Optimization for Active Road Users (Cyclists and Pedestrians)

and

Convoy for Active Road Users (Cyclists and Pedestrians)

Date 15-9-2025

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1. Introduction

To optimize traffic flow for active road users (cyclists and pedestrians), two standards are available, each with its own characteristics and advantages. This document describes the standards that can be applied.

1.1. SRM0 and SRM1

There are two available solutions, and the choice of which one to use is up to the road authority. The recommendation is to choose one solution for a given region.

SRM0: This solution is based on a combination of CAM messages with one SRM0 message per approach of an active road user.

SRM1: This solution is based on the CROW priority principle, where the SRM1 messages continuously inform the iVRI about the active road user's approach, and CAM messages are used only for support. Additionally, the service provider is informed about the handling via SSM messages.

The SRM0 solution should be offered by every ITS app as a basic solution.

Note: SRM (including SRM0) should be described in general for all road users and not just for motorized traffic. To make the entire document congruent, D3047-4_IDD RIS-FI_v2.0.0 should refer to ITS-Stations in combination with SRM messages (and not just Vehicles).

1.2. Characteristics

The solutions have the following advantages and characteristics:

SRM0 - characteristics	SRM1 - characteristics
The solution works based on CAM messages and a single SRM0 message. The principle is a basic one for an iVRI and can be easily supported by both the iVRI and the service provider. The ITS app calculates the ETA of the active road user itself based on CAM messages.	The solution is primarily based on the **priority principle**, using continuous SRM1 messages with constantly updated ETA values. CAM messages are sent for support. This principle also works when an active road user is not in a mapped area, which is especially relevant for pedestrians but also for cyclists at a greater distance. The **service provider** calculates the ETA, and the ITS app uses this value. Active feedback is provided to the active road user via C-ITS SSM messages. The principle supports **multiple crossings** at a single intersection and can also handle **convoys** of active road users. Intelligence regarding the movement, speed, and habits of the active road user resides with the **service provider**, allowing the iVRI to be informed more accurately. This leads to more consistent handling for each ITS app. The information provider can also better manage the active road user's **GPS drift**.

SRM0 - considerations	SRM1 - considerations
Support for pedestrians requires that footpaths are drawn longer than the standard in the ITF. Map matching is a requirement; ITFs must be accurate for the type of road user being served. **Key considerations:** CROW specifications may not currently allow for requesting multiple connections within a single intersection.	The number of messages (SRM and SSM) is significantly higher, both on the UDAP-FI/TLEX-FI and the Vlog. With a large number of active road users, extra filtering may be needed in the Vlog to prevent data saturation.

1.3. Based on document

This document is an addition to document D3047-15 Priority Services which can be found on crow.nl on the tab “Landelijke iVRI standaarden”.

- An understanding of document D3047-15 is advised..
- Abbreviations and referred exceptions which are not mentioned in this document can be found in D3047-15 on CROW.

1.4. Revisions

Revisions		
Version	**Date**	**Description**
0.0	15-4-2025	Concept version
0.9	28-8-25	To be presented to CAB

1.5. Actors

iTLC, RO, PBC, OBU, PRG, EB

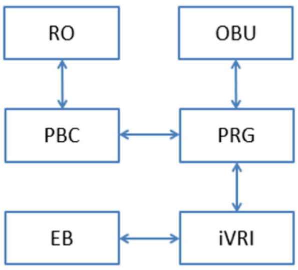

Figure 1. The relations between actors

RO - Road Operator
PBC - Priority Broker Configurator
OBU - On Board Unit
PRG - Priority Request Generator
EB - External Blocking

For more detailed explanation of the actors see: D3047-15_Functional Priority Handling (CROW)

Note: In Mobilidata (Vlaanderen) an extra actor is part of the eco system. Between the PRG and IVRI there is a functional barrier “Priority Valdidator”. This PV is controlled by the road operator and will check if the SRM is legitimate according to the PBC. An invalid SRM will be rejected, there is no feedback of the rejection.

2. SRM0-Solution

2.1. Use Case: Optimization for (individual) Active Road Users

2.1.1. Goal

This use case aims to provide a passage, for an individual Active Road User (ARU), over a signalised intersection without the need to press a button at the signal. The position of the Active Road User and the route information are considered when optimising the traffic flow.

Note: This use case is optimization using CAM messages and a so-called SRM0 message.

Note: The iTLC is responsible for the optimization process. However, this document does not describe how the optimization shall be done, this is vendor specific.

