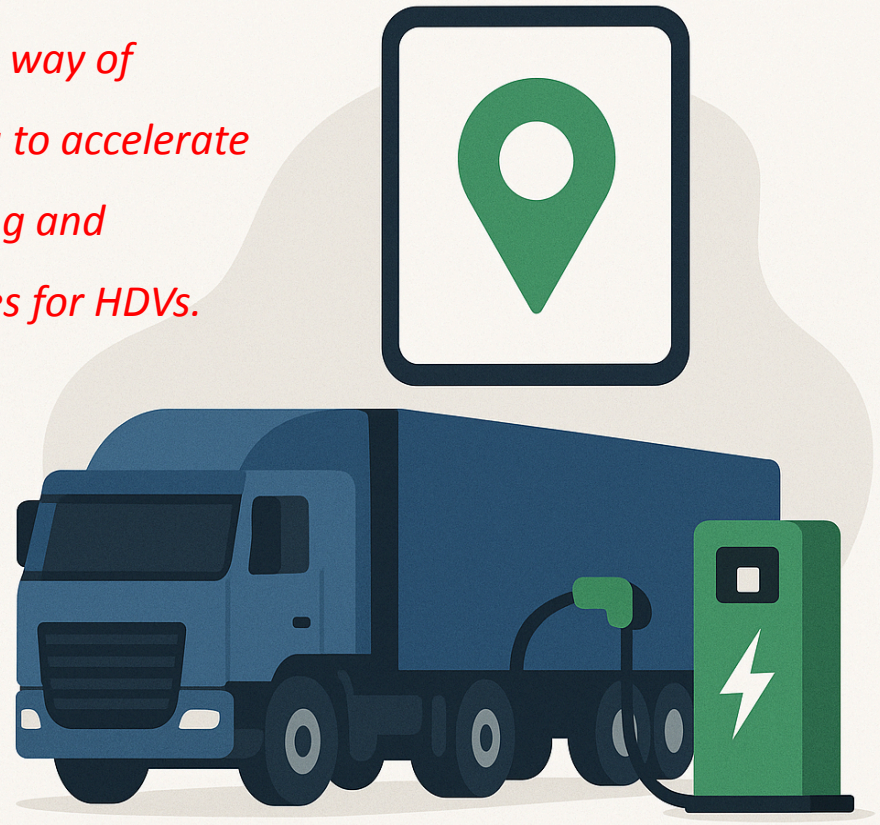
EVRoaming Foundation
Realising cross-border charging

# HEAVY DUTY VEHICLE (HDV) **DYNAMIC** BOOKING

*Towards a standard way of information sharing to accelerate the **dynamic** booking and charging possibilities for HDVs.*



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Version 1.0

# Management summary

This document describes scenarios for DYNAMIC booking of charging stations for Heavy Duty Vehicles (HDVs).

A normal booking process of a charging station is initiated by the (HDV) EV driver, dispatch/planner, EV/Fleet owner or the Fleet manager. In the EVRoaming Foundation HDV ecosystem they are grouped as Transport Operator (TO). They initiate a booking and in case of required modifications they are actively involved for the change of a booking. We call this static booking.

In the situation of dynamic booking, a booked charge time slot is modified automatically based on unforeseen situations. Of course always with a final approval by the CPO and TO. In principle it is even possible that via dynamic booking the reservation itself is initiated / created dynamically based on a certain situation.

An important prerequisite is that the driver's actions while driving should be limited to very simple tasks or preferably avoided at all to avoid distraction while driving.

The following scenarios are recognized that require some kind of dynamic action:

- Earlier and late arrival/delays (independent of the reason)
    - No conflict with permitted drive and/or resting time
    - Conflict with drive and/or resting time
- Overbooking/High Utilization
- Charging station outage/maintenance (predicted and unpredicted)
    - Charging station outage/maintenance (predicted)
    - Unavailable charge stations, due to technical reasons (unpredicted)
- Sliding / Flexible Windows and Permitted Areas
- Insufficient Energy Availability

These scenarios can involve different competing parties e.g. CPOs, when needed to move from one location to another that is managed by another CPO. This will require agreements on cost and lost revenues, etc. It can also have an impact on expected usage of locations. And eventually it can also have an impact on software and protocols.

