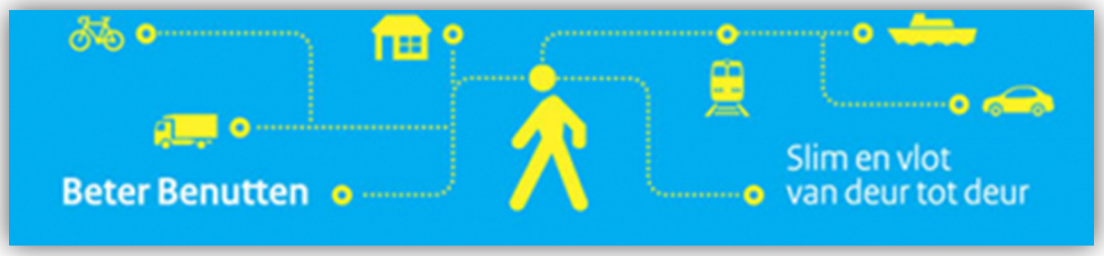
Intelligente Verkeers Regel Installatie (iVRI) – Fase 2

Deliverable 3f: Test specifications

Interoperability



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1 Voorwoord

In mei 2016 is opdracht verstrekt door het Ministerie van Infrastructuur en Milieu via het Beter Benutten Vervolg (BBV) programma aan vijf VRA leveranciers om de in fase 1 opgeleverde iVRI architectuur, te bouwen en te testen in samenwerking met applicatiebouwers.

Dit document is onderdeel van Deliverable 3f van de afgesproken leverdelen in de opdrachtverstrekking en beschrijft de FAT test specificatie voor de TLC.

Dit document is tot stand gekomen door samenwerking van de leveranciers in de werkgroep bestaande uit:

Koos van Vliet

Edwin Henning

Jaap Zee

Michel Huisman

NB. De rest van dit document is geschreven in het Engels om internationale uitwisseling te ondersteunen.

The rest of this deliverable has been written in English to facilitate international exchange.

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2 Introduction

This document describes the interoperability of the iTLC interfaces.

2.1 System overview

The iTLC architecture defines several interfaces of the iTLC. Figure 1 shows these interfaces. See [Ref 1] for a detailed architecture description.

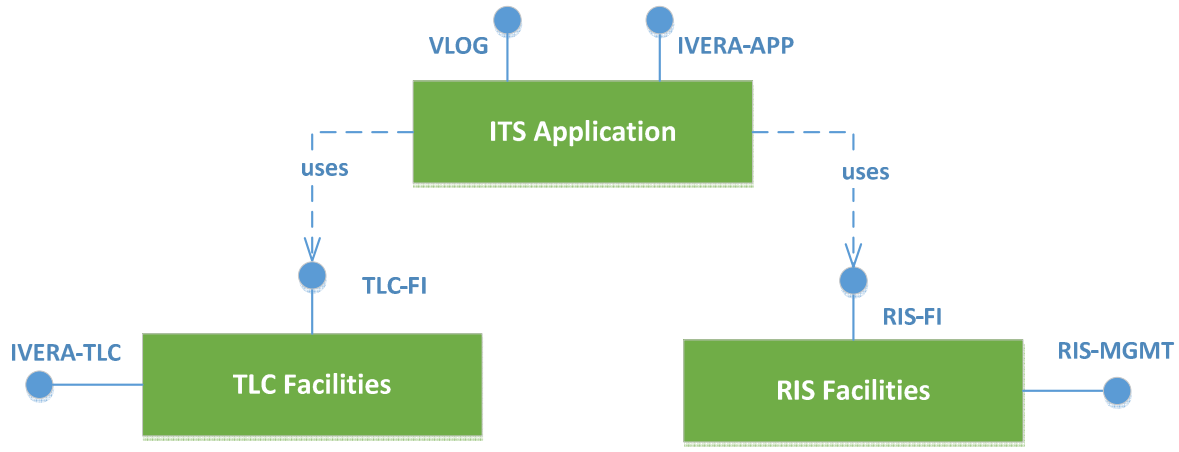


Figure 1 System overview

2.2 Document overview

2.2.1 Purpose

This document provides specifications for the testing of the TLC Facilities. This document is a part of a set of test specifications, which together form deliverable 3f. See [Ref 7] for the description of the iVRI test strategy.

2.2.2 Document structure

Chapter 3 contains references to normative and informative documents.
Chapter 4 explains acronyms and used definitions and concepts.
Chapter 5 outlines the test setup.
Chapter 6 outlines guidelines for the execution of the test scenarios.
Chapter 7 outlines guidelines for the interpretation of the test output.
Chapter 8 outlines the formal specification of the test cases.

2.3 Advise for the reader

It is advised that the reader has taken knowledge of the iTLC Architecture as described in [Ref 1] and the iTLC test strategy as described in [Ref 7].

3 References

3.1 Normative

ID	Reference
[Ref 1]	*Beter Benutten Vervolg, project iVRI, Deliverable F, iTLC Architecture, v1.2*
[Ref 2]	*Beter Benutten Vervolg, project iVRI, Deliverable G2, IRS TLC Facilities Interface v1.2, jan 2016*
[Ref 3]	*Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 1ab IDD Generic Facilities Interface v1.1, aug 2016*
[Ref 4]	*Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 1ab IDD TLC Facilities Interface v1.1, aug 2016*
[Ref 5]	*Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 1d IRS security v1.1, oct 2016*
[Ref 6]	*Beter Benutten Vervolg, project iVRI – fase 1, Deliverable G3, IRSIDD IVERA 4.00, v2.0 sep 2016*
[Ref 7]	*Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 3f iVRI test strategy v1.1, nov 2016*
[Ref 8]	*Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 3f, TLC test specification v1.0, nov 2016*
[Ref 9]	*Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 3f, ITS application test specification v1.0, nov 2016*
[Ref 10]	*IRS-KAR001_v124_20070316.pdf*

3.2 Informative

ID	Reference

4 Acronyms, abbreviations and concepts

Acronyms and abbreviations

C-ITS	Cooperative ITS functionality for exchange of data between in-vehicle and or road side devices making use of either cellular or short range wireless communication
IDD	Interface Design Description
IRS	Interface Requirements Specification
iTLC (Dutch iVRI)	Intelligent TLC performing traffic light controller and C-ITS functions and providing access to these functions for ITS applications
ITS	Intelligent Transport Systems
ITS Station	Functional entity specified by the ITS station reference architecture.
IVERA	Management protocol for traffic light controllers in the Netherlands
IVERA-APP	Management protocol for ITS applications.
IVERA-TLC	Management protocol supported by the RLC Facilities.
RIS	See R-ITS-S
RIS-FI	R-ITS-S Facilities Interface
R-ITS-S	Roadside ITS Station, responsible for C-ITS functionality within a geographical area.
TLC	Traffic Light Controller; controls the signal of one or more intersections
TLC-FI	Traffic Light Controller Facilities Interface
TLS	Transport Layer Security
TMS	Traffic Management System
V-Log	Traffic Data log

