Data Logging for TESTFEST #1

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Terms and abbreviations

Term / Abbreviation	Definition
CAM	Cooperative Awareness Message
CSV	Comma separated file format
CIS	Central ITS-Station
C-ITS	Cooperative Intelligent Transportation System
CMT	Core Management Team
DENM	Decentralised Environmental Notification Message
EC	European Commission
HMI	Human-Machine Interface
I2V	Infrastructure to Vehicle communication
INEA	Innovation and Networks Executive Agency
IPR	Intellectual Property Right
IVI	In-Vehicle Information message
PC	Project Coordinator
RIS	Road side ITS-Station
SQL	Structured Query Language
TIC	Technical & Interoperability Coordinator
UPER	Unaligned Packed Encoding Rules
V2V `	Vehicle to Vehicle communication
VIS	Vehicle ITS-Station
XER	XML Encode Rules

1 Executive summary

This document defines the formats for data logging in the first InterCor TESTFEST in July 2017.

The objective of the TESTFEST is to verify the cross-border interoperability for the InterCor common specifications for Day1 C-ITS services and ITS-G5 communication. The real life setting on the public motorway in The Netherlands, with real life events such as road works, service vehicles, and traffic jams, will be managed and controlled from the traffic control center using measures like lane closures and variable message signage.

Verification will initially focus on potential interoperability issues resulting from gap analyses of various C-ITS profiles, and in particular the implementation of services and use cases on Vehicle ITS-Stations and Road side ITS-Stations (RIS). The road side stations will send DENM and IVI messages according to the InterCor and C-ITS Corridor profiles.

Processing and interpretation of CAM, DENM and IVI messages will be verified for the services; Road Works Warning, In-Vehicle Information and Probe Vehicle Data. ITS-G5 communication performance will also be verified to evaluate RSU deployment and the effects on services.

Log data will be collected from On-Board Units (OBU) and Road Side Units (RSU) to verify interoperability during the TESTFEST, and also for further evaluation of interoperability after the TESTFEST. The objective of this document is to define a common log format that participants can provide with minimal development efforts either directly from unit logging or by transformation of their existing logging. If participants can provide logging in the common format(s) during the TESTFEST, than the data can be analysed and evaluated in the debriefings during the TESTFEST. Data in other formats are still welcomed for evaluation and included in the reporting shortly after the TESTFEST.

This document does not include conformance testing of the ITS-G5 communication stack in Vehicle ITS-Stations or Road side ITS-Stations, nor the communication with Central ITS-Stations or Traffic Control Centers.

2 Introduction

The objective of the TESTFEST is to verify the cross-border interoperability for the InterCor common specifications. The TESTFEST in July 2017 is the first TESTFEST with a focus on Day1 C-ITS services and ITS-G5 communication on a motorway and services in The Netherlands. The InterCor common specifications and the TESTFEST test scenarios can be found in other documents.

2.1 Purpose of this document

This document defines the formats for data logging in the first InterCor TESTFEST. It also explains the rationale for logging from the objectives for testing and verification in the TESTFEST.

2.2 InterCor Contractual References

InterCor (Interoperable Corridors) links the C-ITS corridor initiatives of the Netherlands C-ITS Corridor Netherlands-Germany-Austria and the French one defined in SCOOP@F, and extending to the United Kingdom and Belgium C-ITS initiatives.

InterCor is an action co-financed by the European Union under the Grant Agreement number INEA/CEF/TRAN/M2015/1143833. The Project duration is 36 months, effective from the 1st of September 2016 until the 31st of August 2019. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

Communication details of the Agency:

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3 Testing and Verification of Interoperability

3.1 Scope

The objective of the TESTFEST is to verify the cross-border interoperability for the InterCor common specifications. The TESTFEST in July 2017 is the first TESTFEST with a focus on Day1 C-ITS services and ITS-G5 communication on a motorway and services in The Netherlands.

Focus is on technical testing and verification of interoperability and evaluation of the effects of communication performance and interpretation of CAM, DENM and IVI messages on the services; Road Works Warning, In-Vehicle Information and Probe Vehicle Data.

Verification and evaluation in the TESTFEST will be based on black box testing, in which the logical entities are considered for a Vehicle ITS-Station (VIS), Road side ITS-Station (RIS), and Central ITS-Station (CIS). The various assemblies of stations are not directly considered, e.g. whether a VIS has a separate On-Board Unit and ITS-G5 Communication Unit, or whether a RIS has a separate Communication Unit and Road Side Unit.