Sooner or later the described scenarios will happen. The HDV market is a cost driven market. If we are not prepared for these situations, it will have a serious impact on the usage and adoption of electric HDVs.

The document is a start for the discussions and for the further steps that are required.

# Content

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# 1. Background and document setup

This document describes scenarios for DYNAMIC booking of charging stations for HDVs, based on a created booking via the current static booking system as described in the earlier published Business Case Booking document.

This document is describing several scenarios where dynamic actions are required related to booked charging stations for HDVs. The document is a living discussion document and can be the basis for further discussions. It might result in future changes or improvements of business models, how parties work together and also on protocols. Parties active in the HDV market are invited to use it, give feedback and they can always join the EVRoaming Foundation and participate in the HDV work and task groups.

The document is written by the contributors of the Heavy Duty Vehicle workgroup of the EVRoaming Foundation.

## 1.1 Dynamic vs Static booking

A normal booking process of a charging station is initiated by the (HDV) EV driver, dispatch/planner, EV/Fleet owner or the Fleet manager. In the HDV ecosystem they are grouped as Transport Operator (TO). They initiate a booking and in case of required modifications they are actively involved for the change of a booking. We call this static booking.

In the situation of dynamic booking, a booked charge time slot is modified automatically based on unforeseen situations. Of course always with a final approval by the TO. In principle it is even possible that via dynamic booking the reservation itself is initiated/created dynamically based on a certain situation.

The big difference between static and dynamic booking is that with static booking actions from the TO are always needed for every initiation or modification, while dynamic booking is a much more automated process that ‘only’ requires approval from the TO and that can react on specific situations e.g. late arrival or no arrival because of weather or traffic conditions.

The driver's actions while driving should be limited to very simple tasks or preferably avoided at all to avoid distraction while driving.

## 1.2 Scope

Based on UCs HDV Booking 2.0 (static booking), this document is focussed on booking/reservation of charging stations in the public*, semi-public** and semi-private*** areas for HDVs, where the creation and/or modification of a booking of charging station is not done by active initiation of the TO, but by some kind of automated system.

[*public area = locations where you can charge that are open for everyone or in case of exclusive HDV locations it is open for all HDVs]

**semi-public area = locations that are open for everyone, but behind gates or with some kind of barrier e.g. closed parking/charging locations

*** semi-private area = locations that are privately owned but the chargers can be used by others then location owner e.g. depots, logistic centers]

## 1.3 Objectives

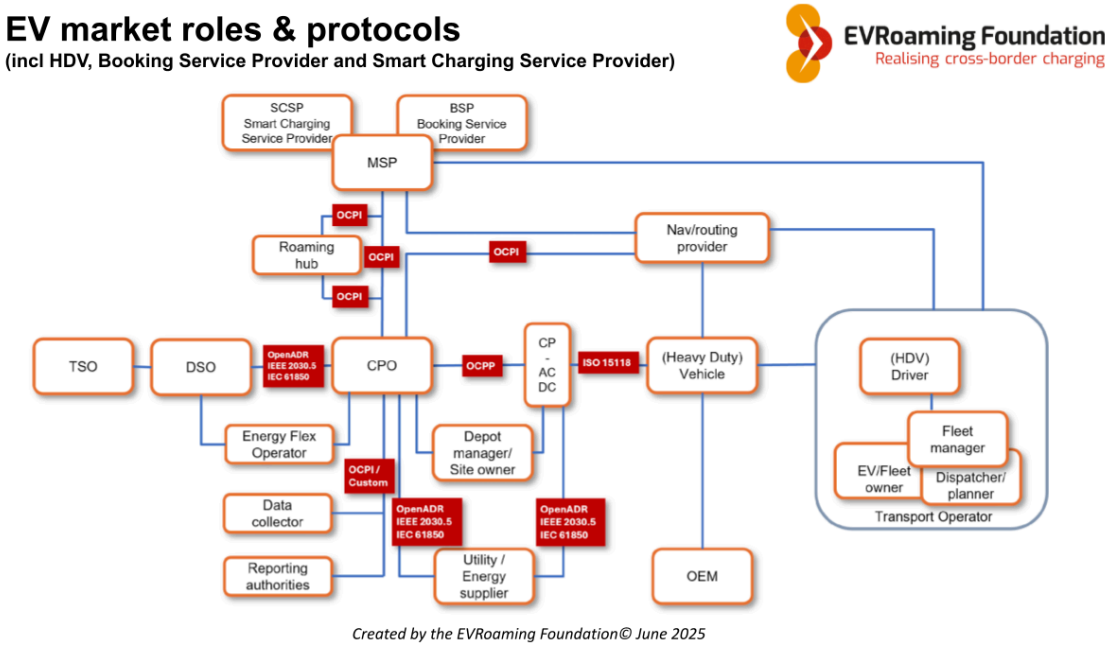
- a driver should not have to queue if they have made a booking
- a driver should be given maximum flexibility to change bookings and secure a charging location for their planned rest period
- Transport Operators should continue to optimise paid routes, not bookings
- CPOs should not lose revenue due to reservations