Concepts

ITS Control Application	A Traffic Control Application which uses TLC- and/or RIS-interfaces
ITS Application (ITS-APP)	An application which supports one or more ITS use-cases. Range of possible ITS Applications include an ITS Control Application
RIS Facilities	Component providing RIS Facilities to users (internal and/or external). Includes amongst others: • Access to information stored in the LDM • Services to trigger C-ITS messages
TLC Facilities	Component providing facilities of a TLC to users (internal and/or external). Includes amongst others: • Access to information from the TLC • Services to trigger actuators

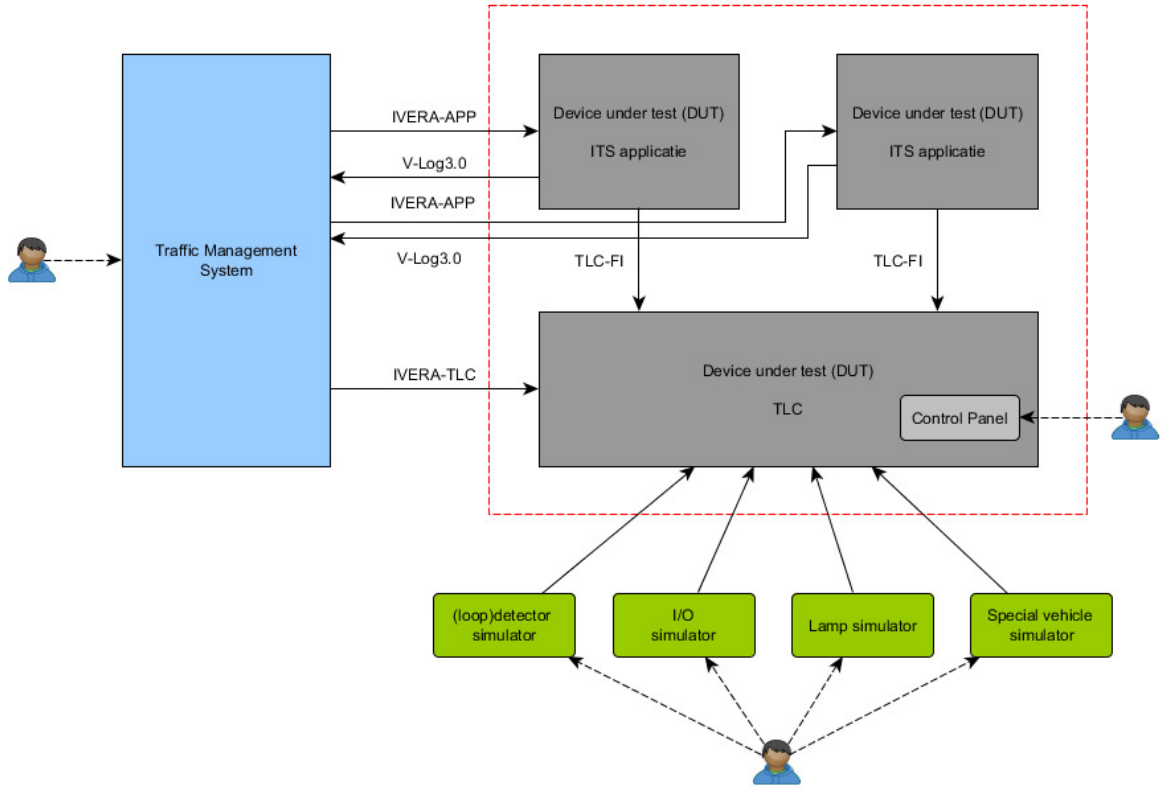
5 Test setup

5.1 Introduction

This chapter outlines the test setup.

5.2 Device under test

The device under test (DUT) is an iVRI consisting of a TLC and two ITS control applications. The iVRI implements the IVERA-TLC, IVERA-APP and V-Log 3.0 external interfaces.



5.3 Network configuration

Device	Static IPv4 address
TLC	192.168.10.10
ITS-CLA1	192.168.10.20
ITS-CLA2	192.168.10.30
TMS	192.168.10.40
NTP server	192.168.10.50

The router has DHCP and assigns IP addresses to other devices on the network (like PC's) in the range 192.168.10.200 .. 192.168.10.250.

The default port numbers of the iVRI system interfaces are configured in the components: (add table with list of port numbers expected or refer to configuration document)

5.4 Certificates

Vialis is the Certificate Authority (CA) that issues the certificates required for the interoperability testing during the iVRI2 project.

5.5 Test tooling

5.5.1 NTP server

The NTP server is a separate device on the network.

5.5.2 iTLC exerciser

Used as an ITS consumer, ITS provider and ITS control application, depending on the test scenario.

5.5.3 IVERA command line tool

Used in case the TMS does not support a specific IVERA feature.

5.5.4 Oscilloscope

Used for time measurement.

5.5.5 Variac

Used for voltage variation (EN50556)

5.5.6 Voltage dip generator

Used for generating voltage dips (EN50556)

6 Test execution

6.1 Introduction

This chapter provides guidelines for the execution of the test scenarios specified in this document.

6.2 Structure

During a test the Device Under Test (DUT) is subjected to the documented test cases. This test specification is structured as follows:

- Test specification
    - Test scenario(s)
        - Test case(s)
            - Test step(s)

6.3 Execution

The tests are executed in the documented order. No alternations should be made to the device under test during the test, unless explicitly documented.

The results are documented per test step.
A test step has passed if the pass criteria has been met.
A test step has failed if the pass criteria has not been met.
A test case has passed if all test steps have passed.
A test scenario has passed if all test cases have passed.

6.3.1 Verify in the TMS

In case a TMS does not support the functionality to execute a test step then an IVERA command line tool can be used to execute the test. Make a remark if an IVERA command line tool is used.

6.3.2 Direct

In several test cases the word direct or directly is used. This is to indicate a timely response to an event. For example when the dark button on the control panel is pressed, the iVRI shall switch off the signals directly. In case of doubt, the tester can measure the time and note the measured time in the remarks column. By default, the time is not measured unless time measurement is listed as an explicit action in the test step.

6.3.3 Exploratory

The tester decides how the test step is executed.

6.3.4 Additional testing

The iVRI is a complex system with several interfaces. This test specification aims to cover the basic operations and some common exceptions. On top of this test specification, there are many more combination of events that could be verified or validated, however this is not practical. It is therefore left to the discretion of the tester(s) to assess if additional testing is required based on the outcome of the documented test cases.

6.4 Test case notation format

The following format is used to specify the test cases and document the test results.

Test Case:	
ID:	

Objective:			
Pre-conditions:			
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Actions **Verify**		
2.			
3.			
Tested by:		**Date:**	

- Test case: A short description of the test case.
- ID: A unique ID
- Objective: The objective of the test case.
- Pre-conditions: The pre-conditions before the test case is executed.
- STEP: Number of the step.
- DESCRIPTION: A description of the actions to be executed and a description of the items to be verified.
- PASS/FAIL: The test result.
- REMARKS/ACTIONS: Remarks and actions related to the test results.
- Tested By: Person who executed the test case.
- Date: The date at which the test case was executed.