3.2 Scenario

The TESTFEST provides three possible levels of testing interoperability:

1. In-door lab tests to enable a participant to test, analyse and debug a single unit in doors, on a table, before installation in a vehicle.
2. Parking lot tests to enable a participant to drive around the parking lot to test and debug a single unit installed in a vehicle in a “dynamic” low speed situation.
3. Field testing on the public motorway in daily traffic with live signage and messages.

In lab tests (level 1 and 2), RSUs of the organisation send predefined test messages, either as an isolated message or at low broadcasting frequency, to enable participants to test and debug their units.

The field tests (level 3) are considered in this document as the main TESTFEST. The motorway is equipped with traffic detection systems, variable message signs and other signalling systems, and RIS for I2V and V2X communication. The RIS is connected to a Central Unit and traffic management services. Traffic measures are initiated from the CU and sent to the RIS. The traffic measures are transformed into DENM and IVI messages for events such as road works, and IVI messages with variable message signs. The RIS will broadcast DENM and IVI to inform VIS about speed measures and lane closures.

The VIS sends CAM and DENM to other VIS and to the RIS. This data will be collected at the RIS for the PVD service.

The interaction between VIS and RIS will be the main subject for verification and discussion with participants during the TESTFEST. The interaction between the RIS and traffic operator systems will be evaluated afterwards and is not covered in this document.

3.3 Verification

During the TESTFEST, the cross-border interoperability of the services is verified from two key test objectives:

- Potential differences in the interpretation and processing of DENM and IVI between VIS and RIS for the realization of the intended traffic measures and implementation of the InterCor specifications and C-ITS Corridor profile in The Netherlands.
- Effects of communication performance and RSU deployment on the services and use cases.

Following potential issues for cross-border interoperability are anticipated in the verification:

1) Processing and interpretation of message contents, especially the optional data elements, for example:
   a) Relevance, detection and awareness zones or traces
   b) Driving direction, parallel roads, on and off ramps
   c) Applicable lanes and lane closures
   d) Road signs
   e) Concurrent events
2) Application logic to inform and warn drivers, especially the timing and location of triggers and revocations to the HMI. Note that HMI design and presentations are not subject of the TESTFEST or the verifications.

Facilities that impact the interoperability and system performance will also be verified, such as:

3) Time synchronisation of units is a basic requirement and effects the services and data analyses. An example is the offsets due to CAM delta generation timestamps.
4) Communication performance affects the performance of services in several ways. The detection and updating of DENM and IVI events for road works events and the variable message signs activated by the Automatic Incident Detection (AID) for example depends on:

a) Fixed locations of road side communication units relative to event locations.

b) Antenna configurations on vehicles.

c) Tunnels, bridges, bends, trees, parallel roads, trucks and traffic density.

5) End-to-end delays from traffic control event triggering, and automatic incident detections to informing and warning drivers.

It should be noted that back end architectures and interfaces, or trigger conditions of road operator services are not in scope of the TESTFEST. The HMI design, presentation and driver interaction are not in scope of the TESTFEST either.

3.4 Evaluation

Verification during the TESTFEST will be limited to data analyses that can be executed automatically or on short notice. More detailed analyses and evaluations, e.g. of anomalies and alternative approaches, will be executed afterwards and reported separately.

4 Data Logging

To verify cross-border interoperability between VIS and RIS during the TESTFEST, participants need to log and provide data in a common format. The log data of vehicle and road side units will be collected and analysed, from which feedback will be provided on potential interoperability issues for discussion with participants during the TESTFEST.

Participants are requested to provide basic logging data during the TESTFEST, especially from the level 3 tests on the motorway (section 3.2). This section describes the principles for the common logging and log format. If a participant cannot record or transform the log data in the common format then their data will be processed and included in the evaluations after the TESTFEST.

4.1 Three levels of logging

Figure 1 and Figure 2 show simplified architectures of Vehicle and Road side ITS Stations with a component to send and receive ITS-G5 messages, and applications implementing the Day1 services and use cases. The applications have interfaces to input and output ITS-G5 messages. Applications also have interfaces to other components, i.e. the HMI in vehicles, and the interface between road side units and central units for traffic management and control.

