collect a wider range, including data not relevant to the RUC program.
- More secure: smartphones can be configured to use secure data transmission methods like encryption, to protect PII from being intercepted by unauthorized parties.
- More control over access: smartphones can be configured to only share data with specific parties such as RUC program managers, providing users with more control over who has access to PII.
- Greater flexibility: smartphones can be updated or replaced more easily than dongles or telematics units, providing greater flexibility for the RUC manager.

Smartphones typically have "bank-level" security, meaning they use the same level of encryption and security measures as online banking systems. This level of security involves multiple layers of protection such as encryption, biometric authentication, and secure data storage to ensure that sensitive information is protected from unauthorized access and hacking. The term "bank-level" security refers to the high standard of security that banks use to protect financial transactions and customer information. Makers of smartphones have adopted similar measures to protect the sensitive information and activities conducted on the device, providing users with peace of mind and protection for their sensitive information.

It is important to note there are no one-size-fits-all solutions, but in a RUC context, using smartphones can be a superior way to protect privacy and ensure data security.

## VI. Conclusion

The growth of EVs and reluctance to raise gas taxes have created a shortage of funds. RUC solves these challenges by charging drivers based on actual use.

Smartphone-based RUC allows for convenient, efficient and agile systems that can accurately report miles driven and securely manage the data generated by the system.

Effective data management is crucial for the success of RUC. The ability to analyze data on the device improves efficiency as the program scales. Data security is a key concern as well, and smartphones can protect sensitive information from unauthorized access.

RUC is a viable solution to the challenges we face re transport funding. Using your smartphone as the substrate for RUC permits the most convenient, private, accurate, dynamic, agile and fair system - all which leads to high adoption. Adopting GeoToll's Smart MRO, with its E-GPS™ accuracy, Overlay-as-a-Service and Edge Data features, a state or national RUC solution stands the highest chance of achieving its goals.