## 1.4 Document setup

The first version of this document is describing the different scenarios for Dynamic booking. Next versions will go deeper into the impact and ways how to deal with this. This should NOT automatically result in changes for OCPI or other protocols; it might be but is not the goal of this document.

## 1.5 Actors

The following overview, created by the EVRoaming Foundation HDV workgroup, shows the Eco-system which is used as the basis for the creating the Static and Dynamic Booking scenarios and the OCPI Booking module.




* The SCSP and BSP are Service Provider roles, but can be placed at different positions in the Eco-system and are not automatically part of the MSP role.

## 1.6 Booking via a 3rd party

In the Ecosystem and the Business Use Cases, the role of a separate booking party is not described, but it is taken into account. Booking is a service and can be done in many ways by many parties. A MSP or CPO can also outsource that activity to a 3rd party, e.g. like booking websites are doing for hotels. In the ecosystem this is seen as an activity of a mobility service provider, which can be a different entity than the one submitting the access tokens and managing the invoice. This is also how it is seen in the Business Use Cases. In other words: the use case describing MSP books at CPO should not be too restrictive on the actual Service provider. E.g. a schedule aggregator, a SaaS service that receives availability information from CPOs and aggregates it. They can provide a service to transport operators (TOs) and navigation system providers (NSPs) across multiple CPOs so they can optimise the route for the driving time, target destination time or SoC => this can be seen and is in the eco-system a Mobility Service Provider (MSP).

## 2. Introduction

The EV Roaming Foundation has published the "HEAVY DUTY VEHICLE (HDV) BOOKING" document, along with its associated technical protocol specification. This marks a significant step towards standardized booking for heavy-duty electric vehicles. However, while static bookings provide a foundation, dynamic bookings offer a more adaptive and efficient approach, aligning seamlessly with the complexities of real-world route optimization.

Static bookings can lead to inefficiencies and negative consequences for all stakeholders. For Charge Point Operators (CPOs), no-shows result in wasted capacity and lost revenue. For eMobility Service Providers (eMSPs), inflexible bookings can lead to customer dissatisfaction and logistical challenges. Drivers face potential delays and frustration when unforeseen circumstances disrupt their planned charging schedule. HDV companies suffer from operational inefficiencies and increased costs due to rigid planning. For example, a traffic jam can easily make a static booking worthless, and a CPO will be stuck with an empty spot for a time.

This document seeks to foster dialogue and generate insights into the use cases, benefits, and potential solutions for implementing dynamic reservations within the OCPI protocol. By exploring the possibilities of decentralized, real-time booking adjustments, we aim to enhance the efficiency and reliability of HDV charging infrastructure.

