# Functional requirements for EasyGo+ OBUs

## Enclosure A to Document 202
## “Roadside and on board equipment”

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# Document revision history

| Version | Date | Author | Main changes |
|---|---|---|---|
| | | HHA | Source: ASFINAG "IOP_OBU_requirements_V10_100128" |
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| | | | |
| | | | |

# Abbreviations

| Abbreviation | Definition | | Abbreviation | Definition |
|---|---|---|---|---|
| AID | DSRC-Application Entity Identifier | | MAC | Medium Access Control |
| APDU | Application Protocol Data Unit | | MAC | Message Authentication Code |
| AttrID | Attribute Identifier | | MAS | Toll station |
| BST | Beacon Service Table | | MEAcK | MasterElementAccessKey |
| CE | Conformity Declaration | | MEAuK | MasterElementAuthenticationKey |
| CEN | European Committee for Standardization | | MEDIA | International interoperability project (for reference only) |
| CI | Contract Issuer = Toll Service Provider (TSP) | | MLW | Maximum Laden Weight |
| DES | Data Encryption Standard, ANSI X3.92 | | MMI | Man Machine Interface |
| 3DES | Triple Data Encryption Standard | | MSB | Most Significant Bit |
| DSRC | Dedicated Short Range Communication | | OBE | On-Board Equipment |
| EAcK | ElementAccessKey | | OBU | On Board Unit |
| EAuK | ElementAuthenticationKey | | OSI | Open Systems Interconnection |
| EFC | Electronic Fee Collection | | RF | Radio Frequency |
| EID | Element Identifier | | RoHS | Restriction of Hazardous Substances Directive 2002/95/EC |
| FCS | Frame Check Sequence | | RSE | Roadside Equipment |
| HDLC | High Data Link Control | | SKE | Stationary checking device |
| HF | High Frequency | | TC | Toll Charger |
| HGV | Heavy Goods Vehicle | | TSP | Toll Service Provider, Contract Issuer (CI) |
| LED | Light Emitting Diode | | UI | User Interface (= MMI) |
| LID | Link Identifier | | VST | Vehicle Service Table |
| LLC | Logical Link Control | | WEEE | Waste Electrical and Electronic Equipment Directive 2002/96/EC |
| LSB | Least Significant Bit | | | |

# 1 Introduction

In order to offer interoperable toll services, Toll Service Providers (Contract Issuers (CI)) have to issue approved, certified and personalised on board equipment to their customers.

The electronic tolling systems of EFC operators have different technical requirements for on board equipment. This document refers to the requirements of CEN DSRC systems acc. to EN15509 considering also special demands of the affected Toll Chargers.

## *1.1 Objectives*

This document provides functional requirements for a CEN DSRC on board unit (OBU) acc. to EN15509 for usage in interoperable context in EasyGo. Consequently, this document shall enable Toll Service Providers (TSP) to select suitable CEN DSRC OBUs for operation in this context.

This document lists some essential requirements as well as recommended solutions for problems that might occur in specific situations or in some EFC systems.

Information and requirements about personalisation and configuration data and the detailed transaction specification for tolling/enforcement and personalisation will be handled in separate documents:

- Personalisation and configuration data is described in: “OBU personalisation, configuration and operation data description” [OBU_data],
- DSRC transaction for tolling and enforcement is specified in: “DSRC transaction for tolling and enforcement” [DSRC]
- DSRC transaction for personalisation is specified in: : “DSRC transaction for personalisation” [DSRC_P]” (OBU model dependent)

As it never can be guaranteed that referenced specifications or standards are conflicting, ambiguous, incomplete or unintentionally leave room for interpretation, the supplier is obliged to contact the purchasing TSP for clarification.

## *1.2 Core requirements*

The OBU shall provide a platform for services and functions available in the framework of a CEN DSRC communication within a vehicle. Furthermore, the OBU shall represent the interface to the user offering MMI functionalities.

**Multilane free-flow ability**
The OBU must be able to communicate in a multilane environment with overlapping communication zones using different RF-channels. The performance of the OBU must not decrease due to the multilane free-flow functionality.

**Testing**

The various technical requirements of different CEN DSRC EFC systems necessitate extensive testing of the OBU functionalities. Tests in laboratory, at test site and on-the-road will have to be performed in every CEN DSRC system where the OBU should be used.

Passing of all required tests will have to be proven by submitting detailed test reports.

Test specifications are available on request.

# 2 CEN DSRC

## 2.1 DSRC Interface

### 2.1.1 General

The OBU supports CEN compatible DSRC communications at 5,8 GHz and must conform to **EN 15509** [IAP]. This implies indirect reference to the following standards (in their latest versions):

The following standards are supported:

- Layer 1: **EN 12253** [L1]
- Profile definition: **EN 13372** [Profiles]
- Layer 2: **EN 12795** [L2]
- Layer 7: **ISO15628/ EN 12834** [L7]
- Application Interface for EFC: **EN 14906** [EFC API] and **EN 14816** [AVI No]

### 2.1.2 Layer 1 – Physical layer

The OBU must conform to EN 15509 [IAP] (this implies indirect reference to EN 12253 [L1]).

All 4 downlink channels shall be supported (D1 in EN 12253 [L1]). The OBU must be able to handle simultaneous radiation of different carrier frequencies in case of overlapping communication zones of neighbouring beacons.

Physical layer parameter set L1-B shall be supported (see also **Profiles**).

### 2.1.3 Profiles

The OBU must conform to EN 15509 [IAP] (this implies indirect reference to EN 13372 [Profiles]).

DSRC profiles 0 and 1 shall be supported.

