5GAA Automotive Association

# C-V2X Tolling in the United States

5GAA Automotive Association
White Paper



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# Executive Summary

Cellular Vehicle-to-Everything (C-V2X) Tolling is emerging in the United States because four conditions are aligning at the same time: a maturing US C-V2X regulatory environment; a standard basis for toll-specific messaging under the standard SAE J3217; a sequence of demonstrations and first deployments led by toll agencies, original equipment makers (OEMs), tolling industry providers and telecom providers; and growing pressure on the long-term spectrum environment used by legacy radio-frequency identification (RFID) tolling in the 902-928 MHz band. A potential triple-win business model is thus emerging for toll agencies and OEMs, but also road users. Together, these factors make the US the most active market for early commercialisation while also reinforcing the need to evaluate C-V2X as a complementary path to traditional RFID-based toll collection and sets up a possible next-generation solution for payments.

In practical terms, C-V2X Tolling changes toll collection from primarily an infrastructure-based recognition model to a transaction model in which the vehicle can identify itself, receive toll information in advance, and confirm the transaction in-vehicle. This does not eliminate legacy tolling but creates a hybrid path in which V2X augments RFID, video tolling, and back-office processes while helping to reduce leakage, lowering roadside complexity and operational costs over time, and improving customer experiences by facilitating US interoperability.

C-V2X brings two complementary transmission modes for C-V2X Tolling. C-V2X direct communications over the 5.9GHz spectrum, supporting low-latency exchanges between vehicles and roadside units and mobile network-based communications over commercial systems, supporting infrastructure-light and virtual-zone models by using wireless connectivity in combination with GPS/GNSS.

Satellite solutions like GPS/GNSS provide precise real-time positioning and synchronisation benefits, while high-speed wireless links transmit instant vehicle data.Refining the business models and the ecosystem interoperability remain the biggest challenges facing the wider take-up of C-V2X Tolling. The tolling sector still needs agreement on how operator back-offices, OEM systems, account issuers and commercial settlement models interact at scale. The roles of the toll service provider (TSP) and toll charger (TC) may vary depending on which entities originate, process and, ultimately, pay for the toll transaction. This is why the TSP role and, in some models, a hub or exchange layer is considered highly relevant. The long-term value of C-V2X Tolling depends on whether the industry can make the customer experience seamless – avoiding or not creating fragmentation points.

The near-term roadmap is therefore evolutionary, not disruptive in one step: pilots and limited operational rollouts now; stronger testing, certification and business-rule convergence next; with scaled production and broader OEM participation increasing over time. Evidence from tolling agencies in the US states of North Carolina and Florida, associations such as OmniAir, IBTTA, 5GAA, SAE and private-sector participants including Indra Group, Kapsch, Audi, Verizon, Ettifos, Cohda Wireless, Microsec and others show that this transition is already underway.

# 1 V2X Tolling in the US

*Why the opportunity is particularly strong in the United States*

The US market is the most credible near-term launch environment for V2X Tolling because of technology readiness, policy readiness, spectrum uncertainty around legacy RFID tolling, and commercial need. On the standards side, tolling-specific message exchange is no longer purely conceptual: US stakeholders have utilised SAE J3217 and SAE J3217/R for interoperable fee collection messaging. On the policy side, the Federal Communications Commission (FCC) completed C-V2X rules for the 5.9 GHz ITS band in November 2024, establishing final technical and operational parameters. In parallel, the tolling industry faces a separate spectrum risk linked to the possible reorganisation of the 902-928 MHz band, which IBTTA has flagged as potentially disruptive for RFID-based electronic toll-collection systems. These moves increase the strategic relevance of V2X as a complementary path to legacy RFID tolling and set up the next-generation solution for in-vehicle payments.

The commercial opportunity is equally important; US toll operators manage high transaction volumes through a mix of RFID, video tolling, enforcement, customer service, account management, and exception handling. Existing tolling systems work, though their operations can be enhanced with V2X Tolling, reducing both leakage and operational costs associated with toll operations. Unregistered users, unpaid tolls, labour-intensive (manual) video validation and interoperability gaps all increase cost. V2X tolling augments the current tolling ecosystem by allowing the vehicle to become a trusted participant in the transaction, with the potential to move toll information and confirmation directly into the cockpit. It is also a commercial opportunity for automakers because they have the technology in their connected-vehicle fleets to support C-V2X Tolling, and they have expressed interest in enabling this use case for drivers – in turn, generating new revenue streams for markets where they add value.