The "HEAVY DUTY VEHICLE (HDV) BOOKING" document outlines a foundational set of use cases for the static booking approach. These use cases primarily address the reservation of specific charging slots at predetermined times. Key elements include the ability to search for available charging locations, manage bookings (creation, modification, cancellation), initiate and manage charging sessions, and handle payment and settlement. While essential, the static booking approach lacks the adaptability required for the dynamic nature of heavy-duty transport. It does not fully account for real-time variables such as traffic, weather, or unexpected delays, leading to potential inefficiencies and lost opportunities. The fundamental elements of a booking are: time slot, location, tariff and available energy.

# 3. Considerations

## 3.1 Driver interaction to take into account for all scenarios

While driving, driver tasks should be very limited to avoid any distraction. Information exchange with the driver should be limited to

- Communicated charge time
- Communicated booked time slot
- Charge location and/or charge parking bay

## 3.2 Changes impact scheduled route and booked charge slots and locations

When a booking needs to be changed during the trip, this can have large impact on full trip:

- Different charge location and/or charge slot might result in a change of the route
- If the time of the charge slot is changed, it will have impact on further charge slots along the route
- This might result in a situation where all further booked/scheduled charge slots might need to be changed.

## 3.3 Block charger before a booking

If a charge station is in use just before the booking, there might be a conflict that the HDV using that charger at that moment did not leave in time. To prevent this, consider creating time windows before bookings to prevent Ad hoc charging. Of course this time, which results in a better guaranteed available charger, would have an impact on the cost of the booking.

## 3.4 Make a booking visible

To make sure that other HDV drivers know that a certain charge station is booked, it is advised to share this with MSPs (incl. Navigation Providers), but also indicate this clearly near the charger via either a display or other signage.

## 3.5 Impact on other parties

The described scenarios do not yet take into account the impact on other parties. Focus in this version of the document is on the direct involved parties (eg. the TO/Driver that made the booking). However changes in booking, especially when different locations from different operators are involved, a change can have implications on other parties, eg grid companies, HDV parking lot owners, charge navigation parties, etc..

# 4. Scenarios for Dynamic Booking and their Benefits

Dynamic bookings offer significant advantages by adapting to real-time changes and unforeseen circumstances. This chapter describes several scenarios and user stories where dynamic booking provides clear benefits.

The scenarios are described in the following format:

- Scenario description
- Detailed scenario
- Dynamic booking action in this scenario

The User stories are described in the following format:

- Given [a specific situation or context],
- when I [perform an action],
- then I expect [a specific result].

## 4.1 Earlier and late arrival/delays (independent of the reason)

### 4.1.1 No conflict with permitted drive and/or resting time

Scenario: An HDV is either earlier than expected or delayed, e.g. due to unexpected weather conditions or traffic congestion, road closures, or loading/unloading delays.

Detailed Scenario: The HDV's planned arrival at the charging station is now outside the booked time slot.

Dynamic booking action: Instead of wasting the booked slot or incurring penalties, the booking system automatically searches for and secures an alternative charging slot at a nearby location or a later time at the same location, minimizing downtime for the driver and optimizing the CPO's resource utilization.

User story

1. Given a booking is made by driver or transport operator (TO) at a specific location from a specific operator (CPO) with specific start and end time.
2. When the driver notices that they will be at the location earlier or later than expected, via their route/navigation information system, or
3. When the driver/TO notices that the new arrival time does not result in issues with the drive / resting time window.
4. Then I expect that the driver/TO wants to change the booking to an earlier or later moment, at same location and operator
5. Then either
    a. the CPO needs to be informed (preferable automatically) to find and offer a new charge slot.
        i. Check if new time slot is available
        ii. If OK, new time slot booked and shared with TO for final confirmation
        iii. If not possible, TO is informed, without any additional action.

b. Or the TO e.g. dispatcher can change the booking and inform directly the driver and/or sent it to the vehicle information system
c. If a new time slot is not available with that CPO at that location (in situation I or II), an alternative location will be searched.

