EV ComboCS - The CCS Tester

Accelerate and make CCS developments more reliable

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Trialog is working on EV charge since more than 10 years and had several opportunities to develop a strong expertise on Electro-Mobility charge protocols like IEC 61851-1, DIN 70121, ISO 15118 and OCPP 1.6/2.0.
In this context, Trialog has developed several testing and validation tools.

ComboCS, the EV CCS Simulator is one of these tools. It aims to enables and simplifies CCS developments by providing simulation and test means of DIN 70121 and ISO 15118 protocols without any power transfer. This tool allows to:

- Simulate the EV part of a CCS implementation in order to perform or simulation charging session following IEC 61851-1, DIN 70121 and/or ISO 15118;
- Follow in real-time the communication though the embedded UI;
- Change in real-time the EV behaviour;
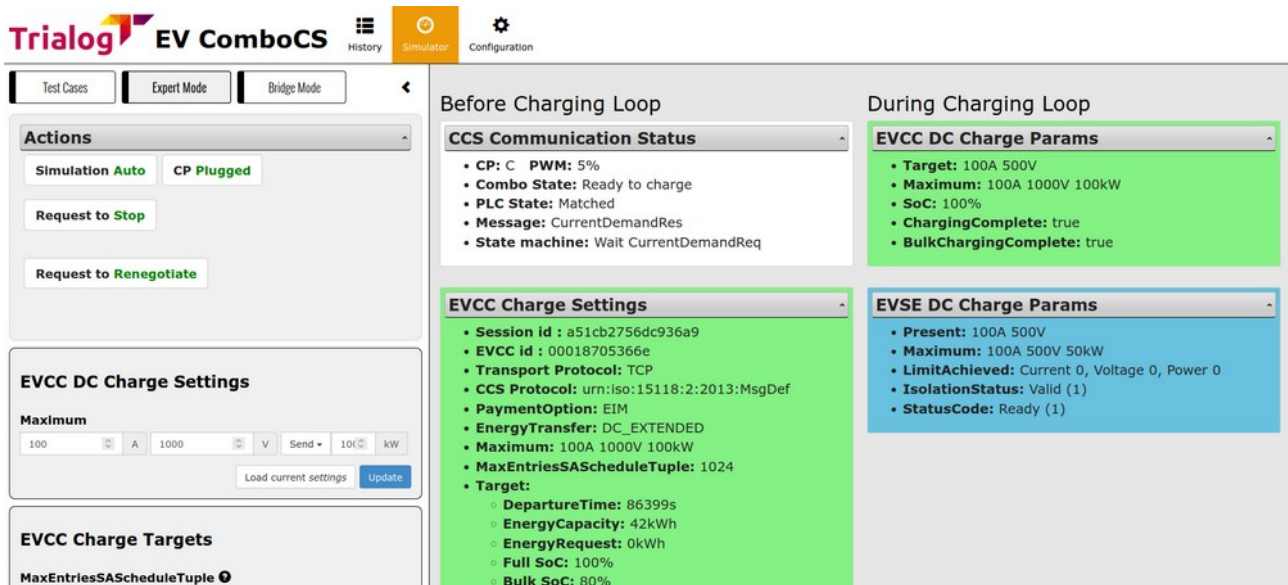- Launch different test case scenario to trigger nominal and non-nominal test cases.

Figure 1: ComboCS User Interface

Technical Details

ComboCS is a box allowing to perform AC or DC, ISO 15118 or DIN 70121 communications, including the HPGP PLC and IEC 61851-1 communications.

