# Carma Occupancy Declaration
# Interface Control Document
# And Business Rules

Version 2.0

June 2022

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# Revision History

| Date | Version | Modifications |
|---|---|---|
| 2018/05/20 | 0.1 | First Draft |
| 2018/12/02 | 0.2 | Incorporated Carma ICD to COG |
| 2019/01/03 | 0.3 | Clarified Carma API requirements |
| 2019/02/13 | 0.4 | Additional updates and clarifications |
| 2019/04/25 | 1.0 | Initial Release |
| 2019/05/01 | 1.1 | Added additional definitions, corrected minor issues, updated Subscriber and Service Provider ICD references to remove specific version number, updated and split BR #5 in section 7.2 into two items to improve understanding. |
| 2019/05/06 | 1.1.1 | 1.4 – Table 3: Added NTE35W, Appendix E – changed Cintra to LBJ/NTE/NTE35W |
| 2019/05/17 | 1.1.2 | Modified sections 1.1, 1.3, 6.0, 6.2 |
| 2019/05/24 | 1.1.3 | Modified statement 7.2(7) b to clarify. |
| 2019/08/01 | 1.1.4 | Updated 2.1-item 4, added section 3.2, updated section 3.3.2, corrected Closing Tags in sample code-tables 7 & 8, added item10 to section 7.1. |
| 2019/11/11 | 1.2 | ~~Updated "FULL" to "BULK" to be consistent with Service Provider ICD~~, updated Table 1 to show .ZIP & .XML instead of .CUTS file extension, updated definitions to include "Forced HOV", updated section 3.2 to include filenames in both zipped and unzipped formats, updated Table 17, 18 & 19 to correct field names to camelCase, updated Table 19 to include 'status' field in Sample Request, updated section 7.2, item 7b, to include Forced HOV. |
| 2019/12/20 | 1.2.1 | Reverted "FULL to "BULK" where it applies to CUTS files. Included new definitions for TVL and CUTS files to clarify terms for each. Table 19, corrected example response #2 – Unknown responses will have occ=1. Added definition for Unknown Response. |
| 2022/6/22 | 2.0 | - Update Business Rules 7.2 Items 4, 5, 6, and 7 to reflect the receipt of a 50x error message as equivalent to no response and the operator must act accordingly.<br>- Update Business Rule 7.2 Item 8 to identify the action taken if transactions older than 60 days are submitted for occupancy to Carma.<br>- Several punctuation/grammar corrections. |

# 1 Introduction

The purpose of this document is to describe the interfaces between a Service Provider, a Subscriber, and Carma for purposes of vehicle occupancy declaration in the Dallas-Ft. Worth region high-occupancy vehicle (HOV) lanes. For purposes of this document, a Service Provider is the North Texas Tollway Authority (NTTA) and a Subscriber may be LBJ Infrastructure Group's LBJ TEXpress Lanes system or TxDOT's express lanes system. This document includes both the detailed descriptions of each associated workflow, along with the data interface and the specifics of fields, files, naming conventions, etc., with which each party to integration must comply.

## 1.1 Integration Overview

Technical integration with the Carma system occurs primarily at two (2) places:

1. The first integration point occurs in relation to the **User Tag Set**, which is a list of transponders associated with Carma users. Subscribers use this User Tag Set to confirm whether a transponder identified at a toll gantry is a potential candidate for a HOV toll discount. Transponders that are not present in the Subscriber's copy of the Carma User Tag Set are not eligible for HOV discounts. The User Tag Set list is sent to the Subscribers, by Carma, periodically.
2. The second integration point occurs in relation to **verifying vehicle occupancy** for a transponder that is identified at a toll gantry and confirmed as being in their local copy of the Carma User Tag Set. The Subscriber queries Carma for the verified occupancy of the vehicle for the moment at which the vehicle was detected at the toll gantry.

The following diagram shows the basic data flow between Carma systems and the Subscribers.

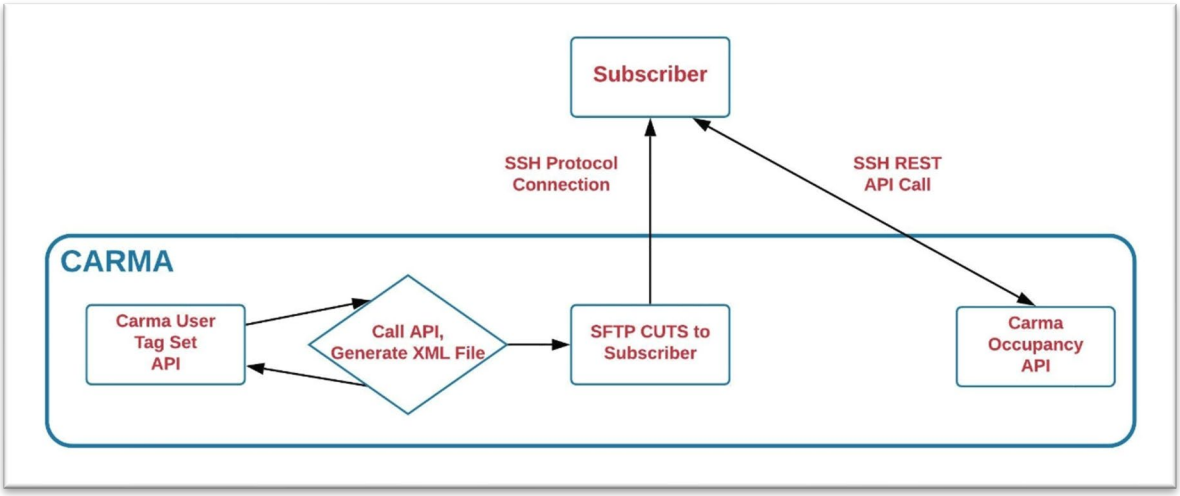


**Figure 1 – Typical Data Flow Diagram**

In Figure 1, data flows between the Carma systems and Subscribers utilizing SSH connections for the Carma User Tag Set and SSL Rest APIs for the Occupancy request/reply. The Occupancy request/reply process occurs only after the subscriber validation of the tag transponder ID has been performed (such validations are unchanged by this integration, and so are not discussed further here). To enter this flow, a Tag Transponder ID is required.