After the V2X Tolling standard was approved in 2022, the US tolling sector quickly advanced from concept stage to public demonstrations including:

- In May 2025, Indra, Audi, and Qualcomm demonstrated C-V2X Tolling during OmniAir interoperability testing at SunTrax in Florida, and Indra, Qualcomm, Audi and Kapsch all performed live demos of the technology's readiness.
- At ITS World Congress 2025 in Atlanta, Indra and Cohda Wireless publicly demonstrated combined C-V2X Tolling and safety applications from the same roadside unit.
- In February 2026, 5GAA demonstrations in Sacramento showed both network-based and direct C-V2X Tolling working effectively before an audience of Caltrans and California tolling industry officials. Other participants included 5GAA members, Audi, Indra, Ettifos, Qualcomm, Verizon, Volkswagen, Valeo, Microsec, and Cohda Wireless with support coming from other innovators including Kapsch and the Federal Highway Administration's Saxton Transportation Operations Laboratory.

These activities matter because they show ecosystem coordination in the field.

Moving from demonstrations to pilots in 2025 and 2026, the North Carolina Turnpike Authority (NCTA) is especially relevant because it anchors the first wave of US operational learning. In November 2025, Stellantis teamed up with Verra Mobility Corporation to launch AutoKinex for paying tolls. Other production-level initiatives included an in-vehicle payment pilot between NCTA, Volvo Car USA and Mastercard conducted in September 2025, Indra's I-485 work in December 2025, and Kapsch's Triangle Expressway implementation in February 2026. Collectively, these activities show that US agencies are not just exploring C-V2X Tolling as a research topic; they are using it to test real transaction processing, roadside integration, and customer experience models.

# 2 Tolling Business Model

*How C-V2X Tolling and OEMs could disrupt the Toll Service Provider's role*

Traditional tolling is built around physical roadside infrastructure, recognising vehicles and agency-controlled customer accounts. With C-V2X Tolling, an additional actor emerges thanks to connected vehicles: the OEM as a TSP. Depending on the model, this role may be played by an OEM itself, an OEM-affiliated platform, an existing account issuer, or another trusted TSP. The key difference is that the vehicle is no longer only a passive object being detected. It becomes a source of authenticated transaction data and, in some cases, an embedded payment endpoint.

The business model logic is attractive because C-V2X Tolling can become a true triple win when structured correctly. For toll agencies and operators, given the introduction of some back-office complexity, this solution promises lower exception-processing costs, better vehicle identity quality, richer transaction attributes, and over time, a pathway to lighter roadside infrastructure. For OEMs, tolling creates a monetisable connected service use case that goes beyond safety alone, increases the value of embedded connectivity, and grants a new role in the mobility-payment ecosystem. For users, the benefit is simpler travel: no separate transponder logistics, no fragmented app experience, more transparent toll information before and after the charge, and potentially broader US interoperability across facilities. These incentives need to be aligned to solidify the value for the OEM/toll operator/customer.

C-V2X Tolling can support various business models. One places the OEM in a true TSP role, where operators handle customer relationships and settle transactions. A second model keeps the issuer relationship unchanged and uses the OEM primarily as the in-vehicle user-experience channel for an existing toll account along with their onboard sensor suite and communications. A third model resembles a third-party payer arrangement, with the OEM or partner remitting tolls and charging the driver. These distinctions matter because they affect pricing, settlement, customer service, dispute resolution, and the long-term ownership of the user relationship. The toll operators' back-offices remain central in all versions. Even where the vehicle supplies richer data, agencies still need rating, transaction correlation, enforcement policy, auditing, reconciliation, settlement, and customer support logic.

A final aspect aligned with the business model is that C-V2X Tolling provides a standards-based communications platform that extends beyond toll collection. While tolling can be deployed as a standalone use case, the same C-V2X capabilities can support future safety and mobility applications, such as work-zone notifications, roadway hazard alerts, traffic information, and road-surface condition updates. This enables tolling to evolve from a siloed payment solution into a connected vehicle service that integrates traffic management, mobility and road safety functions. This broader value proposition distinguishes C-V2X Tolling from single-purpose tolling technologies and helps to establish a foundation for future connected-vehicle services.