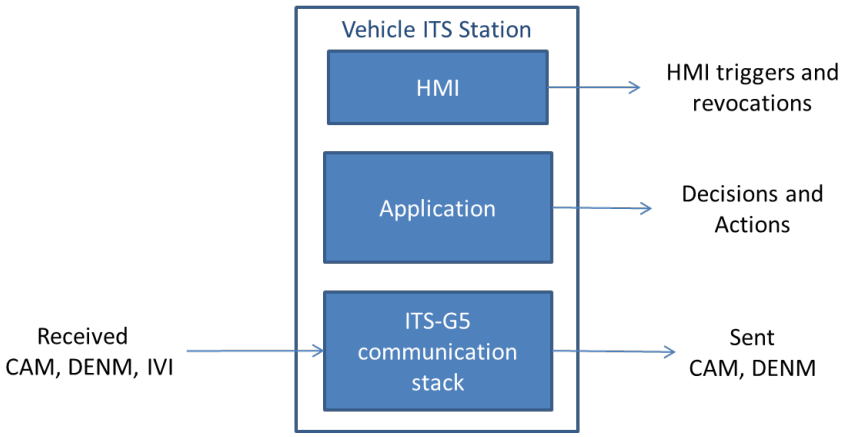

Figure 1: Vehicle ITS-Station simplified architecture

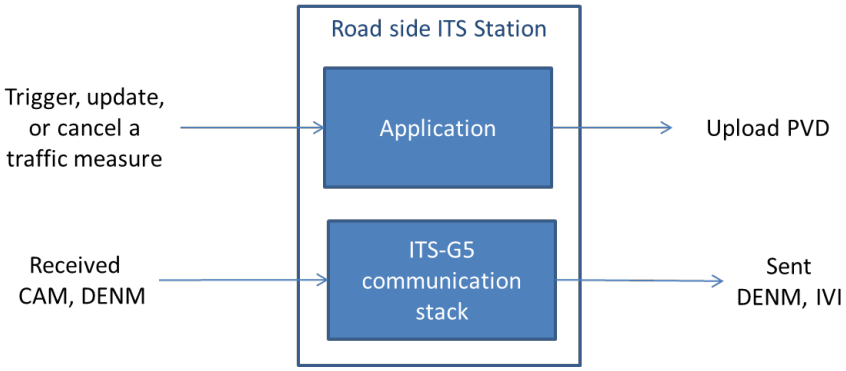

Figure 2: Road side ITS-Station simplified architecture

Black box verification of services requires the collection of data from VIS and RIS at three (or 2) levels:

1. CAM, DENM and IVI messages are logged upon reception and transmission.
2. Basic decisions and actions in the application logic.
    - The application logic on the RSU is of less relevance in this TESTFEST as the RSU only transforms traffic measures into DENM and IVI messages.
3. External inputs and outputs to applications.
    - On vehicles, only the trigger or revocations to presentation on warnings or information on the HMI are used in the verification.
    - On the road side units the triggers, updates and cancelation of traffic measures from the central units are most relevant for verification.

Logging of the communication at level 1 is defined in section 5. Application and HMI logging at levels 2 and 3 is defined in section 6.

4.2 Standard log item data

Data logging follows a few simple conventions:

- Every ITS-Station provides its own logging, and manages the integrity of its logging with unique identifiers (see Table 1).
- All data element names are defined in small letters only, and do not use spaces or special characters, to avoid conversion issues between various log and storage systems.
- The common log format is defined in [1] and [2]. This definition is extensive and includes all data elements forseen in the analyses. If some field should be logged, please use this format or transform the data into this format.
- Not all data elements need to be logged all the time and can be left empty (or null, or ..). In fact most data elements may not be needed, such as specific optional elements and containers in the DENM and IVI messages. The minimum required data elements are indicated in bold in [1] and [2]. Additional data elements may also be provided for reference by participants.
- All timestamps are logged in msec UTC.
    - Timestamps in CAM, DENM and IVI are defined in TAI, and may also be logged in TAI. However, it is strongly preferred to include the timestamps also to UTC on the logging unit or ITS-Station, to minimise time synchronisation errors.
    - The CAM delta generation times must be converted to UTC timestamps on the ITS-Station and added in the logging.
- Locations or positions are defined in WGS84 coordinates: latitude, longitude, bearing/heading. Latitude and longitude should be in degrees with min 10^{-7} precision. Locations may be supplemented with roadid, direction, lane id, etc. for reference.
- Log data is provided per test run or test session. Please do not provide redundant data, i.e. do not include data from previous test sessions.