1. On entry, transactions may be held for a period by the Subscriber to allow the Carma service time to receive up-to-date occupancy information from the vehicles.
2. Once released from the hold stage, the set of transactions is divided into two subsets: the first subset consists of tags whose owners are not users of the Carma system; the second subset consists of tags belonging to Carma users.
3. To perform this filtering, each transactions' Tag Transponder ID field is checked against a locally held copy of the Carma User Tag Set and if a transactions' Tag Transponder ID is confirmed, then that transaction is placed into the "Carma User" subset of transactions. In the case of a "flushed" tag scenario, or similar, the subscriber may exclude the transaction from the filtering process and place them directly in the "non-Carma users" list for standard processing.
4. The "non-Carma Users" subset undergoes no further processing until the standard subscriber process takes effect and transactions are submitted to the back-office provider.
5. The timestamp and Transponder ID from each transaction in the "Carma Users" subset is sent to the Carma Occupancy Verification service, which returns the computed occupancy for the vehicle with that tag at the specified time.
6. Occupancy information from the Carma Occupancy Verification service is used to adjust the transaction records, when applicable.
7. The HOV eligible transaction subset is merged with the non-HOV transaction subset to form a complete transaction set for back-office processing.

At this point, there exists a fully formed Transaction Record File, in which the HOV events have had this status noted, and the pricing fields reflect the HOV discount.

An additional interface will exist between Carma and TxDOT, where Carma will retrieve the TVL. TxDOT will receive the local TVL from NTTA and place the file in a location for Carma to retrieve. Upon retrieval, Carma will process the file and utilize the TVL to validate customer account set up and maintenance.

## 1.2 Data Types

This section defines the formats for all data that shall be transmitted between the Parties within this relationship. The interface data types defined are:

**Table 1 - Data Types**

| Data Type | File Extension | Usage |
|---|---|---|
| **Carma User Tag Set** | ZIP<br>XML | A Carma-maintained list of drivers actively enrolled in the Carma HOV application. |
| **Subscriber Occupancy Request** | N/A | A request from the Subscriber, or roadside integrator, to Carma including the transaction details needing occupancy details |
| **Carma Occupancy Response** | N/A | A response from Carma to the Subscriber, or roadside integrator, including the occupancy details associated with transaction requests. |

## 1.3 Definitions

The following table includes definitions of commonly used terms in this document.

**Table 2 - Definition of Terms**

| Term | Definition |
|---|---|
| Application Programming Interface | API. A set of subroutine definitions, communication protocols, and tools for building software that communicates among various components. |
| Away Agency | An Interoperable Agency that is not the Customer's Home Agency. |
| Bulk TVL | A Tag Validation List containing all tags that are considered good, zero or negative balance by a Home Agency and provided to other Agencies via the local IOP Hub. The tags in the Bulk Tag Validation List with a valid tag status are good tags until they are identified as zero or negative balance, i.e., invalid, on the Tag Validation List or drop off the next Bulk Tag Validation List. |
| Carma User Tag Set | CUTS. Carma's list of registered users with verified transponders. This list enables a Toll Operator to identify transactions for which it is possible to request occupancy. |
| Differential CUTS | A Carma User Tag Set containing two sets of records, new users and deleted users, as compared to the most recent Differential or Full CUTS file that was delivered. |
| Differential TVL | A Tag Validation List that contains the tags that have changed status since the last Full Tag Validation List. If a tag has changes status multiple times, it is listed based on the last tag status as long as it is different from the last Full Tag Validation List. |
| Forced HOV | A transaction that has been provided HOV eligibility due to a non-response in the Occupancy Request process. |
| Full CUTS | A Carma User Tag Set containing all records of users that are considered active. |
| High Occupancy Vehicle | HOV. High Occupancy Vehicle, i.e., a vehicle with at least 2 occupants. |
| Home Agency | An Interoperable Agency which owns the Customer Account and maintains the information related to the vehicle(s), license plate(s) and tag(s) to which interoperable toll transactions are posted. |
| HOV Discount | A toll discount that is applied for transactions in which at least 2 people are present in the vehicle. |
| HTTP/S | Hypertext Transfer Protocol/Secure |
| Integrator | The company or organization that wishes to add the Carma Occupancy Verification Service to their tolling system. This may be a Road Operator or a Toll Authority |
| Interface Control | ICD. Document that describes the data interface and the specifics of fields, files, naming conventions, etc., with |

| Term | Definition |
|---|---|
| Document | which each part to integration must comply. |
| Interoperability Hub (IOP Hub) | The technical and procedural implementation of the Interoperability Interlocal Agreement (IOP ILA). |
| License | The registration or vehicle-license plate number issued to the vehicle by the government and affixed to the front or rear of the car. |
| Parties | The primary organizations involved in the integration of Carma's automated vehicle occupancy verification system. |
| Service Provider | An entity that operates a back-office system for toll account management and transaction processing. |
| SFTP | Secure File Transfer Protocol |
| Secure Shell | SSH. Protocol that uses encryption to secure the connection between the client and server. |
| Subscriber | Any entity who or which (a) manages and operates a tolled facility and (b) participates with a Service Provider to process transactions. |
| Tag Validation List | TVL. A comprehensive list of transponders and associated license plates issued by toll authorities, along with status details (valid, canceled, etc.). The TVL is the ultimate authority on the mapping of a tolling tag to a license plate. |
| TEXpress Lanes | Managed lanes that offer more reliable and congestion-free journeys within existing freeway corridors and converted express / HOV lanes. |
| Toll Authority | The organization that manages the issuing of transponders and billing of customers for their use. The Toll Authority is the final consumer of the tolling information produced by the Toll Operator and Carma. |
| Toll Gantry | The point on a roadway at which a tolling transaction event occurs. |
| Toll Operator | The organization that operates and maintains the tolling infrastructure and collects and processes information about tolling transactions. |
| Transaction | A billing event that occurs when a transponder is detected as vehicle passes a toll gantry. |
| Transaction Batch File | A data file containing one or more transaction records. |
| Transaction Record | The electronic record of a tolling transaction. Among other information, the Transaction Record contains the time and place of the event, the tolling transponder ID ("tag number") event, HOV discount, and the price to be paid by the driver. |
| Transponder | An electronic tag that is used to communicate with roadside equipment to identify the unique toll user account for which a toll agency can pursue the collection of tolls. May also be called "tag." |
| Unknown Response | An Unknown Response to an occupancy request indicates that the transponder information in the transaction was not in the Carma system, therefore Carma cannot identify it nor reply with an occupancy. |
| User | A user of Carma's occupancy verification system. |
| Verified Occupancy | The vehicle occupancy that is calculated and reported by Carma for a particular transaction. |
| Virtual Private Network | VPN. Extension of a private network across a public network and enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network. |
| Extensible Markup Language | XML. Structured text files used for storing and transporting data. |

### Integration Parties

The following table identifies the primary organizations related to the integration of Carma's automated vehicle occupancy verification system.