Figure 2: ComboCS connectors - Face 1

Figure 3: ComboCS connectors - Face 2

- Size: 23x15x6 cm
- Power: +12V

- Connectors:
  - Control Pilot and Protective Earth : BNC
  - Ethernet: RJ45
  - CAN: DB9 *(reserved for future usage or specific development)*
  - 6 GPIO: AWHW 10G-0202-T *(reserved for power transfer add-on or specific development)*
- Wires provided with the Simulator
  - AC/DC 230V/12V
  - Type 2 plug with BNC connector
  - Ethernet wire

Supported Features

ISO 15118 and DIN 70121 standards define several use cases and functions. ComboCS supports almost all functions and more specifically:

- ISO 15118-3 / DIN 70121
  - SLAC
  - Validation
- ISO 15118-2 / DIN 70121
  - SDP
  - Supported state machines: AC and DC
  - Supported payment options: EIM and PnC
  - Supported optional functions:
    - Service Details
    - PnC Certificate installation
    - Smart Charging
    - Renegociation
    - Metering Receipt
    - Welding Detection (DC charge only)
    - Pause / Resume

For test purpose, the Simulator could also be used to perform ISO 15118-2 communication over Ethernet without the PLC ISO 15118-3 link.

> ### *Implementation in progress*
> "Amplitude Map exchange" of ISO 15118-3 is still under validation and provided as developer preview into the ComboCS.

ComboCS Modes

SIMULATOR MODE

By default, the EV ComboCS can be plugged to a charging station and perform a standalone and nominal CCS charging session without any other inputs.
The default configuration is:
- ISO 15118 or DIN 70121
- DC Charge

- EIM payement option
- Charge Maximum Limits: 32A, 400V, 22kW
- Charge Minimum Limits: 6A, 0V
- CurrentRegTolerance: 1A, PeakCurrentRipple: 15A

This default behavior can be modified using the Configuration view, and adapted in live using the expert and test case modes defined below.

SUPERVISOR MODE

ComboCS is provided with a Web interface, compatible with Windows, Linux and Mac, accessible over Ethernet or Wifi. It provides access to real-time evolution of the ongoing CCS communication.

Figure 4: ComboCS interface - Example of ISO 15118 communication

All data exchanged between the EVSE of the EV is available through the user interface. The history of the whole decoded communication can be downloaded as a log file.

TEST CASE MODE

The Test Case Mode of ComboCS triggers CCS communication session for a list of nominal and non-nominal predefined cases.
The Test Case Mode proposes two types of test cases:

- **Conformance testing:** DIN 70122, ISO 1518-4 and ISO 15118-5 documents define test cases to validate conformance of the implementation to the normative documents. ComboCS is providing a subset of these test cases. The coverage is not yet complete, but increasing regularily.
- **Interoperability testing**: Because of existing ambiguities in the norms and the multiplicity of the implementations, ComboCS is providing several test cases with limit and non-nominal behaviour of the EV, and even invalid behaviour of the EV observed « in the street ». Thanks to the experience of Trialog in the field, this list is increasing regularily.
  Interoperability tests allow to reproduce the behaviour of several existing vehicles, especially for the following list of vehicles: BMW i3, DS3, Ioniq, Jaguar i-pace, Kia e-Niro, Peugeot e208 and e2008, Porsche Taycan, Renault Zoé, Tesla Model S.

Additionaly to the available test cases, an HTTP/REST and WebSocket API is provided with ComboCS, allowing to define its own test cases and integrate ComboCS to its own validation process (end of line test, non regression tests, …).

These test cases provides a great overview of the implementation state of the Charging Station in several use cases.

Figure 5: ComboCS Test Case Mode

Each test case is provided with a description of the test, explaination of the successive steps, and the expected results with links to the normative requirements.
An indicative result is provided at the end of the scenario.

> ***Posibility of custom developments***
> On demand, it is possible to update ComboCS in order to create test cases specific to your needs and projects.

EXPERT MODE

Using the expert mode, it is possible to modify at any time the nominal behavior of the EV ComboCS before or during the Charging Loop.

Expert mode allows to define precisely each values sent by the EV in a CCS communication. Some cases require synchronisation and timing that cannot be done manually. Therefore, such cases can be passed using the Test Case mode.

