Draft

Guidelines to GNSS-based Tolling System in India

PREPARED BY

G-7 Sub Committee on GNSS-Based Tolling System

INTELLIGENT TRANSPORTATION SYSTEM

IRC COMMITTEE G -7

PREFACE

The document has been prepared in pursuance to the first meeting of the G-7 Committee for Intelligent Transportation System held in September 2021 and subsequent review meetings. This document is intended to serve as a guideto ITS professionals, engineers, MoRTH, NHAI, IHMCL, and various stakeholders dealing with tolling systems on Indian highways. This document is produced as an outcome of a series of deliberations, discussions, and observations made in the G-7 ITS Committee. Every attempt has been made to address the relevant comments, problems and issues while preparing this guide to implementing advanced tolling technology. It is advised that this document be reviewed based on the feedback and updated at least once annually.

Abbreviations

Abbreviation	Meaning
ANPR	Automatic Number Plate Recognition
API	Application Programming Interface
AVC	Automatic Vehicle Classification
GNSS	Global Navigation Satellite System
GOI	Government of India
HGV	Heavy Goods Vehicles
IHMCL	Indian Highway Management Company Limited
MoRTH	Ministry of Road Transport and Highways
NHAI	National Highways Authority of India
NAVIC	Navigation with Indian Constellation
OBU	On-Board Unit
PPI	Pre-Payment Instrument
RFID	Radio Frequency Identification
RTO	Regional Transport Office
TBC	Telematics Billing Centre
VMS	Variable Message Sign
TDP	Time Distance Place
TMS	Toll Management System

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1. Introduction

Roads are India's primary mode of transportation, carrying about 82% of passenger traffic and more than 66% of freight. Despite the rise of multimodal transportation, roads remain one of the most convenient and cost-effective modes of transportation in India, with a high penetration level and door-to-door accessibility. However, the high logistics cost of road transport is a challenge, and a major reason for the high logistics cost is the lack of free-flow travel on highways due to numerous toll plazas. Despite the implementation of the FASTag system using RFID technology that has drastically reduced congestion at toll plazas from 12 minutes to just a few seconds and improved toll collection efficiency, it doesn't facilitate free flow of traffic. GNSS-based tolling offers a transformative solution of free flow, distance-based tolling, and the possibility of multiple value-added services to road users.

No IRC Manual/Code or guideline is available on the subject matter. This document presents new guidelines based on the available literature and best practices of GNSS tolling systems used in different countries.

2. Objectives ~~of the Policy~~

This document aims to establish a guideline to uniformize workflows, standardise processes, and a broader architecture for an integrated and interoperable GNSS-based electronic toll collection system in India. We hope that this document developed by experts at the IRC Committees after months of study and deliberation of global best practices for the GNSS tolling system is a handy tool for implementation agencies.

This guideline will serve as a base document for scaling the GNSS tolling system implementation with interoperable and vendor-neutral plug-and-play concepts for different tolling agencies, NHAI, State Authorities, ToT, InVIT, or any other toll operators.

Care has been taken to minimise disruption to the existing toll collection system by continuing to utilise the existing FASTag ecosystem while upgrading to GNSS.

The guideline introduces a new tolling concept of 'pay as you use' for the first time. It differs from the existing system, where a fixed toll must be paid at a toll plaza regardless of the distance travelled.

It also promotes sustainability in tolling by eliminating the need for huge infrastructure in the form of toll plazas.

3. Scope ~~of the Policy~~

3.1 **Geographic Coverage**: This policy applies to national highways, expressways, and selected state highways earmarked for GNSS-based tolling implementation, initially focusing on high-traffic corridors.

3.2 **Tolling Infrastructure**: This includes the deployment of GNSS devices(AIS - 140 compliant OBUs), ANPR cameras, enforcement gantries & mobile unit ecosystem and Telematic Billing Centres, ensuring seamless integration with existing tolling networks of toll plazas and the FASTag system to optimise the cost and speed up implementation. This includes the specification of GNSS unit installation in vehicles for automatic toll calculation and payment, ensuring interoperability and accuracy.

3.3 **Backend Systems**: Requirements for backend systems, emphasizing data security, scalability, and disaster recovery measures for system reliability. Robust security measures, including data encryption, access controls, and cybersecurity protocols to protect user data and system integrity.

3.4 **Regulatory Framework**: Outlines compliance with relevant laws, regulations, and guidelines to be issued by MoRTH and other regulatory bodies, emphasizing collaboration with stakeholders for effective implementation.

3.5 **Satellite Interface**: The NavIC (Navigation with Indian Constellation) constellation is functional with signals in the L1 band in the upcoming NavIC satellites. The NavIC L1 signal is interoperable with the other GNSS signals. NavIC already provides two levels of service: the "standard positioning service," which is open for civilian use, and a "restricted service" (an encrypted one) for authorized users (including the military). The GNSS trackers that use NavIC are already compulsory on commercial vehicles in India as outlined in the AIS-140 specification.

3.6 **User Interface**: Development of user-friendly interfaces for account management, payment options, and customer support services, ensuring accessibility and integration with payment gateways. Easy availability of OBUs, recharge, and top facilities, as well as real-time transaction alerts, payment settlement, and complaint redressal.

3.7 **Implementation Strategy and Stakeholder Engagement**: The guidelines suggest the implementation methodology.

3.8 **Current preparedness**

3.9 **Switching over to GNSS System**

3.10 **Contractual challenges due to the "Distance-based" system**: NHAI's older or ongoing contracts are based on a stretch-based tolling system. The sudden change to a distance-based system needs to be tackled legally and contractually.

3.11 **Data Privacy**: Data privacy of private vehicles is an important issue. The guideline touches on this subject based on Government of India's Data Privacy policy and various Honourable Supreme Court judgments on this issue.

3.12 **Monitoring and Evaluation**

Establishment of performance metrics, regular reporting mechanisms, and knowledge-sharing initiatives to evaluate project progress and ensure accountability.

4. Global Navigation Satellite System (GNSS) concept

4.1 Global Navigation has the capability of positioning and timing any object on the globe at any time, anywhere, using a constellation of artificial satellites. The Global Positioning System of the USA is a well-known example of GNSS; other important ones being GALILEO of the European Union, GLONASS of Russia and BEIDOU of China.