*C-V2X Tolling business model design questions*

| Question | Why it matters | Primary stakeholders |
|---|---|---|
| Who holds the customer account? | Determines who owns billing, service and dispute handling | -TSP (agency/authority)<br>-Third-party account provider<br>-OEM |
| Who guarantees payment? | Defines risk allocation and settlement mechanics | - TSSP (agency/authority) guarantees TC<br>-Third-party account provider guarantees<br>-OEM guarantees |
| How are transaction fees shared? | Creates or limits OEM incentive to factory-enable tolling | -TSP charges processing fee to TC<br>-Third-party account issuer charges fee to user<br>-OEM charges fee to user |
| How is interoperability managed? | Prevents fragmentation across agencies and OEMs | -Policy manager for functional operational roles (TSP, TCs and users)<br>-Interagency Group (IAG) hubs<br>-Standards bodies |

# 3 U.S. C-V2X Tolling Technologies

*Direct and network V2X as complementary deployment paths, not mutually exclusive ideologies*

C-V2X supports two relevant communications modes for tolling: direct communications between the vehicle and roadside infrastructure (roadside units or RSUs). It does not depend on the public cellular network for the local exchange itself and is suited to deterministic, toll-zone-specific interactions. In the tolling context, the RSU can advertise the toll area, toll geometry and applicable fee to the approaching vehicle; the vehicle can then return toll usage information and receive a transaction acknowledgement from the RSU.

There is also network-based communication through commercially deployed 4G and 5G cellular infrastructure. With such a model, the vehicle exchanges relevant data through the mobile network and associated cloud or edge systems rather than relying solely on local direct radio with a physical RSU. This enables a C-V2X Tolling system to be less dependent on roadside infrastructure.

From a systems perspective, direct and network V2X differ in latency control, infrastructure needs, dependency chains, security implementation details, as well as adoption by automakers. Direct V2X is closely associated with local RSU interaction, short-range awareness and alerts for safety use cases, and highly localised proof-of-presence. Network V2X is associated with broad coverage and simpler extensibility to other mobility services and depends on a mobile network operator (MNO).

Several public demonstrations and pilots in 2025/6 (mentioned in section 1) explicitly showcased both paths in the same event, reinforcing the idea that the eventual market will likely support a communication-agnostic back-office rather than a single mandated transport model.

# 4 Main Challenges

Addressing the **business model** is the main challenge because C-V2X Tolling is not only a technological evolution; it changes the allocation of roles, responsibilities, revenues and risks across the tolling ecosystem. For production deployment, the industry must define who acts as the TSP, who owns the customer relationship, who guarantees payment, how transaction fees are shared, and how disputes, refunds, enforcement exceptions and customer support are handled. This is particularly important if OEMs, connected-vehicle service platforms, payment partners, or hub providers become active participants between the toll operator and the driver. Without a clear and scalable business model, C-V2X Tolling could remain limited to pilots even if the technical components work correctly.

Closely linked to the business-model challenge, **back-office interoperability** is another critical condition for moving C-V2X Tolling from pilots to production. The issue is not only whether vehicles and roadside or network systems can exchange messages; it is whether tolling operator back-offices, OEM platforms, account issuers, user identities, etc. can operate coherently across multiple agencies and commercial models.

This creates a second-order challenge around **deployment timing** and **fleet penetration**. Tolling operators need a sufficient base of C-V2X-capable vehicles to justify production investment, while OEMs need visible operator demand, interoperable back-office interfaces, and a credible revenue model before enabling tolling-specific services at scale. This chicken-and-egg dynamic reinforces the importance of early pilots, common business rules, and clear commercial incentives for both sides to invest with confidence.

A third challenge is **business rule standardisation** beyond the message layer. Even if SAE J3217 and related message structures are stable enough for pilots, the industry still needs alignment to further elaborate this model for direct communication and cellular communication. Associations such as IBTTA and OmniAir are important in this transition because they can help move the discussion from technical feasibility to production readiness through interoperability testing, certification frameworks, and common security and operational rules.

Additionally, toll operators use various tolling regimens driven by contractually defined parameters including discounts for vehicles with more passengers, which require vehicle occupancy detection and validation systems, as well as vehicle classifications (i.e. axle counting or measuring vehicle dimensions) that impact toll multipliers. Business rule standardisation might be challenging and could require additional development or case-by-case back-office modifications to ensure that V2X fee collection aligns with local rules.