Note: This use case explicitly supports passing more than one connection (i.e. signals) on the same intersection.

Note: The term <u>intersection</u> in this document corresponds with an intersection as defined in the MAP data. An iTLC can control one or multiple intersections.

Note: An Active Road User is a Pedestrian or a Cyclist.

2.1.2. Pre-Conditions

- The intersection is controlled by an iTLC that supports the use case Optimization for Active Road Users.
- The OBU of the Active Road User (pedestrian or cyclist) provides the required data.
- CAM-messages, with stationType pedestrian(1) or cyclist(2) has been sent to the iTLC for the Active Road User.
- SRM0 message with the route information.
- All system clocks of the actors are synchronised.
- MAP information has to be sufficient for mapping. A short lane will result in a late detection of the ARU.

2.1.3. Trigger

- ARU is detected on the MAP.

2.1.4. Normal Flow

- The Active Road User (ARU) approaching an intersection sends Cooperative Awareness Messages (CAM) to the iTLC, which contain information about the ITS station (ARU) such as type, position, heading, speed, etc.
- The ARU approaching an intersection shares the route information via a so-called SRM0 message. The route information received in the RIS with the SRM0 message, is provided to the ITS application by the 'signalgroup' attribute of the ItsStation object of the corresponding CAM message.
- The RIS of the iTLC performs map-matching by taking the reference position of the ITS station, and the accuracy of this position, and projects that onto the intersection topology. The map-match information is provided to the ITS application by the 'matches' attribute of the ItsStation object of the corresponding CAM message.
- The ITS application determines based on the CAM data, stationType (ARU: cyclist(2) or pedestrian(1)) , heading, speed, matches, signalGroup, the position (distance) of the ITS station (ARU) to the stopline.
- The ARU signal requests shall be serviced by the ITS application based on these CAM-data.

2.1.4.1. Feedback

- The iTLC will inform signal changes in the SPAT timing information.
- For directions that will encounter additional waiting time the iTLC will send out SPAT messages with 'reason for waiting' information

2.1.4.2. Update

- The ARU (ITS station) sends CAM-update messages to the iTLC (once per second on the MAP).
- The iTLC updates the position (distance) of the ITS station (ARU) to the stopline.

2.1.4.3. Crossing the intersection

2.1.4.3.1. ARU request for single connection

- The iTLC shall terminate the ARU request when the iTLC determines that it is likely that the Active Road User has started to cross.
- The iTLC removes the ARU request and adapts the traffic control if necessary.

Note: To prevent unnecessary green extension; the ITLC shall terminate the ARU request when it is 'likely' that the Active Road User has started the crossing. How the iTLC does this is outside the scope of this document; this is vendor specific.

2.2. ARU request for multiple connections

- The iTLC subsequently terminates the ARU request for the connections when the iTLC determines that it is likely that the Active Road User has started to cross.
- The iTLC shall not grant an ARU request on a connection before granting or terminating the ARU request of the preceding connection.

Note: The iTLC realises the connections in the requested sequence, considering the travel time from a connection to the next connection in the sequence. How the iTLC does this is outside the scope of this document; this is vendor specific.

2.2.1. Demand wait indicator (if present)

The iTLC shall activate the demand wait indicator ('drukknop terugmelding') when the signal is red and a demand for the Active Road User for the signal is set.
Once the demand wait indicator is lit the corresponding signal will go to green, irrespective if the ARU is cancelled.

2.1.4.5. More than one request

When the iTLC receives ARU requests from multiple Active Road Users (i.e. different stationId's), for the same signal, the iTLC shall act as follows:

The ARU requests shall be serviced based on the position of the ARU to the stopline. It is up to the iTLC to determine if multiple ARU requests are handled in one or multiple green realisations. The logic used by the iTLC is outside the scope of this specification; this is vendor specific.

2.2.2. SSM status

There is no C-ITS feedback by an SSM-message.

2.2.3. ETA calculation

Vendor specific

2.2.4. Post-Conditions

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3. SRM1 - solution

3.1. Use Case: Optimization for Active Road Users

3.1.1. Goal

This use case aims to provide a passage, for an individual Active Road User (ARU), over a signalised intersection without the need to press a button at the signal. The requested connection(s) and estimated arrival time(s) of the Active Road User are considered when optimising the traffic flow.

Note: This is not a use case of prioritisation, this use case is optimization using a priority request with requestImportanceLevel "1"[1]. A so-called ARU request.