**Table 3 - Organizations Involved in the Integration of Carma's Technology**

| Organization | Role |
|---|---|
| **Carma** | Service Provider of automated technology for verifying vehicle occupancy for users of tolled managed lane facilities in the Dallas-Ft. Worth (DFW) area. |
| **LBJ Infrastructure Group** | Subscriber who is the Toll Operator of the Lyndon B. Johnson (LBJ) TEXpress lanes. |
| **NTE Mobility Partners** | Subscriber who is the Operator of the North Tarrant Express (NTE) TEXpress lanes. |
| **NTE Mobility Partners Segments 3** | Subscriber who is the Operator of the North Tarrant Express I-35W (NTE35W) TEXpress lanes. |
| **North Central Texas Council of Governments (NCTCOG)** | The Metropolitan Planning Organization (MPO) for transportation in the Dallas-Fort Worth (DFW) area. |
| **Texas Department of Transportation (TxDOT)** | Toll Operator of all non-LBJ/NTE tolled managed lanes. |
| **The North Texas Tollway Authority (NTTA)** | Service Provider and owner and toll operator of all tolled non-managed lanes in DFW, and back-office provider for the tolled managed lanes in DFW. |
| **Regional Transportation Council (RTC)** | The independent transportation policy body of the MPO. It provides the Toll Managed Lane Policies with which all high-occupancy vehicle toll discounts must comply. |
| **TransCore** | Subscriber who is the toll systems provider and maintainer for TxDOT lanes. |

# 2 General Data Requirements

## 2.1 File transfers

1. All participating Parties shall support the exchange of individual data records or blocks of records utilizing secure web services via HTTPS.
2. When using XML file data exchange over SFTP, files shall be compressed using the current PKWARE published ZIP file format specification.
3. When using XML file data exchange over SFTP, upon compression, file names shall be converted from {FILE_NAME}.{FILE_TYPE} to {FILE_NAME}_{FILE_TYPE}.ZIP and all files names shall be created using uppercase characters only.
4. The date/time values contained in a file name represent the creation date/time of the file as it is written to the filesystem.
5. All date/time values within the data contents of a submission shall be transmitted as Coordinated Universal Time (UTC) unless otherwise indicated.
6. All data will be transferred as text. Binary information transfer is not used, with the one exception of using ZIP file compression of the text-based Carma User Tag Set files to save transmission time.

## 2.2 Web Services

### 2.2.1 General Guidelines

REST Web Services shall be used.

### 2.2.2 General Exception Handling

Exceptions to normal behavior are communicated by means of HTTP error codes. Appendix A lists the status codes, their general meaning and suggested actions.

### 2.2.3 Request Timeouts

A timeout condition occurs when no response is received from the Service Provider within some configurable timeout interval. When a timeout occurs, the Subscriber typically does not know if the Service Provider received the request. The Subscriber may resubmit the request with the expectation that if the prior submission was received and successfully processed, the Service Provider will return the same response that would have been sent had the timeout condition not occurred. Such re-submissions would not result in the request being reprocessed resulting in possible duplication.

Appendix B provides indicative response times and suggested timeout values for the HTTP requests used in the Carma service. Note that these values are indicative only, and Subscribers should set timeouts based on their own measurements at time of deployment.

# 3 Carma User Tag Set

## 3.1 Usage

1. Carma maintains a list of drivers using the Carma Occupancy Verification service.
2. This list is called the Carma User Tag Set and it contains the Tag verified against the TVL.
3. The Carma User Tag Set list is made available to the Subscriber to allow them to separate tolling transactions into two sets: tolls incurred by drivers who use the Carma service (and thus may need referral to Carma to determine occupancy), and those who do not.
4. To reduce data throughput, a differential version of the User Tag Set is also provided. Instead of listing all tags, this shows only those items that have changed, been removed or been added since a the most recent Bulk or Differential TVL has been provided.

## 3.2 Filename Format

The format of the filenames for the Full and Differential Carma User Tag Set is defined below.

- Full File Format
  - Zipped: YYYYMMDDHHMMSS_FCUTS.ZIP
  - Unzipped: YYYYMMDDHHMMSS_FCUTS.XML

- Differential File Format
  - Zipped: YYYYMMDDHHMMSS_DCUTS.ZIP
  - Unzipped: YYYYMMDDHHMMSS_DCUTS.XML

## 3.3 Data Records/Fields

The Carma User Tag Set is delivered to Subscribers as an XML file. Differential and Full versions of this file are delivered. The schedule of delivery is defined in the Business Rules section of this document.

### 3.3.1 Carma User Tag Set, Full Format

The file is composed of a header structure, followed by a body which contains the Carma User Tag records. The meaning of each field is described in the table below.

User Tags are described using their serial number, tag agency code ("Tag Agency ID") and the agreed issuer code corresponding to the agency that is responsible for the tag ("Home Agency ID"). The structure of the Carma User Tag record has been deliberately chosen to be a subset of the information transferred in the TVL document.

The structure of the Full file is as follows:

**Table 4 - Full Carma User Tag Set**

| Level | Field | Description | Type | Size | Count | Comments |
|---|---|---|---|---|---|---|
| 0 | **CarmaUserTagSet** | Document root | Container | — | 1 | |
| 1 | **CarmaUserTagSetHeader** | File information | Container | — | 1 | |
| 2 | **ListType** | Type of list | Char | 4 | 1 | Value is "FULL" for complete files |
| 2 | **SourceDateTime** | Timestamp of last received TVL on which this list is based. | Timestamp | — | 1 | Matches "SubmissionDateTime" value of TVL |
| 2 | **LatestChange** | | Timestamp | — | 1 | |
| 2 | **RecordCount** | Count of tags in this file. | Number | 10 | 1 | Determines the number of "CarmaUserTag" elements under "AllTags". |
| 1 | **CarmaUserTagSetBody** | File contents | Container | — | 1 | |
| 2 | **AllTags** | Records in the complete tag set. | Container | — | 1 | |
| 3 | **CarmaUserTag** | An individual user tag | Container | — | 1–n | See "RecordCount" above |
| 4 | **HomeAgencyID** | ID of agency that manages tag account | Number | 4 | 1 | |
| 4 | **TagAgencyID** | Agency ID as encoded in tag | Number | 4 | 1 | |
| 4 | **TagSerialNumber** | Numeric Serial number of tag | Number | 8 | 1 | |
| 4 | **LicensePlateNumber** | License Plate Number associated with Tag/User | Char | 15 | 1 | |
| 4 | **LicensePlateState** | License Plate State associated with Tag/User | Char | 2 | 1 | |
| 4 | **LicensePlateType** | License Plate Type associated with Tag/User | Char | 20 | 1 | |
| 4 | **LicensePlateCountry** | License Plate Country associated with Tag/User | Char | 2 | 1 | |

### 3.3.2 Carma User Tag Set, Differential format

The differential format is an extension of the basic format described previously. Instead of a single list of tags, two lists are provided: first list (New Tags) is of tags that have been added to the set, second list (Deleted Tags) is of tags that have been removed from the set. The "New Tags" list describes those tags which are to be added to a local copy of the Carma User Tag Set. The "Deleted Tags" list describes those tags which are no longer part of the Tag Set and should be removed from any local copy.