A logging unit should complement every log item (as defined in the following sections) with the basic registration data defined in Table 1. The basic registration data is more detailed in tab “each table” in [1] and [2].

The registration data identifies the station, its component and time of logging the data. This registration data is needed to manage data from multiple stations and components. An ITS-Station may consist of multiple hardware units, multiple application and communication components and may have multiple logging components. A station may have multiple components processing DENMs for example, and multiple components can log the same DENMs. It is assumed that every ITS-Station has a unique stationId. Within this stationId every component should have a unique id to identify this component as provider of the log item. So it is up to the participant to use different applicationIds if components that provide the same log data items need to be distinguished in the analyses. Redundant log data items may be deleted from the analyses.

Table 1: Mandatory data elements for every log item

Parameter	Description
rowid	If data is provided in table or database format (e.g. as a database dump), then every log item or row should have a unique row number.
log_timestamp	Timestamp at which the application (log_applicationid) logs the data row. Timestamp is in elapsed time in msec since midnight January 1st 1970 UTC
log_stationid	StationId of the host ITS-Station that logs this log item or rowid.
log_applicationid	Identifier of the application, or component, that provides the data item for logging. Applicationid is at least unique within the station (log_stationid).

Note that the log_timestamp is the system time of the logging unit at which the data is actually logged. This is not the generation time of a message for example!

5 Communication logging

The CAM, DENM and IVI messages are logged upon transmission and reception on all ITS-Stations. All messages should be logged with the elements from Table 1 off course, and:

- An action label to denote whether the message was ‘SENT’ or ‘RECEIVED’.
- The data elements of the messages to be logged are defined in [1]. The data element names and formats are exactly as specified in the asn.1 definitions from

ETSI and ISO/CEN, following the principles of section 4.2 (e.g. all small letters). The message structure, including lists and containers, have been normalised in sub tables/sheets.

The registration data logs timestamps in UTC. Note that timestamps in the ITS-G5 messages use TAI and are also logged in TAI (see next sub sections). Additionally, the timestamps in the ITS-G5 messages may also be converted by the ITS-Station and logged in UTC.

5.1 Sent messages

In principle a sender should log the complete message contents. This approach minimises the logging resources for all receivers.

Note that Vehicle ITS-Stations should log their position, heading and speed in the sent CAMs.

5.2 Received messages

The receiver should at least log the information that uniquely identifies the message and sender as defined in Table 2. The message element names (e.g. “CAM.stationid”) are defined in [1]. This approach minimises the logging resources for all receivers. However, a receiver may log additional parameters as well.

Table 2: Mandatory log parameters of received ITS-G5 messages

Message type	Mandatory data elements of the received message
CAM	• Action = {SENT', 'RECEIVED'} • CAM.stationid of the sender • CAM.generationdeltatime • Generationtimestamp of the CAM, converted by the logging station from the CAM.generationdeltatime in TAI.
DENM	• Action = {SENT', 'RECEIVED'} • DENM.originatingstationid • DENM.sequencenumber • DENM.referencetime in TAI.
IVI	• Action = {SENT', 'RECEIVED'}

Message type	Mandatory data elements of the received message
	• IVI.stationid • IVI.serviceproviderid • IVI.iviidentificationnumber • IVI.timestamp in TAI

5.3 Log file formats

The logging of sent and received ITS-G5 messages can be provided in different formats. Table 3 defines the file types that can be processed, in the order of preference from top to bottom (i.e. preferably in database dump files). Examples files are provided with this document [3].

Table 3: Communication log file formats

File Type	Description
SQL	Log data is provided as an SQL data base per test run or test session. MySQL data files and Postgresql backup (dump in fc format) files can be processed. The data base schema is defined according to the tables in [1].
CSV	Log data can be provided in csv files per test run or test session. A csv file is provided for each relevant table from [1], with the sheet name as file name. The csv files contain a header line defining the field names from the sheet from [1].
UPER	The ITS-G5 messages can be provided in csv files per test run or test session. This file is similar to the CSV file above; i.e. it contains a header line, the mandatory registration data from Table 1, while the message is provided as the hexString dump of the UPER encoded ASN.1 message.
XER	The ITS-G5 messages can be provided in an xml file per test run or test session. The xml file contains the XER encoded ASN.1 message, complemented with the mandatory log registration data from Table 1.