Note: The iTLC is responsible for the optimization process. However, this document does not describe how the optimization shall be done, this is vendor specific.

Note: This use case explicitly supports passing more than one connection (i.e. signals) on the same intersection.

Note: The term intersection in this document corresponds with an intersection as defined in the MAP data. An iTLC can control one or multiple intersections.

Note: An Active Road User is a Pedestrian or a Cyclist.

3.1.2. Pre-Conditions

- The intersection is controlled by an iTLC that supports the use case Optimization for Active Road Users.
- The OBU of the Active Road User (pedestrian or cyclist) provides the required data.
- At least one CAM-message, with stationType pedestrian(1) or cyclist(2) has been sent to the iTLC for the Active Road User.
- The full chain of the services, including the PRG, is operational.
- All system clocks of the actors are synchronised.
- The PBC has been configured for the intersection to support this use case: Role = 0; Subrole = 0; requestImportanceLevel = 1.[2]
- The PV (Mobilidata only) has been configured to support this use case.

3.1.3. Trigger

- The PRG determines that the Active Road User will pass a connection of the intersection within [90] seconds for cyclists, or [60] seconds for pedestrians.

[1] RIL=1 has been chosen to allow for support for multiple requests/crossings on the same intersection. This avoided changing the specs and implementations for handling SRM0 in the RIS and the UDAP/TLEX.

[2] The PBC rule (role=0, subrole=0, requestImportanceLevel=1) is exclusively intended for the ARU request (i.e. only a PRG issuing a ARU request shall process the PBC rule, other PRG's shall ignore the PBC rule).

3.1.4. Normal Flow

- The PRG determines which connection(s) of the intersection the Active Road User will take.
- The PRG validates the request against the rules stored in the PBC.
- The PRG sends an ARU request (role=default(0) and subRole=default(0)) for the first connection, including ETA.
- The iTLC determines based on (requestImportanceLevel=1, role=default(0), subRole=default(0) and stationType = (cyclist(2) or pedestrian(1))), that Active Road User optimization has been requested.
- The iTLC starts a reception window of [1500] ms.
- The iTLC acknowledges the receipt of the ARU request within [1000] ms and sends a response (SSM – Requested) to the PRG.
- The PRG forwards the status to the OBU (optional).
- The PRG sends ARU requests for subsequent connections within a time window of 1000ms after the ARU request for the first connection has been sent.
- The iTLC acknowledges the receipt of an ARU request within [1000] ms and sends a response (SSM – Requested) to the PRG
- The PRG forwards the status to the OBU (optional).
- At the end of the reception window the iTLC determines the sequence based on the ETA (i.e. lowest ETA is the first connection in the sequence and highest ETA is the last connection in the sequence).

Note: The reception window is per stationId per intersection.
Note: *The iTLC is allowed to ignore the ETA for subsequent connections if the iTLC respects the order in the sequence and takes the travel time between the connections into account.*

3.1.4.1. Feedback

- Periodically the iTLC determines the actual status (requested, processing, granted) of the ARU request(s).
- On a status change the iTLC will inform the PRG (SSM - requested, processing, granted).
- The PRG forwards the status to the OBU (optional).
- The iTLC will inform the PRG on changes in the SPAT timing information.
- The PRG forwards the timing information to the OBU (optional).

3.1.4.2. Update

- The PRG determines that the last message (SRM – priorityRequest, priorityRequestUpdate) has been sent more than [10] seconds ago, or the ETA has changed (see 2.6. ETA calculation)
- The frequency of SRM - priorityRequestUpdate message shall not surpass 1Hz.
- The PRG sends an update message (SRM – priorityRequestUpdate) with the current ETA to the iTLC.
- The iTLC replies to the PRG with an SSM message containing the status.
- The PRG forwards the status to the OBU.

Note: The ETA in an ARU message (SRM – priorityRequest, priorityRequestUpdate) shall not be in the past (i.e. ETA >= now).

3.1.4.3. Crossing the intersection

3.1.4.3.1. ARU request for single connection

- The PRG determines that it is likely that the Active Road User has started to cross and terminates the ARU request (*SRM - priorityCancellation*) with the iTLC.
- The iTLC removes the ARU request and adapts the traffic control if necessary.
- The PRG forwards the status to the OBU (optional).

Note: To prevent unnecessary green extension; the PRG shall terminate the ARU request when it is 'likely' that the Active Road User has started the crossing. How the PRG does this is outside the scope of this document; this is vendor specific.

