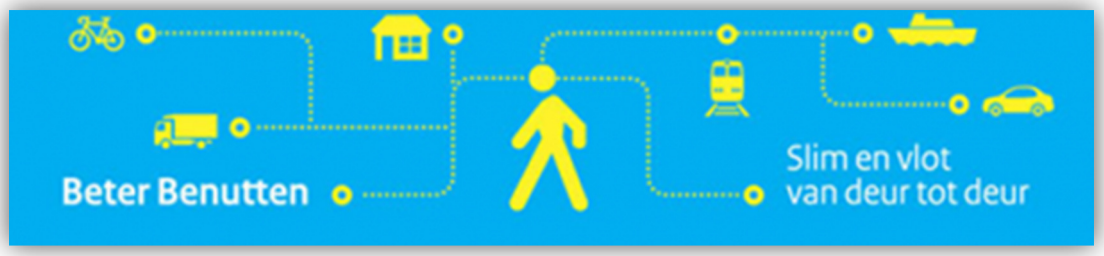
Intelligente Verkeers Regel Installatie (iVRI) – Fase 2

Deliverable 3f: Test specifications

iTLC test strategy



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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 iVRI test strategie.

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

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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.

DOCUMENT CONTROL SHEET

Document versions:

Version	Date	Author	Comment
0.8	14-09-2016	WG T&C	Version for internal review.
0.9	26-09-2016	WG T&C	Final draft
0.91	12-10-2016	WG & TC	Processed review comment on 0.9
1.0	28-10-2016	WG & TC	Final
1.1	11-11-2016	WG & TC	§6.2 Multiple audits iVRI2-BT §6.2 Interoperability test (PoC) removed §7.3 Interoperability test setup updated §8 Test intersection is a fictive intersection. §8.1.9 Added detector events
1.2	6-12-2016	WG & TC	§8 'wachtstand rood regeling' §8.1.10 Reason for delay §8.1.11 Environmental factors

Approval:

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CONTENT

2 Introduction

This document describes the test strategy for the iTLC architecture.

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.

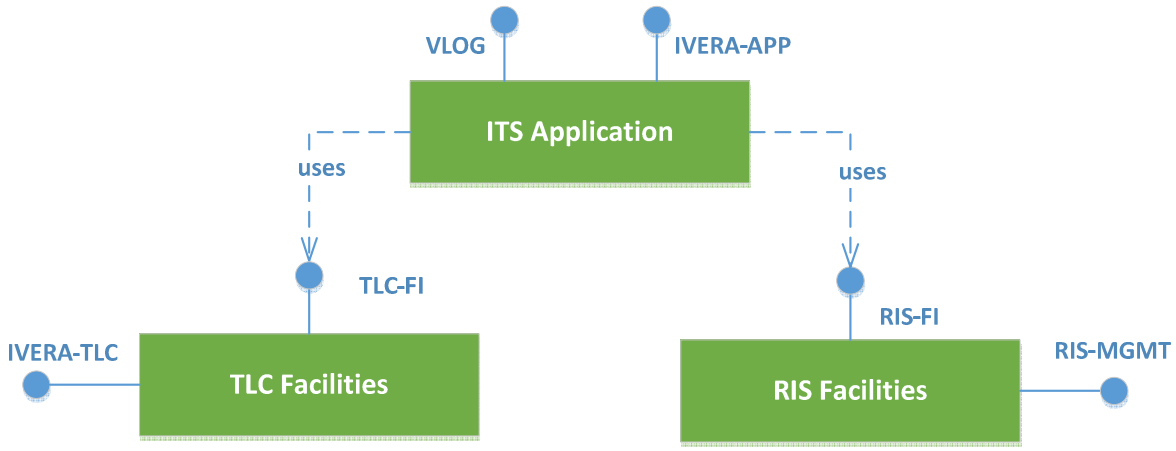


Figure 1 System overview

2.2 Document overview

2.2.1 Purpose

This document outlines the test strategy for the iTLC architecture.

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 objectives.
Chapter 6 outlines the test strategy.
Appendix A outlines a summary of the test setup.
Appendix B outlines the test intersection configuration.

2.3 Advise for the reader

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

Where applicable “out-of-scope” is used in this document to indicate that a specific item is out of scope of the iVRI2 project.

