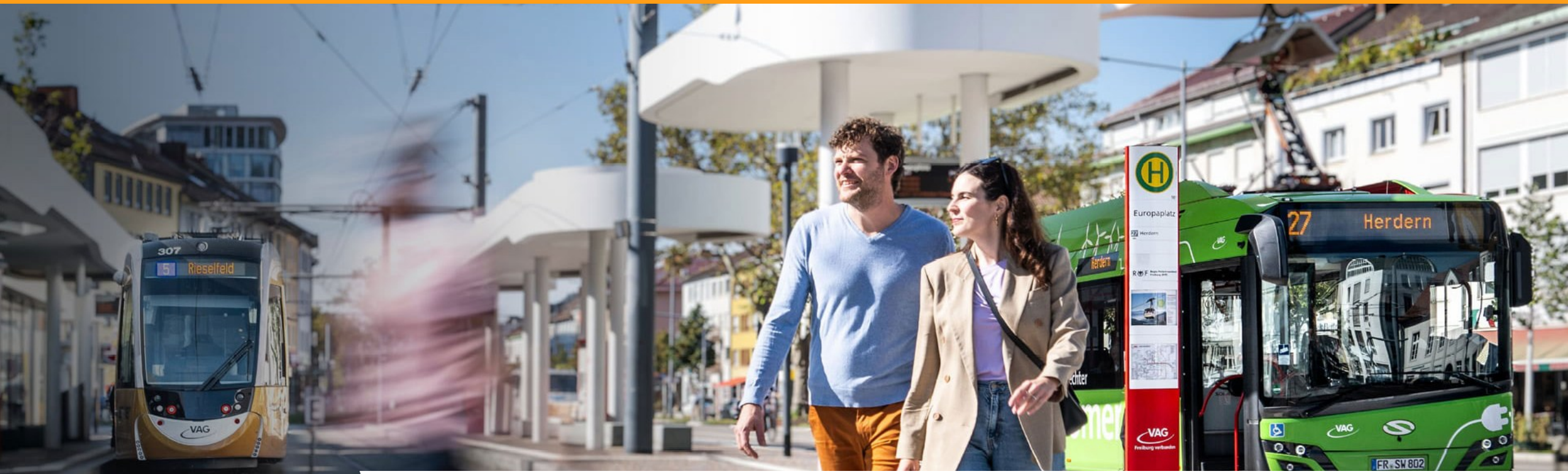


Integration of ITCS IBIS with V2X OBU

PTX Interface

Dominique Müller (Trapeze) – 07.11.2025

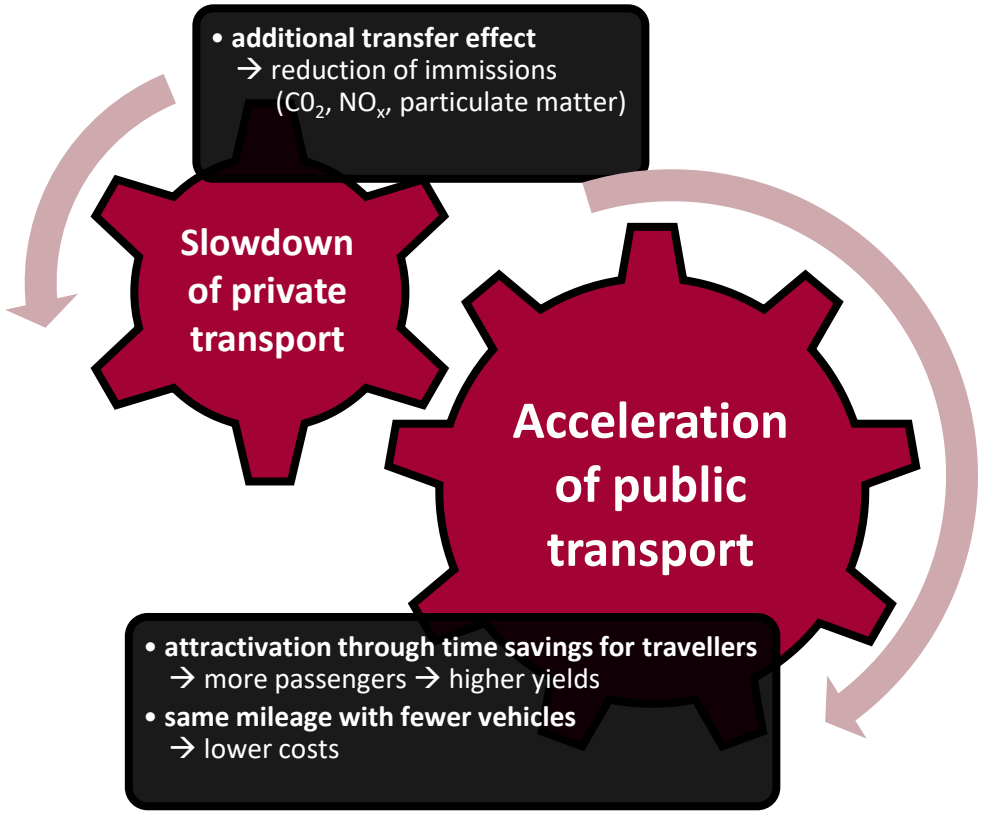
#GemeinsamMenschenBewegen


SCHWARZWALD
CITY
Mein Einkaufszentrum
Nur 1 Minute von hier!
SATURN
Hier rechts!
ZONE
27 Herdern
100% Stromer

Use Cases

What Does V2X Promise for Public Transport?

Conventional public transport priority at traffic lights



Continuous Communication

no reporting points
→ less effort for data supply
→ allows flexible dispatching

continuous ETA update
→ reduction of «wasted green»