Expert mode allows to control the EV:
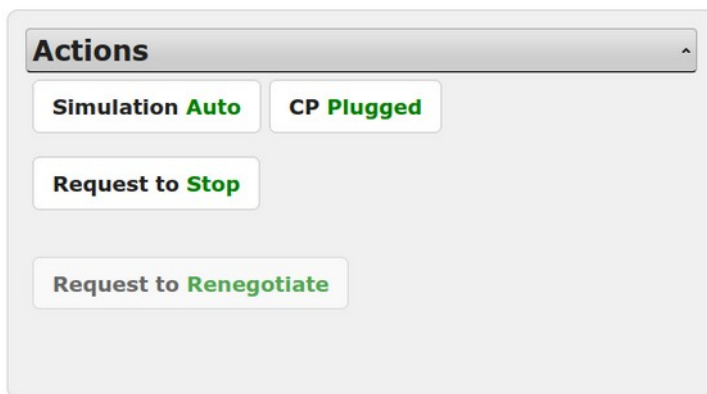
Figure 6: Start, stop, renegotiate, unplug

Expert mode allows to configure the EV charging settings:
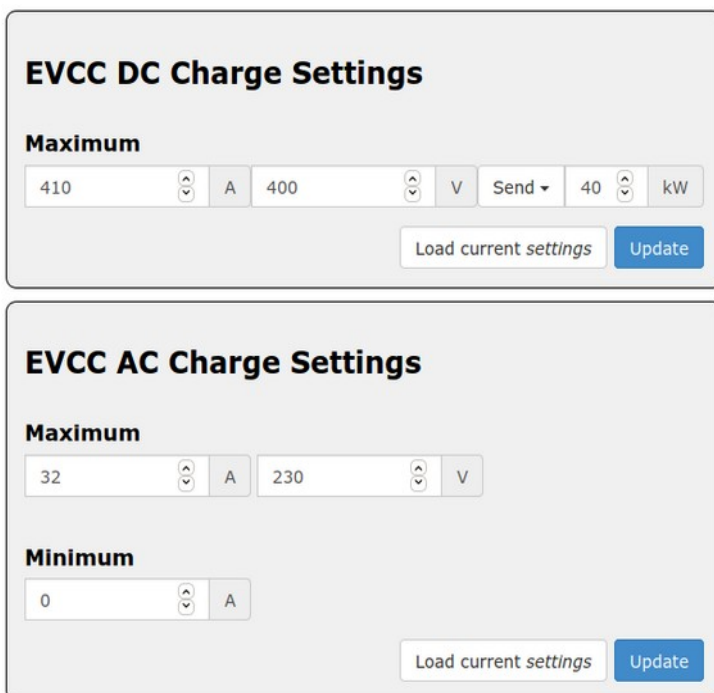

Figure 7: AC and DC charge settings

Expert mode allows to configure the EV charging request during the DC charging loop, especialy the target current and voltage:

Figure 8: Updating a request during the Charging Loop

INSPECTION **MODE**

When ComboCS Inspection mode is enabled, all PLC trafic is redirected to a Wireshark opened on the operator machine, providing access to the raw Ethernet trafic from SLAC to ISO 15118-2 or DIN 70121 for further analysis.
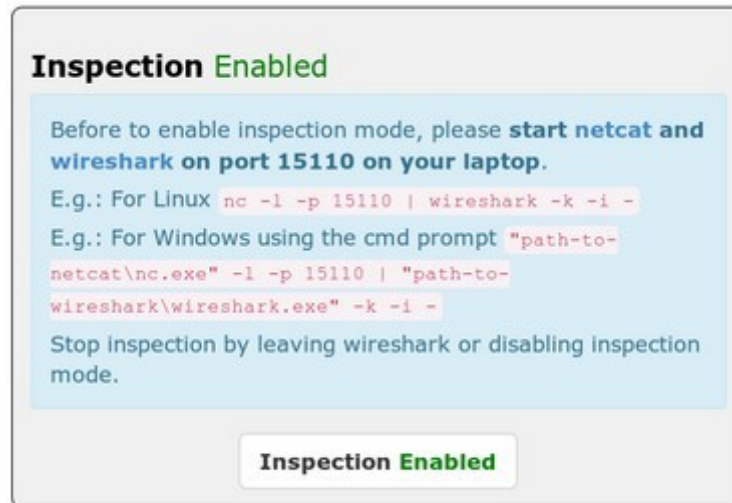