GPS originally used a 24-satellite constellation arranged into six equally spaced orbital planes surrounding the earth. The orbits are roughly at an altitude of 20,200 km and each satellite makes two complete orbits around the earth each sidereal day (roughly 23h 56m 4s) covering the same ground track. Three more satellites were added by expanding three of the slots for better coverage. With four more additional stand-by satellites, GPS currently operates using a 31-satellite configuration. This constellation ensures that at least 4 satellites are visible from any point on the surface of the earth at 15° or higher above the horizon, which is the minimum number of satellites required to calculate the position by a receiver.

4.2 Each satellite is equipped with a stable atomic clock. All the clocks in the constellation are synchronised with each other and with reference atomic clocks on the ground. The satellites send radio signals to Earth on L1 and L2 frequency band carrier waves with two 'codes' and a 'message.' The codes are the "Coarse/acquisition' (C/A) code and the 'Precision' (P) code. P Code (becomes Y code when encrypted) is for military use only, not civilian use. The message is about the satellites in the constellation, ephemeris data (current and predicted satellite positions), weather, the general health of satellites, etc. C/A code is unique to each satellite by which a satellite can be identified. The C/A code is sent every milli second and the messages take about 12.5 minutes to reach the receiver.

4.3 The position of a point at any time on the globe (including air and sea) is determined by the GNSS receivers internally. The broad principle of distance calculation is trilateration – the calculation of location using distances from three known points . The ephemeris data provides the position of satellites from where the signals are fired to the receiver. The signals travel at the speed of light. The transmitted signal contains information about the time when the signal is generated. If the receiver clock were very accurate, this information could have been used to calculate the time of flight and hence the range (distance between the receiver and the satellite).

However, GPS receivers use less accurate consumer grade clocks resulting in an unknown clock drift or time difference between the receiver clock and the satellite clocks. Hence, the ranges measured by the receiver are called pseudo ranges consisting of the actual range and an error component due to the receiver clock drift. If the receiver has pseudo ranges from four satellites, we will conceptually have the equivalent of a set of four simultaneous equations with four knowns: latitude, longitude and altitude of the receiver and the error component. This problem can be solved to determine the receiver position and the clock drift simultaneously. If signals are available from more than four satellites, the additional information is used to improve the positional accuracy; for example, the receiver uses a weighted least squares estimate with weightages determined for satellites based on signal strength and position.

4.4 GNSS receivers are onboard units (OBU) mounted on vehicles with built-in antennae and electronics. These are passive units containing the details of the vehicle, the owner, the user's account numbers, etc. The passive receivers can only receive signals but cannot transmit any information. If an OBU has some memory of its own and is provided with a Modem and SIM, the OBU data can be transmitted periodically through a mobile network, like Global System of Mobile Communications (GSM), to a Telematics Billing Centre, which can charge the toll from the users by debiting their accounts/wallet.

4.5 Regional Navigation Satellite Systems (RNSS)

While GNSS systems such as GPS, GLONASS and Galileo provide global coverage, there are regional GNSS systems that cover only a part of the globe. India has its own Regional Satellite Constellation comprising eight satellites. These were earlier called Indian Regional Navigation Satellite Systems (IRNSS), which has now been named NavIC or Navigation in Indian Constellation. The coverage of NavIC is 1500 km beyond India's boundary. AIS-140 specification mandates that GNSS receivers that are compliant with the standard support NavIC.

Apart from GNSS satellites, there are constellations of regional satellites such as EGNOS (Europe), WAAS (North America), SDCM (Russia), MSAS (Japan) and GAGAN (India) that provide additional information and error correction data that can be used to improve the performance of GNSS. Such regional systems that are used to augment the performance of the GNSS to achieve better accuracy are called Satellite-Based Augmentation Systems (SBAS).

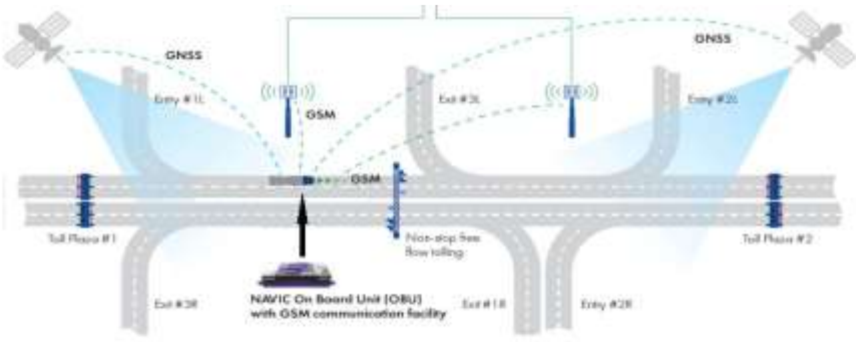

Figure 1 - GNSS base tolling concept

5. Toll charging using the GNSS System

Road User charging or Tolling is done based on the user's reported position when users enter or exit the highway system's geofencing-delineated boundaries. To accomplish this, several aspects have to be considered. First, **Checkpoint cross-**

detection at the geofencing boundaries of the highway network must be reliable to avoid the risk that the user's reported position triggers a charging event when it is in a free-of-charge or non-tolling position. Second, the service required to get the user's actual position must be available, thus triggering a charging event.

A series of steps, shown below, must be followed to properly determine the charge to be applied to a vehicle user.

~~(a)~~I. **Positioning:** The Onboard Unit's (OBU) integrated GNSS receiver periodically provides information such as position, speed, orientation, and degree of confidence. Location data is transferred over a GSM network to a back-end system known as the Telematics Billing Centre (TBC).

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~~(b)~~II. **Toll Calculation:** Using a geographic map-matching mechanism to accurately determine the vehicle's movement, the TBC can calculate the number of kilometres the vehicle has travelled on the toll road. The toll amount for the journey is then calculated by multiplying the 'per km' tariff with the kilometres travelled as determined above.

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~~(c)~~III. The toll calculation can be done in the following two ways:

- ~~1.~~ At the Backend TBC, use the data OBU sent to TBC and map matching.
- ~~2.~~ OBU itself uses geofence data received by TBC to calculate at the OBU end and send the Toll-charged transactions to TBC. The OBU should contain the geofenced data of tollable highways, which keeps on refreshing as and when a new highway is added or any new structure is made.