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, nov 2016
[Ref 4]	Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 1ab IDD TLC Facilities Interface v1.1, nov 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, TLC test specification v1.0, nov 2016
[Ref 8]	Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 3f, ITS application test specification v1.0, nov 2016
[Ref 9]	Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 3f, Interoperability test specification v1.0, nov 2016

3.2 Informative

ID	Reference
[Ref 10]	Beter Benutten Vervolg, project iVRI – fase 2, Deliverable 1h.

4 Acronyms, abbreviations and concepts

Acronyms and abbreviations

CEN	European Committee for Standardization
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
FAT	Factory Acceptance Test
IDD	Interface Design Description
IRS	Interface Requirements Specification
ISO	International Organization for Standardization
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 (see [Ref 1])
IVERA	Management protocol for traffic light controllers in the Netherlands
IVERA-APP	Management protocol for ITS applications
IVERA-TLC	Management protocol supported by the TLC Facilities.
iVRI2 project	The iVRI fase 2 project.
iVRI2-BT	'Begeleidingsteam' of the iVRI2 project.
iVRI2-TT	'Toetsteam' of the iVRI2 project.
LDM	Local Dynamic Map
PoC	Proof of Concept
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
SAT	Site Acceptance Test
TLC	Traffic Light Controller; controls the signal of one or more intersections
TLC-FI	Traffic Light Controller Facilities Interface
V-Log3.0	Traffic Data log

Concepts

ITS Control Application	A Traffic Control Application which uses TLC- and/or RIS-interfaces.
ITS Application	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 Local Dynamic Map (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.
Verification and validation[1]	Verification and validation are independent procedures that are used together for checking that a product, service, or system meets requirements and specifications and that it fulfils its intended purpose.
Validation	The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders.
Verification	The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition.
Independent Validation and Verification (IV&V)	Verification and validation performed by an independent third party.
Product supplier	In the iTLC context a supplier of iTLC's or iTLC components.
Product certifier[2]	An independent organisation that certifies iTLC components.

[1] Source: https://en.wikipedia.org/wiki/Verification_and_validation
[2] Source: https://en.wikipedia.org/wiki/Product_certification

5 Objectives

The objective of this test strategy is threefold:

- Verification and validation of the iTLC architecture during the iVRI2 project.
- Testing of iTLC components
- Certification of iTLC components

5.1 iVRI2 project

During the iVRI2 project the interfaces are being defined and the first systems based on the iVRI architecture are being developed and tested. The (test) objectives during the iVRI2 project are:

- Development of the test strategy and test specifications
- Test the developed products (TLC's and ITS applications).
- Validate the iTLC architecture and the standardized interfaces by means of real implementations in the lab and in the field.

5.2 iTLC component testing

The objective is a set of test specifications for testing iTLC components. The test specifications shall be useable for:

- Testing new iTLC components
- Regression testing of iTLC components (i.e. new software releases)
- Interoperability testing

5.3 iTLC certification (out-of-scope)

The objective is to issue certificates for iTLC components by an independent organization (i.e. the product certifier).

The working group advises the following minimum requirements for the iTLC certification:

- The product supplier test the products, using the test specification.
- The product supplier applies for certification.
- The product certifier reviews the product supplier's application information, including the testing data.
- If the certifier's evaluation concludes that the test data shows that the product meets all required criteria as listed in the certification scheme, and the decision maker(s) of the product certifier concur with the evaluation then the product is deemed "certified" and is listed in a directory that the Product certifier is required to keep.
- ISO Guide 65 requires that the final decision to grant or not grant certification be made only by a person or group of persons not involved in the evaluation of the product.
- The road authority refers to the certificate as a mandatory requirement in tenders for iTLC's or iTLC based solutions (e.g. level playing field).

The selected product certifier will specify the details of the certification.

Please refer to [Ref 10] for the proposal of the Stichting IVERA to act as product certifier for the iTLC architecture.

Note: The working group identified a risk for products being installed in the field in the period between the completion of the iVRI2 project and the first products being certified by the independent organization. There will be cost involved in case products in the field must be updated based on the outcome of the certification. These costs are not covered within the iVRI2 project

6 Test strategy

6.1 Introduction

This chapter outlines the test strategy for the iTLC architecture.