Set L1-B (“Set B OBU”) of EN 13372 [Profiles] of alternative physical layer parameter values has to be selected.

### 2.1.4 Layer 2

The OBU must conform to EN 15509 [IAP] (this implies indirect reference to EN 13372 [Profiles]).

All layer 2 functions, as required in [Profiles] shall be supported.

### 2.1.5 Layer 7

The OBU must conform to EN 15509 [IAP] (this implies indirect reference to EN 12834 [L7]).

The following **T-APDU** are supported:

- Initialisation
- Get
- Set
- Action
- Event-Report

According to EN 15509 [IAP] the following DSRC layer 7 features shall be supported:

- **Concatenation** of multiple consecutive T-APDU fragments in one L2 frame (i.e. LLC-service) with and without chaining, if the size constraints for the LLC-frames are not violated (i.e. fit into 1 L2 frame);
- **Fragmentation** header length: 1 octet;

Valid combinations of APDUs are listed in EN 13372 [Profiles].

### 2.1.6 Application interface for EFC

The table below specifies the EFC functions that are supported according to [L7] and EFC API] as actions:

| Name | Action Type | Action Parameter | Response Parameter | Remarks |
|---|---|---|---|---|
| Get_Stamped | 0 | GetStampedRq | GetStampedRs | retrieves data with an authenticator from the OBE |
| Get_Nonce | 6 | - | Octet String | Reads a random number generates by OBU<br>Optional, not used in the Austrian system |
| Set_MMI | 10 | SetMMIRq | - | invokes an MMI function (e.g. signal Ok via buzzer) |
| Echo | 15 | Octet String | Octet String | OBU echoes received data |

**Table 1 Action functions**

### 2.1.7 Frame structure

Content of the fill bits = ”0”

Maximum length of frame = 128 Byte

The combinations of frames supported by the OBU are listed in EN 13372 [Profiles].

### 2.1.8 OBU internal states and processes

To guarantee OBU interoperability during transactions, the

- states
- state transitions
- events
- internal OBU actions

defined in EN 15509 [IAP] shall be implemented.

In case of doubt, reference is made to [GSS].

## 2.2 Application

The OBU shall support any CEN DSRC post pay transaction whose attributes, parameters, functions and security features are according to this document, [IAP] and "[OBU_data]".

The transaction is permitting data exchange for tolling, enforcement and personalisation/ re-personalisation via the DSRC interface.

### 2.2.1 Data elements

Data elements are defined in this document, [IAP] and "[OBU_data]".

For tariff calculation, different information (different attributes) is needed in the different systems of EFC operators. Data to be stored into the OBU's attributes is defined in [OBU_data]

In order to allow a correct calculation of tariff and avoid being enforced, some EFC systems need up-to-date information stored in OBU's attributes (e.g. in case a trailer is coupled with a truck).

### 2.2.2 Tariff calculation based on number of axles

For enabling the Road Side Equipment (RSE) to calculate the correct tariff, it is necessary that the related attributes in the OBU contain up-to-date values. In a toll context, where the tariff is based on the number of axles, a mechanism is required to modify the relevant attribute's values, when e.g. a trailer is attached to the tractor unit (otherwise the OBU must be personalised with data for the maximum tariff class to avoid enforcement).

Such a mechanism shall be realised by a push button on the OBU which enables the modification of the trailer presence bit in the attribute VehicleClass as well as the value of the number of axles of trailer in the attribute VehicleAxles (see also chapter 0 and [OBU_data]). This applies independently of the settings in VehicleClass.

[The trailer presence bit in the attribute VehicleClass shall be set/reset automatically by the OBU logic, depending on the value in VehicleAxles.VehicleAxlesNumber. NumberOfAxles.TrailerAxles.

## 2.3 Security

### 2.3.1 Keys

The OBU can store at least:

- eight AuthenticationKeys
- one AccessKey

Updating the OBU keys is possible at any time with the personalisation transaction (as defined in [DSRC_P].

### 2.3.2 Data security and encryption

**Access credentials**

The OBU shall support both security level 0 and 1 acc. to EN15509, allowing selection of operating mode at personalisation.

Use of access credentials means that each attribute holds specific read and write protection rights - the OBU grants access to an attribute only if access credentials corresponding to its individual protection level are presented by the requesting layer 7 function).

The following protection levels shall be supported:

- No protection (free read and write operations)
- Password protection
- DES protection
- 3DES protection

Access credentials are calculated according to [IAP].

The AccessCredentials parameter is supported in the following functions:

- Get
- Get_Stamped
- Get_Instance
- Set

### 2.3.3 Authentication

Authentication is obtained by the GET_STAMPED command.

The RSE can require authentication from the OBU. For this purpose, the Get_Stamped function is used. In this case, the OBU will authenticate the requested data.

For details see also [IAP] and [DSRC].

### 2.3.4 Speed of security calculations

In order to support free-flow systems the OBU shall execute security calculations with sufficient speed such that the transaction duration is successfully completed in less than 70ms. The transaction duration is measured in the communication zone of any free-flow RSE from the first BST message to the reception of a RELEASE or ECHO message.

### 2.3.5 Protection of code, data and keys

If the architecture of the OBU allows in principle readout of code or data e.g. for debugging purposes on test OBUs, this must not be possible for units delivered for customer use.

All keys stored in the OBU shall be protected against unauthorised read out. There shall be no read access to AuthenticationKeys as well to AccessKeys.

## 2.4 Remarks and requirements

### 2.4.1 Multilane free-flow ability

Tests have shown that some existing OBU types have troubles under multilane free-flow conditions. The main requirements are:

The OBU shall support all 4 downlink channels (D1 in EN 12253 [L1]).