The differential lists contain timestamps to indicate the previous known User Tag Set published by Carma (ChangesAfter), the current known TVL published by TxDOT (SourceDateTime), and the current published User Tag Set (LatestChange).

The "ChangesAfter" time indicates the starting point in time for this differential. This is used to ensure that a differential is not applied to the wrong local copy, such as if the data is somehow received out of sync.

If a differential file contains no tag records, i.e., NewRecordCount and DeletedRecordCount are both zero, the differential is still sent but will only contain the opening tag followed by the closing tag.

The structure of the differential file is as follows:

**Table 5 - Differential Carma User Tag Set**

| Level | Field | Description | Type | Size | Count | Comments |
|---|---|---|---|---|---|---|
| 0 | **CarmaUserTagSet** | Document root | Container | — | | |
| 1 | **CarmaUserTagSetHeader** | File information | Container | — | 1 | |
| 2 | **ListType** | Type of list | Char | 4 | 1 | Value is "DIFF" for differential files |
| 2 | **ChangesAfter** | Timestamp of last change *before* the time span covered by this differential | Timestamp | — | 1 | See note in text, above. |
| 2 | **LatestChange** | Timestamp of latest modification in this differential | Timestamp | — | 1 | |
| 2 | **SourceDateTime** | Timestamp of last received TVL on which this list is based | Timestamp | — | 1 | Matches "SubmissionDateTime" value of TVL |
| 2 | **NewRecordCount** | Count of tags that are to be added or changed. | Number | 10 | 1 | Determines the number of "CarmaUserTag" elements under "NewTags". "0" is a permitted value. |
| 2 | **DeletedRecordCount** | Count of tag records that are to be deleted | Number | 10 | 1 | Determines the number of "CarmaUserTag" elements under "DeletedTags". "0" is a permitted value. |
| 1 | **CarmaUserTagSetBody** | File contents | Container | | 1 | |
| 2 | **NewTags** | Records added to the tag set. | Container | | 1 | |
| 3 | **CarmaUserTag** | | Container | | 1–n | |
| 4 | **HomeAgencyID** | ID of agency that manages tag account | Number | 4 | 1 | |

| Level | Field | Description | Type | Size | Count | Comments |
|---|---|---|---|---|---|---|
| 4 | **TagAgencyID** | Agency ID as encoded in transponder | Number | 4 | 1 | |
| 4 | **TagSerialNumber** | Numeric Serial number of tag | Number | 8 | 1 | |
| 4 | **LicensePlateNumber** | License Plate Number associated with Tag/User | Char | 15 | 1 | |
| 4 | **LicensePlateState** | License Plate State associated with Tag/User | Char | 2 | 1 | |
| 4 | **LicensePlateType** | License Plate Type associated with Tag/User | Char | 20 | 1 | |
| 4 | **LicensePlateCountry** | License Plate Country associated with Tag/User | Char | 2 | 1 | |
| 2 | **DeletedTags** | Records removed from the tag set. | container | | 1 | |
| 3 | **CarmaUserTag** | | container | | 1–n | |
| 4 | **HomeAgencyID** | ID of agency that manages tag account | Number | 4 | 1 | |
| 4 | **TagAgencyID** | Agency ID as encoded in transponder | Number | 4 | 1 | |
| 4 | **TagSerialNumber** | Numeric Serial number of the tag | Number | 10 | 1 | |
| 4 | **LicensePlateNumber** | License Plate Number associated with Tag/User | Char | 15 | 1 | |
| 4 | **LicensePlateState** | License Plate State associated with Tag/User | Char | 2 | 1 | |
| 4 | **LicensePlateType** | License Plate Type associated with Tag/User | Char | 20 | 1 | |
| 4 | **LicensePlateCountry** | License Plate Country associated with Tag/User | Char | 2 | 1 | |

### 3.3.3 Details Provided Per User Tag

In both the Differential and Full versions of the Carma User Tag Set, the following information is provided per User Tag:

**Table 6 - User Tag Details**

| Carma User Tag Set Data Detail Record | | | | |
|---|---|---|---|---|
| **Field** | **Type** | **Max Length** | **Required/ Optional** | **Description** |
| **HomeAgencyID** | Char | 4 | Required | The ID assigned to the Home Agency. This is the agency that manages the customer account to which toll charges may be posted. |
| **TagAgencyID** | Char | 4 | Required | Agency ID as encoded on the transponder. |
| **TagSerialNumber** | Char | 8 | Required | Numeric Serial number of Tag. |
| **LicensePlateNumber** | Char | 15 | Required | Plate letters/numbers. Shall follow format required for DMV lookups including required prefixes, suffixes, or handling of special characters as dictated by the state which issued the plate. |
| **LicensePlateState** | Char | 2 | Required | Standard Postal Service state abbreviation (or Province abbreviation for Canada). For Mexico, this field would contain MX. |

| Carma User Tag Set Data Detail Record | | | | |
|---|---|---|---|---|
| **Field** | **Type** | **Max Length** | **Required/ Optional** | **Description** |
| **LicensePlateType** | Char | 20 | Required | Plate type as required for DMV lookups. If Home Agency provides License Plate Type, Away Agency must match to that License Plate Type and must include License Plate Type in any plate-based transactions. |
| **LicensePlateCountry** | Char | 2 | Required | Country Code associated with LP.<br>Values: US – United States, CA – Canada, MX – Mexico |

### 3.3.4 Interpretation of Tag Set

If a transaction is processed by the subscriber and the Tag ID has been confirmed as present in the latest available Carma User Tag Set, then that transaction should be referred to Carma for an occupancy calculation.