6.4.1 Remarks / actions

A remark shall be documented if:

- the test step does not meet the pass criteria;
- the test step cannot be executed;
- the test is interrupted;
- the test results are unusable;

6.5 Test Readiness Review

A Test Readiness Review (TRR) is held to verify readiness for formal interoperability type testing. The conditions are:

- The test configuration as specified in chapter 5 is available.
- A release version of the software is loaded in the iVRI components (TLC, ITS-CLA1 and ITS-CLA2)
- The test intersection is configured in the TLC, ITS-CLA1, ITS-CLA2 and the traffic management system.
- ITS-CLA1 supports the functional behaviour required for the documented test cases.
- ITS-CLA2 supports the functional behaviour required for the documented test cases.
- The pre-conditions as documented in the test scenarios/test cases are met.
- The product identification tables are filled in.
- A pass on all test cases in the smoke test scenario.

7 Test verification

7.1 Introduction

This chapter provides guidelines on how to interpret the test output.

7.2 Validation

In several test cases there are steps to validate the functioning or performance of the iVRI. The tester validates if the system fulfils its intended purpose. Where applicable the tester performs exploratory testing to asses this.

These steps typically require knowledge of the functional behaviour of the ITS applications and the outcome depends on the judgement of the person who executes the test case.

An example of a validate step is outlined below based on test case 8.3.3. (Green on demand). The tester can verify that a signal group turns green when a detector is activated (i.e. a demand is set). The tester can validate things like:

- The time between the detector being activated and the signal group turning green.
- Expected and unexpected state changes on other signal groups.
- The time the signal group stays green.
- Etc.

The tester(s) based on expert judgement fills in pass or fail.
The tester(s) notes any issues/concerns in the remark/action column.

8 Test scenarios

8.1 Introduction

This chapter describes the test scenarios and the test cases per scenario.

8.2 Product identification

Please document below the relevant information of the product(s) under test.

8.2.1 Traffic light controller

Manufacturer		
Product		
Software release		
IVERA-TLC	TLS / VPN	
TLC-FI	TLS / VPN	
Backup program	Yes / No	Program number:
[Ref 1] QA_PERF_002 Note 1)		
[Ref 1] QA_PERF_003 Note 2)		
Input pulse width Note 3)		
Pre-conditions met		
Remarks (if any)		

Note 1) Maximum latency between change of hardware inputs and internal state of TLC objects. Specify the time in milliseconds.
Note 2) Maximum latency between updated internal TLC objects (like 'requested output-states') and actual changed hardware outputs. Specify the time in milliseconds.
Note 3) The minimum duration that a hardware input of the TLC should be active to guarantee an input state change in the TLC. Specify the time in milliseconds.

8.2.2 ITS application 1 (ITS-CLA1)

Manufacturer	
Product	
Software release	
Supports IVERA-APP	Yes/No
Supports V-Log3.0	Yes/No
Pre-conditions met	
Remarks (if any)	

8.2.3 ITS application 2 (ITS-CLA2)

Manufacturer	
Product	
Software release	
Supports IVERA-APP	Yes/No
Supports V-Log3.0	Yes/No
Pre-conditions met	

Remarks (if any)	

8.2.4 Traffic Management System

Manufacturer	
Product	
Software release	
Supports IVERA-TLC	Yes/No
Supports IVERA-APP	Yes/No
Supports V-Log3.0	Yes/No
Pre-conditions met	
Remarks (if any)	

8.3 Test scenario 0: Smoke test

This test scenario is a quick scan to verify that all components are operational and that all interfaces are available and accessible.

8.3.1 Smoke test

Test Case:	**Smoke test**		
ID:	SC0.SMO.01		
Objective:	Verify that all systems are operational and all interfaces are available and accessible		
Pre-conditions:	The system is switched on.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	**Verify** that the TLC is operational.		
2.	**Verify** that ITS-CLA1 is operational.		
3.	**Verify** that ITS-CLA2 is operational.		
4.	**Verify** that an IVERA administrator user can login into the TLC. (Admin,AdminPassword)		
5.	**Verify** that an IVERA administrator user can login into the ITS-CLA1 from the traffic management system. (iAdmin,iAdminPassword)		
6.	**Verify** that an IVERA administrator user can login into the ITS-CLA2 from the traffic management system. (iAdmin,iAdminPassword)		
7.	**Verify** that the traffic management system can setup a connection to receive V-Log 3.0 output from ITS-CLA1.		
8.	**Verify** that the traffic management system can setup a connection to receive V-Log 3.0 output from ITS-CLA2.		
9.	**Verify** that all components (TLC, ITS-CLA1, ITS-CLA2, TMS) are NTP synchronized.		

10.	**Verify** that the certificates (required for TLS) are installed.		
Tested by:		**Date:**	

8.4 Test scenario 1: Normal operation

This test scenario is designed to verify and validate the normal operation of the iVRI consisting of a TLC and an ITS application. During this test scenario the intersection is under control of ITS-CLA1 (i.e. program number 1 active in the TLC).

8.4.1 Start-up

Test Case:	**Start-up**		
ID:	SC1.NO.01		
Objective:	Verify that the iVRI starts up correctly after power-up.		
Pre-conditions:	The TLC and both ITS applications are switched off.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Switch-on the power of the TLC and both ITS applications at the same time.		
2.	**Verify** that the intersection starts with amber flashing. - fc02, fc03, fc05, fc07, fc08, 21: amber flashing - 31, 32: dark **Write** in the remark column the time (in seconds) between power-up and the start of amber flashing.		
3.	**Verify** that the intersection shows amber flashing for at least 15 seconds.		
4.	**Verify** that the intersection shows steady amber for 5 seconds - fc02, fc03, fc05, fc07, fc08, 21: amber - 31, 32: red **Write** in the remark column the time (in seconds) between power-up and the start of steady amber.		
5.	**Verify** that the intersection shows all red for at least 11 seconds.		
6.	**Verify** that ITS-CLA1 is the active ITS application (controlState = inControl)		
7.	**Verify** that ITS-CLA2 is in the state ReadyToControl.		
Tested by:		**Date:**	

8.4.2 Cyclic operation

Test Case:	**Cyclic operation**		
ID:	SC1.NO.02		
Objective:	Verify that all signal groups are being served when all detectors are activated.		
Pre-conditions:	ITS-CLA1 is the active control application. All signal groups are red.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Activate all detectors (occupied)		
2.	**Verify** that the signal groups are served, respecting the safety and transmission timing.		
3.	Monitor the system for at least 15 minutes. **Validate** that the iVRI functions as expected		
Tested by:		**Date:**	

Note: In which order the signal groups are served depends on the functional behaviour of the ITS Control application.