6.2 Validation iTLC architecture and interfaces

The validation of the iTLC architecture is done during the iVRI2 project, by writing the Interface Design Descriptions and building and testing the first systems using iTLC architecture. The following validation activities are included in the iVRI2 project:

- The specifications written by the working group(s) are reviewed by the iVRi2-BT and iVRI2-TT.
- The VRI suppliers develop the iTLC components and document/report issues found in the specifications.
- The iVRI2-TT develops (test) software and document/report issues found in the specifications.
- The VRI suppliers execute type testing on the iTLC components.
- The VRI suppliers execute interoperability tests, in cooperation with the iVRI2-TT.
    - ITS applications of the iVRI2-TT will be used during interoperability testing (for testing TLC-FI).
    - Traffic Management Systems of the iVRI2-TT will be used during interoperability testing (for IVERA-TLC, IVERA-APP and V-Log3.0).
- The iVRI2-BT performs audits per VRI supplier (i.e. audit type test results and interoperability test results).
- Each VRI supplier executes a field trial with an own iTLC (i.e. PoC location).

6.3 Traffic Light Controller (TLC)

This test strategy covers the required functions and interfaces of the TLC, including the TLC Facilities, to fit in the iTLC architecture (e.g. TLC-FI, IVERA-TLC and security).

6.3.1 TLC type test

The objective of the TLC type test is to verify (under lab conditions) that:

- The TLC-FI interface is compliant with the specification.
- The IVERA-TLC interface is compliant with the specification.
- The TLC meets the iTLC security requirements.
- The TLC supports the functionality required for TLC-FI and IVERA-TLC

An important pre-condition, for the TLC type test, is that the TLC has the required type approvals (i.e. NEN3384) for using the product in the Dutch market. The type approval and all related testing is the sole responsibility of the TLC manufacturer and out-of-scope for this document.

The manufacturer executes the TLC type test, using the real product hardware and software, for each type of TLC. The manufacturer declares that the test has been successfully executed.

The TLC type test is described in a test specification. The test scenario's cover normal use and exception handling. The exception handling will be tested for the exceptions documented in the interface design descriptions. Please refer to the TLC type test specification [Ref 7] for details. Please refer to Appendix B for the test intersection specification.

6.4 Roadside ITS Station (RIS) (out-of-scope)

This test strategy covers the required functions and interfaces of the RIS to fit in the iTLC architecture (e.g. RIS-FI and security).

6.4.1 RIS type test

The objective of the RIS type test is to verify (under lab conditions) that:

- The RIS-FI interface is compliant with the specification.
- The RIS meets the iTLC security requirements.
- The RIS supports the functionality required for RIS-FI

An important pre-condition, for the RIS type test, is that the RIS has the required type approvals for using the product in the Dutch market. The type approval and all related testing is the sole responsibility of the RIS manufacturer and out-of-scope for this document.

The manufacturer executes the RIS type test, using the real product hardware and software, for each type of RIS. The manufacturer declares that test has been successfully executed.

Note: The RIS type test specification is out-of-scope for the iVRI2 project.

6.5 ITS application

This test strategy covers the required functions and interfaces of the ITS application to fit in the iTLC architecture (e.g. TLC-FI, IVERA-APP, V-Log3.0, security and in the future RIS-FI).

6.5.1 ITS application type test

The objective of the ITS application type test is to verify (under lab conditions) that:

- The TLC-FI interface is compliant with the specification.
- The RIS-FI interface is compliant with the specification (out-of-scope)
- The IVERA-APP interface is compliant with the specification.
- The V-Log3.0 output is compliant with the specification.
- The ITS application meets the iTLC security requirements.

The functionality of an ITS application is out of scope of the iTLC architecture and is not covered by the type test. The functionality of an ITS application is the sole responsibility of the supplier of the ITS application.

The manufacturer executes the type test, using the 'real' product hardware and software. The manufacturer declares that the test has been executed.

The ITS application type test is described in a test specification. The test scenario's cover normal use and exception handling. Please refer to the ITS application type test specification [Ref 8] for details. Please refer to Appendix B for the test intersection specification.

6.6 Interoperability test

The objective of the interoperability test is to verify (under lab conditions):

- Interoperability between various TLC and ITS applications.
- Interoperability between various RIS and ITS applications (out-of-scope).
- Interoperability between management systems and iTLC's:
    - Management using IVERA-TLC and IVERA-APP.
    - Logging using V-Log3.0
- The security of the system.

An interoperability test is executed as a joined effort by the manufactures of the various components (TLC, RIS, ITS application and management system).

Pre-conditions:

- TLC type test
- RIS type test (out-of-scope)
- ITS application type test
- The management system shall support IVERA-TLC, IVERA-APP and V-Log3.0.

