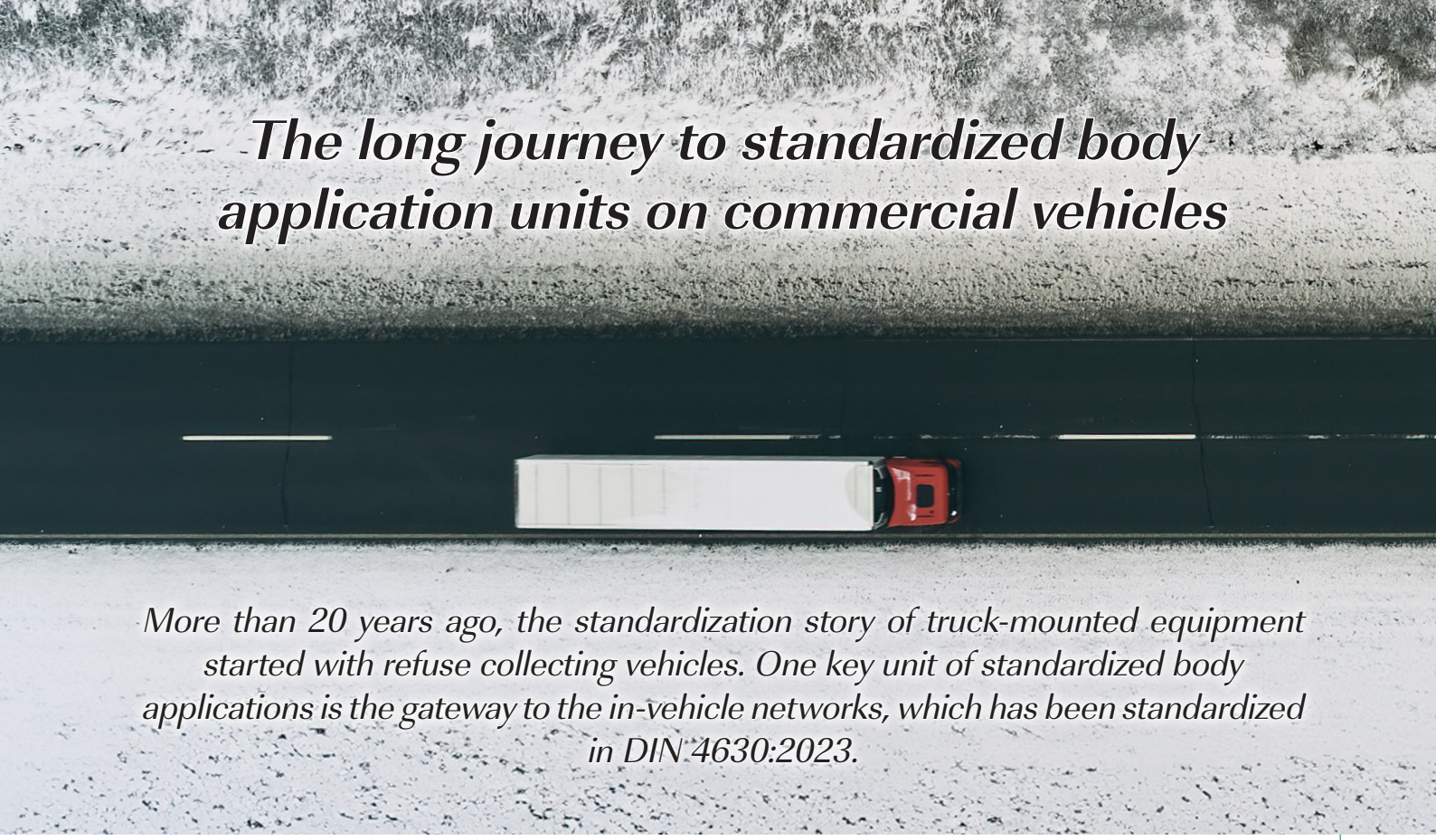
The long journey to standardized body application units on commercial vehicles



More than 20 years ago, the standardization story of truck-mounted equipment started with refuse collecting vehicles. One key unit of standardized body applications is the gateway to the in-vehicle networks, which has been standardized in DIN 4630:2023.

In 2002, CiA established the SIG (Special Interest Group) municipal vehicles. The participating companies agreed to develop a CANopen application profile for refuse collecting vehicles. Original equipment manufacturers (OEMs) requested standardized interfaces for units like bin lifter, weighing/measuring sub-systems, compacters, washing equipment, etc., which they wanted to purchase from different suppliers. Such open interfaces can overcome single-source problems. The dependency on suppliers decreases. On the other hand, suppliers can reduce the number of customer-specific interface variants.

The first version of the CiA 422 CANopen application profile specification series was released in May 2004. It is also known as C*le*ANopen and is standardized in the meantime in EN 16815:2019 (C*le*ANopen – Application profile for municipal vehicles). One of the key elements of this standardized body application was the interface to the in-vehicle networks (IVN) of the truck. There was the hope that such a standardized IVN gateway would be provided by the truck manufacturers. In the beginning several OEMs participated in the CiA 422 development, which was done in co-operation with the German VKA nonprofit association, representing the interests of equipment and municipal vehicle manufacturers in Europe.