## 3.4 XML Definitions

### 3.4.1 Carma User Tag Set, Full format

**Table 7 - XML Definitions: Full**

**Sample document**

```
<?xml version="1.0" encoding="UTF-8"?>
<CarmaUserTagSet> <CarmaUserTagSetHeader>
 <ListType>FULL</ListType>
 <LatestChange>2017-03-24T17:41:00Z</LatestChange>
 <SourceDateTime>2017-03-24T17:41:00Z</SourceDateTime >
 <RecordCount>173087</RecordCount>
 </CarmaUserTagSetHeader>
 <CarmaUserTagSetBody>
 <AllTags>
  <CarmaUserTag>
   <HomeAgencyID>0042</HomeAgencyID>
   <TagAgencyID>1120</TagAgencyID>
   <TagSerialNumber>05271189</TagSerialNumber>
   <LicensePlateNumber>ABC-1234</LicensePlateNumber>
   <LicensePlateState>TX</ LicensePlateState>
   <LicensePlateType>Type</ LicensePlateType>
   <LicensePlateCountry>US</ LicensePlateCountry>
  </CarmaUserTag>

                    [ 173086 further CarmaUserTag elements omitted ]

 </AllTags>
</CarmaUserTagSetBody>
</CarmaUserTagSet>
```

### 3.4.2 Carma User Tag Set, Differential format

**Table 8 - XML Definitions: Differential**

**Sample document**

```
<?xml version="1.0" encoding="UTF-8"?>
<CarmaUserTagSet>
<CarmaUserTagSetHeader>
 <ListType>DIFF</ListType>
 <ChangesAfter>2017-03-24T11:32:21Z</ChangesAfter>
 <LatestChange>2017-03-24T17:41:00Z</LatestChange>
 <SourceDateTime>2017-03-24T17:41:00Z</SourceDateTime >
 <NewRecordCount>207</NewRecordCount>
 <DeletedRecordCount>5</DeletedRecordCount>
 </CarmaUserTagSetHeader>
 <CarmaUserTagSetBody>
  <NewTags>
   <CarmaUserTag>
    <HomeAgencyID>0042</HomeAgencyID>
    <TagAgencyID>1120</TagAgencyID>
    <TagSerialNumber>05271189</TagSerialNumber>
    <LicensePlateNumber>DEF-5678</LicensePlateNumber>
    <LicensePlateState>TX</ LicensePlateState>
    <LicensePlateType>Type</ LicensePlateType>
    <LicensePlateCountry>US</ LicensePlateCountry>
   </CarmaUserTag>
                                        [ 206 CarmaUserTag elements omitted ]
  </NewTags>

  <DeletedTags>
   <CarmaUserTag>
    <HomeAgencyID>0042</HomeAgencyID>
    <TagAgencyID>1121</TagAgencyID>
    <TagSerialNumber>03879123</TagSerialNumber>
    <LicensePlateNumber>GHI-9101</LicensePlateNumber>
    <LicensePlateState>TX</ LicensePlateState>
    <LicensePlateType>Type</ LicensePlateType>
    <LicensePlateCountry>US</ LicensePlateCountry>
    </CarmaUserTag>
                                        [ 4 CarmaUserTag elements omitted ]
  </DeletedTags>
 </CarmaUserTagSetBody>
</CarmaUserTagSet>
```

### 3.5 Processing Requirements

1. Exchange of User Tag Set data will be via SFTP.
2. The User Tag Set records are encoded using the UTF-8 transformation of the Unicode character encoding scheme (ISO-10626).

### 3.6 File Transfer Requirements

SFTP servers must be password protected, and usernames and passwords will be shared at a mutually agreed time between the Subscriber and the Service Provider.

#### 3.6.1 Carma User Tag Set, File Transfer

The Subscriber uses the following location on its SFTP Servers to receive files required by the Subscriber / Carma interface.

**Note:** The Subscriber shall frequently monitor its SFTP site for file transfers from Carma.

Carma creates a Carma User Tag Set file and transmits the file to the Subscriber for processing.

The structure of the file system on the Subscriber SFTP Server for delivery of the CUTS files shall be as follows:

- SFTP://(Subscriber SFTP Server)/(SFTP CUTS dir)/(Carma)/input
- SFTP://(Subscriber SFTP Server)/(SFTP CUTS dir)/(Carma)/input/sending
- SFTP://(Subscriber SFTP Server)/(SFTP CUTS dir)/(Carma)/input/arch

Carma shall push the CUTS files (via SFTP) into the proper /input/sending directory on the Subscriber SFTP Server. After the file transmission is complete, Carma then moves the file from the /input/sending subdirectory up into the main /input directory. This is done to prevent the Subscriber from picking up a file that has not completed transmission. The Subscriber shall pick up the file from the /input directory and then shall move the file to the /input/arch directory for archive purposes after the file is processed.

# 4 Authentication API

## 4.1 Overview

1. The Authentication API is used to control access to the Carma Occupancy Verification service.
2. Subscribers will be given login credentials by Carma which allow their applications to authenticate with the Carma service.
3. Using the Authentication API, Subscribers present their credentials to Carma, and receive an Authentication Token in response.
4. The Authentication Token must be included in every subsequent request to the Carma API.
5. If an Occupancy Request API receives the HTTP error code 401, unauthorized, the Authenticate API should be called again.

## 4.2 Interface Definition

### 4.2.1 Protocol

The request must be invoked over an HTTPS connection.

### 4.2.2 Method

**Table 9 - Protocol Method**

| HTTP verb | Path |
|---|---|
| **POST** | /api/authenticate |

### 4.2.3 Required Headers

**Table 10 - Protocol Headers**

| Header | Value |
|---|---|
| **Content-Type** | application/json;charset=UTF-8 |

### 4.2.4 Request Structure

The Authentication Request is encoded as a JSON Dictionary object, with the following structure:

**Table 11 - Protocol Request Structure**

| Authentication Request Document | | | | | |
|---|---|---|---|---|---|
| **Field** | **JSON name** | **Type** | **Max Length** | **Required/ Optional** | **Description** |
| **User Name** | username | Char | 128 | Required | Username of Subscriber |
| **Password** | password | Char | 128 | Required | Password of Subscriber |

Carma will supply Subscriber with Username and Password credentials as part of the integration process.