The iTLC components have been subjected to type testing prior to be used in an interoperability test. Secondly the security should be fully configured. The aim of the interoperability test is to identify any issues when the components work together as a system. The majority of the test scenarios is based on monitoring system functioning under normal conditions. At the system level the exception testing is focussed on recovery. Does the system (as a whole) correctly (respond to) and recover from an exception. Please refer to the Interoperability test specification [Ref 9] for details. Please refer to Appendix B for the test intersection specification.

6.7 Field trial

During a field trial, an iTLC is tested in a 'real life' setting (as opposed to testing under artificial laboratory conditions). Both the product and the field trial setting are designed to be as close as possible to actual usage. In case of the iTLC this means installing an iTLC on a real intersection (a PoC location) and then monitoring its performance over a period of time. It is common to allow users to operate equipment as they would in actual usage, and it is common practise to monitor that usage using objective and subjective measures.

The field trial is executed to validate the completed product by monitoring the equipment for an agreed period of time (2-4 weeks). The issues during the field trial are documented in an "issue list" which contains valuable information for designers regarding the potential for improving the product.

6.7.1 Field trial test specification

There is no common test specification for a field trial. The field trial is executed by the supplier in close cooperation with the road authority and in accordance to an agreed field trial plan.

6.7.2 Process validation

The field trial offers an opportunity for the supplier to validate the processes need to configure, test, install and maintain an iTLC, like:

- Validation of the configuration process.
- Validation of the factory acceptance testing process (FAT)
- Validation of the installation process
- Validation of the site acceptance testing process (SAT)
- Validation of the maintenance process

6.8 Test tooling

The following test tooling is needed to support the testing:

- **iTLC exerciser**, for testing TLC-FI (out-of-scope)
- **IVERA test tool**, for testing IVERA-TLC and IVERA-APP (out-of-scope)
- **iRIS exerciser**, for testing RIS-FI (out-of-scope)

Please refer to the test specifications for the test setup and a description of the test tools.

The test tools are required for the iTLC certification and will be defined by the product certifier at a later stage.

The IVERA testing, during the iVRI2 project is restricted to tests that can be executed using an IVERA command line tool, eliminating the need for the development of a 'full blown' IVERA test tool during the iVRI2 project.

The iTLC exerciser is included in the test specifications, meaning that an iTLC exerciser or a tool with similar capabilities is required to execute the test scenarios and test cases, during the iVRI2 project.