8.4.3 Green on demand

Test Case:	**Green on demand**		
ID:	SC1.NO.03		
Objective:	Signal groups are served when demand is set.		
Pre-conditions:	All detectors are inactive and all signal groups are showing red (i.e. waiting in red).		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Toggle detector d2. **Verify** that fc02 turns green and after the configured fixed green time turns to red.		
2.	Repeat step 1 for all detectors - d2 -> fc02 - d3 -> fc03 - d5 -> fc05 - d7 -> fc07 - d8 -> fc08		

	- dk-21 -> 21 - dk31_1 -> 31 - dk31_2 -> 31		
3.	Toggle detector d2 Wait until fc02 turns green. Toggle detector d5 while fc02 is green. **Verify** that fc05 turns green after fc02 turns to red.		
Tested by:		**Date:**	

8.4.4 Demand wait indicators

Test Case:	**Demand wait indicators**		
ID:	SC1.NO.04		
Objective:	Verify that the demand wait indicator functions as expected		
Pre-conditions:	All detectors are inactive and all signal groups are showing red (i.e. waiting in red).		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	**Verify** that the wait indicator output w31 is off. Toggle detector d2. Wait until fc02 turns green. Toggle detector dk31_1 **Verify** that the wait indicator output w31 directly goes on (state=1) and stays on.		
2.	Wait until 31 turns green. **Verify** that the demand wait indicator w31 goes off (state = 0) at the same time 31 turns green.		
Tested by:		**Date:**	

8.4.5 Public Transport

Test Case:	**Public transport**
ID:	SC1.NO.05
Objective:	The corresponding signal group is served when a PT vehicles checks in.
Pre-conditions:	All detectors are inactive and all signal groups are showing red (i.e. waiting in red)

STEP	DESCRIPTION	PASS / FAIL	REMARKS/ACTIONS
1.	Generate a KAR message with the following attributes. - KAR[2,vehicle type]= 1 (bus) - KAR[3,line number PT] = 102 - KAR[4,block number] = 25 - KAR[5,company number]=6 (RET) - KAR[6,vehicle id]=5698 - KAR[7,direction]=2 - KAR[8,vehicle status]=1 (driving) - KAR[10,punctuality class]=1 (late) - KAR[11,punctuality]=60 - KAR[12,length]=18 - KAR[13,speed]=13 - KAR[19,command]=1 (entering announcement)		
2.	**Verify** that fc02 turns green.		
3.	Wait 30 seconds. **Verify** that fc02 stays green during this period.		
4.	Generate a KAR message with the following attributes. - KAR[2,vehicle type]=1 (bus) - KAR[3,line number PT]=102 - KAR[4,block number]=25 - KAR[5,company number]=6 (RET) - KAR[6,vehicle id]=5698 - KAR[7,direction]=2 - KAR[19,command]=2 (leave announcement)		
5.	**Verify** that fc02 turns to red (via amber)		
6.	Generate a KAR message with the following attributes. - KAR[2,vehicle type]=1 (bus) - KAR[3,line number PT]=108 - KAR[4,block number]=1 - KAR[7,direction]=8		

	- KAR[19,command]=1 (entering announcement)		
7.	**Verify** that fc08 turns green.		
8.	Wait 30 seconds. **Verify** that fc08 stays green during this period.		
9.	Generate a KAR message with the following attributes. - KAR[2,vehicle type]=1 (bus) - KAR[3,line number PT]=108 - KAR[4,block number]=1 - KAR[7,direction]=8 - KAR[19,command]=2 (leave announcement)		
10.	**Verify** that fc08 turns to red (via amber)		
11.	Generate a KAR message with the following attributes. - KAR[2,vehicle type]=1 (bus) - KAR[3,line number PT]=108 - KAR[4,block number]=1 - KAR[7,direction]=8 - KAR[19,command]=1 (entering announcement) **Verify** that fc08 stays red.		
12.	**Verify** that the ITS application correctly receives and interprets the attributes of a special vehicle. Use a KAR message generator to send KAR messages to the TLC. Use the table below to document the results per attribute. Please refer to [Ref 10] for details. *Note: Testing the KAR attributes overlaps with the type testing.* • *See ITS-CLA FAT test: SC1.CLA.06.HA* • *See TLC FAT test: SC1.CRA.10.HA*		

Tested by:		Date:	

8.4.5.1 KAR attributes

#	Attribute / description	PASS / FAIL	REMARKS/ACTIONS
1	Virtual loop number		
2	Vehicle type		
3	Line number PT		
4	Block number (‘Wagendienst nummer’)		
5	Company number		
6	Vehicle Id		
7	Direction at intersection, signal group number		
8	Vehicle status		
9	Priority class		
10	Punctuality class		
11	Punctuality [s]		
12	Vehicle length [m]		
13	Actual vehicle speed [m/s]		
14	Distance to stop line [m]		
15	Driving time till stop line [s]		
16	Journey number (‘ritnummer’)		
17	Type of journey		
18	Route Public Transport		
19	Type of command		
20	Activation point number		
21	Location conform WGS84.		
22	Actual time of sending message in on board computer (year, month, day, hour, minute, second)		
23	Reserved		
24	Reserved		
Tested by:		**Date:**	

8.4.6 Emergency vehicles

Test Case:	Emergency vehicles
ID:	SC1.NO.06

Objective:	Signal groups are served when an emergency vehicles checks-in.		
Pre-conditions:	All detectors are inactive and all signal groups are showing red (i.e. waiting in red)		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Generate a KAR message with the following attributes. - KAR[2,vehicle type]=3 (police) - KAR[7,direction]=5 - KAR[19,command]=1 (entering announcement)		
2.	**Verify** that fc05 turns green.		
3.	Wait 30 seconds. **Verify** that fc05 stays green during this period.		
4.	Generate a KAR message with the following attributes. - KAR[2,vehicle type]=3 (police) - KAR[7,direction]=5 - KAR[19,command]=2 (leave announcement)		
5.	**Verify** that fc05 turns to red.		
Tested by:		**Date:**	

8.4.7 Manual control

Test Case:	**Manual control**		
ID:	SC1.NO.07		
Objective:	Verify that the iVRI responds correctly to user actions on the police panel		
Pre-conditions:	All detectors are inactive and all signal groups are showing red (i.e. waiting in red)		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	**Verify** (during step 2 t/m 9) that the intersection state (VRISTAT) and the signal group status is correctly presented on the GUI of the traffic management system (e.g. using the real-time monitoring function in the TMS).		
2.	Select dark on the control panel. **Verify** that the signal groups are directly switched off.		