Physical layer parameter set L1-B shall be supported (see also [Profiles]).

The OBU must be able to handle - without decrease of its performance - simultaneous radiation of different carrier frequencies in case of overlapping communication zones of neighbouring beacons.

### 2.4.2 Slow response (late response)

When the OBU cannot send an answer frame to a request frame in the allocated private uplink window, the late response procedure will be used. This means use of DATA_1 and DATA_2 states in the Interlayer Management and request of a private window, followed by a late response issued via an UI LLC Service.

In case of OBUs using “late response” the supplier is obliged to ensure proper interacting with the RSE e.g. in Austria.

Therefore it is strongly recommended not to use late response procedures.

### 2.4.3 SET_MMI.request command

Due to ambiguities in previous versions of the standards the OBU shall accept SET_MMI.request command with ActionParameter (Container Type) “0” (“Integer”) as well as “45”(hex) / “69”(dec).

### 2.4.4 Data storage

Personalisation and transaction data shall be stored in a way that data integrity is ensured under all operating conditions, including battery low-voltage situations.

In situations where data integrity cannot be guaranteed, the OBU shall not respond on the DSRC link (i.e. in case the OBU cannot ensure that stored data are correctly retrieved or that received data are correctly stored).

It must be assured, that transaction data written to OBU are corresponding to the transaction data of the RSE.

### 2.4.5 Multiple transactions

The OBU shall not produce more than one transaction inside the RSE communication zone, even for a longer period.

The OBU shall not produce a second or multiple communications after a power-off followed by a power-on of the OBE staying inside the RSE communication zone.

# 3 Personalisation and initial settings ex works

## 3.1 General

The OBU shall support personalisation via DSRC interface.

In the personalisation process, relevant data (vehicle data, payment data, contract data, equipment data, keys) are stored into the OBU via personalisation equipment. For details on personalisation data (attributes, keys) see [OBU_data].

The OBU shall support the related DSRC personalisation transaction and security mechanisms.

## 3.2 AID

For preventing unintentional DSRC communication between de-personalised OBUs and road side equipment, at manufacturing the OBU has to be set into a mode in which it does not respond to a BST containing only AID=1 (e.g. the value of the AID of de-personalised OBUs could be set - ex works - to “0”).

During the personalisation process the OBU has to be set into a mode in which it does respond to a BST containing AID=1 (e.g.by setting AID of OBU to “1”; when the OBU is terminated by using a DSRC termination transaction, the AID is then set to “0” again).

## 3.3 Keys

De-personalised OBU shall contain a manufacturer key which will be replaced with the operating keys in the personalisation process. The OBU supplier will have to hand over the manufacturer key to the purchaser for the purpose of OBU personalisation. In case of OBU termination by using the termination transaction, the operating keys will be replaced with the manufacturer key allowing the supplier / manufacturer of the OBU to read out data for fault analysis purposes (all contract data will be deleted and the AID shall be set to “0” in termination process).

Keys and passwords, stored into the OBU in personalisation process, shall be deleted in termination process.

It shall be possible to select and change the master keys to be used for deriving the individual keys to be stored into the OBU.

The AC_CR_KeyReference for a personalised OBU shall be random. Either the AC_CR_KeyReference of the concerned EFC element is preset randomly ex works, or there must be a possibility to set it randomly at first personalisation.

## 3.4 Preset data ex works

Aside from above mentioned settings ex works following attribute data shall be preset ex works, if not other agreed with the purchaser:

TypeOfContract: FF 00 h

# 4 User interface

## 4.1 MMI elements

The OBU shall have at least following MMI elements:

An operating element (e.g. a push-button) for changing the vehicle category

Display elements to indicate categories (3 LED's, green; indication "2", "3", "4")

A display element to indicate the apparatus status (1 LED, two colours: red/green; indication "S")

An acoustic information element (buzzer with one tone).

### 4.1.1 Push-button

The OBU push-button allows the execution of two functions, that are detailed in the following clauses.

**Vehicle toll category modification**
Toll category can be modified by pressing the push-button for more than 2 seconds.

The OBU allows only toll category settings by the push-button between the base category (base category is the value stored in VehicleAxles.VehicleAxlesNumber.NumberOfAxles.TractorAxles) and a maximum of "4", i.e. manual declaration of trailer axles is possible only for tractor vehicles with 2 or 3 axles.

By selecting a higher category than the base category the value of additionally declared axles is stored in VehicleAxles.VehicleAxlesNumber.NumberOfAxles.TrailerAxles and the trailer presence bit in the attribute VehicleClass is set to 1.

| OBU modification cycle | Possible changes |
|---|---|
| Base category 2 | Category 2 → 3→ 4 → 2→ .... |
| Base category 3 | Category 3→ 4 → 3→ .... |
| Other base categories | No possible changes |

**Table 2 Category modification cycles**

The user is informed after category change takes place (see 4.1.2).

Modifications by pressing the push-button can only be done on personalised OBU's.

In case of vehicle type = bus (VehicleClass.EuropeanVehicleGroup= 3 (large passenger vehicle), no manual declaration of additional axles shall be possible.

**OBU status verification**
OBU status (working conditions, vehicle category) can be verified by the user.

Verification procedures are described in 1.14.2.2.