Figure 9: Bridge mode interface

Thanks to a Wireshark plugin developped by Trialog, provided with the tool, the Ethernet traffic is directly decoded in Wireshark and ready for analysis.
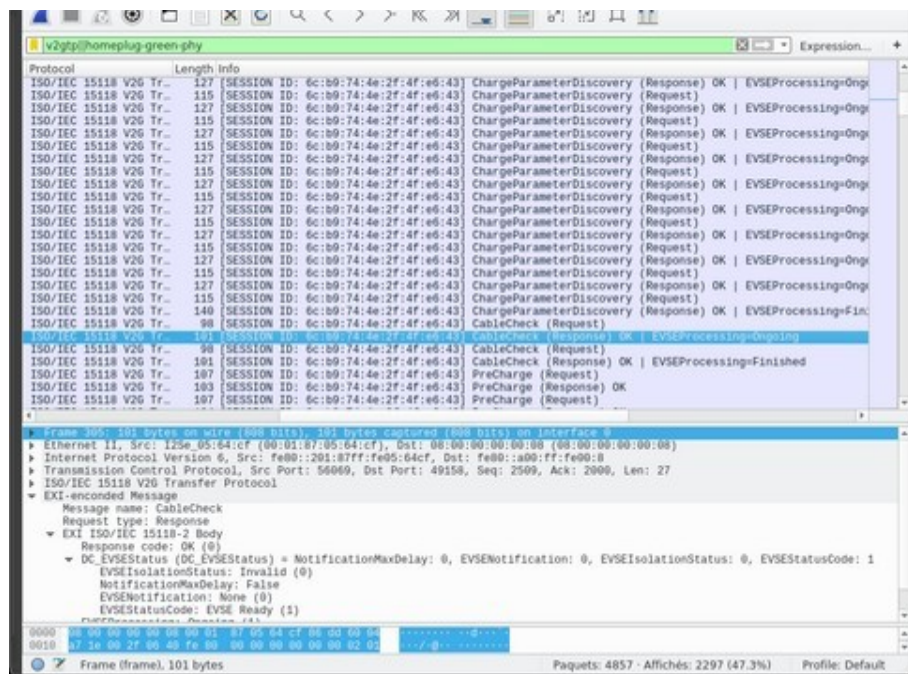

Figure 10: PLC traffic is available through Wireshark

This mode also allows to inject PLC trafic in an existing AVNL.

ComboCS LEDs and GPIOs

Figure 11: Face 2 of the ComboCS

The ComboCS is provided with 6 LEDs indicating the progress of the charging session. At plugin LEDs are blinking and lighting one by one. If an error happen, LEDs are kept in their existing state to visualize quickly where it failed.

Meaning and behaviour of each LED is described below:

- **LED 1 : Control Pilot**
  - LED is off when unplugged (state A/E/F).
  - LED is blinking when plugged but not ready to charge (state B).
  - LED is on when plugged and ready to charge (state C/D). Therefore, for DC charge, it should become one at the beginning of the CableCheck process.

- **LED 2 : PLC Matched**
  - LED is blinking when the first SLAC message is received, until the end of the Matching process described in ISO 1511863 and DIN 70121.
  - LED is on when the SLAC process ifs finished with the succesful Matched state.

- **LED 3 : Cable Checked**
  - LED is blinking when the first SDP request is sent, just after the SLAC Matching process, until the end of the CableCheck process described in ISO 15118-2 and DIN 70121. A lot of steps are done in this stage (SDP, TCP/TLS connexion, Hadnshake, SessionSetup, Authorization, ChargeParameterDiscovery and also CableCheck for DC charge).
  - When CableCheck process is started, the LED 1 "Control Pilot" shall be on, since the EV is required to go to state C before CableCheck.
  - LED is on when the end of the CableCheck mechanism is reached.