3.	Select Amber flashing on the control panel. **Verify** that the signals show amber flashing (31/32 are dark).		
4.	Wait at least 20 seconds. Select all red on the control panel. **Verify** that the signals directly switch to steady amber (31/32 show red) and after 5 seconds all signal show red. **Verify** That all signals remain in red.		
5.	Activate all detectors (i.e. occupied) Select control on the control panel. **Verify** that the ITS-CLA1 is in control and serving the signal groups in cyclic order.		
6.	Activate **fixation** on the control panel when fc02 is green. **Verify** that fc02 is remains green. **Verify** that the fixation indicator on the control panel is lit (if present)		
7.	Keep fixation active for at least 10 minutes. **Verify** that fc02 remains green during this period and that no error occurs.		
8.	De-activate fixation on the control panel. **Verify** that the ITS-CLA1 is in control and serving the signal groups in cyclic order. **Verify** that the fixation indicator on the control panel is off (if present)		
9.	**Validate** control panel operation by exploratory testing, including monitoring the status on the user interface of the TLC and the ITS application.		
10.	Review the events in the IVERA logbook in the TLC, especially event code: 2001 (VRI status). **Verify** that the events match with the actual state transitions.		
Tested by:		**Date:**	

8.4.8 *Inputs / Outputs*

Test Case:	**Inputs / Outputs**		
ID:	SC1.NO.08		
Objective:	Verify that the iVRI handles inputs and outputs correctly		
Pre-conditions:	The inputs are inactive.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Activate inputA (state=1) **Verify** that output exclOutputA is activated (state=1).		
2.	De-activate inputA **Verify** that output exclOutputA is de-activated (state=0).		
Tested by:		**Date:**	

8.4.9 *Detector events*

Test Case:	**Detector events**		
ID:	SC1.NO.09		
Objective:	Verify that detectors events are handled correctly by the iVRI.		
Pre-conditions:	Detector ds2 is available and exclOutputB is off		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Generate a vehicle event (50km/h, 4.5m, normal direction, unknown class) **Verify** that output exclOutputB is off and stays off.		
2.	Generate a vehicle event (80km/h, 17.5m, normal direction, unknown class) **Verify** that output exclOutputB goes on and stays on for 1 second.		
3.	Generate a vehicle event (80km/h, 4.5m, normal direction, unknown class) **Verify** that output exclOutputB is off and stays off.		
4.	Generate a vehicle event (80km/h, 17.5m, reverse direction, unknown, class) **Verify** that output exclOutputB is off and stays off.		

Tested by:		**Date:**	

8.4.10 Signal group predictions

Test Case:	**Signal group predictions**		
ID:	SC1.NO.10		
Objective:	Verify that the TLC receives signal group predictions and sends notifications to subscribed applications		
Pre-conditions:	All detectors are inactive, all signal groups are red.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Use an iTLC exerciser tool and connect to the TLC as an ITS consumer application (Consumer3, L0gin4You!) Subscribe to the signal groups.		
2.	Monitor the signal group predictions in the iTLC exerciser. **Validate** the signal group prediction		
3.	Activate all detectors.		
4.	Monitor the signal group predictions in the iTLC exerciser. **Validate** the signal group predictions while the iVRI serves the signal groups in cyclic order.		
Tested by:		**Date:**	

8.5 Test scenario 2: IVERA-TLC

This test scenario is designed to verify the IVERA-TLC interface between the TLC and the TMS. Please note that this is not a full-blown test of all IVERA capabilities. The aim is to verify the interoperability between an iVRI and a TMS using basic operations.

8.5.1 Real-time monitoring

Test Case:	**Real-time monitoring**		
ID:	SC2.IVT.01		
Objective:	The status of the intersection, signal groups, detectors, inputs and outputs are correctly presented in the real-time monitoring view of the TMS (‘kruispuntplaatje’).		
Pre-conditions:	All detectors and inputs are inactive. All signal groups are red.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Exploratory testing of detectors (i.e. activate detectors). **Verify** that the status of the detectors and signal groups as presented (on the GUI) in the TMS matches with the actual status.		
2.	Exploratory testing of inputs (i.e. activate inputs). **Verify** that the status of the inputs and outputs as presented (on the GUI) in the TMS matches with the actual status.		
3.	Exploratory testing of the intersection state (i.e. using the control panel). **Verify** that the status of the intersection as presented (on the GUI) in the TMS matches with the actual status.		
4.	**Verify** on the GUI of the TMS that the program 1 is active.		
Tested by:		**Date:**	

8.5.2 Detectors

Test Case:	**Detectors**		
ID:	SC1.IVT.02		
Objective:	Verify that the swico state and detector status work properly		
Pre-conditions:	All detectors and inputs are inactive. All signal groups are red.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**

1.	Use the TMS to set the detector swico for d2 = ON. **Verify** That signal group fc02 has a permanent demand and goes to green.		
2.	Use the TMS to set the detector swico for d2 = OFF **Verify** that fc02 goes to red and stays red.		
3.	Toggle detector d2. **Verify** that fc02 stays red.		
4.	Make a hardware fault for detector d2 (by disconnecting the loop) **Verify** the detector status in the TMS. **Verify** that fc02 stays red.		
5.	Repair the loop. Make detector d2 inactive. Use the TMS to set the detector swico for d2 = AUTO. **Verify** the detector status in the TMS. **Verify** that fc02 stays red.		
6.	Toggle detector d2. **Verify** that fc02 goes to green.		
Tested by:		**Date:**	

8.5.3 Logbooks

Test Case:	**Logbooks**		
ID:	SC1.IVT.03		
Objective:	Verify that everything that should be logged is logged		
Pre-conditions:	All detectors and inputs are inactive. All signal groups are red.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Exploratory testing of detectors. **Verify** events in the detector logbook in the TMS. **Verify** events in the signal group logbook in the TMS.		

2.	Exploratory testing of inputs **Verify** events in the inputs logbook in the TMS. **Verify** events in the output logbook in the TMS.		
3.	Exploratory testing of special vehicle events (i.e. using the KAR message generator). **Verify** events in the Public Transport logbook in the TMS.		
4.	Exploratory testing of parameter changes. **Verify** events in the parameter logbook in the TMS.		
Tested by:		**Date:**	

8.5.4 User management

Use IVERA command line tool if TMS does not support this functionality.

Test Case:	**User management**		
ID:	SC1.IVT.04		
Objective:	Verify user management		
Pre-conditions:	An TMS is active		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Use the TMS to change the password of an IVERA-TLC user. (Kantonnier,K.nt.nn..r) to (Kantonnier,new{P!) **Verify** that the user Kantonnier can login with the password new{P!		
2.	Use the TMS to change the password of a TLC-FI user. (Consumer3,L0gin4You!) to (Consumer3,new{P!) **Verify** that Consumer3 can login with the password new{P!		
3.	Power-down the TLC for 5 minutes. Switch-on the TLC		
4.	**Verify** that the user Kantonnier can login with the password new{P!		
5.	**Verify** that Consumer3 can login with the password new{P!		

	(i.e. using a iTLC exerciser tool).		
6.	Restore the original password. **Verify** that the user Kantonnier can login with the password K.nt.nn..r		
7.	Restore the original password. **Verify** that Consumer3 can login with the password L0gin4You!		
Tested by:		**Date:**	

8.6 Test scenario 3: IVERA-APP

This test scenario is designed to verify the IVERA-APP interface between the ITS control application and the TMS. Please note that this is not a full-blown test of all IVERA capabilities. The aim is to verify the interoperability between an ITS application and a TMS using basic operations.