Driving Assistance

Energy-optimised approach to junction
→ energy savings up to 30% (*)

Time-optimised departure from stop
→ increased customer satisfaction

Timely lane change
→ smoother traffic

Additional benefits thanks to V2X

Global Standard

→ interaction with private vehicles

→ not limited to traffic light priority

Warnings

→ increased safety

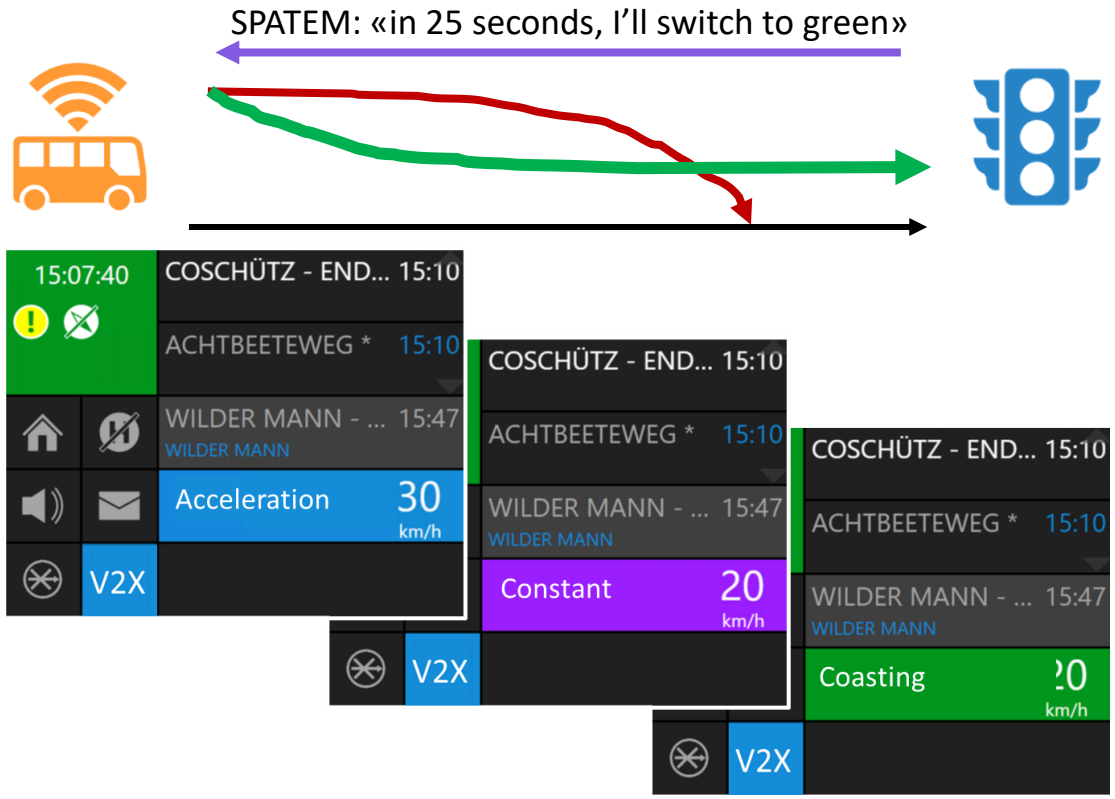
- approaching emergency vehicles
- oncoming traffic in bottlenecks
- dangerous road conditions, construction sites
- vulnerable road users in the blind spot
- etc.