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~~(d)~~IV. **Rating:** If the vehicles are driving on a chargeable road segment or passing through a virtual gantry, the toll charge is calculated based on the tariff rules linked to the toll object. This process is called 'rating' and generates a Charge Data Record (CDR). In such a case, the vehicle's position is not transmitted.

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~~(e)~~V. **Transmission:** The stored CDRs are reported by the vehicle's OBU to the Toll Service provider (TSP) via a secure Mobile Network Operator (MNO). The CDRs received from a particular vehicle are processed for billing on the Back End or Central System. The data sent by OBU should be transmitted through a secure channel; VLTD data is transmitted to the Server, and from there, it can be used as required.

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~~(f)~~VI. **Matching algorithm:** These algorithms identify the correct road segment that a vehicle is travelling on or the virtual gantry it is crossing. The required digital map is downloaded to the OBU (e.g., Over-The-Air (OTA)) to do so.

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~~(g)~~VII. **Toll detection:** Once the matching algorithms verify that the vehicle has used a road segment or passed through a virtual gantry, the toll detection process verifies the area of a chargeable road network by searching on a toll object table. If the detected segment or virtual gantry is not part of the toll road network, all the data is immediately deleted, thus protecting user privacy.

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~~(h)~~VIII. **Validation:** Validations are required at locations to check the vehicle plying on the road is of the appropriate toll class. Vehicles moving on the road may switch off or disconnect the OBU to avoid user fees. For this, ANPR cameras are mounted on gantries at certain locations, which capture the registration number of vehicles and transmit the data to the TMS and from there to the respective Toll Control Room (TBC), which is validated with the OBU. In addition to fixed validation locations, there will be a requirement for Mobile Enforcement units on the highways/road, that check for violations and impose penalties.

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Figure 2- GNSS Road User Charging Process

~~(i)~~IX. **Enforcement:** The system is free to flow; toll collection occurs after the toll-able road or highway. To recover the unpaid toll, strict enforcement regulations or laws are required.

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~~3.~~7. GNSS-based tolling in the Indian context

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Global Navigation Satellite System (GNSS) is a next-level tolling system that can implement the 'Pay as you use' road tolling mechanism in India. This mechanism, based on the Time Distance Place (TDP) road pricing policy where vehicles are charged on "when," "where," and "how much they drive," is acknowledged by transportation experts as a fairer means of tolling than the present "Point-based" (i.e., toll plaza-based) tolling.

Using the 'Pay as you use' system, users pay only for the stretch they use on the highway instead of the full toll amount when crossing a toll plaza. In fact, among the current toll technologies, it is the only technology that can accurately implement the TDP concept.

Apart from providing an opportunity to implement a 'fairer' tolling concept (Pay as you Use) in India, GNSS-based tolling offers other important advantages, including:

- ~~i.~~ **Flexibility**: GNSS can charge according to different principles (time, distance, pace, vehicle type, level of emission, etc.) and can effortlessly and effectively adapt to evolving needs.

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- ~~ii.~~ **Extensibility:** It is easy to add new sections of roads to the toll scheme, affecting only the back-office system.

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- ~~iii.~~ **Revenue potential:** OBUs could be used as a platform for additional applications (e.g., fleet management, real-time traffic information, etc.).

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- ~~iv.~~ **Environment and cost:** Gantries are not required for tolling except for enforcement. This allows for around 80% less roadside infrastructure, thus minimising the environmental impact and installation costs.

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- ~~v.~~ **Traffic management**: Policy-makers and road infrastructure operators could use the aggregated and anonymous data for traffic modelling and to improve traffic policies.

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- ~~vi.~~ **Low transaction costs:** This can be considered a cost-efficient solution in large and complex new networks involving different vehicle categories.

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- **Road Safety:** OBU transmits tracking data and can give alerts like overspeed, emergency alerts, real-time driving behaviour, insurance telematics, etc.

7. The available resources in India for the GNSS System

7.1 As already discussed above, global satellite systems combined with SBAS by regional satellites have great potential in vehicle tracking in terms of their position and time. India has access to both the Global and India-specific regional satellite systems (NavIC and GAGAN). Thus, the availability of technology is assured.

7.2 GNSS and NavIC-compatible OBUs need to follow the Automotive Industry Standard AIS 140. The government of India has already made AIS 140-compliant OBUs mandatory for all public transport and commercial vehicles. Several equipment suppliers offer competitive prices. This has not been made mandatory for passenger cars. Besides, its use so far has been confined to fleet management and emergency interventions, and the tolling application is yet to be tested.

7.3 Under the National Master Plan (NMP), the Gati Shakti Ministry of Road Transport and Highways (MoRTH) will upload GIS maps of 1,41,000 km of National Highways on the NMP Portal by December 2022. This would cover over 90 percent of the NH network. The GIS database needs to be kept updated as and when sections are realigned and redeveloped.

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7.4 As of 2023, the penetration of mobile phone internet users was more than 68 percent. Thus, mobile communication infrastructure is not a problem.

7.5 Institutional experience of successfully implementing (97 percent of all tolls) by Radio Frequency Identification (RFID) based electronic tolling using FASTag as OBU on all vehicles is already available; therefore, migration to GNSS-based system is not expected to pose any institutional hurdle.

7.6 India already has a functional Automatic Number Plate Recognition (ANPR) system, which can identify vehicles at entry/exit. This, coupled with geofencing of the highway (using the GIS platform), would ensure that only those vehicles that use the highway and are liable to pay tolls are tracked by the satellites and not all vehicles on other roads so that privacy issues do not legally conflict with the government's tolling rights.