8.6.1 Parameter modification

Test Case:	**Parameter modification**		
ID:	SC3.IVA.01		
Objective:	Verify that application parameters can be modified in the ITS-CLA1.		
Pre-conditions:	An ITS-CLA is in control of an intersection		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Set the vastgroentijd of fc03 to 15 seconds. **Verify** that the parameter is changed and recorded in the parameter logbook.		
2.	Set the ontruimingstijd from fc03 to fc05 to 10 seconds. **Verify** that the parameter is changed and recorded in the parameter logbook.		
3.	Toggle d3 **Verify** the green duration of fc03.		
4.	Wait until fc03 is red. Toggle d3 Wait until fc03 is green. Toggle d5 **Verify** the clearance time from fc03 to fc05.		
5.	Power down ITS-CLA1 for at least 5 minutes. Switched ITS-CLA1 on.		
6.	**Verify** the vastgroentijd of fc03.		
7.	**Verify** the ontruimingstijd from fc03 to fc05		
8.	Restore the original parameter settings.		

Tested by:		**Date:**	

8.6.2 User management

Use IVERA command line tool if the TMS does not support this functionality.

Test Case:	**User management**		
ID:	SC3.IVA.02		
Objective:	Verify user management.		
Pre-conditions:	An TMS is active and ITS-CLA1 is connected to the TLC		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Use the TMS to change the password of an IVERA-APP user. (iKantonnier,iK.nt.nn..r) to (iKantonnier,new{P!) **Verify** that the user iKantonnier can login with the password new{P!		
2.	Use the TMS to change the TLC settings in ITS-CLA1. (Control1,Im?h@ppy!2meet(<you>)&5isSpeci@l) to (Control1,new{P!) Use the TMS to change the user settings in the TLC for ITS-CLA1. (Control1,Im?h@ppy!2meet(<you>)&5isSpeci@l) to (Control1,new{P!) Disconnect ITS-CLA1 from the TLC.		
3.	**Verify** that ITS-CLA1 reconnects to the TLC.		
4.	Power down ITS-CLA1 and wait 5 minutes. Power up ITS-CLA1. **Verify** that ITS-CLA1 reconnects to the TLC.		
5.	**Verify** that the user iKantonnier can login in the ITS-CLA1 with the password new{P!		
6.	Restore the original passwords in ITS-CLA1 and the TLC. **Verify** that the user iKantonnier can login with the password iK.nt.nn..r		
7.	Disconnect ITS-CLA1 from the TLC. Reconnect ITS-CLA1. **Verify** that ITS-CLA1 reconnects to the TLC.		

Tested by:		**Date:**	

8.7 Test scenario 4: File transfer

Verify that the TMS can access files on the TLC, ITS-CLA1 and ITS-CLA2 as an FTP user.
Skip this test scenario if the TMS does not support file transfer.

8.7.1 File transfer

Test Case:	**File transfer**		
ID:	SC4.FT.01		
Objective:	Verify that the file transfer functionality works properly		
Pre-conditions:	An TMS is connected to the TLC using IVERA-TLC		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Use the TMS to set up an FTP user in the TLC, through IVERA-TLC **Verify** that the TMS can access the TLC using FTP.		
2.	Use the TMS to set up an FTP user in ITS-CLA1, through IVERA-APP **Verify** that the TMS can access the ITS-CLA1 using FTP.		
3.	Use the TMS to set up an FTP user in ITS-CLA2, through IVERA-APP **Verify** that the TMS can access the ITS-CLA2 using FTP.		
Tested by:		**Date:**	

Note: What if the TLC or an ITS-CLA only supports a secure version of FTP. The IVERA specification only mentions FTP.

8.8 Test scenario 5: V-Log3.0

Verify the V-Log3.0 output from ITS-CLA1 and ITS-CLA2.

8.8.1 V-Log3.0

Test Case:	**V-Log3.0**		
ID:	SC5.VL3.01		
Objective:	Verify that the V-log3.0 works properly		
Pre-conditions:	ITS-CLA1 is in control of the intersection		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	TMS connects to ITS-CLA1 for streaming V-Log **Verify** that the connection is established. **Verify** that the TMS receives the V-Log data.		
2.	Exploratory testing of detectors and signal groups.		
3.	**Verify** The V-Log detector data received by the TMS.		
4.	**Verify** The V-Log signal group data received by the TMS.		
5.	**Verify** The V-Log signal group prediction data received by the TMS.		
6.	PT vehicle on fc02 and fc08 -> 'OV ingreep' Emergency vehicle on fc05 -> 'Hulpdienst ingreep' **Verify** The reason for delay data received by the TMS.		
7.	Input 1 -> 'regen' Input 2 -> 'Kans op gladheid' **Verify** The environmental data received by the TMS		
Tested by:		**Date:**	

8.9 Test scenario 6: Application hand-over

Verify that the iVRI correctly switches between ITS-CLA1 and ITS-CLA2 and if applicable runs a backup application inside the TLC.

8.9.1 Application hand-over

Test Case:	**Application hand-over**		
ID:	SC6.AHO.01		
Objective:	Switching between ITS-CLA1 and ITS-CLA2.		
Pre-conditions:	ITS-CLA1 in control. ITS-CLA2 is ReadyToControl All detectors are activated and all signal groups are being served.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	The TMS connects to the TLC using IVERA-TLC. **Verify** in the TMS that program 1 is active (VRIPROG/#0) **Verify** that ITS-CLA1 is the active ITS application.		
2.	Use TMS to select program 3 in the TLC **Verify** that the control is correctly handed over from ITS-CLA1 to ITS-CLA2.		
3.	**Verify** in the TMS that program 3 is active. **Verify** that ITS-CLA2 is the active ITS application.		
4.	Select amber flashing on the control panel. **Verify** that the intersection goes to amber flashing via all red. **Verify** that ITS-CLA2 remains the active ITS application.		
5.	Select control on the control panel. **Verify** that the intersection goes via steady amber and all red back to control. **Verify** that ITS-CLA2 remains the active ITS application. **Verify** that the signal group are being served in cyclic order by ITS-CLA2.		
6.	Power-down the TLC and ITS-CLA1 and ITS-CLA2. Wait 5 minutes. Power-up the TLC and ITS-CLA1 and ITS-CLA2.		

	Activate all detectors.		
7.	**Verify** that the iVRI starts up normally (amber flashing, steady amber, all red). **Verify** that ITS-CLA2 is the active ITS application. **Verify** in the TMS that program 3 is active. **Verify** that the signal groups are being served in a cyclic order.		
8.	Remove the program selection from the TMS. **Verify** that the control is correctly handed over from ITS-CLA2 to ITS-CLA1. **Verify** in the TMS that program 1 is active.		
9.	Configure a clock period to select ITS-CLA2 for a defined period based on the clock. **Verify** that at the start of the clock period the control is correctly handed over from ITS-CLA1 to ITS-CLA2. **Verify** that at the end of the clock period the control is correctly handed over from ITS-CLA2 to ITS-CLA1.		
10.	Configure a clock period for amber flashing (KLU/KLA/KLOKPER). **Verify** that at the start of the clock period the intersection switches to amber flashing via all red. **Verify** that at the end of the clock period the intersection switches on and ITS-CLA1 is in control of the intersection		
11.	Let the intersection go again into amber flashing using the clock period. Use the TMS to select program 3 while the intersection is in amber flashing. **Verify** that control is correctly handed over from ITS-CLA1 to ITS-CLA2 (ie. intersection remains in amber flashing).		