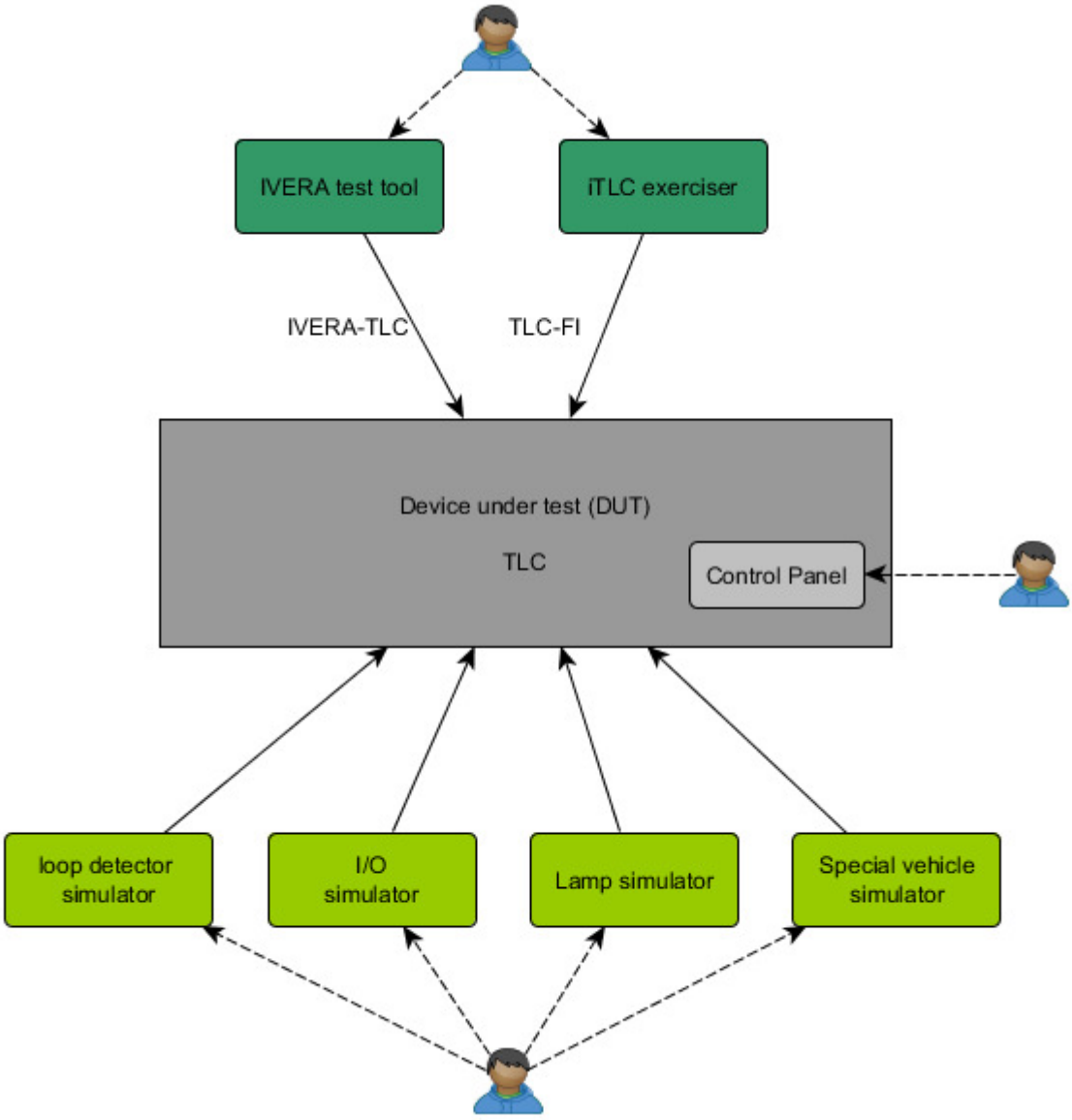
Note: Dynniq has developed an iTLC exerciser and plans to offer this tool to the product certifier. Dynniq has raised this subject in the 'IVERA bestuursvergadering'. The tool will also be ready in time for the testing during the iVRI2 project. The working group assumes a positive outcome regarding the iTLC exerciser, meaning that the Dynniq iTLC Exerciser is timely available to all VRI suppliers and the iVRI2-TT for the testing during the iVRI2 project.

7 Appendix A: Test setup summary

This provides a short summary of the test setup for each test. Please refer to the test specifications for details.