### 4.1.2 LED

| N° | Indication | Colour | Meaning |
|---|---|---|---|
| 1 | 2 | Green | Category setup: 2 axles |
| 2 | 3 | Green | Category setup: 3 axles |
| 3 | 4 | Green | Category setup: 4 or more axles |
| 4 | S | Red/green | OBU status (working conditions ) |

**Table 3 Meaning of LEDs**

### 4.1.3 Buzzer

For road safety reasons, information about transaction success is delivered to the driver acoustically and not optically. The driver is informed about the status of the toll transaction after passing a tolling station by means described in 1.14.2.1 below.
The signal of the buzzer shall be within the following limits, measured in the following environment:

- 75 - 85 dB A (measured in front of the OBU, distance 10cm, measured inside an anechoic chamber)
- frequency ~ 3.650 Hz
- beep duration ~ 200 ms; the break between multiple beeps shall be around 100-200 ms

## 4.2 MMI operation

User is alerted on each significant event by the MMI.

### 4.2.1 At the passage of a beacon

| Transaction result | SET-MMI-Code | Status LED (S) | Category LED (2, 3 or 4) | Buzzer |
|---|---|---|---|---|
| Transaction OK (payment done, no warning) | 0 | - | - | 1 short beep |
| Transaction not OK (no payment effected, for example, due to expired contract) | 1 | - | - | 4 short beeps |
| Warning (use is TC specific) | 2 | - | - | 2 short beeps |
| Reserved (use is TC specific) | 3 | - | - | 3 short beeps |
| Interrupted transaction | - | - | - | - |
| Particular scope or future use | 255 | - | - | No beep |

**Table 4 MMI when passing at an RSE**

### 4.2.2 User status queries (by using OBU push-button)

To issue a status query the push-button must be pressed for a short time (less than 2 seconds).

| Status result | Status LED (S) | Category LED (2, 3 or 4) | Buzzer |
|---|---|---|---|
| OBU OK (the journey in the toll section can be done, no warnings) | 1 short flash (green) | 1 short flash of the LED corresponding to the selected category | - |
| OBU not OK (the journey in the toll section cannot be made)[1] | 4 short flashes (red) | - | - |
| | | | |
| OBU not personalised or terminated/de-personalised | 1 short flash (green) | - | - |

**Table 5 MMI for status queries**

### 4.2.3 Category setup

The push-button must be pressed for more than 2 seconds to select the next category. The category LED flashes corresponding to the selected category.

Status indication and category switching must be possible while the OBU is in a communication field (but priority is to finish the transaction).



[1] 4 short flashes are signalling to the user that tolling by use of this OBU is not possible, e.g. the OBU logic detected malfunction by a self test routine or something other like that.

# 5 OBU application element contents within inter-operable context

| ATTRIBUTES (EID>0) | AttrId | Type ***) | Length in bytes | Read | Write | Remarks |
|---|---|---|---|---|---|---|
| CONTRACT | | | | | | Information associated with the service rights of the Contract Provider (ETS Provider) |
| EFC Context Mark | 0 | 32 | 6 | Yes | No | Contains the Contract Provider Identification. Transmitted as part of the VST. |
| PAYMENT | | | | | | Data associated with the Payment transaction. |
| PaymentMeans (including PAN) | 32 | 64 | 14 | Yes | No | Includes:<br>the Personal Account Number, including the Payment Means Issuer (identified by the IIN),<br>The PAN Expiry Date<br>The payment means Usage Control |
| Contract Authenticator | 4 | 36 | 4+1 | Yes | No | Value defined by the CI (to be used in VIA T context) *) |
| VEHICLE | | | | | | Information pertaining to the identification and characteristics of the vehicle. |
| VehicleLicencePlateNumber | 16 | 47 | Variable 13 to17bytes | Yes | No | Length of the attribute, incl. country code, Alphabet Indicator and length. **) |
| VehicleClass | 17 | 49 | 1 | Yes | No | |
| VehicleDimensions | 18 | 50 | 3 | Yes | No | |
| VehicleAxles | 19 | 51 | 2 | Yes | No | |
| VehicleWeightLimits | 20 | 52 | 6 | Yes | No | |
| VehicleSpecificCharacteristics | 22 | 54 | 4 | Yes | No | |
| VehicleAuthenticator | 23 | 55 | 4+1 | Yes | No | Value defined by the CI *) |
| EQUIPMENT | | | | | | Information pertaining to the OBU. |
| EquipmentOBUId | 24 | 56 | 5 (=4+1) | Yes | No | Length of EquipmentOBUID is fixed to 4+1 bytes as specified in EN 15509 |
| EquipmentStatus | 26 | 58 | 2 | Yes | Yes | Includes transaction counter and black list flag |
| RECEIPT | | | | | | Information associated with a specific session, including both financial and operational data. |
| ReceiptData1 (last) | 33 | 65 | 28 | Yes | Yes | |
| ReceiptData2 (penultimate) | 34 | 66 | 28 | Yes | Yes | |

*) These attributes are not mandatory; but for compatibility reasons the implementation is recommended.

**) Acc. to EN15509 the length of this attribute is fixed to 14+3= 17 bytes, but for compatibility reasons the implementation of a variable length is recommended.

"Read" and "Write" define access rights to a given attribute for GET, GET Stamped or SET used by RSE.

Each attribute contains one or several data field according to EN 14906. Personalisation must be made by the Contract Issuer according to the rules as specified in this specification.

***) Container choice type value

For further details on specification of attributes, security features (authentication mechanisms to be implemented, etc.) which have to be implemented and supported in interoperable context, see [IAP].

# 6 Physical characteristics

## 6.1 Case

- The housing material and labelling ink must be UV-resistant (5 years life time minimum must be proven).
- The case dimensions must not exceed 115x 68x 27 mm (Lx Wx H)
- Maximum weight shall be 125 g (including fastener strips)
- The case shall provide user interface elements (LEDs, buzzer, push-button switch).
- The case shall provide identification elements (conformance data, serial number, logo, etc.
- The case shall be resistant to the mechanical and thermal loads seen in Heavy Goods Vehicles (HGV).
- Opening of the OBU case must not be possible without clearly visible damages. This must be true also for access to the battery (if applicable).
- The case material shall be recyclable.
- The colour of the OBU-case at the antenna side must allow the clear recognition capability of a correct windscreen-mounted OBU on the enforcement pictures by day and night (daylight and IR illumination 820 - 1000nm.