3.1.4.3.2. ARU request for multiple connections

- The PRG subsequently terminates the ARU request for the connections (SRM – priorityCancellation) when the PRG determines that it is likely that the Active Road User has started to cross.
- The iTLC shall not grant an ARU request on a connection before granting or terminating the ARU request of the preceding connection.

Note: The iTLC realises the connections in the requested sequence, considering the travel time from a connection to the next connection in the sequence. How the iTLC does this is outside the scope of this document; this is vendor specific.

3.1.4.4. Demand wait indicator

The iTLC shall activate the demand wait indicator ('drukknop terugmelding') when the signal is red and the Active Road User is within 3 seconds of the signal[3].

Once the demand wait indicator is lit the corresponding signal will go to green, irrespective if the ARU request is cancelled.

3.1.4.5. More than one request

When the iTLC receives ARU requests from multiple Active Road Users (i.e. different stationId's), for the same signal, the iTLC shall act as follows:

- The ARU requests shall be serviced based on the provided ETA. It is up to the iTLC to determine if multiple ARU requests are handled in one or multiple green realisations. The logic used by the iTLC is outside the scope of this specification; this is vendor specific.

[3] The number of seconds may be increased vendor specific.

3.1.5. SSM status

ETSI	Applicable
Unknown(0)	
requested (1)	See D3047-15.
processing (2)	See D3047-15.
watchOtherTraffic (3)	Not used for Active Road Users.
granted (4)	The signal is green and the iTLC expects that the Active Road User will cross during this green (i.e. the Active Road User is close enough to start to cross during this green (ETA < Planned end of green)). If the iTLC produces SPAT timing information the ARU request has been incorporated.
rejected (5)	The ARU request is rejected.
maxPresence (6)	The ARU request is rejected with reason 'maxPresence'. This status can only appear: - if the ARU request is still present at the end of green. - after a timeout exception in the processing status.
reserviceLocked (7)	See D3047-15.

3.1.6. ETA calculation

The PRG shall calculate the ETA as realistic as possible.

- To avoid encouraging of speeding and hence crossing an amber or red light, calculation should be done with a safe speed of the ARU.

The PRG shall periodically check if the ETA has changed:

Approaching	The PRG calculates the ETA and determines that the ETA differs from the previously sent message. - calculated ETA differs by more than 10% of the remaining travel time from the previous ETA sent to the iTLC.
At the signal	The PRG maintains the ETA.

Note: It is assumed that the PRG builds a 'profile' of an Active Road User and that the PRG uses the 'profile' and the actual data from the OBU to calculate the ETA. However, this document does not describe how the PRG should calculate the ETA; this is vendor specific.

Note: The ETA can vary in each ARU update message (SRM priorityRequestUpdate), upwards and downwards.

Note: The quality of the ETA has a direct impact on the optimization performed by the iTLC (i.e. the iTLC uses the ETA in its planning).

Note: It is advised that the road operator implements a KPI on the ETA calculation of ARU requests in UDAP. This will allow a road operator to monitor the quality of the calculated ETA's and to take actions in case the quality is insufficient.

3.1.6.1. ETA calculation for pedestrians

The PRG shall calculate an offsetted ETA, to mitigate the positioning inaccuracy. The offset shall be 5 seconds.

Approaching: The PRG shall add the offset to the calculated ETA, while the pedestrian is approaching the signal.

At the signal: When the PRG determines that the pedestrian has reached the signal (i.e. stopline) it maintains the ETA (irrespective of the actual position of the pedestrian).

Note: The offsetted ETA is used to prevent the issue of a pedestrian getting green too early: the CAM position of the pedestrian is at the signal, but the real position of the pedestrian is still too far away to reach the signal before it switches to red again. Especially in urban areas the GPS position and heading may be inaccurate for walking pedestrians.

3.1.6.2. ETA calculation and order in the sequence on multiple connections

- The ETA for all connections is calculated according to the above-described principle.
- The ETA for the subsequent connections shall be calculated based on free flow condition (i.e. without taking the signal phasing and timing into account).
- The ETA for each subsequent connection must be later than the ETA for its preceding connection.
- The pedestrian ETA offset shall only be applied to the first connection.