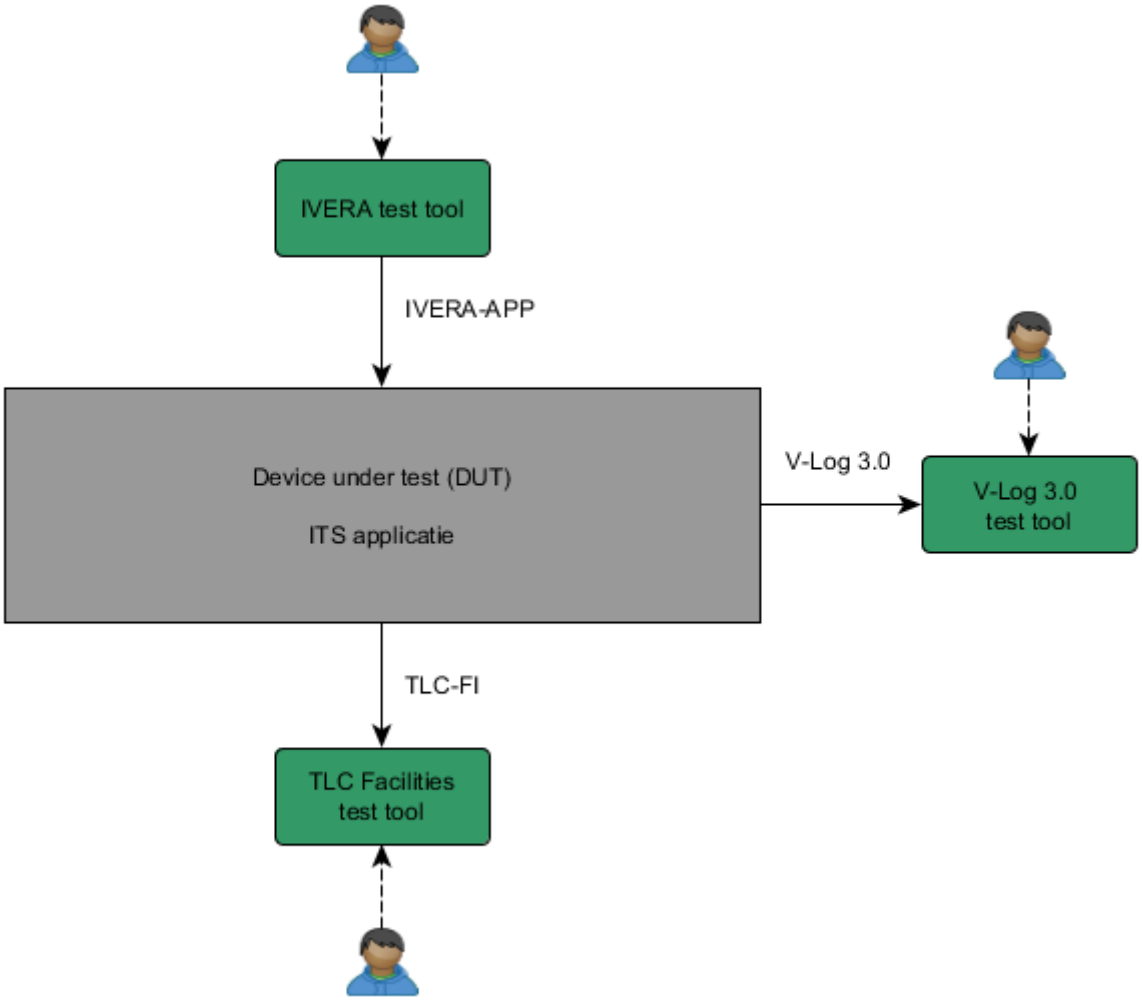
7.1 TLC type test

The device under test (DUT) is a traffic light control (‘het regeltoestel’) including the TLC facilities.



7.2 ITS application type test

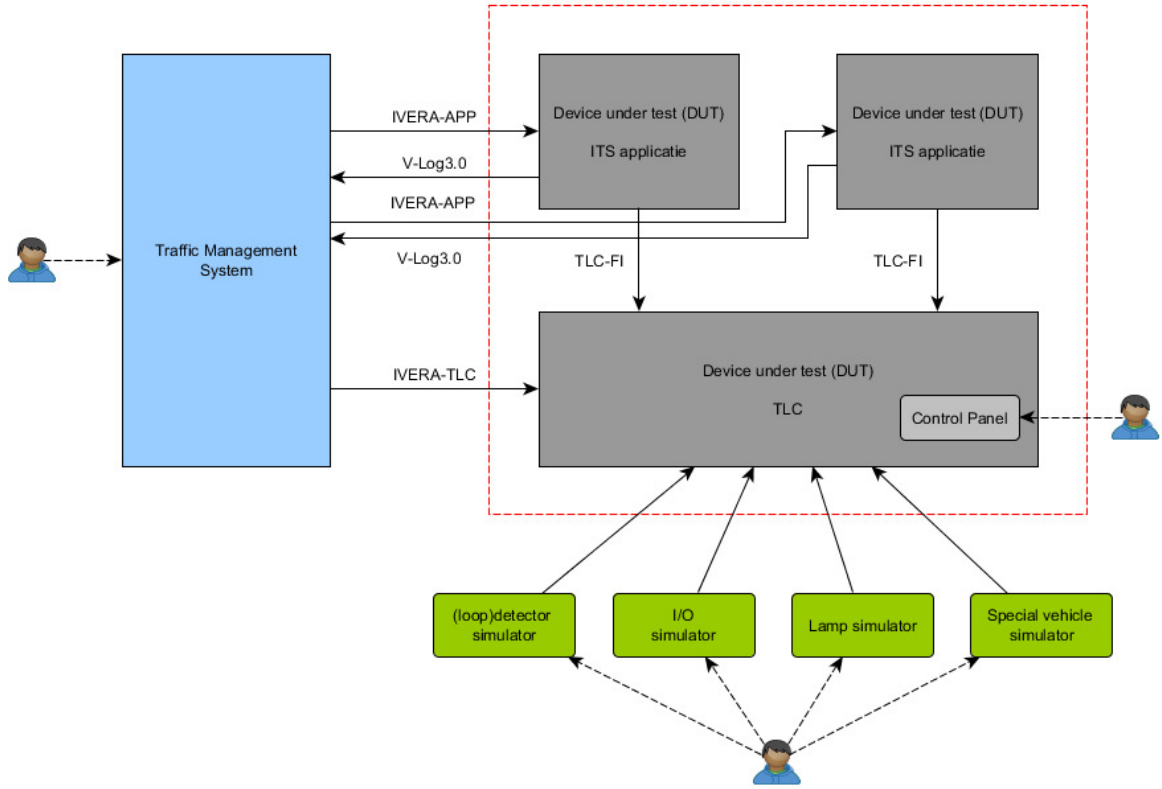
The device under test (DUT) is an ITS application.