## 6.2 Materials

Any material used shall comply with Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).

## 6.3 Unit Identification

Details about the marking (imprinted information) of the OBU has to be agreed between supplier and purchaser.

In minimum following requirements apply:

Imprinted information on the back of the unit:

- CE mark and other conformance declarations
- ContractProvider, ManufacturerId and EquipmentOBUId, presented in readable hex characters
- ManufacturerId and EquipmentOBUId presented as barcode (code 128)
- Producer's brand mark and model/version designation
- Marking according to the Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE).

Further applies:

- The ink must be formulated to be abrasion, solvent and UV-radiation resistant.
- The equipment serial number must be unique and unambiguous permitting retrieval of production batch, production date. Further an indicator for production details (like refurbishment cycle, production site etc. can be requested by the purchaser.

[Remark: Above mentioned Ids and other info, e.g. PAN can be printed on a label at personalisation to be attached over the original barcode printed by manufacturer, if necessary ]

## 6.4 Packaging

The design of the OBU packaging has to be agreed between supplier and purchaser.
The unit identification (Equipment serial number) shall be readable even when the OBU is packed.

## 6.5 Mounting

Following requirements apply:

- The OBU is mounted on the vehicle windscreen with adhesive-backed Velcro® brand hook and loop fasteners (or equivalent).
- The mounting must be able to resist all mechanical vibrations normally present in a vehicle in the operational temperature range.
- The mounting must allow for easy mounting/de-mounting of the OBU to/from the windscreen to permit normal maintenance operations.
- The mounting must withstand > 1000 mounting/de-mounting operations.

## 6.6 User manual

The design of the user manual has to be agreed between supplier and purchaser

## 6.7 Power supply

The OBU is supplied by a battery (or battery pack)

The battery (or battery pack) must be constructed in such a way as to prevent:

- Explosion
- Chemical leakage

i.e. precautions must be taken against hazardous situations (explosion, fire/overheating, leakage etc.) The supplier is obliged to prove the precautions. Reference is made to [CEI EN 60086-4] (safety standards for Lithium batteries).

The battery (or battery pack) must conform to the specifications in section 6.9 of this document.

The minimum lifetime of a battery pack must be:

- 60 months under normal operating conditions.

Normal operating conditions are example:

- Up to 80 transactions a day for 280 days in a year.
- 2 (two) MMI uses a day for 280 days in a year for a long active time (4 seconds).
- 2 (two) MMI uses a day for 280 days in a year for a short active time (1 second).
- The OBU is mostly used at a normal environment temperature.
- The OBU is used at low temperatures (less than 5°C) for less than 1% of the global utilization time.
- The OBU is used at high temperatures (more than 50°C) for less than 15% of the global utilization time.

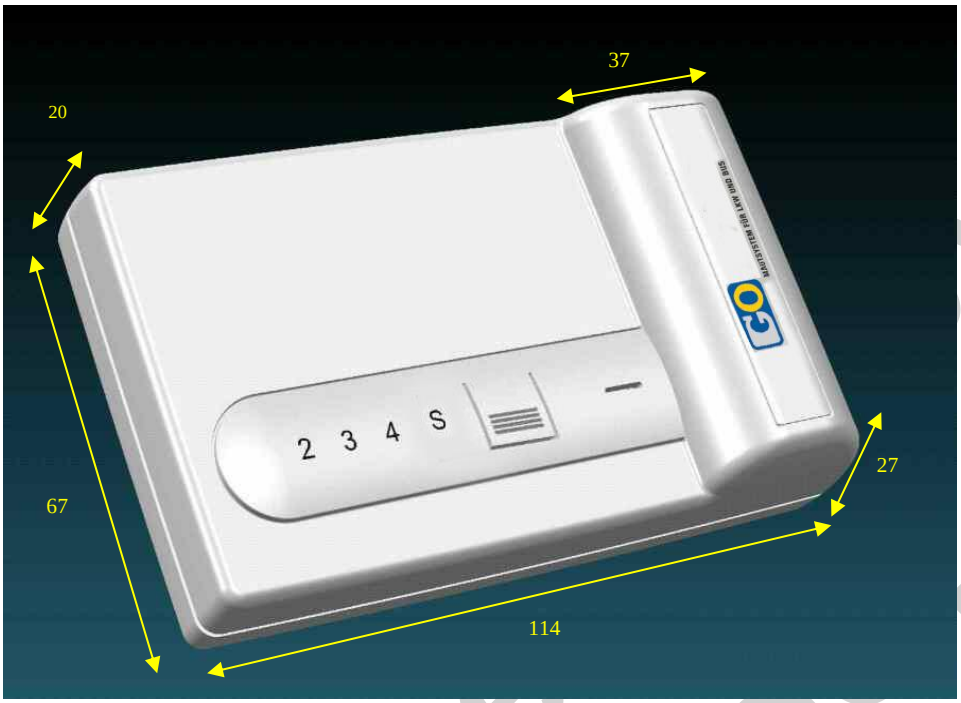
The following values have to be provided by the OBU supplier in order to calculate the estimated life time of the battery during operation:

- active mode current (mA)
- standby current (µA)
- short transaction time (maximum for complete tolling transaction) (s)
- long transaction time (maximum for tolling transaction, but release command lost, waiting add. 100ms to sleep (s)
- battery capacity nominal (mAh)
- battery capacity worst case (mAh)
- battery self discharge (Ah per year)

The OBU-wakeup under normal operating conditions shall only occur by DSRC beacons and not by other common RF signals.