### 4.1.2 Conflict with drive and/or resting time

Scenario: An HDV is either earlier than expected or delayed, e.g. due to unexpected weather conditions or traffic congestion, road closures, or loading/unloading delays. (Similar to scenario 3.1).

Detailed scenario: The HDV's planned arrival at the charging station is now outside the booked time slot. And the expected new arrival time at the booked location is outside the drivers resting time. This requires a new charge location in close proximity from the actual position of the HDV.

Dynamic booking action: Based on resting times (this must be known by the system) and driver location the booking system automatically searches for and secures an alternative charging slot at a new charge location that fits in the resting time period, minimizing downtime for the driver and optimizing the CPO's resource utilization.

User story

1. Given a booking is made by driver or transport operator (TO) at a specific location from a specific operator (CPO) with specific start and end time.
2. When the driver/TO notices that the new arrival time result in a conflict with his drive/resting time
3. Then I expect that the driver/TO wants to change the booked charge slot to a different time at a different location which can be from a different operator (CPO).
4. Then a new booking will be made by the TO (e.g. dispatcher)
    a. If this is not possible, the driver will be informed
5. Then the CPO need to be informed that the booked charge session need be cancelled
    a. Then the TO can share the new booked time slot and location with the driver and/or sent it to the vehicle information system
6. *Note: how to deal with cost for change or cancellation of the booking need to be agreed as part of the booking terms - common agreed market approach is welcome.*

## 4.2 Overbooking/High Utilization

Scenario: The planned charging station experiences unusually high demand, exceeding its capacity in available places at a certain moment. (This is not about exceeding energy demand).

Detailed Scenario: All charging stations that fit driver requirements are in use when the driver arrives and wants to use the booked time slot/charger. It is also possible that the booked

charging station is still in use by a previous charging session that extends beyond its allocated time.

Dynamic booking action:

- Drivers that use a booked charge station must be (automatically) informed and asked to move their HDV
    - Although it might be hard to get in touch with the concerned drivers - because almost all locations are unmanned - and in case of an Ad Hoc (spontaneous) charging session, the driver is unknown, ways should be found to enforce them to move their vehicle.
    - If enforcement is not possible it punishes the one who booked a charge slot and cannot use it. And the one using the charger unauthorized can keep on using it and is that way awarded.

User story

1. Given a booking is made by driver or transport operator (TO) at a specific location from a specific operator (CPO) with specific start and end time.
2. Given that at requested time, no chargers are available that fit user requirements, because of overbooking or because the previous charging session extends beyond its allocated time. HDVs are still charging / using all the chargers.
3. When this is known in the CPMS from the CPO and visible for the driver
4. Then CPO should be notified via his/her CPMS that no charge stations are available for a booked slot.
5. Then CPO should trigger a system to inform the drivers that use a booked charge station should move their vehicle.

## 4.3 Charging station outage/maintenance (predicted and unpredicted)

### 4.3.1 Charging station outage/maintenance (predicted)

Scenario: A booked charging station becomes unavailable due to technical failures, scheduled maintenance, or predicted/expected power outages.

Detailed Scenario: The CPO expects the problem and broadcasts an update via changing status of the charge station for a certain moment in time, and blocks the booking calendar for that station for that moment.

Dynamic booking action: No real dynamic booking action is required. The booking possibilities must be blocked for the expected moment. This can be done automatically based on status change, but also via human action. If it was already booked at that moment, the TO that booked the location must be informed. This does not need to be dynamic - can also be done via manual interaction of the station operator.

User story: not relevant for dynamic booking. A possible already made booking needs to be cancelled. As it is a predicted outage, it does not require specific dynamic action.

### 4.3.2 Unavailable charge stations, due to technical reasons (unpredicted)

Detailed Scenario: The CPO detects an unexpected problem and broadcasts an update via changing status of the charge station.