There are also regulatory and adoption barriers that shape the realistic pace of deployment. The FCC's final C-V2X rules for the 5.9 GHz band reduce one major uncertainty for direct C-V2X tolling, but regulation alone will not create market adoption. Tolling operators must continue to manage coexistence with RFID, video tolling/ANPR, managed-lane enforcement, and legacy customer-service processes for many years. For that reason, the most credible path remains additive and evolutionary: C-V2X could first operate as an augmentation layer that improves existing tolling operations, before any broader shift toward large-scale replacement is considered.

# 5 C-V2X Tolling vs. Road-Usage Charging (RUC)

*Clarifying similar but distinct concepts*

C-V2X Tolling and RUC both involve payments for road infrastructure use, but they differ in their objectives and approach. C-V2X Tolling is primarily a transaction mechanism for specific tolled facilities or priced zones, whereas RUC is designed to charge road users by distance travelled and is being evaluated as an alternative to fuel-tax revenues. The distinction matters because C-V2X Tolling can mature faster in corridors where tolling authority, customer expectation, and pricing logic already exist, while RUC requires broader legislative, equity, privacy and tax-policy decisions.

However, the two concepts require related building blocks. Both rely on trustworthy vehicle identification, distance measurement, secure data exchange, back-office rating and settlement, and strong privacy governance. Positioning is also a key enabler for both use cases. In the case of C-V2X Tolling, vehicle-native GNSS data can support advanced tolling applications, such as multi-lane free-flow (MLFF) and managed lanes, where higher positioning accuracy and, in some scenarios, lane-level determination may be required.

This is why standards and industry discussions increasingly reference tolling and road-user charging together. For instance, SAE J3217 defines standards for C-V2X Tolling (Direct Communication) and J3217/R defines standards for RUC.

*Structured comparison of tolling and RUC*

| Dimension | Tolling | RUC |
|---|---|---|
| Primary purpose | Facility or corridor charge collection | System-wide road-charging mechanism |
| Policy basis | Existing tolling authority often sufficient | Requires broader legislation and public acceptance |
| Technical need | Precise lane/location proof and transaction confirmation, account settlement | Mileage determination and jurisdiction attribution, account settlement |
| Customer interaction | Toll-zone specific, often immediate | Recurring mileage-based charging relationship |
| US current maturity | Early demos and first deployments | Many pilots; a limited number of ongoing state programmes |

# 6 C-V2X Tolling Roadmap

*A realistic US pathway from pilot to scaled production*

A three-stage approach can be envisioned for the deployment of C-V2X Tolling:

- **Stage 1 – Piloting** (*the current phase*): Demonstrations, pilot environments and first operational deployments. This stage has already included SunTrax testing, OmniAir Plugfest activity, ITS World Congress demonstrations, and North Carolina pilots or early deployments. The objective of piloting C-V2X Tolling is to prove end-to-end transaction behaviour, end-user experience, roadside integration, and back-office processing. A larger-scale pilot might be very useful to work on interoperability issues and other challenges highlighted in the document.
- **Stage 2 – Pilot to production:** Focus on interoperability and production-readiness, harmonising tolling operator-OEM interfaces and refining hub or exchange models which reduce the bilateral integration burden.
- **Stage 3 – Scale-up:** Scaled deployment, which likely begins in selected US corridors rather than universally. Managed lanes, express lanes and facilities already experimenting with connected vehicle applications are the most logical first candidates because they benefit from lane-aware precision, dynamic pricing, and integrated safety use cases.

Over the long term, the winning approach will likely be ecosystem-led and communication-agnostic. The most scalable end state is therefore one in which common business rules, strong certification and interoperable back-office exchange allow direct and network V2X to coexist while the market gradually shifts the vehicle towards becoming a trusted payment and mobility endpoint.

The 5G Automotive Association (5GAA) is a global, cross-industry organisation of over 100 members, including leading global automakers, Tier-1 suppliers, mobile operators, semiconductor companies, and test equipment vendors.
5GAA members work together to develop end-to-end solutions for future mobility and transport services.
5GAA is committed to helping define and develop the next generation of connected mobility, automated vehicles, and intelligent transport solutions based on C-V2X.
For more information, please visit https://5gaa.org


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