### 4.2.5 Response Format

Response is encoded as JSON. The request is a dictionary object with a single field:

**Table 12 - Protocol Response Format**

| Authentication Response Document | | | | | |
|---|---|---|---|---|---|
| **Field** | **JSON name** | **Type** | **Max Length** | **Required/Optional** | **Description** |
| **Authentication token** | id_token | Char | 500 | Required | Value to use as Bearer Authorization token for other API calls. |

### 4.2.6 Sample Request (Successful)

**Table 13 - Protocol Sample Request (Successful)**

| | |
|---|---|
| **Request** | POST /api/authenticate<br>Content-Type: application/json;charset=UTF-8<br><br>{"username":"subscriberuser@org.org","password":"secret123"} |
| **Response** | 200 OK |
| **Response Body** | {<br>"id_token":"eyJhbGciOiJIUzUxMiJ9.lyJzdWIiOiIxMjYyNTEwOTQiLCJhdXRoIjoiUk9MRV9BRE1JTixST0xFX1NVUFBPUlQsUk9MRV9UT0xMV0FZX0FHRU5ULFJPTEVfVFNfTURNSQ4sUk9MRV9VU0VSIiwiZXhwIjoxNTQ2Njk5MjcyfQ.KuH5lrrpw_4poPXHjLdNU6j-7G6ur_i_GomEqwhu6r_ogb6sEo7k406tmjQM_nHER_cFtNvEfkJUgPZL52sr9g"<br>} |

The value of the "id_token" field should be stored and used in the “Authorization” header of future API requests.

### 4.2.7 Sample Request (Failed)

**Table 14 - Protocol Sample Request (Failed)**

| | |
|---|---|
| **Request** | POST /api/authenticate<br>Content-Type: application/json;charset=UTF-8<br><br>{"username":"subscriberuser@org.org","password":"wrong"} |
| **Response** | 401 Unauthorized |
| **Response Body** | {<br>"type" : "http://www.jhipster.tech/problem/problem-with-message",<br>"title" : "Unauthorized",<br>"status" : 401,<br>"detail" : "Bad credentials",<br>"path" : "/api/authenticate",<br>"message" : "error.http.401"<br>} |

The response body can be ignored in failed authentication; it simply provides additional information about the failure and does not need to be parsed by the client.

# 5 Subscriber Occupancy Request API

## 5.1 Overview

1. This is the primary function of the Carma application. A Subscriber sends one or more sets of toll transaction records (tag, time of transaction and plaza identifier) with intent of receiving the occupancy value of the transaction.
2. The request may include a single or bulk request.
3. Requests are made by making an HTTPS POST request to the specified URL. The API Response is returned by the service in the body of the HTTP response to the HTTPS POST request.
4. Success or failure is communicated using the HTTP Status code.

## 5.2 Interface Definition

### 5.2.1 Method

**Table 15 - Interface Definition Method**

| HTTP verb | Path |
|---|---|
| **POST** | `/api/occupancy/occupancy` |

### 5.2.2 Required Headers

**Table 16 - Interface Definition Required Headers**

| Header | Value |
|---|---|
| **`Content-Type`** | `application/json;charset=UTF-8` |
| **`Authorization`** | `Bearer` authorization token |

See Section 4, Authentication API, for the process by which the "Authorization" header value is obtained.

### 5.2.3 Request Structure

Requests are encoded as JSON. The request is a simple array where each element has the following structure:

**Table 17 - Interface Definition Request Structure**

| Carma Occupancy Request Record | | | | | |
|---|---|---|---|---|---|
| **Field** | **JSON name** | **Type** | **Max Length** | **Required/ Optional** | **Description** |
| **Tag Identifier** | tagNumber | Number | 12 | Required | 12-digit Tag Transponder ID, as defined in Transaction Record (See Appendix C) |
| **Event time** | timestamp | Number | 15 | Required | Time of the Transaction expressed as the number of milliseconds since 1. January, 1970 00:00:00 UTC ("the Unix Epoch") |

| Carma Occupancy Request Record | | | | | |
|---|---|---|---|---|---|
| **Field** | **JSON name** | **Type** | **Max Length** | **Required/ Optional** | **Description** |
| **Plaza Identifier** | plazaID | Char | 15 | Required | Unique (for the Facility ID) identifier of the plaza on the facility at which the vehicle exited the facility. For Barrier type transactions, this is the plaza used. For Unmatched type transactions, this may be inferred information. |

To check a single event, send a document containing only one element. For performance reasons, however, Carma recommends that occupancy requests should be sent in batches.

### 5.2.4 Response Format

Responses are encoded as JSON. The request is a simple array where each element has the following structure:

**Table 18 - Interface Definition Response Format**

| Carma Occupancy Request Record | | | | | |
|---|---|---|---|---|---|
| **Field** | **JSON name** | **Type** | **Max Length** | **Required/ Optional** | **Description** |
| **Tag Identifier** | tagNumber | Number | 12 | Required | 12-digit Tag Transponder ID, as defined in Transaction Record (See Appendix C) |
| **Event time** | timestamp | Number | 15 | Required | Time of the Transaction expressed as the number of seconds since 1. January 1970 00:00:00 UTC (“the Unix Epoch”) |
| **Plaza Identifier** | plazaID | Char | 15 | Required | Unique (for the Facility ID) identifier of the plaza on the facility at which the vehicle exited the facility. For Barrier type transactions, this is the plaza used. For Unmatched type transactions, this may be inferred information. |
| **Computed Occupancy** | occ | Number | 1 | Required | Calculated Occupancy for vehicle. |
| **Status** | status | Char | 15 | Required | Two possible values:<br>- OK: Tag ID known; data retrieved<br>- UNKNOWN_TAG: Tag ID not known / not in Carma User Tag Set |

The "Tag Identifier” and “Event Time” fields are returned so that the client can cross-reference the entries in the response with those in the original request.

### 5.2.5 Sample Request

**Table 19 - Interface Definition Sample Request**

| | |
|---|---|
| **Request** | POST /api/operator/occupancy<br>Content-Type: application/json;charset=UTF-8<br>Authorization: Bearer eyJhbGciOiJIUzUxMiJ9.lyJzdWIiOiIxMjYyNTEwOTQiLCJh… *etc.*<br>[<br>{ "tagNumber": "110091234567", "timestamp": "1546613808", “plazaID”: “I820-SH121E-9"},<br>{ "tagNumber": "101000013103", "timestamp": "1546613815", “plazaID”: “SH121-SH183W-16"},<br>*[records omitted]*<br>{ "tagNumber": "101000999103", "timestamp": "1546613927", “plazaID”: “I820-I35W-3"} |
| **Response** | 200 OK |
| **Response Body** | [<br>{ "tagNumber": "110091234567", "timestamp": "1546613808", “plazaID”: “I820-SH121E-9", "occ": “1”, “status”:“ok” },<br>{ "tagNumber": "101000013103", "timestamp": "1546613815", “plazaID”: “SH121-SH183W-16", "occ":”1”, “status”:”Unknown” },<br>*[records omitted]*<br>{ "tagNumber": "101000999103", "timestamp": "1546613927", “plazaID”: “I820-I35W-3", "occ:”2”, “status”:”ok” }<br>] |

# 6 Tag Validation List

The Tag Validation List (TVL) definition is referenced within the current “Service Provider to Subscriber ICD” document in Section 5.1. Carma will retrieve the TVL from TxDOT for purposes of processing the file and creating the basis of the Carma User Tag Set.