3.1.7. Post-Conditions

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3.2. Convoy of Active Road Users (ARU)

3.2.1. Goal

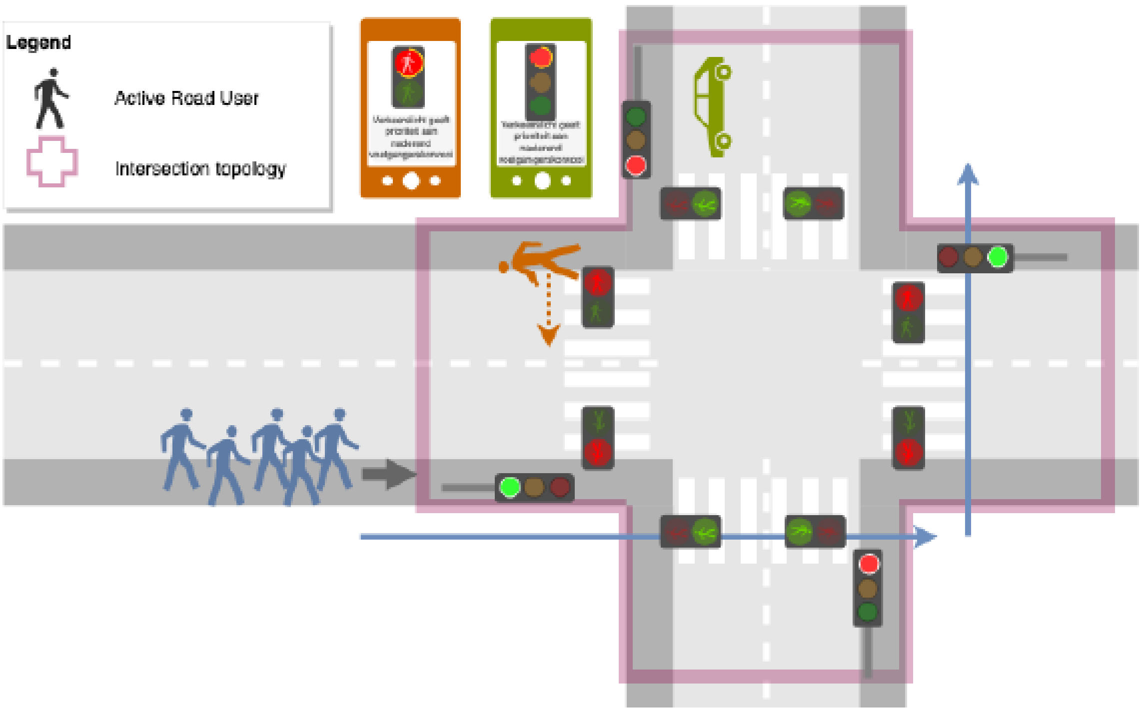
This use case aims to provide a passage, for a group of active road users (aka ARU-convoy), over a signalised intersection without the need to press a button at the signal.

This use case explicitly supports passing more than one connection of the same intersection.
The group is an organised group and all the members of the group shall have the same stationType (i.e. Pedestrian or Cyclist).

Once the first Active Road User in the ARU-convoy has passed the stopline the signal will remain green until the last Active Road User in the ARU-convoy has passed the stopline. An ARU-convoy cannot be interrupted by other road users, except for emergency vehicles requesting absolute priority.

Note: The Active Road Users in an ARU-convoy can use different OBU’s (e.g. Apps) connected to different PRG’s.

Note: Whether an OBU is authorised to be part of an ARU-convoy is subject to governance of the RO. The governance is out of scope of this specification.



3.2.2. Pre-Conditions

- The intersection is controlled by an iTLC that supports the use case ARU-convoy.
- The OBU of the Active Road Users in the ARU-convoy (pedestrian or cyclist) provides the required data.
- At least one CAM-message which is projected on the MAP, with stationType pedestrian(1) or cyclist(2) has been sent to the iTLC for the Active Road User.
- The full chain of the services, including the PRG, is operational.
- All system clocks of the actors are synchronised.
- The PBC has been configured for the intersection to support the ARU-convoy use case (Role = 0; Subrole = 11; requestImportanceLevel=1).
- The PV (Mobilidata only) has been configured to support the ARU-convoy use case.
- All Active Road Users in the ARU-convoy:
    - Must use the same ARU-convoy identification, in the RouteName field.
    - Must request the same connection(s).
    - Must be the same type (i.e. SRM-role, SRM-subRole and CAM-stationType)[4]

3.2.3. Trigger

- Chapter 2.3. Trigger is applicable.