- **LED 4 : Charging**
  - LED is on when the Charging Loop is reached (CurrentDemandReq in DC or ChargingStatusReq in AC)

- This LED is always either on or off, it does not blink, in order to let the user use this GPIO as a a logical state to switch a charge relay.
- **LED 5 : End of charge**
  - LED is blinking when the end of the charge is requested by the EV or the EVSE
  - LED is on when the charging session is ended
- **LED 6 (red) : Test result**
  - LED is blinking when the session result is "Failure"
  - LED is on when the session result is "Success"

As a sumary:

- A LED is off when the related state is not yet reached.
- A LED is blinking when the related state is in progress. With an exception for PreCharge: LED 4 is kept off until Charging Loop is reached in order to let the user use this GPIO as a a logical state to switch a relay.
- A LED is on when the related state is finished.

Therefore, all LEDs are going off when unplugged.

Without the Power Transfer option, the GPIO connector of the ComboCS is a mirror of the LEDs. It alows the GPIO to be used to read the digital status of the LEDs, and therefore to know the status of the charging session.

The illustration below describes the pinouts of the GPIO connector:
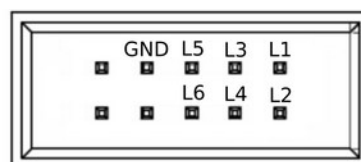
Figure 12: GPIO pinout

Female connector is not provided with the tool. Search for HCSD-05-D-11.40-01-N-G-R reference (10 pins, 2 entries, 2.54mm space between pins).

ComboCS Options

NON-INTRUSIVE SNIFFER OPTION

> This feature is an option, not provided by default in ComboCS. It requires to add some measurement hardware.

In Sniffer mode, the ComboCS does not simulate anymore an EV or a Charging Station, but is plugged directly between an EV and a Charging Station communicating using CCS. ComboCS can then snif passively the communication without interacting in any way with

the PLC trafic. In such a mode, all PLC trafic is available on a dedicated RJ45 port, providing access to the raw Ethernet trafic from SLAC to ISO 15118-2 or DIN 70121. This trafic can be displayed on a Wireshark opened on the operator machine, for further analysis.