(*) Christian Gassel, DVB, C-ITS Forum 2024

Use Cases for V2X in Public Transportation

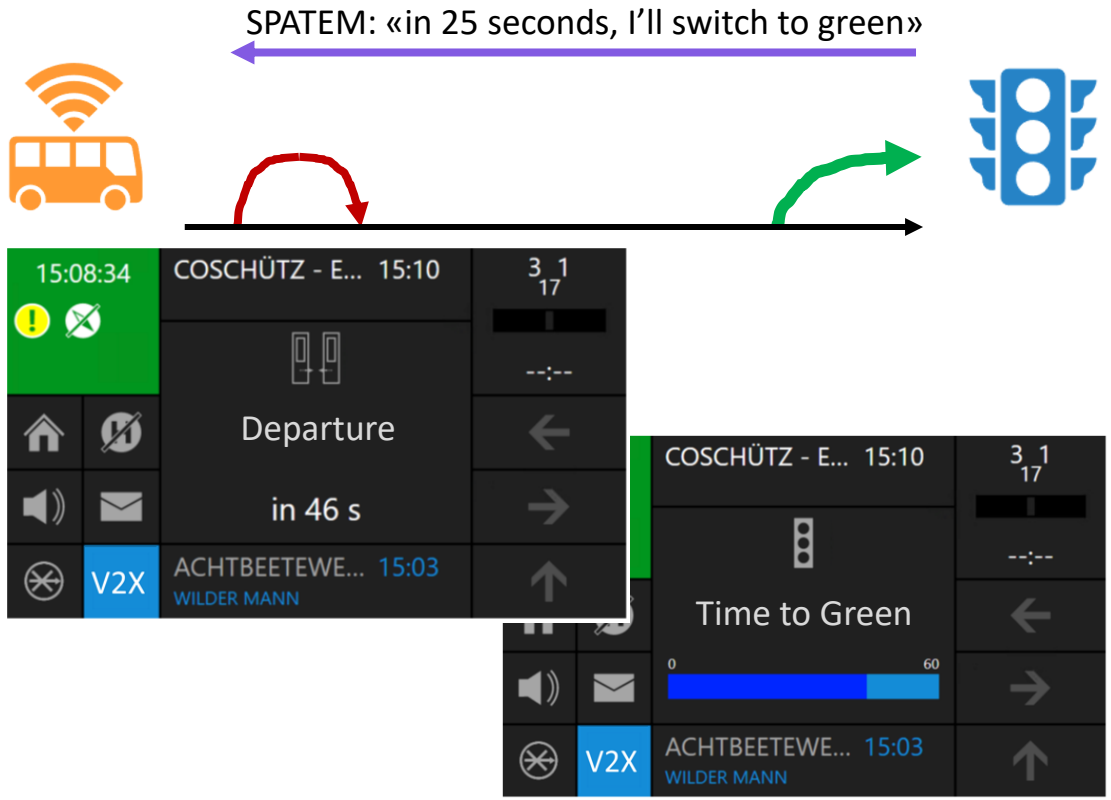
Energy-optimsed Approach to Junction

→ carry momentum



Time-optimised Departure from Stop

→ carry passengers

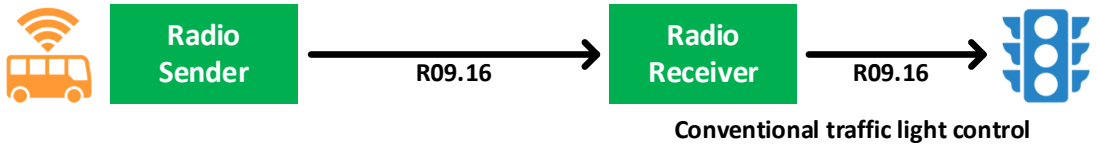


Architecture

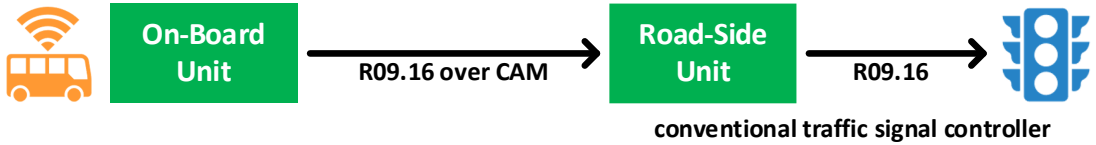
Traffic Light Priority Migration from VDV 420/426 (R09.16) to V2X

Switch from analogue or digital radio to V2X – coordinated between municipality and public transport company