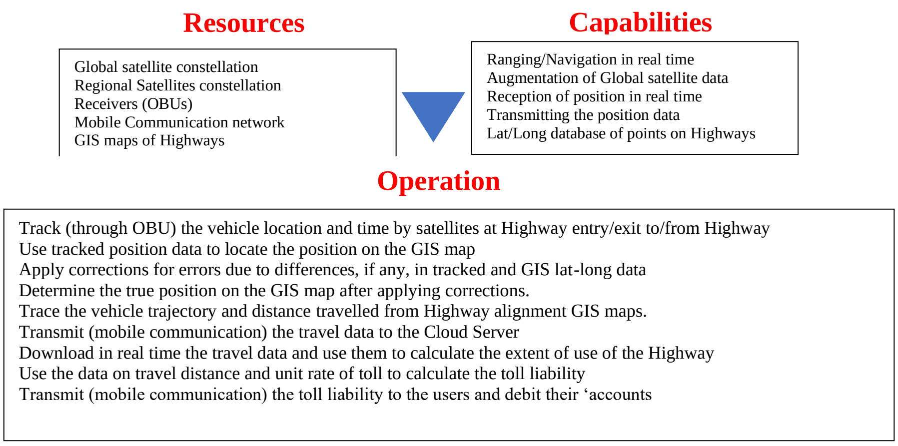

Figure 3. Components of GNSS-based tolling

8. Major components of the GNSS-based tolling system

~~1.~~8.1 On-Board Units (OBU)

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One way of using GNSS for road tolling is using a thin OBU. These OBUs are equipped with a GNSS receiver and a Global System for Mobile Communication Modules (GSM) and GPRS. The receiver calculates the vehicle's position and sends the position data to a central data centre via GSM, where the correct charges are calculated. The corresponding invoice is sent to the users.

In addition to the GNSS receiver and the GSM module supported with GPRS, *thick* or *smart* OBUs contain memory and a processor. The thick OBU calculates the correct charge onboard. Therefore, the up-to-date pricing data must be downloaded from the data centre. The position and pricing data can be used to determine the correct amount to be charged. This amount is then sent to the central data centre via GSM, where invoices are created.

The thin OBU is less expensive for the users. However, it raises privacy concerns since the position data is sent to the data centre, enabling the generation of movement profiles. Sending the position data to the data centre also creates high data volumes. The cost advantage is countervailed to some extent as the data centre has to do the calculations and, therefore, is more expensive to maintain.

Commented [RK2]: Local caching when network is not available is a part of AIS-140 specification already.

The Toll calculation in the case of thin OBU can be done on TBC based on data received from VLTD, road stretch detection by the TBC, and charging records forwarded to TMS by the TBC.

Device management/ control (OTA, etc.) needs to be established for security reasons. It is advised that it be controlled through the central server). Currently, the AIS-140 VLTD manufacturers and end users control the devices.

Single Unit (OBU) to be considered with all basic specifications as per the AIS-140 for ETC to make it more economical.

The thick OBU offers a higher degree of privacy since no position data is shared with the TBC. Nevertheless, it still creates a high-volume data stream because current maps must be downloaded every time a charge is calculated. This also limits the degree of interoperability because when travelling in a new area, the correct maps must be downloaded. This can also raise the costs since downloading the maps will usually lead to higher roaming costs. The processing unit needed for thick OBUs also raises the OBU-related costs.

Overall, there seems to be a trade-off between privacy and the cost of OBU. High costs for data transfer and the data centre counterbalance the lower cost for a thin OBU. Therefore, the costs are transferred from the user (thick OBU) to the provider (thin OBU).

Firmware updates for OBUs shall be a part of routine upkeep and maintenance. The possibility of tampering with OBUs shall be addressed.

Regardless of the choice made between thick and thin OBUs, the AIS-140 standard needs to be upgraded to (say AIS-140T) for supporting tolling functionality. AIS-140 standard currently supports sending data to two servers: the application server and the state emergency platform server. The specification needs to be upgraded to add a third server IP address for the TBC server. In the case of the thick client, the standard also would need to add a new message type for CDR events.

~~2.~~8.2 Telematics Billing Centre

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The Telematics Billing Centre (TBC) would have to be a complex software developed for accurate toll free calculation using data received from the OBU. The system needs to have multiple submodules with functions for tolling, map matching, billing and settlement, etc. Using an open Application Programming Interface (API), the TBC can be integrated with third-party software such as those of banks' Issuance systems and toll management systems.

The role of NHAI/IHMCL should be to stipulate fare rules, register assets, etc., for all TBCs.

TBC System service		Details
1	Telematics Billing Centre (TBC)	• GIS road network layout • Map matching • OBU AIS-140 protocol support • Toll Calculation services • Billing & Settlement services • Report Data Generation services • Situation Centre
2	GIS Subsystem	• Map matching • A digital map of the Indian road network with visualisation support
3	OBU AIS-140	• Data storage system for data received via AIS-140 protocol • OBU module to support interaction with OBU via AIS-140 protocol • OTA firmware updates • OTA road network updates

The TBC should be integrated with the Toll Management System (TMS) operated by NHAI/IHMCL. The TMS would serve as a centralised system that holds tolling policies, fare rules, and GIS datasets of toll roads. Additionally, the TMS would link to the enforcement units and pass vehicle information to the respective Issuer/TBC.

~~1.~~9. Implementation Strategy & Methodology

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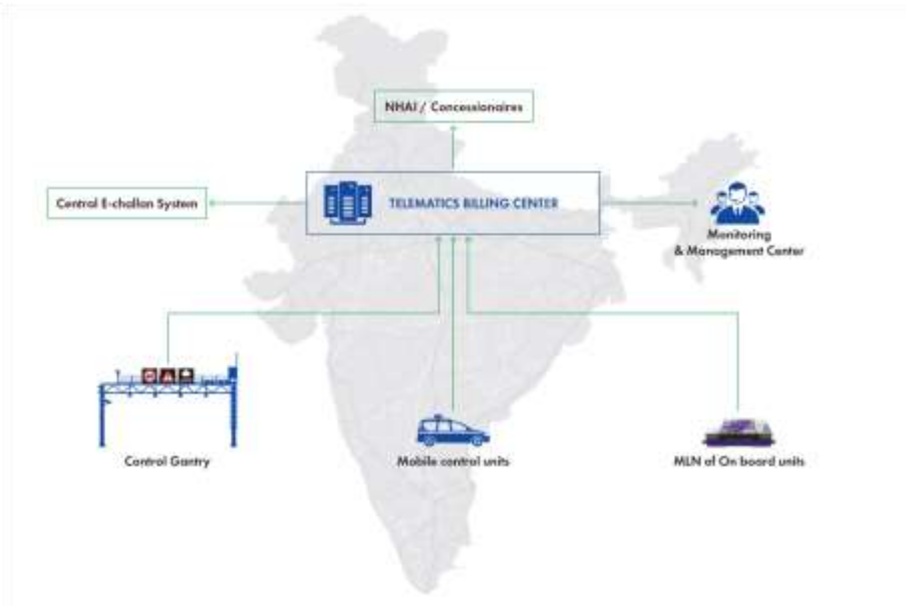