Figure 13: ComboCS + sniffer option

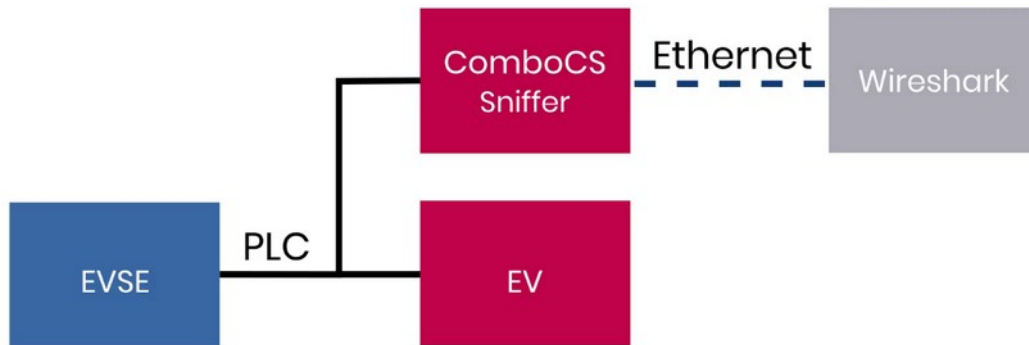Thanks to a Wireshark plugin developped by Trialog, the same used in the Bridge mode described above, the Ethernet traffic is directly decoded in Wireshark and ready for analysis.
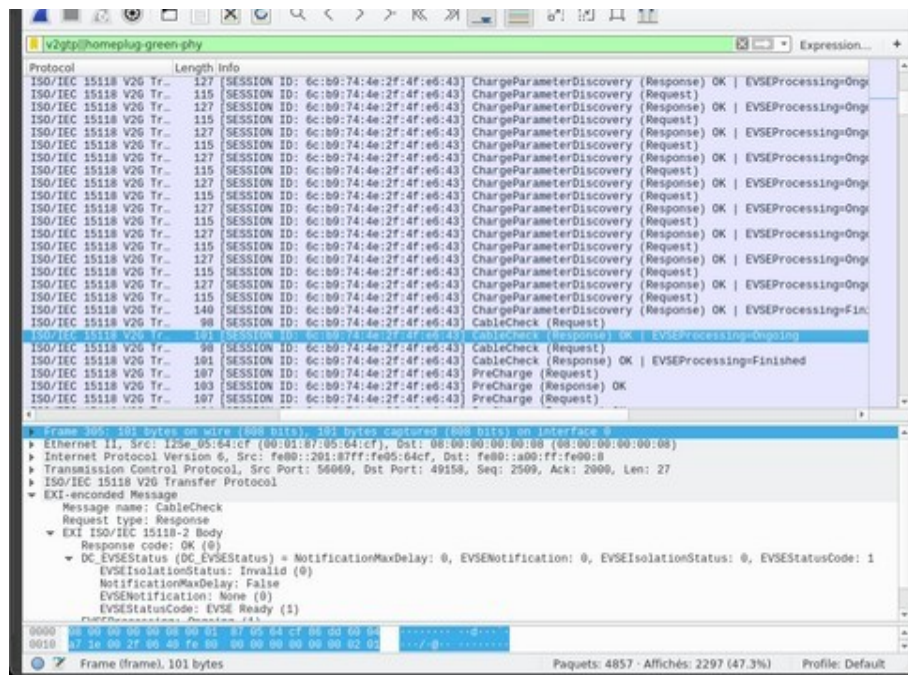

Figure 14: PLC traffic is available through Wireshark

Such a mode could have an impact on PLC power emission and shall not be used during PSD measurement.

PSD MEASUREMENT OPTION

> **Specific development required**
> This feature is an option, not provided by default in ComboCS. It requires to add some measurement hardware.
> To fully automate the process, the CCS implementation shall be adapted to use the ComboCS interface, or a custom development is required on the ComboCS to put the CCS implementation in a dedicated measurement mode and change the PLC calibration.

In order to comply with ISO 15118 and DIN 70121, a CSS implementation shall emit a PLC level of -35dBm (i.e. -75dBm/Hz) for each PLC carrier beween 1.8MHz and 30MHz. The measurement shall be done at the Charging Station DC plug or AC inlet , a calibration shall be done according the internal wiring of the Charging Station from the point of measurement to the PLC Modem.

The generic PSD Measurement option of the ComboCS facilitates the calibration of a CSS implementation. In this mode, the ComboCS shall be connected to a Charging Station that communicates permanently over PLC. A specific development is recommended on the Charging Station to trigger such a communication[1]. The ComboCS will then measure the PLC power emission on each carrier thanks to the setup defined in ISO 15118-3 and DIN 70121 summarized below.
The result is analysed and computed by the ComboCS in order to provide the delta to be applied on the Charging Station PLC Modem calibration.
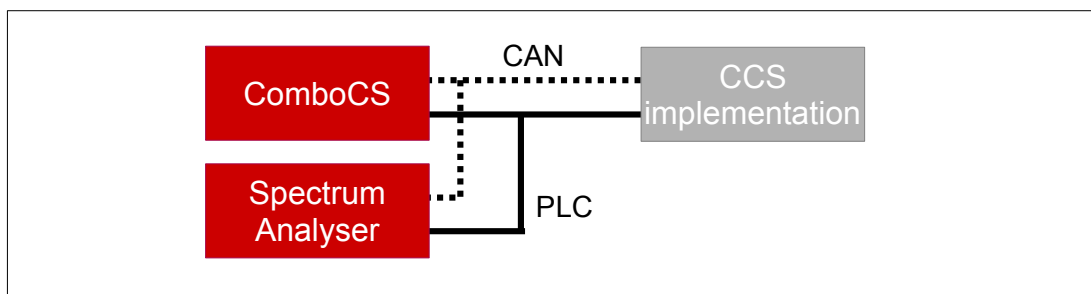
PSD measurement add-on basic setup