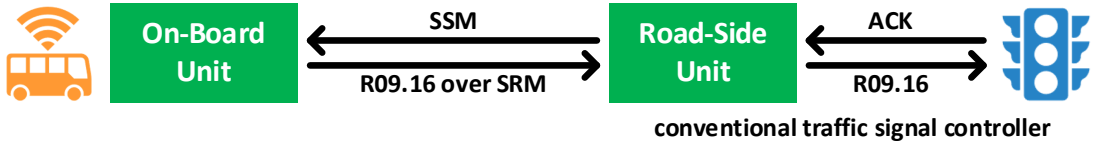
Current Situation: VDV 420 (analog) or 426 (digital)



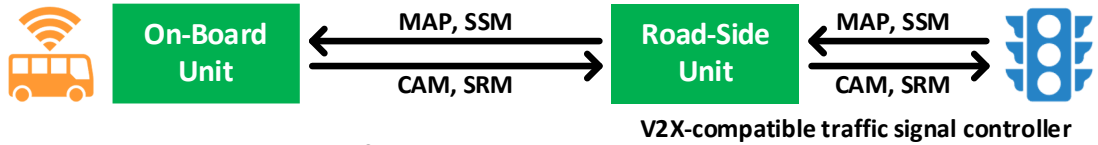
Stage 1A: Conversion of radio link (uni-directional)



Stage 1B: Conversion of radio link (bi-directional, hopping)

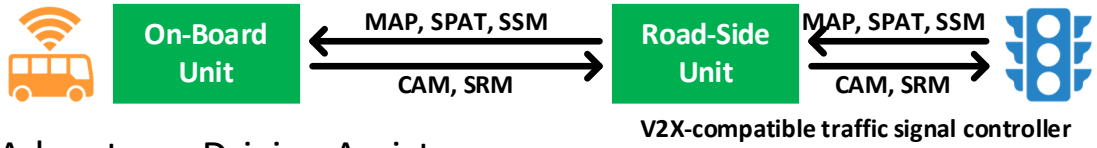


Stage 2A: Traffic Signal Priority with V2X



Advantage: No need for reporting point chains
→ less effort for data preparation
→ flexible dispatching (e.g. path dispatch) becomes possible
→ reduced waste of «green» thanks to continuous ETA updates

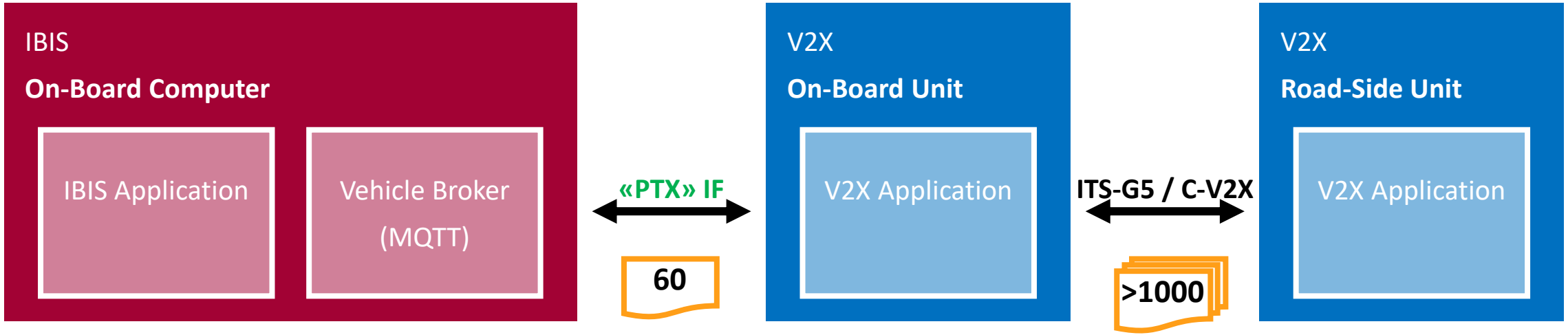
Stage 2B: Traffic Signal Priority incl. Signal Phase Assistance



Advantage: Driving Assistance
→ traffic becomes smoother, safety increases
→ energy savings and increased passenger satisfaction

BASt-Handlungsempfehlung: «Nutzung der C2X-basierten ÖV-Priorisierung an signalisierten Knotenpunkten» (Kap. 3.3)