Figure -4 Key Elements

9.1 Implementation Strategy

The Implementing strategy of GNSS-based tolling in India can be in three ways:

~~1.~~(a) Gradually in Hybrid mode at toll plazas along with the existing FASTag system

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~~2.~~(b) Stretch-based implementation- make select stretch free flow with GNSS

~~3.~~(c) One time on all tollable highways in India

~~1.~~(a) Gradually in Hybrid mode with the existing FASTag system

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Without changing the existing tolling system, the GNSS tolling system can be implemented in phases as was done for FASTag implementation.

Dedicated free-flow lanes can be created at the existing toll plazas for vehicles opting for GNSS tolling and having fitted with tollable OBUs. Other lanes can remain as FASTag lanes. As GNSS toll share increases, more lanes can be dedicated to GNSS based free-flow tolling. To attract users to switch to the GNSS tolling system, a rebate can be offered for up to 3 years, starting with 15% in the first year, 10% in the second year and 5% in the third year. In three years, the majority of traffic would switch to GNSS tolling because of the free-flow traffic at toll plazas and the rebate. This is quickly and easily doable without much disruption to the existing ecosystem and the existing NH fee rules to start with. This is most suitable for Indian conditions.

~~2.~~(b) Stretch-based implementation- make select stretch free flow with GNSS

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This is the methodology adopted by most countries. They declared selected stretches for free-flow tolling and implemented a GNSS-based system for the entire stretch at one time. This gives seamless convenience to the stakeholders and avoids duplication of efforts and operational costs and the hassle of identifying and penalising no-OBU vehicles crossing through free-flow lanes.

~~3.~~(c) One time on all tollable highways in India

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Some smaller countries implemented this approach, but it is challenging for India considering India's size and geo-socio-political diversity.

9.2 Implementation Methodology

In addition, implementation requires many actions, from Legal provisioning to firming up open specifications for various components/devices, highway geofencing, and robust enforcement mechanisms.

The existing National Highway Fee Rules 1997 and 2008 are based on stretch-based tolling collected at a point called NH Fee Plaza. Meanwhile, in GNSS-based tolling, there will be no physical toll fee plaza, and the tolling fee will be calculated based on the NH stretch travelled for or used by the vehicle. This requires suitable changes in the NH Fee Regulations.

~~1.~~9.3 OBU Issuance

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~~1.~~i) Customer Acquisition to build a critical mass of customers

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Even though the government of India may mandate the use of GNSS-based tolling, the Issuing entity still has to attract customers to grow the programme rapidly. It may have to do that by attractively pricing the entry into GNSS-based tolling for such customers and including value-added services like vehicle tracking and fleet management. Marketing programmes that increase awareness among the target customers (e.g., Fleet Owners) and the general public should be conducted.

MoRTH has issued the SOP date of 22nd February 2021 for VLT registration and activation in VAHAN, which can be enhanced as per the issuer's requirements.

2. ii) OBU Life-cycle management.

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Device management/ control (OTA, etc.) needs to be established for security reasons. It is advised that it be controlled through the centre (Central server), at least for the tolling related parameters. Currently, the AIS-140 VLTD manufacturers /State backend controls the devices.

The data sent by OBU should be transmitted through a secure channel. VLTD data is transmitted to the server, and it can be used as required.

There are two categories of OBUs:

Category I refers to the new commercial vehicles (Trucks, buses, delivery vans, etc.) that have already been delivered with an AIS-140 compliant GNSS OBU . However, whether this OBU can be used for tolling purposes needs to be examined as these GPS devices are initially designed for tracking only. If these OBUs are suitable for tolling, the firmware needs to be updated and road network data uploaded, and the Issuer will only register the vehicle and the OBU and install vehicle number plates that are machine-readable to a high level of accuracy.

Category II refers to the old commercial vehicles as well as the old and new non-commercial vehicles (e.g., passenger cars). The Issuer will have to supply and register the OBU that supports GNSS tolling and install machine-readable number plates on these vehicles.

The OBUs will be procured from certified vendors, such as the RFID fitment and its transceivers. Their units will be type-tested and certified by organisations like ARAI and ICAT against the specifications released by MoRTH under a Gazette notification. MoRTH/ NHAI/IHMCL can mandate the capping rate after a suitable price discovery process.

All TBCs and devices must be certified by CMVR 126 testing agencies.

TBCs should be multiple, and all TBCs must be certified as per AIS-140.

There is no current example in Indian of banks performing electronic OBU Issuance for any electronic payment. Such an Issuance is limited to RFID tags (FASTag) and pre-paid and post-paid media in the form of debit, credit, and pre-paid cards. Even though new commercial vehicles are mandated to be delivered with the AIS-140 OBU, the older fleet and private vehicles need to be retrofitted with an OBU. The banks must establish agreements with the OBU manufacturers, who will involve their service centres or distributors in OBU installation, commissioning and maintenance.

~~3.~~iii) **Interfacing the Issuing entity's Issuance system with the IHMCL/NHAI Acquirer system.**

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This involves interfacing the Issuing entity's existing / legacy Issuance systems to the TBC system of IHMCL/NHAI. This effort shall be on the part of each Issuing entity, which will build the interface based on specifications published by the TBC. The Issuing entities should be approved by IHMCL/ NHAI, based on which the TBC provider will include them in the system and interface with their Issuance system. OBU Issuer agencies will need to have robust device management capabilities and certification as per NPCI or any central clearing house appointed by the government.

The role of NHAI/IHMCL should be to fare rules, register assets, etc., for all TBCs.