6 Application logging

6.1 Event Types, Models and Actions

Every ITS-Station may use a different model of “events” at every level and component in Figure 1. Figure 3 gives an example of events for a RWW use case:

1. Traffic Control Centre or Central Unit sets a RWW traffic measure, for which a series of road side units generate DENM and IVI messages. A VIS passing the road side units receives the messages for a period of time. At this level, the event is the series of similar message received, while the reception of every message is an action.
2. During this period, the vehicle application triggers events when entering the relevance area and the awareness area for the road works.
3. For another period of time, a road works warning is triggered and later revoked on the HMI.

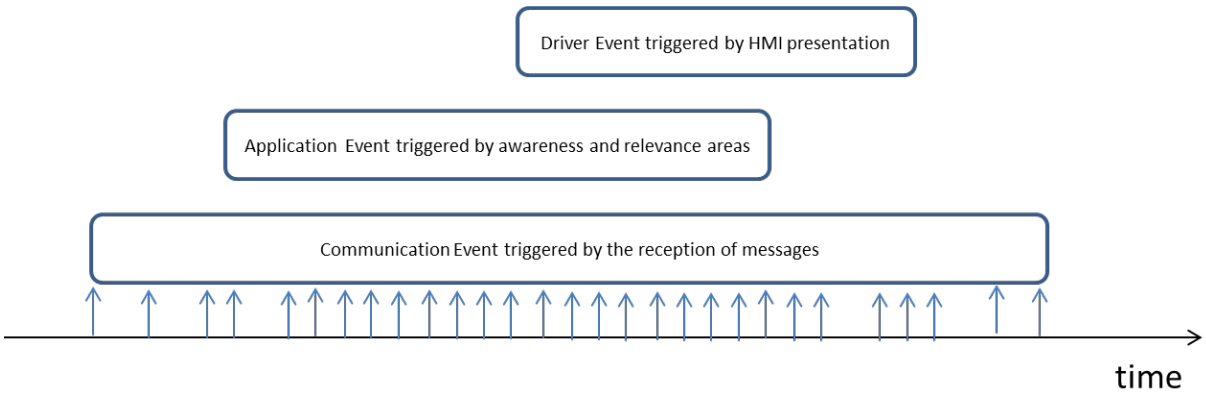

Figure 3: Example of events on a time line

To analyse and verify the generation, processing, interpretation and presentation of DENM and IVI messages, a generic model of events is adopted using the terminology of Table 4.

Table 4: Event terminology

Term	Description
Event Type	Event type identifies the (external) cause of processes and actions within an ITS-Station. The most relevant event types for the TESTFEST are {DENM, IVI}. Other types of events, such as the GPS signal loss are not considered for verification in the TESTFEST.

Term	Description
Event Model	A model of typical actions in a state machine or task model for processing a specific event at a specific application level.
Event Action	Relevant action or decision to be logged (Figure 1, Figure 2), such as the generation or reception of a DENM or IVI message, or the classification of the relevance or awareness of the message, and the warning of the driver.

“Event” is an abstract term that defines a time period in which the application performs a series of actions in reaction to an external event; i.e. the event that causes or triggers processes and actions within an ITS-Station. The reception of a DENM or IVI message is an external event. The detection of a hazardous situation is also an external event for which a DENM message has to be generated.

The reception of a DENM, for example, causes a series of events, subevents and actions. Events and actions could be modelled in a state machine, in which external events trigger actions and transitions between internal states. The state machines are nested; i.e. state machines at subsequent levels in the applications are dependent. The state machines are obviously implementation specific and will remain “hidden” in the common data analyses and verifications, i.e.:

- Nesting of the state models is implicit in the event models.
- An event model does not imply any state machine of task model, and only defines the relevant actions to be logged and analysed.

Figure 3 shows schematically how event models can differ at various layers:

1. At communication level,an event is the transmission or reception of a DENM or IVI message. The event model defines actions to trigger, update and terminate the message.
2. An application can be considered as a state machine with events that are decisions triggering state transitions. An event model describes the actions in the processing of a received DENM or IVI message, and includes actions to detect and distinguish the trigger, an update, a cancellation and a negation in the series of repeated messages. At the next applicatino level, another event model defines actions in the process to determine the relevance of the DENM, including the mapping onto the relevance area, driving direction, and matching on a trace or eventHistory.