Note: The TLC Facilities test tool is typically a known TLC or a software simulation of that TLC.

7.3 Interoperability test

Testing an iTLC, consisting of a TLC and two ITS applications, in combination with an iTLC compliant traffic management system.



8 Appendix B: Test intersection specification

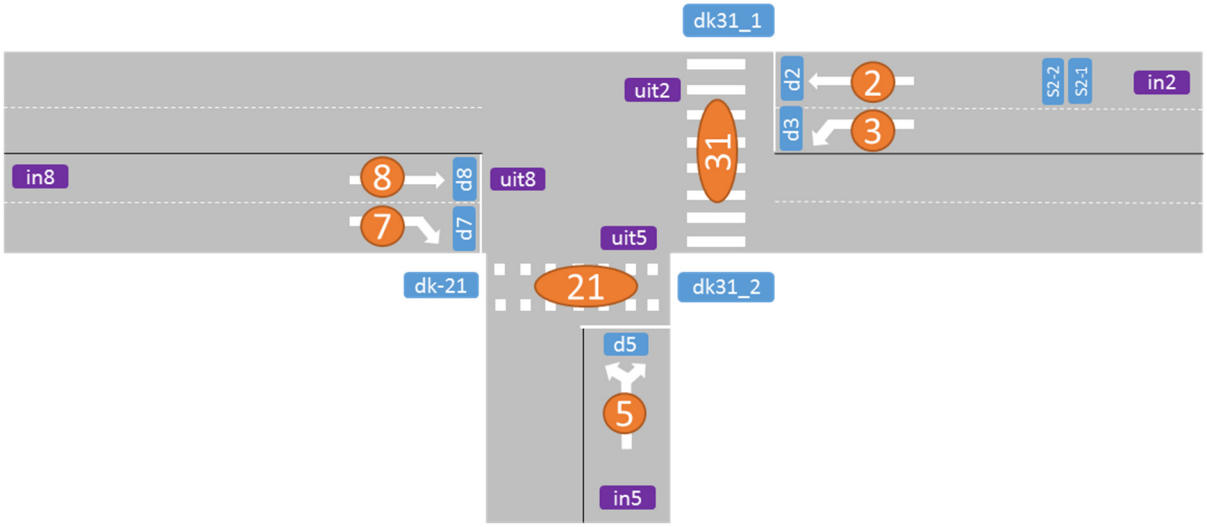
A single test intersection will be used for the following tests:

- TLC type test
- ITS application type test
- Interoperability test

The test intersection is designed to cover all function aspects of the TLC-FI interface.

- Limited numbers of signal groups, detectors en I/O.
- Various types of signal groups (vehicles, pedestrians and bicycles)
- Mixture of objects, including special characters and various lengths.
- One intersection (no support for multiple intersections in a TLC)
- Special vehicles (public transport and emergency).

In case there are no demands and extensions then all signal groups will revert to red (‘wachtstand rood regeling’).



Note: The names of the signal groups, detectors, inputs, outputs, etc are choosen to demonstrate that difference naming schemes are supported (i.e. names, numbers, etc).
Note: The test intersection is a fictive intersection, any resemblance with a real intersection or a common practise for designing intersections is pure coincidence.

8.1 Configuration

8.1.1 ObjectID’s

The objects configured in the TLC are outlined in the table below.

Intersection	TINT1
Signal groups	fc02, fc03, fc05, fc07, fc08, 21, 31
Detectors	d2, d3, d5, d7, d8, dk-21, dk31_1, dk31_2, ds2
Inputs	inputA, inputB, 1, 2, fix
Outputs	exclOutputA, exclOutputB, 1, 2, fix, w21, w31
Variables	varA 1 aVeryLongVariableNameIncludingTheAllowedSpecialCharacters-_

spvehgenerator	The ObjectID of the special vehicle generator object is set by the manufacturer of the TLC. The ITS application needs to read the META data to obtain the ObjectID of the special vehicle generator.

Detector ds2 generates events (including speed and length) based on the loop pair (s2-1, and s2-2).