~~1.~~9.4 Enforcement

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As GNSS-based tolling is toll-plaza-free and does not require vehicles to stop, a monitoring and enforcement system is needed for violation detection and enforcement activities. Automatic violation detection equipment installed in toll lanes, gantries, and mobile enforcement vehicles can detect and capture images of errant vehicles, and automatically transfer the details to the TBC. The TBC, in turn, can generate e-challans for enforcement purposes. This process may include a human verification step. The E-challans can automatically be delivered to the registered vehicle owner's address using information from the VAHAN database. Repeated episodes of non-compliance by a vehicle owner can be brought to the notice of the relevant vehicle insurance company and the Regional Transport Office (RTO) for further action, like blacklisting, refusal for further vehicle insurance and impounding of the vehicle.

9.4.1 Enforcement Infrastructure

Gantry-mounted ANPR-based systems for capturing violations have to be set up pan-India on highways supporting GNSS-based tolling. Also required are mobile vehicles for the same purpose to support the above. No such infrastructure exists in the country today. Further, an ANPR system's success depends on the number plate's quality. Standardised 'high security' number plates are limited to a few cities and states. Many commercial vehicles, especially on the highways, do not have standardised number plates, thus leading to poor accuracy (approx. 70%) in the ANPR process. The ANPR performance will improve as standardised number plates get adapted across the country. Till then, a human interpretation of the number plate's image must be carried out.

There is a risk of fraudulent activities such as counterfeiting or cloning GNSS OBUs. Malicious individuals may attempt to create fake OBUs or replicate legitimate ones to avoid paying tolls. Implementing robust security measures, such as unique identifiers, authentication mechanisms, fraud detection algorithms and encryption protocols, can help mitigate these risks.

Tampering with standardised number plates shall also be considered a violation.

~~2.~~9.5 Legal provisions

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~~1.~~9.5.1 Requirements for enabling GNSS-based Tolling

~~1.~~a) The government should include distance-based tolling ('Pay as you Use') as a valid method of paying the central government-levied fee for the use of any section of the national highway, permanent bridge, bypass, or tunnel. Further, the system will support all prevailing Discounts, Passes, and Exemptions.

~~2.~~b) The Government should choose to implement distance-based tolling on any road section and consequently should have the option of suitably amending the relevant Concession Agreement (present or future) if required.

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~~3.~~c) The Applicable fee (fee per km) for distance-based tolling will be the same as that included in the National Highways Fee (Determination of Rates and Collection) Rules, 2008, and the subsequent Amendment Rules. Further, the Annual Fee revision of this Applicable fee will align with the formula included in the above Fee Rules.

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~~4.~~d) The above will require suitable amendments in the current National Highways Fee Rules with guidelines on its implementation on new vehicles and current vehicles, including penalties for violation, fraud, and tampering. The necessary Gazette notifications and Standard Operating procedures required to be published are similar to FASTag.

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~~5.~~e) As a 'toll barrier-less violation enforcement is envisaged as the target scenario for non-stop tolling, a system of enforcement should be implemented (as a further stage of system development) based on the concept of treating user fee (toll) violators as traffic violators. A system of Issuing E-Challans from the TBC is required, supported by evidence from images and vehicle license plate details captured by gantry-mounted and mobile vehicle-mounted ANPR systems. Suitable amendments to the Motor Vehicle Act (MVA) are thus required that will enable such a mechanism of issuing E-challans to Vehicle Owners at their addresses which can be obtained from either the system Mapper (with the Issuer being held liable

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Note: *The Penalty amount should be sufficient to pay for all expenses related to its collection apart from being a deterrent against wilful violation.*

~~6.~~f) Further, as a long-term measure (within 2 years), the AIS-140 GNSS module in the OBU should be upgraded to toll-able OBU as follows to ensure a true non-stop, 'boom barrier-less tolling:

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- ~~1.~~i. All data sent by the OBU device shall be transferred with encryption to ensure data security.
- ~~2.~~ii. The data transfer reliability by the device shall be enhanced to at least 99.95%.
- ~~3.~~iii. The device architecture shall be amended to ensure no data loss of the GPS module, i.e., an additional controller shall be added for this purpose.

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All Public Services Vehicles categories (N1, N2, N3 & M2) except (two-wheeler, three-wheeler & E-Rickshaw) should be fitted with Vehicle Location Tracking Devices (VLTD).

The vehicles category (M1) should be fitted with OBU.

(g) Legal provisions for considering tampering of OBUs as a violation shall be included

4~~.~~.9.5.2 Required key Gazette Notifications and documents

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~~1.~~a) MoRTH should release two key Gazette notifications and a document

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OBU specification and interface specification for TBC and related infrastructure need to be finalized by the AIS-140 /BIS committees. These specifications should include hardware specifications, data format & protocols, testing specifications, etc., for all the key components of the proposed GNSS tolling system (OBU, TBC, TMS & Enforcement).

~~1.~~i. The first Gazette notification should include OBU specifications, operating Characteristics, method of installation on the vehicle, description of the GNSS-based toll system, OBU commissioning & initiation, and the details of the enforcement process and enforcement system as finalised by the AIS-140/BIS Committee.

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~~2.~~ii. The second Gazette notification should be an amendment (e.g., G.S.R. 831 (E) for FASTag) to the NH Fee rule 2008 that includes the following:

a) Introduction of the terms related to GNSS-based tolling into the Fee rule. It should be made mandatory that toll fares are to be assigned by the NHAI/IHPCL.

b) The penalty for a road user who enters the GNSS OBU road without a valid OBU must be fitted with OBU.

~~1.~~9.5.3 Amendments required in the Motor Vehicle Act

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The following additions are suggested for suitable inclusion in the Motor Vehicle Act under a new section (e.g., Section 178A) titled 'Delayed-Payment or Non-Payment of User Fee related to non-stop tolling' under the existing Chapter XIII 'OFFENCES, PENALTIES AND PROCEDURE.'

~~1.~~a) User fee violators shall be treated as traffic violators

~~2.~~b) The pending User fee, along with a penalty, will be recovered via law enforcement agencies from the violator as an amount payable against an E-Challan issued by a MoRTH-approved Central Vehicle User Fee Payment Monitoring facility (e.g., the TBC operated by NHAI/IHMCL).

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~~3.~~c) The above Monitoring facility (or its approved agency) shall periodically send information about all pending dues via SMS service to the mobile phone and/or email address of the Vehicle Owner registered with the regional transport office. However, it shall be the Vehicle Owner's responsibility to monitor the pending dues, if any, on the dedicated public portal of the Authority and other media as possible/applicable.