[4] In case an ARU-convoy of cyclist is followed by (f.i.) a trailer car, this car shall use the same Role, Subrole and stationType.

3.2.4. Normal Flow

- Chapter 2.4. Normal Flow is applicable.
- The PRG sends an ARU request (role=default(0), subRole=requestSubRolePlatoon(11) and routeName=Convoy identification), including ETA.
- The iTLC determines, based on subRole= requestSubRolePlatoon(11) that the ARU is a member of an ARU-convoy, and based on the field routeName which ARU-convoy.
- When the head of the ARU-convoy has passed the stopline, the iTLC shall keep the signal green until the tail of ARU-convoy has passed.

- An ARU-convoy request shall not violate the constraints set by the road operator for the intersection. An ARU-convoy request is typically requested for a relatively small group of Active Road Users that can pass the stop line within a time frame of MaxAruConvoy[5] seconds.

3.2.4.1. Convoy identification

The iTLC distinguishes (specific) ARU-convoys based on: Connection and routeName.

An Active Road User that belongs to an ARU-convoy shall provide the convoy identifier in the routeName field (for example: "De Peddelaars").

3.2.4.2. Convoy changes

The iTLC shall dynamically update the ARU-convoy (at real-time) based on the received information (and exceptions). There are many conditions which may change the convoy. The following non-exhaustive list contains some examples:

- The PRG adds a new Active Road User to the ARU-convoy by sending an ARU request to the iTLC.
- The PRG removes an Active Road User from the ARU-convoy by sending a SRM cancellation.
- Exception #4 (SRM Update timeout)
- Exception #5 (ETA increase)
- An Active Road User in the ARU-convoy overtakes another Active Road User in the ARU-convoy (i.e., Active Road Users changing place).
- An Active Road User in the ARU-convoy stops (while others continue).

3.2.4.3. Demand waiting indicator

Chapter 2.4.4. Demand wait indicator is applicable.

[5] MaxAruConvoy is a run-time modifiable parameter in seconds (i.e. IVERA-APP P/MaxAruConvoy). The default value is determined by the RO.

3.2.5. SSM Status

ETSI	Applicable
Unknown(0)	
requested (1)	See D3047-15.
processing (2)	See D3047-15.
watchOtherTraffic (3)	Not used for Active Road Users.
granted (4)	The signal is green and will stay green until all ARU requests for the ARU-convoy have been cancelled. If the iTLC produces SPAT timing information the ARU request has been incorporated.
rejected (5)	The ARU request is rejected.
maxPresence (6)	The ARU request is rejected with reason 'maxPresence'. This status can only appear: - if MaxAruConvoy has expired. - after a timeout exception in the processing status.
reserviceLocked (7)	See D3047-15.

3.2.6. ETA calculation

- Chapter 2.6. ETA calculation (including subsections) is applicable

3.2.7. Post-conditions

- Chapter 2.7. Post-Conditions is applicable.

3.3. Exceptions

The table below indicates which exceptions described in D3047-15 are applicable to the Active Road User use cases outlined in this document.

Generic exceptions	Applicable
Exception #1 (Rejected by iTLC – invalid priority request)	Yes
Exception #2 (Reject – reservice locked - by iTLC)	Yes
Exception #3 (Reject by iTLC)	Yes
Exception #4 (SRM Update timeout)	Yes
Exception #5 (ETA increase)	Yes; See also exception #30
Exception #6 (Reject by iTLC during priority handling)	Yes
Exception #7 (Processing timeout by iTLC)	Yes
Exception #8 (Granted timeout)	see #31
Exception #9 (Vehicle characteristics)	Yes
Exception #10 (Invalid ETA)	Yes; See also exception #30
Exception #11 (Vehicle characteristics have changed)	Yes
Exception #12 (Change in Connection and/or approach at the same intersection)	Yes
Exception #13 (Changed route, not involving the intersection anymore)	Yes; See also exception #30
Exception #14 (No cancellation received by the iTLC)	See #31 and #34

Exception #15 (SSM not received on time)	Yes
Exception #22 (One vehicle convoy)	Yes

3.3.1. Exception #30 (No crossing, approaching, or leaving the intersection)

When the PRG determines that the Active Road User is no longer approaching the intersection or does not want to cross any more (i.e. lingering). The logic used by the PRG to determine this is outside the scope of this specification.

Handling:

- Flow: PRG_end_priorityrequest (see D3047-15).

Note: The PRG is allowed to retry two times.