3. Applications implement proprietary interfaces to HMI components or external systems. Important output events to distinguish are for example when a warning for a DENM is triggered, presented, updated and revoked on the HMI. An event model defines the actions of an application sending commonds to the HMI. Another event model defines the action of the HMI to actualle present, update or revoke information on the display.

The event types, models and actions are defined in [2].

6.2 Application logging and file formats

Applications and the HMI component log actions as defined in [2]. The ITS-Station is in control for defining and logging events and actions in a format defined in Table 5.

Table 5: Application log file formats

File Type	Description
SQL	Log data is provided as an SQL data base per test run or test session. MySQL data files and Postgresql backup (dump in fc format) files can be processed. The data base schema is defined according to the tables in [2].
CSV	Log data can be provided in csv files per test run or test session. A csv file is provided for each relevant table from [2], with the sheet name as file name. The csv files contain a header line defining the field names from the sheet from [2].

The definition of event types and actions in [2] is intended as a common model for logging, analysis and evaluation of the same events across all ITS-Stations. It is assumed that any proprietary logging contains the same or similar actions and that the proprietary logging can be transformed into the common model. Participants may also refine the event models in their logging, extend the logging or provide logging only at specific levels.

6.2.1 Logging Events

An ITS-Station uniquely defines and logs every event and assigns a unique event identifier for the event. It is encouraged to use the same eventIds in all dependent event models, to enable tracking the processing of events across all levels of the application and the hmi.

Characterisation of events is event type specific and will be defined in following sections.

6.2.2 Logging Actions

Actions are logged with the eventid, and the eventmodelid and eventactionid as defined in the model for the event type. Additional action parameters may be added to the logging.

6.3 DENM event type

The common DENM event type and models are defined [2] on sheet “DENM EventModels”. DENM Event Models are identified for:

1. Generating messages
2. Processing received messages
3. Relevance detection of received messages
4. Location matching of received messages
5. Driver awareness triggering of received messages
6. HMI presentation of received DENM messages

Actions are defined for the most relevant transitions in the communication interaction protocol and for the relevant decisions in processing for each DENM Event Model.

6.3.1 Logging DENM events

An ITS-Station logs every DENM event in sheet “denmevent” of [2]. A DENM event is uniquely defined by the actionid of a DENM; i.e. the originatingstationid and sequencenumber. Preferably all DENM updates and termination messages are considered as the same event. It is discouraged to define each DENM update as a unique event with a DENM.referencetime.

6.3.2 Logging DENM actions

All DENM actions are logged in sheet “denmaction” of [2] by referencing the eventid from the “denmevent” table. Additional parameters can be added to the “denmaction” to refine the analysis of DENM processing.

6.4 IVI event type

The common IVI event type and models are defined [2] on sheet “IVI EventModels”. IVI Event Models are identified for:

1. Generating messages
2. Processing received messages

3. Relevance detection of received messages
4. Location matching of received messages
5. Driver awareness triggering of received messages
6. HMI presentation of received DENM messages

Actions are defined for the most relevant transitions in the communication interaction protocol and for the relevant decisions in processing for each IVI Event Model.

6.4.1 Logging IVI events

An ITS-Station logs every IVI event in sheet “ivievent” of [2]. An IVI event is uniquely defined by the actionid of an IVI i.e. the IVI.stationid, IVI.serviceproviderid and IVI.iviidentificationnumber. Preferably all IVI updates and termination messages are considered as the same event. It is discouraged to define each IVI update as a unique event with a IVI.timestamp.

Complex IVI messages, with multiple GeneralIviContainers, and multiple parts with combinations of zones, could be interpreted and processed as separate events.

6.4.2 Logging IVI actions

All IVI actions are logged in sheet “iviaction” of [2] by referencing the eventid from the “ivievent” table. Additional parameters can be added to the “iviaction” to refine the analysis of IVI processing.

7 Conclusions

This document defines the formats for data logging in the first InterCor TESTFEST in July 2017. The TESTFEST focus on validation of cross-border interoperability of Day1 C-ITS services and technology. Logging formats are defined at three levels to acquire the data for testing and validation during the TESTFEST, and also for evaluation in InterCor after the TESTFEST.

8 Bibliography

[1] InterCor_CommonCommunicationLogFormat_v??.xlsx, spreadsheet defining the common format for communication logging.

[2] InterCor_CommonApplicationLogFormat_v??.xlsx, spreadsheet defining the common format for application logging.

[3] Example files for logging.

Annex

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