~~4.~~d) Suppose the violator fails to deposit the pending user fee dues within 30 days. In that case, the traffic police or the Regional Transport Office (where the vehicle is registered) shall blacklist the vehicle and not allow the processing of anything related to the Vehicle registration (permit, fitness & taxes), the Owner's license, or Vehicle insurance. The Insurance Regulatory and Development Authority of India (IRDA) will be a key member of this initiative and will instruct its member organizations not to insure vehicles that have not paid their toll dues. Further, an additional penalty of two times the payable user fees for the calendar month shall be enforced. This additional penalty shall be applicable for a period of up to six months. The Vahan system shall be extended as a tool to achieve the above.

~~5.~~e) Suppose the dues (including the penalties described above) have been pending for more than six months. In that case, the Regional Transport Office has the right to impound the vehicle until the user pays all pending user fees, including penalties and challans.

~~6.~~10 GNSS Tolling Payment Flow and Settlement

~~1.~~10.1 Payment system model

The payment system model is shown in the figure below.

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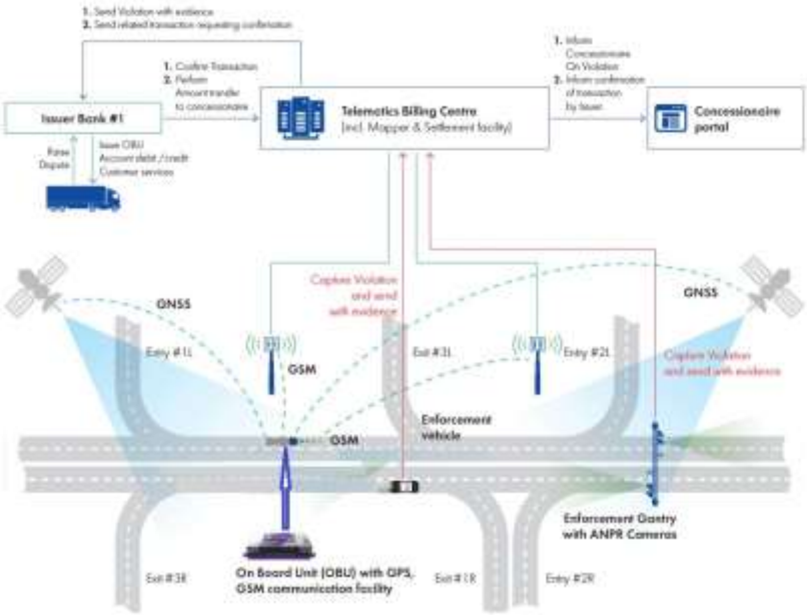

Figure - 5 The Payment system for GNSS-based tolling

The payment System model will be reframed according to the TBC and TMS.

Issuer Banks or OBU issuing registered agencies will need to have robust device management capabilities and certification.

NHAI/IHMCL should formulate rules, register assets, agencies, banks, etc., and TBCs and select agencies for operations.

All TBCs are to be certified by CMVR 126 testing agencies.

The toll road's billing will be calculated based on the data received from the device on a regular frequency (Lat-Longs).

One TBC can connect with multiple issuers, but one issuer should connect with a single TBC.

~~2.~~10.2 Key stakeholder

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The key stakeholders in this system are captured in **the Table** below.

S. No	Stakeholder / Entity	Role
1	Vehicle Owner	The Owner of the vehicle in which an already present OBU will be registered in the program OR if not already present, a registered OBU will be retrofitted.
2	Issuer Bank	The Issuer Bank is a member of the National Payment Corporation of India (NPCI) network that enrols and on-boards (registers) the OBU as above. The issuer bank 'owns' the customer (vehicle owner) by managing the account including the provision of customer services like dispute management.
3	Telematics Billing Centre (TBC) Provider	The Telematics Billing Centre (TBC) provider plays the role of the transaction acquirer and is also responsible for the settlement between the Concessionaires. The TBC also implements and supervises the enforcement systems pan-India, located a) at Toll plazas, b) on open roads that are Gantry-mounted and c) in mobile control units.
4	Concessionaire/Toll Operators	The Toll Road owner / Operator, the service provider who operates the toll road on which the vehicle's journey is made.
5	IHMCL / NHAI	IHMCL and NHAI are responsible for providing the business and toll collection rules. They also lay down the rules and regulations for the management of concessionaires and monitor the system's performance.

~~3.~~10.3 The flow of payment and settlement

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The system is envisaged on a similar model to FASTag, a multi-issuer, multi-acquirer system operating under sponsored banks. Either the government can nominate a new clearing house, or NPCI can continue to be a central clearing house for transaction clearing & settlement. FASTag, fixed on almost all vehicles on the road, can remain as a payment instrument and Digital Identity of vehicles. The FASTag digital identity will reinforce violation detection along with the ANPR system.

The Issuance of OBUs to vehicle owners is to be performed by Issuance banks, which use their systems for customer onboarding and Wallet management. The Issuer can provide the OBU as a stand-alone service or as part of enhanced customer service without replacing the FASTag account. The OBU can be linked with a FASTag account. In addition, the Issuer can add further value-added services to the vehicle owner in vehicle tracking and fleet management services.

A single control server should manage the OBU (AIS-140) for OTA, GIS data updates, firmware updates, etc. The Issuer bank will need to be linked to a TBC to manage all these functionalities.

One TBC can connect with multiple issuers, but one issuer should connect with a single TBC.

For the Reserve Bank of India's (RBI) approval of such a multi-issuer payment system, the OBU Issuance can be slotted among their Semi-closed Pre-Payment Instrument (PPI) programs. A Semi-closed PPI can be issued by a bank (approved by RBI) or a non-bank (authorized by RBI) for the purchase of goods and services (e.g., purchasing the right to use a tolled road as a service), including financial services, remittance facilities, etc., at a group of clearly identified merchant locations/establishments which have a specific contract with the issuer (or contract through a payment aggregator/payment gateway) to accept the PPIs as payment instruments.