8.1.2 Intersection state timing

The following intersection state timing shall be configured in the TLC.

- Amber flashing: 15 seconds
- Steady Amber: 5 seconds.
- All red: 11 seconds

8.1.3 Signal group timing parameters

The signal group timing parameters configured in the TLC are outlined in the table below.

ID	Protected/ Permissive	Min Green [s]	Min Amber [s]	Max Amber [s]	Min Red [s]
fc02	Protected	4.2	3	3	2
fc03	Protected	4.3	3	3	2
fc05	Permissive	4.5	3	3	2
fc07	Protected	4.7	3	3	2
fc08	Protected	4.8	3	3	2
21	Protected	6	3	4	3
31	Permissive	6	3	4	3

Note: The states Red/Amber and Flashing green are not supported by the test intersection.

8.1.4 Conflict matrix

The conflict matrix specifies the inter-green clearance times in seconds as configured in the TLC.

ID	fc02	fc03	fc05	fc07	fc08	21	31
fc02			4.5				4.0
fc03			5.5	5.7	5.8	5.1	5.0
fc05	6.2	6.3			6.8	6.1	
fc07		7.3				7.1	
fc08		8.3	8.5				8.0
21		9.3	9.5	9.7			
31	10.2	10.3			10.8		

Note: Each value in the matrix is deliberately unique.

8.1.5 Special vehicles

The test intersection has two public transport lines using check-in and check-out and absolute priority for emergency vehicles on fc05.

Public transport	Line 102 on fc02 (check-in/check-out) Line 108 on fc08 (check-in/check-out)

Emergency (police, ambulance, fire)	fc05 (check-in/check-out)

8.1.6 I/O

The outputs exclOutputA and exclOutputB are exclusive outputs linked to the intersection. The outputs 1, 2 and fix are non-exclusive outputs.

An ITS control application shall link inputA to exclOutputA (i.e. exclOutputA shall follow the state of inputA).

8.1.7 Fixation

The fix input and output are used to handle fixation.
The TLC makes the fix input active when fixation is requested (on the control panel).
The ITS control application makes the fix output active when fixation is active.

8.1.8 Demand wait indicators

The output w21 and w31 are exclusive outputs.
The ITS application shall use these outputs to drive the demand wait indicators for the signal groups 21 and 31.

8.1.9 Detector events

The ITS application shall activate exclOutputB for 1 second when a fast driving long vehicle in normal direction is detected. (speed >= 75km/h, length>=15m, normal direction, classification=don't care).

8.1.10 Reason for delay

The ITS application shall support the V-Log3.0 message "Reden voor extra wachttijd".

OV Ingreep	Set in case of public transport check-in on fc02 and fc08.
Hulpdienst ingreep	Set in case of emergency vehicle check-in on fc05.

8.1.11 Environmental factors

The ITS application shall support the V-Log3.0 message "Omgevingsfactoren".

Regen	Set in case input 1 is active.
Kans op gladheid	Set in case input 2 is active.

8.1.12 Users

The following TLC-FI users are configured in the TLC.

User	Password	Type	Program number
Control1	Im?h@ppy!2meet(<you>)&5isSpeci@l	Control	1
Control2	Spec('~!@#$%^&*_+-={}[]:;<>.?/)	Control	3
Control3	C1ShouldBelonger	Control	
Control4	WeNeedEnoughUsers!10min	Control	
Provider1	Pr.v.d.r1	Provider	
Provider2	12345678901234567890123456789O	Provider	
Provider3	My.p@ssw0rd4	Provider	
Consumer1	Password1	Consumer	
Consumer2	Password2	Consumer	
Consumer3	L0gin4You!	Consumer	

Consumer4	Littleprairy!7	Consumer	

Note: A colon (,) and double quotes (“) are not allowed in the password. The maximum length is 32 characters.

The following IVERA-TLC users are configured in the TLC.

User	**Password**	**Niveau**
Wereld	L0gin4You!	1
Kantonnier	K.nt.nn..r	2
Verkeerskundige	Spec('~!@#$%^&*_+-={}[]:;<>.?/)	3
Admin	AdminPassword	4 (admin)

The following IVERA-APP users are configured in the ITS-application.

User	**Password**	**Niveau**
iWereld	iL0gin4You!	1
iKantonnier	iK.nt.nn..r	2
iVerkeerskundige	iSpec('~!@#$%^&*_+-={}[]:;<>.?/)	3
iAdmin	iAdminPassword	4 (admin)