De-Central Traffic Light Priority



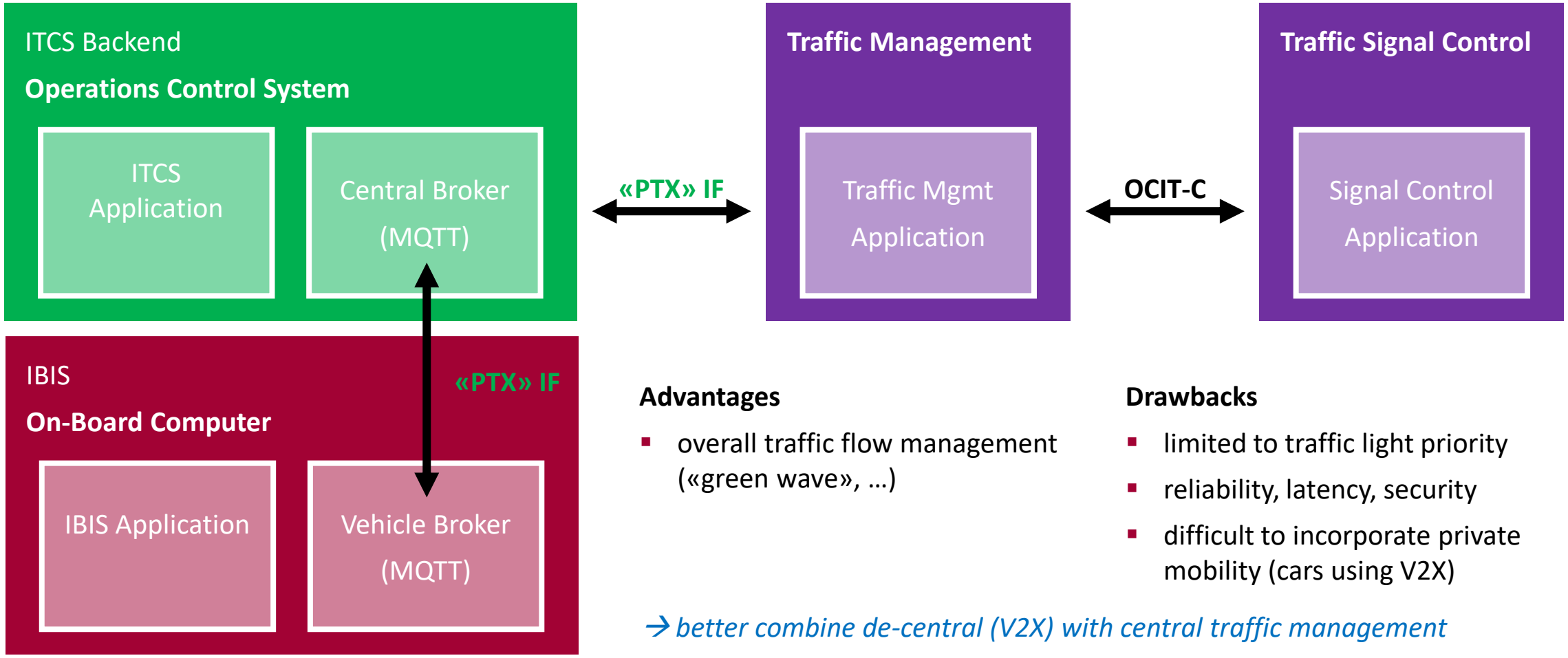
Tasks of IBIS on-board computer

- location tracking (linear and geographical)
- communication with control system
- driving support (timetable deviation, sat nav)
- passenger information in and on the vehicle
- integration of peripheral devices (passenger counters, validators, …)

Tasks of the V2X on-board unit

- communication with V2X road-side unit via air interface (ITS-G5 or C-V2X)
- communication with IBIS via Ethernet
- mediation between IBIS and V2X «worlds» (significant complexity reduction for IBIS)

Central Traffic Light Priority



Advantages

- overall traffic flow management («green wave», …)

Drawbacks

- limited to traffic light priority
- reliability, latency, security
- difficult to incorporate private mobility (cars using V2X)

→ *better combine de-central (V2X) with central traffic management*

PTX Interface

Device Management and Logging (= «the basics»)

IBIS-to-Device

- **Power State** – information about the current power level and about foreseeable «power off»
- **Log Level Configuration** – instruction to the device to publish log messages to the broker
- **Command Trigger** – instruction to the device to «do something» (e.g. reboot)

Device-to-IBIS

- **Power Request** – request to keep «power on» for some time (including need for comms)
- **Log Messages** – publishing of log messages
- **Device Presence** – tells if the device is connected to the broker (including last-will-and-testament)
- **Device Version Info** – version info about device and its components (intended for fleet repository)
- **Device Health Info** – health info about the device (intended for fleet monitoring)

Why? – Device management and logging is required for the V2X OBU to be part of a well-managed on-board network

Operational Information (= «the auxiliaries»)