- TxDOT shall provide Carma with access to NTTA’s TVL data by uploading the TVL file(s) in the standard format to a secure, shared file server on the same schedule as provided to TxDOT by NTTA. Carma acknowledges and agrees that access to such TVL Data is provided “as is” and TxDOT makes no representation or warranty as to the accuracy or completeness of any such TVL Data. Access to the file will be following TxDOT’s processing of the file into the target directory.
- Carma acknowledges and agrees that NTTA’s TVL data and any other customer transaction data provided by TxDOT or Developers in connection with the implementation of the Carma HOV System (collectively, “Transaction Data”) will only be used for (a) incorporation into the deliverable(s), software and/or services described in Exhibit A (Statement of Work) to the SaaS; and (b) performance of Carma’s coordination and assistance activities under the Agreement. Notwithstanding anything to the contrary in the SaaS Agreement, such TVL Data and Transaction Data shall not become the property of Carma.

## 6.1 File Transfer Requirements, TVL

Per the current "Service Provider to Subscriber ICD" document, the TVL files, both Bulk and Differential, are to be transferred using SFTP. SFTP servers must be password protected, and usernames and passwords will be shared at a mutually agreed time between the Subscriber and the Service Provider.

### 6.1.1 TVL File Transfer

TxDOT shall use the following locations on its SFTP Server to place the TVL files, as required.

**Note:** Carma should frequently monitor the TxDOT provided SFTP site for new TVL files.

TxDOT receives the TVL file from the Service Provider and places the file into its SFTP directory for Carma to retrieve and process. The structure of the file system on the TxDOT SFTP Server for placement of the TVL files shall be as follows:

- SFTP://(TxDOT SFTP Server)/(SFTP TVL dir)/Carma/output
- SFTP://(TxDOT SFTP Server)/(SFTP TVL dir)/Carma/output/pulling
- SFTP://(TxDOT SFTP Server)/(SFTP TVL dir)/Carma/output/arch

Once placed into the appropriate /output SFTP directory by TxDOT, Carma shall make a copy of the file and move it into output/pulling. Carma shall pick up the file from the /output/pulling directory.

After the file retrieval is complete from the TxDOT servers, Carma then moves the file from the /output/pulling directory into /output/arch directory for archive purposes. Carma then deletes the file in both the /output and /output/pulling directories.

## 6.2 Exceptions to the current "Service Provider to Subscriber ICD"

The following sections act as an addendum to (and supersedes) the existing, and separate, "Service Provider to Subscriber ICD" document to meet the functionality of the Carma integration. Text presented below originates from the "Service Provider to Subscriber ICD." Text that is struck through shall be removed, and text that is formatted in bold and italics shall be added.

### 6.2.1 Section 4.0 Subscriber – To/From – Service Provider Interface

The Subscriber – to/from – Service Provider Interface consists of the following file transfers:

- Transponder Validation List (TVL) files, Bulk and Differential (~~pushed by the Service Provider to the Subscriber)~~
- ***(The Subscriber shall place the file in the SFTP folder, ready for Carma to retrieve for processing)***.

### 6.2.2 Section 5.1.4 Transponder Validation List Acknowledgement

- ~~Acknowledgment data shall be created by TSA receiving the Transponder Validation List.~~
- ***No automatic acknowledgements will be transmitted by Carma to the Subscriber. Notifications regarding failure of processing the TVL shall be communicated via email.***

# 7 Carma Occupancy Declaration Business Rules

## 7.1 Carma User Tag Set Rules

1. Upon failure to place the Carma User Set, Carma shall attempt daily (01:00 CST), up to 7 days from the original generation date.
2. Data validation for the Carma User Tag Set will occur at the file level.
3. Carma will validate each new user account setup against the most recent Bulk plus Differential TVLs.
4. Carma will validate each user accounts' tag/plate association against the most recently published Bulk and Differential TVLs each time a new file is received.
5. Full Carma User Tag Set files will be available every Sunday no later than 09:00 CST.
6. Differential Carma User Tag Set files will be generated at least once a day, on days when the Full is not generated.
7. Differential Carma User Tag Set file will be sent every day at 23:00 CST. If, upon measurement, it is determined that this is too frequent / infrequent, the schedule can be adjusted.
8. Within the Carma User Tag Set, one (1) tag shall have only one (1) associated license plate.
9. When a differential is received out of sync, that differential will not be processed. The subscriber will send an email alert, Carma then will issue a Full CUTS file for processing.
10. The Differential version of the User Tag Set will always be sent, even if the new or deleted record count is zero.

## 7.2 Occupancy Request API Rules

1. Carma will reply to every transaction received, i.e., if a bulk request has 100 transaction entries, there will be 100 transaction entries in the reply.
2. The Subscriber will call the Occupancy Request API at a time >= 15 minutes (current default minimum) after the transaction timestamp.
3. Single transaction records within the Occupancy Request which have no occupancy recorded will result in a value of "1" for the "occ" data element. The default / minimum response for occupancy in every transaction will be "1".
4. The Occupancy Request API call will be attempted by the Subscriber up to 3 times when no response, or a 50x error message is received.
5. The Subscriber will resubmit an Occupancy Request when no response, or a 50x error message is received. The suggested timeout period is <120 seconds and is configurable to suit the integrator's process.

6. If the first Occupancy Request receives no response, or a 50x error message, the Subscriber will resubmit for an additional 2 attempts. The retry delay will be configured for 1 minute by default but is configurable to suit the integrator's process.
7. If no response, or a 50x error message, is received from the Carma server after 3 attempts for any batch submitted:
    a. The Subscriber will contact Carma via email to notify them of the issue, and,
    b. The Subscriber will continue processing the transaction as HOV eligible and apply the HOV discount. This method of HOV application is labeled as "Forced HOV".
8. Transactions may be queried up to 60 days from the original transaction timestamp.
    a. If a batch received by Carma contains a transaction that is older than 60 days, the entire batch will be rejected.
    b. The Subscriber will send an email alert on any rejected batches.
    c. The Subscriber will remove the outdated transaction(s) and resubmit the remaining transactions in the next batch.
9. No more than 200 (current default, configurable based on actual metrics) transactions shall be sent in a call to the Occupancy Request API.
10. Data validation for Occupancy Request will occur at the detail record level.