On request a spreadsheet [Batt_life] calculating the battery lifetime according to above parameters is available.

## 6.8 Example for OBU case (informative)




## 6.9 Environmental specifications

### 6.9.1 Storage and transportation

**OBU classification (storage) according to [Env Class] parts 3-1 and /A2)**

| | |
|---|---|
| Climate: | 1K4 |
| Biological: | 1B2 |
| Chemically active: | 1C2 |
| Mechanically active: | 1S3 |
| Mechanics: | 1M2 |

**OBU classification (transportation) according to [Env Class] parts 3-2 and /A2)**

| | |
|---|---|
| Climate: | 2K4 |
| Biological: | 2B2 |
| Chemically active: | 2C2 |
| Mechanically active: | 2S2 |
| Mechanics: | 2M2 (free fall according to 2M1) |

**Tests to be performed (according to [ENV tests])**

| Parameter | Reference | Test | Notes |
|---|---|---|---|
| Cold | Aa | -40°C / 16 h | in package |
| Dry heat | Ba | +70°C / 16 h | in package |
| Humid heat | Cb | 93 percent / +40°C / 96 h | in package |
| Free-fall | Ed1 | 1,00m | in package |

**Table 6 Environmental tests for storage and transportation**

### *6.9.2 Operation*

**OBU classification (according to [Env Class] parts 3-5 and /A2)**

Climate: 5K2, heat however up to +85°C instead of +70°C

Biological: 5B1

Chemically active: 5C1

Mechanically active: 5S1

Mechanics: 5M3

**Tests to be performed (according to [ENV tests])**

| Parameter | Reference | Test | Notes |
|---|---|---|---|
| Cold and vibration | Z/AFc | -25°C / 2 h<br>7,5 mm /, 2... 8, Hz<br>25 $^{m/s2}$ /, 8... 200, Hz<br>40 $^{m/s2}$ /, 200 500, Hz | Function test; at windscreen; stimulated vertically;<br>2 samples of OBU and repeating the tests 5 times |
| Dry heat and vibration | Z/BFc | +85°C / 2 h<br>7,5 mm /, 2... 8, Hz<br>25 $^{m/s2}$ /, 8... 200, Hz<br>40 $^{m/s2}$ /, 200 500, Hz | Function test; at windscreen; stimulated vertically;<br>2 samples of OBU and repeating the tests 5 times |
| Humid heat | Ca | 93 percent / +40°C / 96 h | Function test for the beginning, end and in the middle of the test time |
| Temperature alteration | Na | -25.... +70°C, 10° K / min, | Function test for the beginning, end and in the middle of the test time |
| Shocks | Ea | Half sine 1000 $^{m/s2}$ / 3 pushes per direction | Function test; at windscreen; stimulated vertically |

**Table 7 Environmental tests in operation**

# 7 Comments on DSRC protocol related issues (informative)

This chapter provides information on some DSRC protocol related issues often raised by OBE manufacturers and information about tolling context specific characteristics.

## *7.1 Comments on the correct use of the S and N-Bit to control frame retransmissions*

The DSRC protocol provides two different frame retransmission procedures, described in the standard EN12795. The MAC reallocation method is controlled by the S-Bit, an LLC retry is controlled by the N-Bit.

### *7.1.1 MAC allocation / reallocation*

In Table 8 an excerpt of EN12795 concerning the S-Bit can be seen.

| |
|---|
| **7.4.2.2.2 Private uplink window allocation** |
| … |
| In the first private uplink allocation for a new SAP the S bit shall be set to 0. If a private uplink window allocation to a mobile equipment is either the first response to a private uplink window request from that mobile equipment, or is the result of an *F*-MA-DATA.request, then the value of the S bit transmitted shall be the complement of the value of the S bit of the previous private uplink window allocation. |
| **7.4.2.2.3 Private uplink window reallocation** |
| Each time a private uplink window is allocated by the fixed equipment, a transmission is expected from the mobile equipment, to which the window is allocated. |
| If no valid frame was received by the fixed equipment it may reallocate the private uplink window as long as the corresponding private medium response flag has not reached the value 1. |
| The S bit of the MAC control field shall then have the same value as it had on the first occasion that that window was allocated. |

**Table 8 Excerpt of EN12795 concerning the S-Bit**

Summarizing this:

- For the first pWa of a transaction the S-Bit is set to zero.
- For every following downlink frame the S-Bit is toggled when the previous received frame was valid.
- If the received frame was not valid, the private uplink may be reallocated as long as no further BST was sent since the beginning of the transaction (Every BST would increase the medium response flag).
- If the private uplink is not reallocated for what reason ever, the S-Bit is toggled.

In a real application, this means that it is allowed to resend a pWa with an unchanged S-Bit as long as no new BST was issued.

**The Austrian RSU does not support this reallocation procedure.**

### 7.1.2 LLC retry

In Table 9 an excerpt of EN12795 concerning the N-Bit can be seen.

**8.3.22 Acknowledged connectionless**

…

The MSB of the LLC control field for ACn commands and responses is the N bit.

**8.4.3 Acknowledged commands/responses**

The ACn command PDU shall be used to transmit information or to request information, without the prior establishment of a data link connection. Use of the ACn command PDU is not dependent upon the existence of a data link connection between the destination and source. Reception of an ACn command PDU shall be acknowledged by an ACn response PDU at the earliest opportunity. The information field in the ACn command PDU may be either null (having zero length) or non-null, and if non-null shall contain a link service data unit. The ACn command shall have a private LID.