IBIS-to-Device

- **Vehicle Info** – static information about the vehicle

- **Operational Logon** – logon info with IDs traceable back to VDV452 (changes once per journey)
- **Operational Journey** – full details about the current journey (changes once per journey)
- **Operational Status** – geo and «logical» location, door status, … (changes frequently along the journey)

Device-to-IBIS

(none)

Why? – Vehicle Info and Operational Status will directly apply to certain outgoing V2X messages (e.g. CAM); Operational Info in general might be useful for the OBU to provide certain value-added features

V2X-Specific Messages (= «the essence»)

IBIS-to-OBU

- **Configuration** – enabling and disabling of features including air interface mirroring on a per-message basis

- **R09 Request** – 1:1 copy of the city-specific R09 telegram which is sent over analog or digital radio --> can be sent over CAM or SRM

- **Path Definition** – the geometric path the vehicle will travel (= next few kilometers, or the path taken on the current journey)
- **Path Location** – the location of the vehicle on the path (= some kind of «logical location»)

OBU-to-IBIS

- **Capabilities** – advertisement of the services and messages supported by the OBU (= basis for configuration message)

- **R09 Response** – [only if SRM is used] the responses (SSM) from the junction controller

- **Intersection Map** – static info about junction (lanes, layout, signal groups, ingress/egress connections, …)
- **Intersection Phase** – real-time information about signal phases (current, phase next few phase)
- **Intersection Status** – lane assignment and signal status (assigned lane)

Why? – R09 Request and Response enable migration scenarios; Intersection Map/Phase/Status and Path Definition and Location enable the «reporting point free» traffic light priority and assistance for energy- and time-optimised driving

Air Interface Mirroring (= «the engineer's dream»)

OBU-to-IBIS

- Sent Over-the-Air Messages – as transmitted over ITS-G5 or C-V2X
- Received Over-the-Air Messages – as received over ITS-G5 or C-V2X

OBU Storage (not on MQTT broker)

- PCAP Dumps
  - to be retrieved via HTTP or other means
  - can be directly analysed with WireShark (no plug-in required)

Why? –
Air interface mirroring allows lower-level functional testing, verification of RSU messages (e.g. MAP, SPAT), and general discovery of «what is in the air» (e.g. CAM, SREM, IVIM), leading to increased understanding and hopefully further innovation – can be easily forwarded to the backend system in real-time if desired
PCAP dumps are ideal for detailed analyses by communication specialists

Proposals


SCHWARZWALD
CITY
Mein Einkaufszentrum
Nur 1 Minute von hier!
SATURN
Hier rechts!
ZONE
27 Herdern
100% Stromer

PTX for Emergency Vehicles?

Similarities to Public Transport

- vehicle needs priority
- vehicle is dispatched to a specific location
  - route is known
  - ingress and egress lanes can be derived for each intersection

Precondition: On-board Computer

- connected to OBU over MQTT
- receives dispatch instructions from control centre
- on-board calculation of routing (needs not be lane precise)
- subset of PTX messages