In the context of AIS-140 devices and their implementation, the issuer TBC and GIS data would perform the acquirer or originator function. A clearing house connected to a central Telematics Management System (TMS) can facilitate the transactions and settlement process. Detailed specifications and data flow protocols would need to be created to operationalize this system.

The Acquiring and the Settlement functions should be in the scope of the TBC provider, who, based on the acquired progressive vehicle location coordinates, calculates the toll amount for the journey and sends the toll invoice to the Issuer. A consolidated invoice for all journeys performed during 24 hours can be generated and presented to minimize transaction processing costs. A clearinghouse is required to settle multi-issuers and merchants. Either an existing Clearinghouse (Payment Network) may be utilized for this purpose, or a new Clearinghouse may be set up in the future under the RBI proposed framework called 'New Umbrella Entity' (NUE).

4.10.4 Violation handling

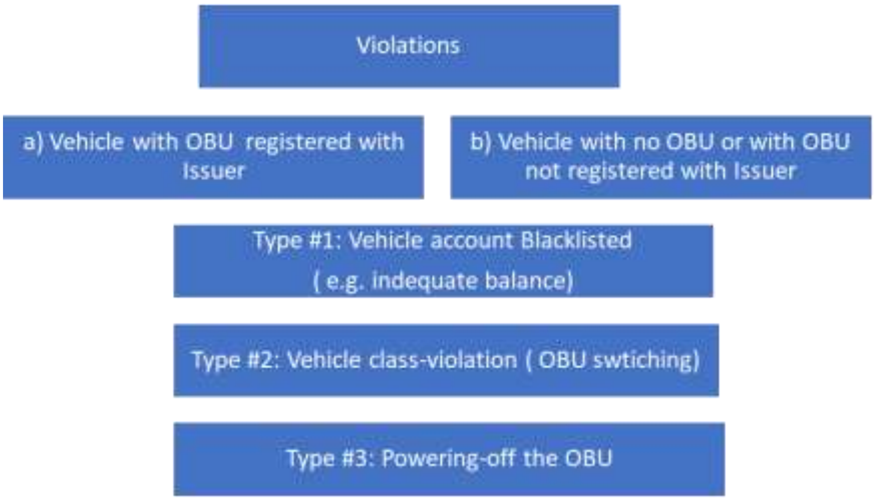

Figure - 6 Violation classification

A classification of the violations in terms of the violator's identity and the type of violation.

Two types of violators can exist—one registered with an Issuer for GNSS-based tolling and one who is not a registered vehicle owner.

Case 1: Vehicle with OBU that is registered with an Issuer for GNSS-based transaction
A violator having an OBU registered with the Issuer can perform three types of violations viz.,

a) Account Blacklisted due to inadequate balance and
b) Using OBU of a wrong vehicle class (Switched-OBU)
c) Powering off the OBU to prevent detection

1.a) Account blacklisted due to inadequate balance.

1.i) The Violation caused by a blacklisted vehicle is detected by a Violation detection (e.g., located on the road. The violation detection system (fixed or mobile) will be equipped with an ANPR reader that will read the

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Collecting the pending amount from the vehicle owner shall involve the following steps:

~~1.~~i. As a first step, the pending amount (and the penalty, if any) will be recovered from a safety deposit (deposit amount depends on the vehicle class) held in the customer's account by the Issuer.

~~2.~~ii. Once this deposit amount is used up, the enforcement of the E-challan will be taken up involving the RTO/ IRDA, as explained earlier.

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~~2.~~b) Using OBU of a wrong vehicle class (Switched OBU)

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A similar methodology Is also used to handle vehicle class violations by registered vehicles. On reading the vehicle number plate and obtaining its class with the valid vehicle database continuously received and updated from the TBC, if the violation detection system finds that this class mismatches with the AVC class, it captures the image of the vehicle (and its license plate) and sends it (after an audit) to the TBC with a claim for the correct toll amount. The TBC, in turn, generates an E-challan for enforcement, as explained earlier.

~~3.~~c) Powering-off the OBU

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This violation will be detected as a 'run-through vehicle' by using the AVC in the toll lane. The captured image of the vehicle will be sent to the TBC along with a claim for toll payment.

~~4.~~d) Tampering with OBUs shall be considered a violation.

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Case 2: A vehicle with no OBU or with OBU not registered with an Issuer enters the GNSS toll lane

If a vehicle with no OBU / unregistered OBU enters the GNSS toll road equipped with the violation detection system, the system, using its ANPR reader, will immediately detect such a vehicle in conjunction with the valid Vehicle database received and continuously updated from the TBC. This violation incident is captured and logged, and the vehicle image will be transferred to the TBC for the E-Challan generation.

~~1.~~10.5 The other salient features and Enforcement system:

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~~1.~~a) The TBC will set up a customer Care Centre (on a toll-free number) as the first line of support. It will also set up and operate a technical help desk for other stakeholders, like the Issuers. The Customer Care services should essentially include dispute management and Grievance addressing.

~~2.~~b) Will the violation system interface with TBC or Toll management system (TMS), which will then distribute vehicle-wise violations to individual TBCs?

~~3.~~c) In addition, the Customer Care Centre will strictly monitor the Issuer SLAs and compute related penalties.

~~4.~~d) **Enforcement** is triggered mainly by the types of violations, as explained above:

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- ~~1.~~i. Vehicle without an OBU or with an OBU with its power turned off
- ~~2.~~ii. Vehicle class violation caused by a Switched OBU, i.e., a car's OBU installed on a truck to pay less toll
- ~~3.~~iii. A Blacklisted OBU of the right vehicle class but with inadequate balance in its account. Evidence about a violating vehicle is captured with ANPR cameras that are mounted on the toll plaza, gantries, or mobile enforcement vehicles.
- ~~4.~~iv. Regulation to put a penalty in case payment is received immediately or within a stipulated period as prescribed by the government.
- ~~5.~~v. The possibility of a vehicle breakdown and the movement of such a vehicle on a flatbed/towing on the highway shall also be addressed. In this case, exemption from being tolled shall be considered.

Enforcements should be implemented using an incremental model introduced to ensure no losses in toll collection for MoRTH/NHAI or Concessionaire.

A separate fund corpus can be created to reimburse the concessionaires or toll operating agencies immediately for the unpaid user fee, which can be replenished with the recovery made after a reasonably long process that may involve legal processes.