The ACn response PDU shall be used to reply to an ACn command PDU. Responses shall be made at the earliest opportunity. The ACn response PDU shall identify the responding LLC and shall be transmitted to the originating LLC. The ACn response PDU shall always contain a status subfield in its information field (see 8.3.3).

The source LLC may retransmit an acknowledged command PDU for recovery purposes but it shall not transmit a new acknowledged command PDU while waiting for an acknowledgement of a previous PDU with the same LID. Acknowledged connectionless information exchange shall not interfere with any unacknowledged connectionless operation.

The N bit in successive PDUs provides a one-bit sequence number, which allows the LLC which receives a command PDU to distinguish between a new PDU and a retransmission of the previous PDU.

Further, the LLC that receives an acknowledgement PDU can ensure that the acknowledgement refers to the last transmitted command PDU. A previously received acknowledgement, which incurred excessive delay, is thus ignored.

**ANNEX C**

**Table C.2**

…

If after the AC1 frame from the ME the FE receives nothing for a long time, the AC command is reissued. (Still AC0, since it is no new command - there was no application layer response yet. The S bit is toggled since it is a new allocation).

**Table 9 Excerpt of EN12795 concerning the N-Bit**

Summarizing this:

The source LLC may retransmit an acknowledged command PDU for recovery purposes.
The N bit in successive PDUs provides a one-bit sequence number.
An acknowledged command (AC) is reissued if the RSU receives nothing for a long time.
The N-Bit of the reissued AC is not changed, but the S-Bit is toggled!

**This method is supported by the Austrian RSUs.**

## 7.2 Comments on OBE DSRC Kernel state after Rec_PrWA event

GSS states:

| | | | |
|---|---|---|---|
| 60 | Rec_BST(BeaconId, DateTime)<br>& BeaconId = SavedBeaconId | SavedDateTime:=DateTime, Transmit_PrWRq | DATA_2 |

| | | | |
|---|---|---|---|
| 62 | Rec_PrWA | Transmit_UI(SAVE) | DATA_2 |

60. On reception of a BST with the same BeaconId, in state DATA_2 the OBE re-transmits the PrWRq, compare transition 50

62. This is the normal transition in state DATA_2: On reception of a PrWA the OBE transmits the delayed response using a UI frame . The state DATA_2 is not left until an implicit layer 7 acknowledge was received.

Remark: Transitions 60 and 62 have the same conceptual meaning in DATA_2 state of the "most common and standardized" transactions 21 and 22 in INIT state:

| | | | |
|---|---|---|---|
| 21 | Rec_BST(BeaconId, DateTime)<br>& BeaconId = SavedBeaconId | SavedDateTime:=DateTime, Transmit_PrWRq | INIT |
| 22 | Rec_PrWA | Transmit_UI(VST) | INIT |

21. This transition occurs if the OBE receives a BST before having received an implicit layer 7 acknowledge, i.e. an addressed frame other than PrWA. The OBE retransmits the PrWRq and stays in the INIT state.

22. A normal situation: After having issued a PrWRq (transition 12, 13 or 21) the RSE will transmit a PrWA. The OBE then transmits the VST and remains in the INIT state until another addressed frame is received.

The OBU has to remain in INIT state after having issued a VST until an "implicit layer 7 acknowledge" is received because VST should be not delivered to the RSU.

Such "implicit layer 7 acknowledge" is simply the first ACn Command that implicitly assures the OBU that the VST was surely received.

In the same way, OBU has to be sure that RSU has received the processed data (SAVE); so has to remain in DATA_2 state as long as an "implicit layer 7 acknowledge" is not received. In this case an "implicit layer 7 acknowledge" is simply a brand new ACn Command.

## 7.3 Comments on Sleep after release

GSS states that an OBE upon receiving a Release command has to move to BLOCKED state. "The BLOCKED state is similar to the sleeping state, but in addition the frames are not notified, i.e. the wake-up signal is blocked". The timeout is app. 3s, but is quite left to the manufacturer to properly tune it.

## 7.4 Comments on ResultFin

The standard (EFC Layer) is very clear:

ResultFin ::= OCTET STRING (SIZE(1))

-- A code designating whether a card transaction was completed successfully or not. Value Assignment : Hexadecimal

-- Most significant 4 bits: 0 OK :

-- '0x'H OK

-- Most significant 4 bits > 0 Not OK :

-- '1x'H Not OK, not specified further

-- '2x'H Not OK, Abnormal (First or Previous) Event

-- '3x'H Not OK, Contract not accepted

-- '4x'H Not OK, Account or Purse not accepted

-- 'x0'H not specified further

-- 'x1'H Balance close to zero

-- 'x2'H Balance now negative

-- 'x3'H Balance Overflow

-- 'x4'H Provider not accepted

-- 'x5'H Authentication failure

-- x6'H Vehicle Class incorrect

So, ResultFin = '01H' means "OK, Balance close to zero"

## 7.5 Comments on OBE Random number generation

Requirements don't impose the RndOBE to be completely random but "freely chosen by the OBU" (EN 14906). Using entirely random RndOBE leads to an increase of security.