12.	**Verify** that at the end of the clock period the intersection switches on (steady amber and all red). **Verify** that ITS-CLA2 is the active ITS application.		
13.	Remove the clock period. Remove the program selection from the TMS.		
Tested by:		**Date:**	

Note: Program selection using VRI.C/#0=52xx, where xx is the program number.
Note: Execution of the test cases depends on optional IVERA-TLC objects. Skip if TLC does not support the objects.

8.9.2 Backup application

Test Case:	**Backup application**		
ID:	SC6.AHO.02		
Objective:	Verify interoperability when a backup application ('noodprogramma') is activated in the TLC. Please note that a backup application in the TLC is not an ITS application.		
Pre-conditions:	ITS-CLA1 in control. All detectors are activated and all signal groups are being served in a cyclic order.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Disconnect ITS-CLA1		
2.	**Verify** that the TLC switches to the backup application, via all red.		
3.	**Verify** in the TMS that the active application is set to 'backup'		
4.	Connect ITS-CLA1 **Verify** that the TLC hands-over control to ITS-CLA1, via all red.		
Tested by:		**Date:**	

Notes: VRIPROG/#0 provides the active program number.
Notes: See section 8.2.1 for TLC information.

8.10 Test scenario 7: Exception handling

Verify that the iVRI correctly handles exceptions.

8.10.1 Disconnect ITS-CLA

Test Case:		**Disconnect ITS-CLA**		
ID:		SC7.EXC.01		
Objective:		Verify that both the ITS-CLA and the TLC take appropriate actions when the network connection is lost		
Pre-conditions:		ITS-CLA1 is in control. All detectors are activated and all signal groups are being served in a cyclic order.		
STEP	**DESCRIPTION**		**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Disconnect ITS-CLA1 (unplug the network cable) **Verify** that the intersection switches to amber flashing.			
2.	Reconnect ITS-CLA1 **Verify** that the intersection switches on (steady amber, all red).			
Tested by:			**Date:**	

8.10.2 Lamp error

Use IVERA command line tool if the TMS does not support the configuration of triggers.

Test Case:		**Lamp error**		
ID:		SC7.EXC.02		
Objective:		Verify the response of an iVRI to an error situation. A lamp error is a common error and therefor used for this test case. Verify that the TLC goes to a safe state. Verify that a trigger is send to the TMS. Verify that the iVRI resumes normal operation when the error is reset.		
Pre-conditions:		ITS-CLA1 is in control. All detectors are activated and all signal groups are being served in a cyclic order.		
STEP	**DESCRIPTION**		**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Use the TMS to configure the TLC to send a trigger to the TMS in case of a red lamp failure (eventcode=1010).			
2.	Make a red lamp failure on fc02. **Verify** that the intersection switches to amber flashing. **Verify** that the TLC correctly sends a trigger to the TMS.			

3.	Repair the red lamp Use the TMS to reset the error. **Verify** that the intersection switches on (steady amber, all red).		
Tested by:		**Date:**	

8.10.3 Trigger from ITS-CLA

Use IVERA command line tool if the TMS does not support the configuration of triggers.

Test Case:	**Trigger from ITS-CLA**		
ID:	SC7.EXC.03		
Objective:	Verify that ITS-CLA1 sends a trigger to the TMS when necessary		
Pre-conditions:	ITS-CLA1 in control. All detectors are activated and all signal groups are being served in a cyclic order.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Use the TMS to configure ITS-CLA1 to send a trigger to the TMS in case of an intersection status change (eventcode=2001).		
2.	Use the TMS to configure ITS-CLA2 to send a trigger to the TMS in case of an intersection status change (eventcode=2001).		
3.	Select all red on the control panel. **Verify** that ITS-CLA1 correctly sends a trigger to the TMS.		
4.	**Verify** that ITS-CLA2 does not send a trigger to the TMS.		
5.	Select control on the control panel.		
Tested by:		**Date:**	

8.11 Test scenario 8: Security

This test scenario verifies that the security is correctly implemented.

8.11.1 TLC certificate

Test Case:	**TLC certificate**		
ID:	SC8.SEC.01		
Objective:	Verify that the system for the TLC certificates works properly		
Pre-conditions:	An TLC is available		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Install an invalid certificate on the TLC. Power-up the system.		
2.	**Verify** that ITS-CLA1 and ITS-CLA2 detect that the certificate is invalid and close the connection (without providing username/password to the TLC).		
3.	**Verify** that the TMS detects that the TLC certificate is invalid and closes the IVERA-TLC connection (without providing username/password to the TLC).		
4.	Re-install the correct/valid certificate on the TLC. Install an invalid certificate on ITS-CLA1. Power-up the system.		
5.	**Verify** that ITS-CLA1 and ITS-CLA2 connect to the TLC. **Verify** that ITS-CLA1 is in control of the intersection.		
6.	**Verify** that the TMS detects that the ITS-CLA1 certificate is invalid and closes the IVERA-APP connection (without providing username/password to the ITS-CLA1).		
7.	**Verify** that the TMS can successfully connect to ITS-CLA2 (using IVERA-APP).		
8.	Re-install the correct/valid certificate on ITS-CLA1.		

	Install an invalid certificate on the TMS. Power-up the system.		
9.	Create an event in the TLC that initiates a trigger to the TMS.		
10.	**Verify** that the TLC detects that the TMS certificate is invalid and closes the IVERA trigger connection (without sending data to the TMS).		
11.	Create an event so that ITS-CLA1 sends a trigger to the TMS.		
12.	**Verify** that ITS-CLA1 detects that the TMS certificate is invalid and closes the IVERA trigger connection (without sending data to the TMS).		
Tested by:		**Date:**	

Note: Vialis is the CA and will also provide a set of invalid certificates for this test case.

8.12 Test scenario 9: EN50556

This test scenario applies to an iVRI where TLC and ITS application are located inside the roadside cabinet.

8.12.1 Power supply dips and voltage variations

Test Case:	**Power supply dips and voltage variations**		
ID:	SC9.EN5.01		
Objective:	The objective is to verify that a specific combination of TLC and ITS applications is resilient to power interruptions and mains voltage variations. Verify that a combination of individually tested components together (as a combination) meet the requirements outlined in the EN550556:2011.		
Pre-conditions:			
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Create power supply voltage dips in accordance with EN 50556:2011 section 6.6.5.		
2.	Perform an under voltage test in accordance with EN 50556:2011 section 6.6.2.		
3.	Perform an power up activation test in accordance with EN 50556:2011 section 6.6.3.		
Tested by:		**Date:**	

8.13 Test scenario 10: Timing and latency

Verify timing and latency as defined in [Ref 1] section 14. The figure below is copied from [Ref 1] for the ease of reference.