## Appendix A: Web Service Status Codes and Messages

The table below list the response codes that will be provided upon usage of a Carma web API call. Codes in boldface (**200, 401, 404, 500, 503 & 504**) are those which will be encountered in normal operation; other codes are primarily indications of misconfiguration or programming errors.

**Table 20 - Appendix A: Web Service3 Status Codes/Messages**

| HTTP Response | Meaning | Suggested Action |
|---|---|---|
| **200 OK** | Client request has been successfully acted upon. | No special action required. |
| 400 Bad Request | Client request is malformed. | Indicates a programming error in the client. |
| **401 Unauthorized** | Client has not authenticated itself with API server.<br>Client is authenticated, but the supplied credentials do not grant permission to access the requested API. | Client should re-submit its credentials to the login API and try again using the authentication token provided.<br>Client should ensure that the correct login credentials are presented for the service being used.<br>If credentials are found to be correct, escalate to Carma. |
| 403 Forbidden | Client has tried to access a URL which is not part of the Carma API. | The occurrence of this error indicates a programming or configuration error in the client.<br>Ensure that the Carma API base URL being used in client matches that provided by Carma. |
| **404 Not Found** | Client is attempting to access an API which is not available | Retry request.<br>Verify that no HTTP proxy has been started between client and server.<br>If problem does not clear, escalate to Carma. |
| 405 Method Not Allowed | Client is using an incorrect HTTP command on valid API (e.g., “POST” where “GET” is expected). | The presence of this error indicates a programming error in the client.<br>Consult the Carma API documentation and use the correct HTTP verb for each API. |
| 406 Not Acceptable | Client has sent, or requested, data in a format that the Carma API does not support. | The presence of this error indicates a programming error in the client.<br>Consult the Carma API documentation and use the correct Content-Type: values for each API. |
| 413 Request Entity Too Large | Client has sent more data than the server is willing to process in one transaction. | The presence of this error indicates a programming error in the client.<br>Keep requests below the suggested maximum number of records.<br>Split offending list into two or more parts, send each as a separate request. |
| 429 Too Many Requests | The number of REST requests has exceeded 100,000 API calls per hour (default value) | This error implies an error or misconfiguration in the client, making too many API calls.<br>Check that calls are efficient, using BULK transactions.<br>Check that you need more than 100,000 calls per hour. Contact Carma. |
| **500 Internal Server Error** | The Carma service is temporarily unable to process the request. | Retry the request.<br>If problem does not clear, escalate to Carma. |
| **503 Service Unavailable** | The Carma service is temporarily unable to process the request. | Retry the request.<br>If problem does not clear, escalate to Carma. |
| **504 Gateway Timeout** | The Carma service is temporarily unable to process the request. | Retry the request.<br>If problem does not clear, escalate to Carma. |

## Appendix B: API Response Times

Requests were made from a client in Western Europe (Ireland) to a server in West Coast USA (Oregon).

**Table 21 - Appendix B: API Response Times**

| Request | Typical Response time (ms) | Suggested Timeout (s) |
|---|---|---|
| Occupancy API | < 100ms | TCP Default (< 120s) |
| | | |
| | | |

## Appendix C: Tag format for Occupancy Verification API

The Occupancy Verification API uses 12-digit numeric values to identify transponder tags. To construct these values, the following format should be used:

**Table 22 - Appendix C: Tag Format for Occupancy Verification API**

| Tag Agency ID (4 digits) | Tag Serial number (8 digits) |
|---|---|
| 1 1 2 0 | 0 0 3 4 5 6 7 8 |

Note that this is intended to be identical to the transponder ID format used in the Transaction Record File.

## Appendix D: Service Provider to Subscriber ICD

The current “Service Provider to Subscriber ICD” document is an external document and should be referenced where required.

## Appendix E: Communication Model: Between LBJ/NTE/NTE35W and Carma

This communication model is exclusively between LBJ/NTE/NTE35W Concessions (LBJ Infrastructure Group, NTE Mobility Partners and NTE Mobility Partners Segments 3) as the Subscriber and Carma as the Service Provider. The communication model will consist of a Virtual Private Network (VPN) connection in order to further secure all data flow between the parties. Both points of integration, the Carma User Tag Set and the Occupancy Verification request/response will be over the VPN.

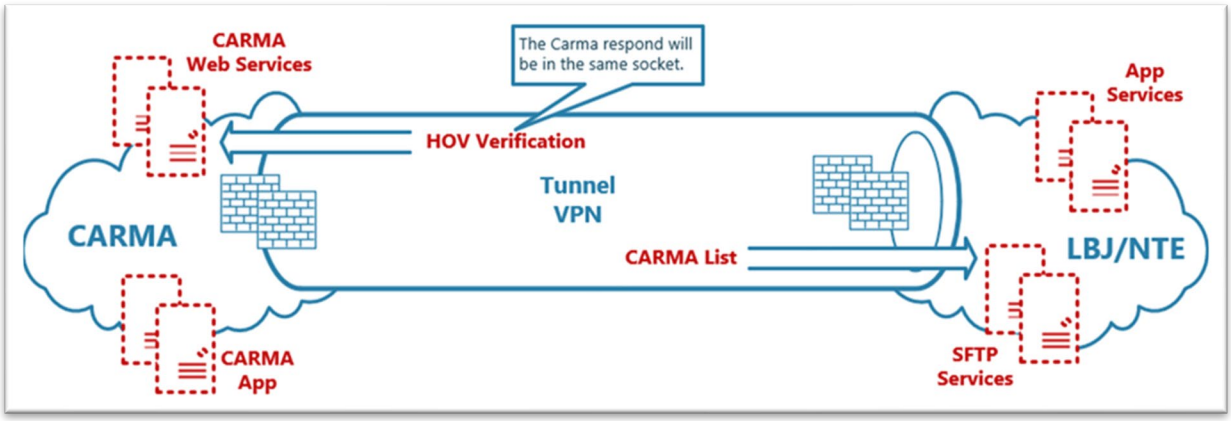


**Figure 2 – VPN Site to Site Communication Model**