To generalize the CANopen-based IVN gateway, CiA established the SIG truck gateway. This group developed the multi-part CiA 413 CANopen truck gateway profile. Unfortunately, this approached has been implemented only by Iveco. All other European truck manufacturers still provide today proprietary interfaces for body application units (BAUs). The CiA 413 gateway profile covered also the parameters of the ISO 11992-2 and the ISO 11992-3 standards. These standards specify the CAN-based link between towing and towed commercial vehicles – in other words between truck and trailers. This means, the body application unit mounted on a trailer can communicate seamlessly via the ISO 11992 networks with the IVNs on the truck, for example to require energy (power take-off) and to get status information (e.g. parking brake engaged). The CiA 413 gateway specification also covers parameters specified in the FMS (fleet management system) specification by ACEA, the European nonprofit association of road vehicle manufacturers situated in Brussels, Belgium.

FireCAN: The standard for fire-fighting equipment

In the meantime, a second body builder application has been standardized: Fire-fighting truck equipment. In the year 2006, the fire-fighting vehicle OEMs and their Tier-1 suppliers started in CiA to develop a CANopen-based solution. After a while, they continued to develop the profile under the leadership of Rosenbauer by their own and submitted with the partners the results to the German DIN standardization body. DIN edited based on these submissions the DIN 14700 document series comprising 12 parts. First FireCAN products were launched in 2010 at the Interschutz tradeshow.

Unfortunately, the quality of these documents was not sufficient to avoid misunderstandings and misinterpretations. The German language was another hurdle. Tier-1 companies from non-German speaking countries were not able to read the documents without loosing information. Additionally, the DIN 14700 series made unclear references to the CiA 301 CANopen specification.

These were the reasons to review the DIN 14700 series. The new edition, still under development, is a one-part document, again with the name DIN 14700 (2nd edition). It is now written in English language and much closer to the CANopen CC (classic) application layer as specified in CiA 301. There are still some differences, but of minor art. The document specifies several fire-fighting units (FFU). All of them are virtual devices, meaning they provide some dedicated functionality and can be implemented on appropriate ECUs (electronic control units). These ECUs can host several FFUs, although those with different functionalities. This is the same approach what the passenger car industry calls a software-defined vehicle (SDV). The above-mentioned C*le*ANopen is a software-defined solution, too. But in those days, the term SDV was not yet invented.

DIN 4630: The standardized body builder gateway

The CiA 413 truck gateway specification was technically a success. Iveco implemented it in many of its vehicles and still uses it. Body builders can configure this interface on the CANopen side according to their application needs by means of a spreadsheet. Commercially, it was not a success story: One implementation is not enough to reduce the body application adaption to other truck brands.

The tail lift industry suffered from this situation. Additionally, some tail lift manufacturers liked to standardize the interface to telematic getaway units (TGU) and fleet management units (FMU). Bär Cargolift, a German company, took the initiative together with other body builders, for example Palfinger, an Austrian/Chinese manufacturer of truck-mounted cranes, and started the development of a CAN-based body builder network. DIN specified the application profile for body builders under the name DIN 4630. The document is written in English language. It specifies a TGU, an FMU, several BAUs, and an IGU (in-vehicle gateway unit). The standardized BAU interfaces include host controllers for tail-lifts, truck-mounted cranes, refrigerators, etc. New body applications such as hook loader are in the pipeline.

The DIN 4630 standard released in 2022 specifies the BAU generic and specific parameters as well as ECU-related parameters. In the annexes, there are standardized mappings to the J1939 and CANopen application layers. The fire-fighting vehicle industry is the first body builder group, which has developed a DIN-4630-based interface for a dedicated market: The DIN 14704:2023 standard specifies a J1939-based interface for FFU-specific IGUs. The corresponding interface for the DIN 14700 host controller is not yet standardized.

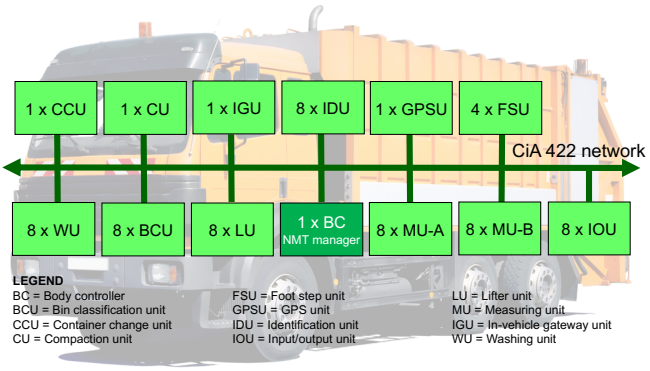


*Figure 1: The C*le*ANopen application profile is based on CANopen CC (classic) and specifies virtual device interfaces such as shown in the schematics (Source: CiA, Adobe Stock)*