3.3.2. Exception #31 (End of green before cancellation)

The iTLC has provided green (with SSM status = 'granted') but decides to end the green prematurely (i.e. before the ARU request is cancelled).

Handling:

- Flow: iTLC_reject_max_presence (see D3047-15).

3.3.3. Exception #34 (Request timeout)

The iTLC concludes that a priority request has been in the state requested(1) for more than [5] minutes.

Handling:

- Flow: iTLC_reject (see D3047-15).

3.3.4. Exception #36 (Crossing multiple signals - invalid path)

The iTLC concludes that the path over multiple connections is invalid.
Example:

- There is no path from signal group A to signal group C without crossing signal group B in between
- iTLC receives an ARU request for signal group A.
- iTLC receives an ARU request for signal group C for the same stationId, with the ETA for C later than the ETA for A.
- No request for B has been received within the reception window.

Handling:

- The iTLC sends a message (SSM - rejected) as response to the ARU request for signal group C, to the PRG.
- The iTLC continues processing the ARU request for signal group A.
- The PRG does not retry (i.e. does not send a new ARU request for signal group C).

3.3.5. Exception #37 (Crossing multiple signal groups – Path too long)

The iTLC concludes that the path over multiple signal groups is longer than it can handle.
Example for iTLC support up to 6 signal groups (A-F):

- iTLC has received ARU requests for 7 signal groups A, B, C, D, E, F, G within the reception window (sequence in that order, and path is valid).
- iTLC has responded to all requests with SSM - requested.

Handling:

- The iTLC sends a message (SSM - rejected) as response to the ARU request for signal group G to the PRG.
- The iTLC continues processing the ARU requests for signal groups A-F
- The PRG does not send a new ARU request for G.

Note: The iTLC shall support paths up to at least 6 signal groups.

3.3.6. Exception #38 (Request outside of reception window)

The iTLC receives an ARU request for an extra connection outside of the reception window.

Example:

- iTLC has received ARU requests for the signal group sequence A-B within the reception window (valid path from A to B).
- iTLC has responded to all requests with SSM - requested.
- The reception window has ended.
- iTLC has started processing the requests.
- iTLC receives a request for a connection X

Handling:

- The iTLC sends a message (SSM - rejected) as response to the ARU request for signal group X to the PRG.

Note: The PRG is allowed to retry (i.e. cancel and send a new ARU request for the new sequence (A,B,X or X,A,B)).

3.3.7. Exception #39 (Connection order changed)

The iTLC determines that the ETA order of priority requests for multiple connections for the same stationId has changed.

Handling:

- The iTLC ends the priority service for all requests for the sequence.
- Flow: iTLC_reject.
- The PRG is allowed to retry and send new priority requests for the correct order.

3.3.8. Exception #42 (No new ARU request or retry while a ARU request for the intersection is active)

The PRG wants to initiate an ARU request or wants to retry an ARU request, while an ARU request for the same intersection/stationId is active.

Handling:

- The PRG needs to wait until active ARU request(s) have been completed or rejected.

3.3.9. ARU-convoy exceptions

In document [1] on CROW several convoy exceptions are described. The following are applicable for ARU convoy:

- Exception #22: One vehicle convoy
- Exception #24: conditional priority - extension
- Exception #25: Convoy lock timeout;
    - A separator parameter MaxARUConvoy has to be set.
- Exception #26: convoy priority versus absolute priority
- Exception #27: convoy priority versus special condition

3.3.9.1. Exception #22 (one ARU convoy)

The iTLC detects that the convoy consists of only one Active Road User.

Handling:

- The iTLC shall not apply the ARU convoy use case and reply with the status SSM-requested (until the convoy consists of at least two Active Road Users).

3.3.9.2. Exception #23 (ARU convoy too long)

The iTLC sees an ARU convoy approaching the intersection. The iTLC estimates (based on the status of the ARU convoy) that the convoy cannot pass the intersection within the maximum time (MaxAruConvoy) defined by the road operator (RO).

Handling:

- Flow: iTLC_reject (see D3047-15).

3.3.9.3. Exception #24 (extension)

The iTLC sees an ARU convoy approaching the intersection during green. The first Active Road User in the convoy can still stop. The iTLC estimates that green extension would violate the constraints of the intersection set by the RO (i.e., violate maximum wait times).

Handling:

- The iTLC shall stop the ARU convoy and let the convoy pass the intersection in the next green realisation.