# 8 References

**Standards and external documents**

For dated references, subsequent amendments to or revisions of any of these publications apply only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

| Reference | Document Ref | Date / Version | Document title |
|---|---|---|---|
| [L1] | EN 12253 | 2004 | Road Transport and Traffic Telematics (RTTT) – Dedicated Short-Range Communication (DSRC) – Physical layer using microwave at 5.8 GHz |
| [L2] | EN 12795 | 2003 | Road Transport and Traffic Telematics (RTTT) – Dedicated Short-Range Communication (DSRC) – DSRC data link layer: Medium access and logical link control |
| [L7] | ISO15628 / EN12834 | 2007/ 2003 | Road Transport and Traffic Telematics (RTTT) – Dedicated Short-Range Communication (DSRC) – DSRC Application Layer |
| [Profiles] | EN 13372 | 2004 | Road Transport and Traffic Telematics (RTTT) – Dedicated Short-Range Communication (DSRC) – Profiles for RTTT applications |
| [AVI No] | EN ISO 14816 | 2005 | Road Traffic and Transport Telematics (RTTT) – Automatic Vehicle and Equipment Identification – Numbering and Data Structures |
| [EFC API] | ISO/DIS 14906.2 | 16.02.2010 | Road Traffic and Transport Telematics (RTTT) – Electronic Fee Collection – Application interface definition for dedicated short range communication |
| [OBU DSRC tests] | CEN ISO/TS 14907-2 | 2006 | Road Traffic and Transport Telematics (RTTT) – Electronic Fee Collection – Testprocedures for user and fixed equipment - Part 2: EFC application interface conformance test specification |
| [ETSI] | EN 300 674 | 2004 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM) - RTTT -DSRC- transmission equipment |

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|---|---|---|---|
| [ISO CC] | EN ISO 3166-1 | | Codes for the representation of names of countries and their subdivisions – Part 1: Country code |
| [ISO 4217] | ISO 4217 | | Codes for the representation of currencies and funds |
| [ISO 7812-1] | EN ISO/IEC 7812-1 | 2000 | Identification cards - Identification of issuers - Part 1: Numbering system |
| [ISO 8731-1] | ISO 8731-1 | 1987 | Banking -- Approved algorithms for message authentication -- Part 1: DEA |
| [ASN.1] | ISO/IEC 8824-1 | 2004 | Information technology - Abstract Syntax Notation One (ASN.1): Specification of basic notation |
| [ASN.1 PER] | ISO/IEC 8825-2 | 2004 | Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER) |
| [CEI EN 60086-4] | IEC 60086-4 | | Primary batteries - Part 4: Safety standards for lithium batteries |
| [EN 301 489-3] | EN 301489-3 | V 1.4.1:2002 | Electromagnetic compatibility and Radio spectrum Matters (ERM) - ElectroMagnetic Compatibility (EMC) standard for radio equipment and services - Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 40 GHz; V1.4.1 :2002 |
| [EN 60950] | EN 60950 | | Information technology equipment - Safety |

| Reference | Document Ref | Date / Version | Document title |
|---|---|---|---|
| [Env Class] | EN 60721-3 | | Classification of environmental conditions –Part 3: Classification of groups of environmental parameters and their severities |
| [ENV tests] | EN 60068-2 | | IEC 60068-2 Environmental testing Part 2 |
| [IAP] | EN 15509 | 2007 | EN 15509:2007 Road Traffic and Transport Telematics (RTTT) – Electronic Fee Collection –Interoperability application profile for DSRC |
| TS102486-L2] | 'SI TS 102486-1 | V1.1.1 | Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Test specifications for DSRC transmission equipment; Part 1: DSRC data link layer: medium access and logical link control;<br>Sub parts 1 - 3 |
| TS102486-L7] | 'SI TS 102486-2 | V1.1.1 | Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Test specifications for DSRC transmission equipment; Part 2: DSRC application layer;<br>Sub parts 1 - 3 |
| | | | |
| [MOPTT] | MOPTT | V1.0:2002 | Conformance tests to the specification for interoperability in the beacon – transponder transaction (Public Works, Transport and Telecommunications Ministry, Chile, Version 1.0, 2002-01-22, CEN/TC278/WG1 N677) |
| [CARDME] | CARDME | 2002 | CARDME-4/ D4.1 – The CARDME concept (Final, 1 June 2002) |
| [GSS] | GSS | V3.2:2003 | Global Specification for Short Range Communication (Kapsch TrafficCom AB, Kapsch Telecom GmbH, Thales e-Transactions CGA SA, version 3.2, 2003-08, http://www.etc-interop.com/pdf/gss_32.pdf) |

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| [A1] | A1 | 1999 | A1 - Interoperable EFC Transaction using Central Account based on DSRC European Commission DG XIII - Telematics Applications Programme – TR4001 June 12, 1999 (Version ER9_1.3) |
| [EG2] | | 01.04.2005 | Definition of parameters to be stored in on-board equipment designed for use with the European Electronic Toll Service - Prepared by: Expert Group 2: Vehicle Classification - Working to support the European Commission DG TREN |
| [EG11] | | 06.02.2006 | Definition of the EFC Application for the EETS Based on Microwave Technologies - Prepared by Expert Group 11 - Working to support the European Commission on the work on Directive 2004/52/EC |
| [UNECE] | | | ECONOMIC COMMISSION FOR EUROPE - INLAND TRANSPORT COMMITTEE - Working Party on the Construction of Vehicles TRANS/WP.29/78/Rev.1/Amend.2 - CONSOLIDATED RESOLUTION ON THE CONSTRUCTION OF VEHICLES (R.E.3) |
| [Reg_doc] | | | Directive 1999/37/EC on Registration Documents |
| | | | |

## EasyGo Documents

| Reference | Document Ref | Date / Version | Document title |
|---|---|---|---|
| [PROCESS] | 401 | | Business Process Definitions for EasyGo+ |
| [OBU_data] | 202-B | | EasyGo+: OBU Data description<br>(EasyGo+ OBU Personalization, Configuration and Operating Parameters ) |
| [DSRC] | 202-C | | EasyGo+: DSRC Transaction for Tolling and Enforcement |