The ComboCS also provides a generic communication interface over HTTP to:
- trigger the permanent PLC communication on the charging station
- retrieve the current PLC Modem calibration of the Charging Station
- apply the new PLC Modem calibration of the Charging Station

If the Charging Station is adapted to integrate this communication interface, the PSD measurement setup could be completely automated. Otherwize, it requires several manuel steps.

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[1] Some other solution are available on the market, that do not required the implementation of this permanent communication over PLC on the Charging Station, but they are not compliant with ISO 15118-3 and DIN 70121.

A custom development can also be discussed with the *TRIALOG* team and added into the ComboCS in order to adapt the setup to your specific needs.

POWER TRANSFER OPTION

Specific development required
This option may require to add some hardware and involve some developments to target your specific needs. For more information, please contact us.

In order to perform power transfer using ISO 15118 communication, you can connect your own power electronics to the ComboCS. The GPIO and HTTP API of the ComboCS allow to connect most power setup to the ComboCS. Depending of your needs, Trialog can also adapt ComboCS hardware or software to fit your specifc solution.

Example of solutions for AC charging:
- Add several consumers to simulate different level of power transfer.
- Or use current loop on Charging Station meter to simulate high power transfer with only a minimal real power transfer exchange.

Example of solutions for DC charging:
- Add several resistors to mimic different levels of power transfer.
- Control generative loads over CAN to test power transfer.

VDC261 and OPPCharge OPTION

Specific development required
This feature is an option, not provided by default in ComboCS. It requires a specific software version.

Development in progress
Implementation of these specific modules for buses and trucks are still under investigation. For more information, please contact us.

Annual Subscription

The ComboCS tool described in this document is ready to use. It has been tested and validated by the Trialog team, tested with several Charging Stations in the field and during 3 Testing Symposiums and 2 CharIN Testivals and is currently used by more than 50 companies around the world.
The ComboCS is also still actively maintained by Trialog to fix eventual remaining bugs, test with new Charging Stations, facilitate the usage of the tool, and ensure the correct behaviour of the Simulation mode regarding the current consensus of the normative groups and ISO 15118 user group.

In order to provide such corrective and evolutive updates of the ComboCS, Trialog is proposing an annual subscription including:

- Access to corrective releases of the ComboCS
- Access to evolutive releases of the ComboCS

Trialog will deliver at least one release per year to fix bugs that might have been detected and to deploy enhancement of existing features (same feature basis).
Trialog can share its internal previsional roadmap but does not garanty any delivery planning in the scope of this annual subscription. A dedicated contract can be defined to adapt this roadmap to your company requirements.

In addition to the access of these releases, the subscription also offers access to Trialog's hotline through an online ticketing system. It can be used to ask questions about ComboCS usage and report issues encounter with the ComboCS.

The subscription is done on a yearly basis. The first year of the ComboCS subscription is already included when buying the tool. Subscription for upcoming years is done on the conditions defined when buying the tool if done continuously. In case of interruption, paying for the not covered period is necessary to get the update.

Contact us

*For more information about **ComboCS**, please contact us:* emobilitysales@trialog.com.

Do you know ComboCS for Maintenance?

Trialog has also developped a lighter version of ComboCS dedicated to Charging Station Maintenance: plug the ComboCS4M to your Charging Station in the street and get a quick result about the status of PLC and ISO 15118 status to know if the station is ready or not to be used! The perfect tool for your technical team installing your stations or managing curative / preventive maintenance.
Interested? Please contact us!