Dynamic booking action: The system proactively re-routes affected HDVs to functional charging stations avoiding disruptions and maintaining service continuity. If no charge stations are available at the same location that matches the user requirements, following alternatives are offered to the Driver/TO:

1. Charge stations that are available at the same location but do not fully match user requirements
2. If within x minutes new timeslot that fits user requirements is available at the same location, this time slot is proposed
3. If 1 and 2 are not possible or refused, alternative charging stations and locations are proposed

User story

1. Given a booking is made by driver or transport operator (TO) at a specific location from a specific operator (CPO) with specific start and end time.
2. Given that at requested time the booked charge station is not working properly
3. When this is known in the CPMS from the CPO and visible for the driver, via status message in the booking and the booked charge station.
4. Then the system proactively re-routes affected HDVs to functional charging stations.
5. If that is not possible, the system automatically offers the following alternatives:
    a. Charge stations that are available at the same location but do not fully match user requirements
    If accepted, then the system automatically informs the driver via the booking contact about the new charge station
    b. If within x minutes new timeslot that fits user requirements is available at the same location, this time slot is proposed
    If accepted, then the booking is changed automatically by the system and the TO/Driver is informed
6. If both alternatives are not accepted, then the full booking is cancelled
7. Then the service provider that created the booking is informed by the CPO and automatically alternative charge locations that match user requirements within a certain reach are offered to the TO/Driver.

## 4.4 Sliding / Flexible Windows* and Permitted Areas

** Sliding windows = allow for dynamic route planning based on real-time conditions and driver needs. This flexibility enables drivers to choose alternative charging stations or adjust their stops, optimizing their routes while adhering to regulations on driving time and breaks.*
*By integrating charging and break flexibility, fleet operators can enhance efficiency, reduce downtime, and improve overall operational effectiveness.*

Scenario: The TO transport management system provides "sliding windows" of permissible locations and times, allowing for flexible charging within operational constraints.

Detailed Scenario: The TOs system sends to the MSP time windows and permitted locations. Based on this information and information from the CPOs about available chargers, booking slots are proposed to the TO. TO can choose between them.

Dynamic booking action: The MSP/Booking provider proposes automatically several possible charging locations that fit requirements. This approach allows for dynamic re-routing without revealing sensitive data like SoC or final destination, preserving privacy while enabling efficient charging.

User story

1. Given a booking is made by driver or transport operator (TO) at a specific location from a specific operator (CPO) with specific start and end time.
2. Given that the TO has flexibility in charge stops, within limitation of e.g. resting and driving time.
3. When during the trip, expected time of arrival changes or the route is changing
4. Then the MSP or booking provider should be notified that the time of arrival or route is changing and that other charging possibilities should be offered
5. Then the MSP or booking provider searches for alternative booking slots e.g. with better timing or at a better location
6. Then this is offered to the TO and the TO can make a choice
7. Then the booking is changed by the MSP (or booking provider):
    a. Earlier booking is cancelled. Incl. Informing the CPO where it was booked.
    b. A new booking is created
    c. Confirmation is sent to the TO.

## 4.5 Insufficient Energy Availability

(NOT describing energy management, but a charger that does not fit booked charge power)
Scenario: The planned charging site cannot provide the required energy due to grid limitations, concurrency factors managed by the Energy Management Systems or other factors.

Detailed Scenario: Upon arrival, the driver of the HDV discovers that the site's energy capacity is lower than expected, or other HDVs are drawing more power than anticipated.

Dynamic booking action: The location should identify the charger that can deliver max amount of power and energy and automatically redirect the HDV with TO to that charger. This might be a different charger than originally foreseen.

User story

1. Given a booking is made by driver or transport operator (TO) at a specific location from a specific operator (CPO) with specific start and end time.

2. Given that the expected / needed amount of energy within a booked time slot is known.
3. Given that at the booked time there is not / will not be enough energy available at a location for all HDVs
4. When this is known by the CPO via information in the CPMS
5. Then CPO should be notified via his/her CPMS that there is not enough energy for the booked charger as required
6. Then the CPO shifts the available energy to the booked charger and reduces the power for the other chargers.
7. Then the CPO informs the Driver/TO via the MSP about the right charger and/or reduced power, including consequences (e.g. longer charge time).