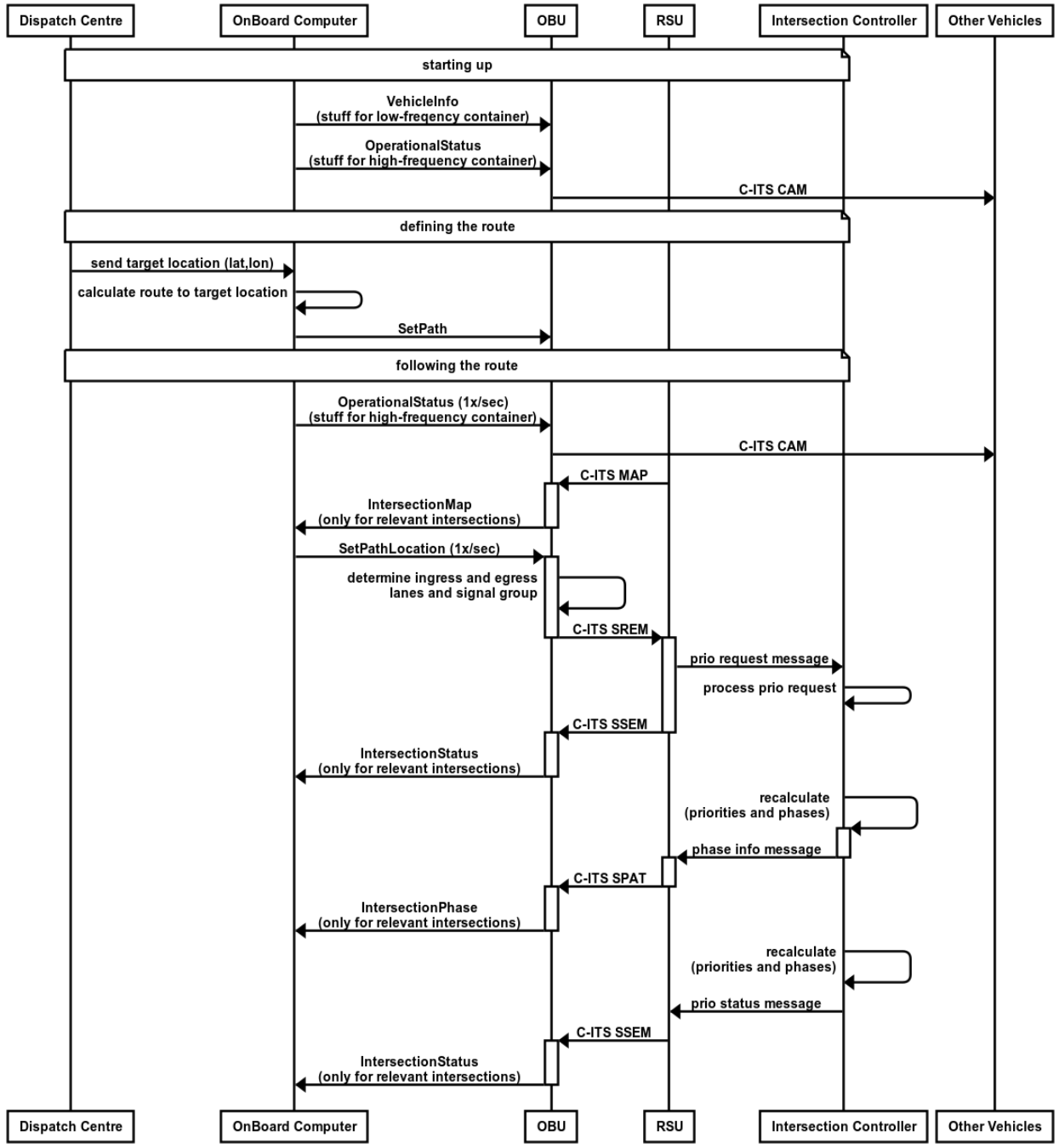
PTX for Emergency Vehicles?

Minimal Effort

- 4 messages to be sent by OBC
- 3 messages to be handled by the OBC

Benefit

- emergency vehicles can request priority towards their target location
- no need to shut down the complete intersection when emergency vehicle is approaching
- traffic in front of emergency vehicle can move away
- impact on other traffic is reduced



www.websequencediagrams.com

R09-over-CAM – current state

CAM: uses «PtActivation»

```
PublicTransportContainer ::= SEQUENCE {
  embarkationStatus EmbarkationStatus,
  ptActivation PtActivation OPTIONAL
}

PtActivation ::= SEQUENCE {
  ptActivationType PtActivationType,
  ptActivationData PtActivationData
}

PtActivationType ::= INTEGER {
  undefinedCodingType (0),
  r09-16CodingType    (1), -- conforms to VDV420
  vdv-50149CodingType (2)  -- is based on VDV420
} (0..255)

PtActivationData ::= OCTET STRING (SIZE(1..20))
```

Evaluation

- 1:1 implementation of BASt recommendation: «R09 over C-ITS» (i.e. change of transport)
- city-specific “misuse” of VDV420/426 can be dealt with with zero effort (same byte array)
- integration with legacy intersection controller should be simple (forward the R09 octet string)

R09-over-SREM – current state

SREM: uses «OcitRequestorDescriptionContainer»

```
RequestorDescription ::= SEQUENCE {
  id VehicleID,
  type RequestorType OPTIONAL,
  position RequestorPositionVector OPTIONAL,
  name DescriptiveName OPTIONAL,
  routeName DescriptiveName OPTIONAL,
  transitStatus TransitVehicleStatus OPTIONAL,
  transitOccupancy TransitVehicleOccupancy OPTIONAL,
  transitSchedule DeltaTime OPTIONAL,
  regional SEQUENCE (SIZE(1..4)) OF <cut> OPTIONAL,
  ...,
  ocit OcitRequestorDescriptionContainer
}

OcitRequestorDescriptionContainer ::= SEQUENCE {
  reportingPoint ReportingPoint OPTIONAL,
  priorityLevel PriorityLevel OPTIONAL,
  length TrainLength OPTIONAL,
  route RouteNumber OPTIONAL,
  line LineNumber OPTIONAL,
  direction TransitDirection OPTIONAL,
  tour TourNumber OPTIONAL,
  version VersionId OPTIONAL,
  ...
}
```