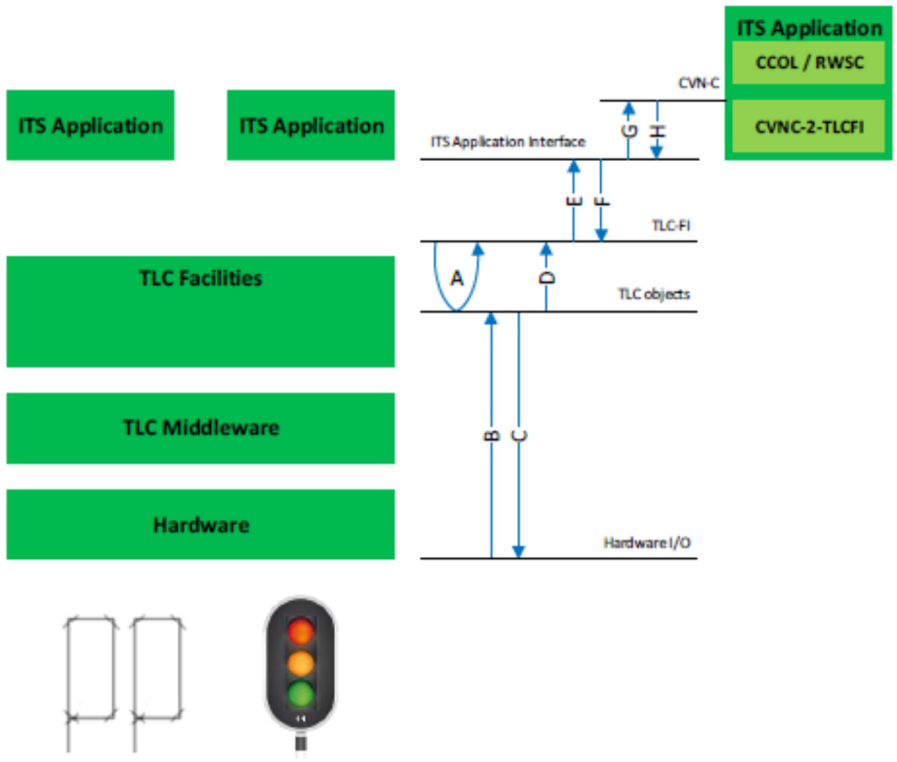


Figure 26 Latency requirements – overview TLC & TLC-FI

The following values are specified in [Ref 1]:
A: Maximum latency 100ms
B: TLC specific (see section 8.2.1)
C: TLC specific (see section 8.2.1)
D: Maximum latency 50ms
E: Depends on used network-layer. Advise: 75 ms
F: Depends on used network-layer. Advise: 75 ms
G: Maximum latency 20ms
H: Maximum latency 20ms

Assuming that a state change on a TLC input leads to an immediate response of the iVRI then the maximum time between the input state change and the output state change is defined as:

T = B + D + E + G + H + F + C

For the execution of the test cases the latency items E and F are assumed to be 0ms (all components are connected on a LAN using Ethernet).

8.13.1 Demand response time

Test Case:	**Demand response time**		
ID:	SC10.TAL.01		
Objective:	Verify that the response time of the iVRI to a demand remains consistent and within acceptable levels.		
Pre-conditions:	ITS-CLA1 in control. All detector de-activated and signal groups red.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**

1.	Toggle dk31_1 **Measure** the time between pressing the push button input and the start of green for signal group 31. Execute this measurement 10x and document minimum/average/maximum.		
2.	Calculate T = B + D + E + G + H + F + C **Verify** that the measured time meets the latency requirements (i.e. maximum time stays within the calculated limit **T**).		
Tested by:		**Date:**	

8.13.2 Input / Output

Test Case:	**Input / Output**		
ID:	SC10.TAL.02		
Objective:	Verify that the response time of the iVRI to an input changes remains consistent and within acceptable levels. Verify that a defined input pulse leads to a defined output pulse.		
Pre-conditions:	ITS-CLA1 in control.		
STEP	**DESCRIPTION**	**PASS / FAIL**	**REMARKS/ACTIONS**
1.	Connect a pulse generator to inputA. Generate a 0.5Hz input signal (1sec high, 1sec low). **Measure** the duty cycle of exclOutputA. **Measure** the time between the rising edge of inputA and the rising edge of exclOutputB. **Document** the measurement results.		
2.	Calculate T = B + D + E + G + H + F + C **Verify** that the measured time meets the latency requirements (i.e. maximum time stays within the calculated limit **T**).		
3.	Generate a pulse of 100ms on inputA. **Verify** that exclOutputA is activated.		

4.	**Measure** the duration of the exclOutputA active state. **Document** the measured result		
5.	Generate a pulse of **x** ms on inputA. **Verify** that exclOutputA is activated. Note **x** is the minimal duration as specified for the TLC to change an input state. See section 8.2.1		
Tested by:		**Date:**	

9 Appendix 1: Overview iVRI

This appendix provides an overview of the available products that are compliant with the iVRI architecture. (Status per November 2016).

Explanation on the columns in the tables below:

- Type testing: The product will be subjected to type testing by the manufacturer as part of the iVRI2 project.
- Interoperability testing: The product will be subjected to interoperability testing as part of the iVRI2 project.

9.1 Traffic Light Controllers (TLC)

Company	Product	Type testing	Interoperability testing
Dynniq	EuroController EC-1	√	No
Dynniq	EuroController EC-2	√	√
Ko Hartog	CIVA2014	√	√
Ko Hartog	HR2002	√	No
Swarco	ITC-2	√	√
Vialis	ViTrac	√	√
Vialis	LTC+	√	No
Vialis	FR9x	√	No

9.2 ITS applications

Company	Product	Type testing	Interoperability testing	TLC-FI	IVERA-APP	V-Log3.0
Dynniq	ImFlow	No	No	√	√	√
Dynniq	[1)]	No	No	√	√	√
Swarco	SCC[2)]	√	√	√	√	√
Vialis	ICAH[3)]	√	√	√	√	√
TNO		√	√	√	No	No
RHDHV	FLOWTACK Test exerciser	√	√	√	No	No

Notes:

1. Dynniq provides a CCOL 9.0/CVN-C 5.0 ITS application that runs on the processor of the Dynniq Traffic Light Controller.
2. Swarco Communication Controller, running on CCOL 9.0.
3. ITS Control Application Host, running CCOL 9.0.

9.3 Traffic Management Systems

Company	Product	Type testing	Interoperability testing	IVERA-TLC	IVERA-APP	V-Log3.0
Technolution	MobiMaestro	n/a	√	√	√	√
Trinite	Traffic-Link Online	n/a	√	√	√	√

9.4 Test tooling

Company	Product	TLC-FI	IVERA-TLC	IVERA-APP	V-Log3.0
Dynniq	iTLC exerciser	√			