3.3.9.4. Exception #25 (ARU convoy lock timeout)

The iTLC has locked the traffic control for an ARU convoy for too long (i.e., the first road user in the ARU convoy has passed the stopline and the signal is green), longer than the maximum time (MaxAruConvoy) defined by the road operator (RO).

Handling:

- The iTLC ends the ARU convoy service.
- Flow: iTLC_reject_max_presence (see D3047-15).

3.3.9.5. Exception #26 (convoy priority versus absolute priority)

The iTLC receives a conflicting absolute priority request while it is servicing an ARU convoy (i.e., the signal is green).

Handling:

- The iTLC shall keep the signal green until the road users in the convoy that received SSM-granted have passed the stopline.
- The iTLC ends the service for the ARU convoy (even though not all road users in the convoy have passed the stopline).

3.3.9.6. Exception #27 (ARU convoy versus special condition)

The iTLC detects a special condition while it is servicing an ARU convoy (i.e., the signal is green). Examples of special conditions are: Bridge open, Tunnel closed, Railway crossing, etc.

Handling:

- The iTLC ends the service for the ARU convoy
- Flow: iTLC_reject.

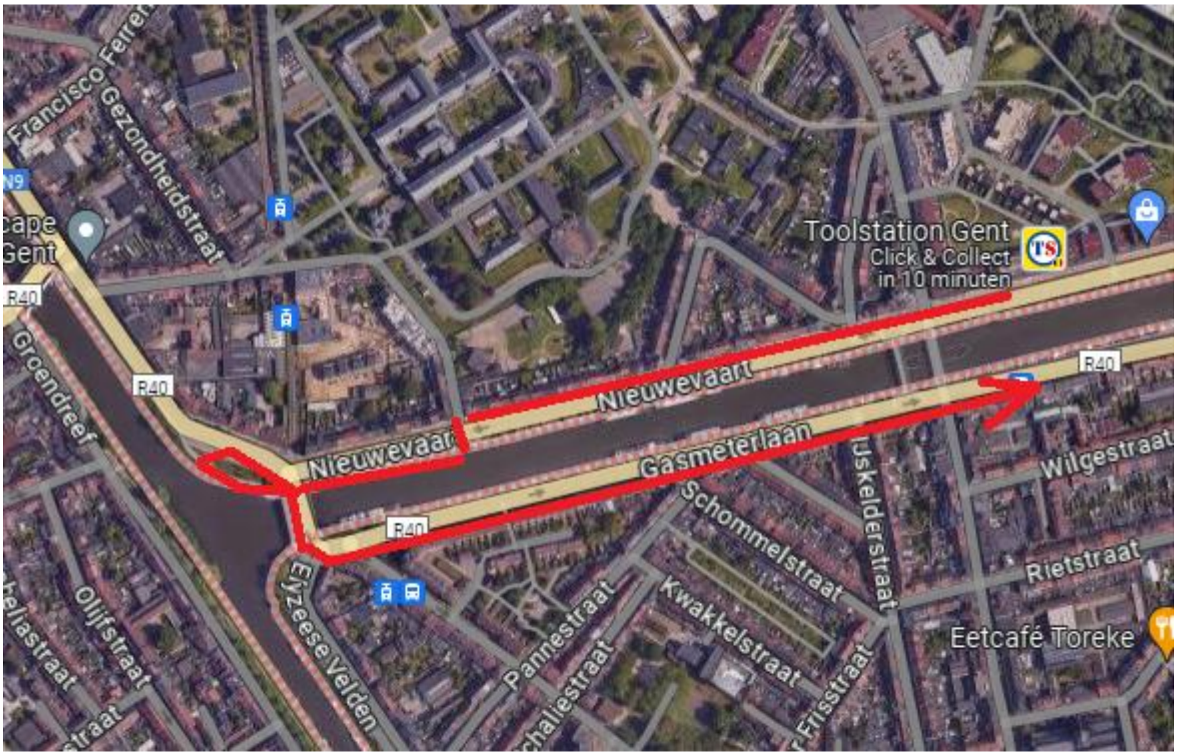
Note: The iTLC also provides a reason for delay in the SPAT data in this case.

3.4. Lessons Learned

3.4.1. Avoid short loops during testing

Avoid short loops during testing: in that case there can be a priority request in 90 seconds which will be rejected by exception #36.

An example of such a loop is:



Since this is not realistic in normal use, avoid these loops to avoid unpredictable results.