Evaluation

- not a change of transport, but a new spec
- allows harmonized analysis and reporting (performance of traffic flow management)
- attributes do not match VDV420/426 (or 452)
  - different naming
  - different bit length
- city-specific “misuse” of VDV420/426 is absent
- integration with legacy intersection controller requires city-specific reconstruction of R09 message (but some attributes will be missing)

R09-over-SREM – proposal

Option A) Add «PtActivation» to OcitContainer

```
OcitRequestorDescriptionContainer ::= SEQUENCE {
  reportingPoint ReportingPoint OPTIONAL,
  priorityLevel PriorityLevel OPTIONAL,
  length TrainLength OPTIONAL,
  route RouteNumber OPTIONAL,
  line LineNumber OPTIONAL,
  direction TransitDirection OPTIONAL,
  tour TourNumber OPTIONAL,
  version VersionId OPTIONAL,
  ...,
  ptActivation PtActivation OPTIONAL
}
```

Evaluation

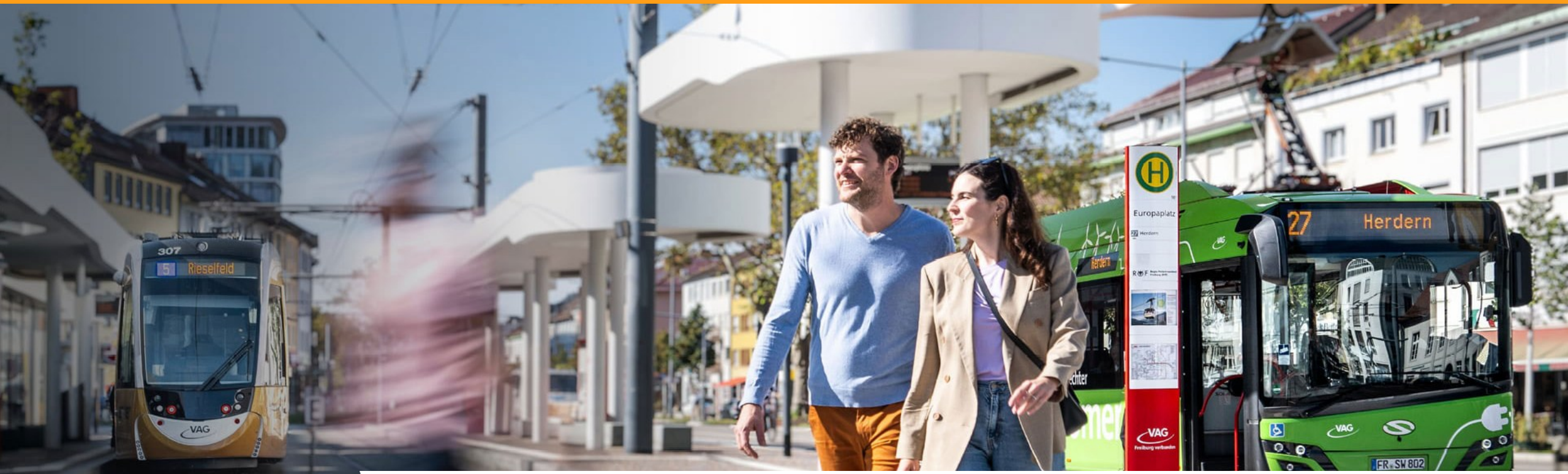
- city-specific R09 message can be forwarded to junction controller (same as R09-over-CAM)
- attributes can be used for statistical analysis (= improvement)

Option B) Add «PtActivation» to SREM directly

```
RequestorDescription ::= SEQUENCE {
  id VehicleID,
  type RequestorType OPTIONAL,
  position RequestorPositionVector OPTIONAL,
  name DescriptiveName OPTIONAL,
  routeName DescriptiveName OPTIONAL,
  transitStatus TransitVehicleStatus OPTIONAL,
  transitOccupancy TransitVehicleOccupancy OPTIONAL,
  transitSchedule DeltaTime OPTIONAL,
  regional SEQUENCE (SIZE(1..4)) OF <cut> OPTIONAL,
  ...,
  ocit OcitRequestorDescriptionContainer,
  ptActivation PtActivation OPTIONAL
}
```

Evaluation

- same as adding to OcitContainer
- might be quicker, as only ETSI is concerned (OcitContainer: first VDV/OCA, then ETSI)



Thank you for your attention.

Do you have any questions?

HERMAN

IVU TRAFFIC TECHNOLOGIES

Trapeze™

YUNEX TRAFFIC