C*le*ANopen: Some technical details

The CiA 422 application profile for refuse collecting vehicles is based on CANopen CC (classic) as specified in CiA 301 respectively in EN 50325-4 (compliant with CiA 301 version 4.0.0). It is a network specification approach, which comprises virtual interfaces for specific units. Due to the software-defined approach of CANopen with logical and virtual devices the scalability and configurability is very high. The OEM can implement up to eight instances (logical networks) of refuse collecting equipment networks running on the same physical CAN network. This is as if one vehicle has different bin lifters and related measuring/weighing units for several kinds of garbage. Each logical network comprises virtual devices such as a bin classification unit, a compaction unit, a bin lifting unit, and a body controller with the network management (NMT) manager. This gives the body application designer the possibility to scale the functionality of the ECU interfaces by means of software. Of course, the ECU needs to provide the appropriate input/output functionality. ▷

Brief news: Gateways

- ***Telematics gateway:*** CiA member TTControl (Austria) supplies the TTConnect Wave 4G W, coming with two CAN CC ports, one LIN channel, and one Ethernet interface. It provides GNSS, 4G LTE Cat 4, 3G UTMS, 2G GSM, and Bluetooth connectivity. The product comprises an accelerometer, a gyroscope, and local I/O ports.
- ***Telematics control unit:*** CiA member Iwave Systems (India) offers the IW-RainboW-G62H, featuring GNSS, LTE Cat 1, and Bluetooth connectivity. The IP67-rated product provides two CAN FD interfaces. CANopen, FMS, J1939, and UDS software support is available. Additionally, the gateway is equipped with generic I/O ports, an accelerometer, and a gyroscope.
- ***Remote access unit:*** The Epec 6200 by CiA member Epec (Finland) has two to six CAN CC interfaces supporting CANopen, J1939, and NMEA2000. It connects to GNSS and WLAN. There are also some local I/O ports. The IP67-rated telematics gateway is programmable in Codesys (IEC 61131-3).
- ***LTE gateway:*** The IP40-rated Maxx GW4101 by Iotmaxx (Germany) is a Phyton programmable device. It comprises one CAN and one Ethernet port as well as sensor interfaces and local I/Os. GNSS and 4G LTE connectivity is provided.

hz

The CiA 422 application profile pre-defines all necessary TPDO and RPDO (transmit/receive process data object) messages as well as some additional SDO (service data object) channels. PDOs are transmitted unconfirmed in a broad/multi-cast manner, while the pear-to-pear SDOs are confirmed by the receiver. The specified process data and configuration parameters are organized as arrays in the CANopen dictionary addressable by means of a 16-bit index and an 8-bit sub-index. The CANopen ECU interface implements only those CANopen dictionary parameters, which correspond to the desired functionality. For example: Lifter unit 5 supports sub-index 5 of the related data objects.

The CiA 422 application profile specification includes six parts:

- Part 1: General definitions and physical layer specifications
- Part 2: Virtual devices definitions
- Part 3-1: Pre-defined TPDOs
- Part 3-2: Pre-defined RPDOs
- Part 3-3: Pre-defined SDOs
- Part 4: Detailed application object specification

CiA has submitted the CiA 422 series (version 2.0.0) to CEN for European standardization. It is published as EN 16815:2019 standard. CiA members improve and extend the C*le*ANopen documents. Currently, the version 2.1.0 is released. An update is expected, soon.

C*le*ANopen is widely accepted. OEMs such as the Kirchhoff Group with the brands Faun and Zoeller among others use CiA 422 compliant networks in refuse-collecting vehicles. There are also refuse-collecting vehicles in the Near and Far East implementing C*le*ANopen. C-Trace and Moba are suppliers of C*le*ANopen measuring/weighing units. The standardized communication in refuse collecting vehicles enables to record data on the CANopen network for telematic and other purposes. Squarell supports this with its vehicle data collection devices and Moba offers for 20 years the Mawis bin-identification and weighing unit, which can be used for a demand-driven provision of bins. The increased transparency of the disposal process saves considerable time since it enables an efficient route optimization of the vehicles. This is supported by AI ▷

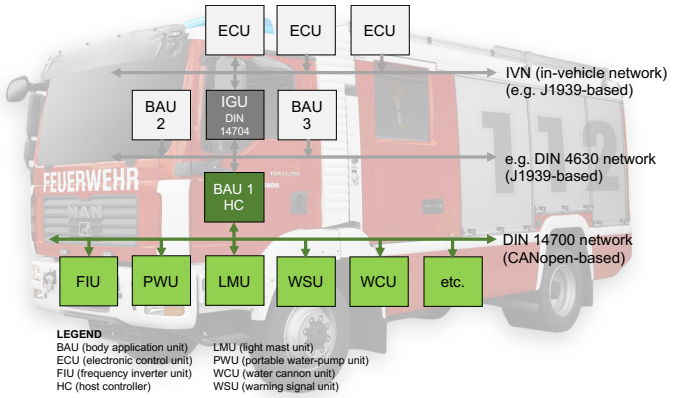


Figure 2: The FireCAN application profile is based on CANopen CC (classic) and specifies functional units such as shown in the schematics (Source: CiA, Adobe Stock)

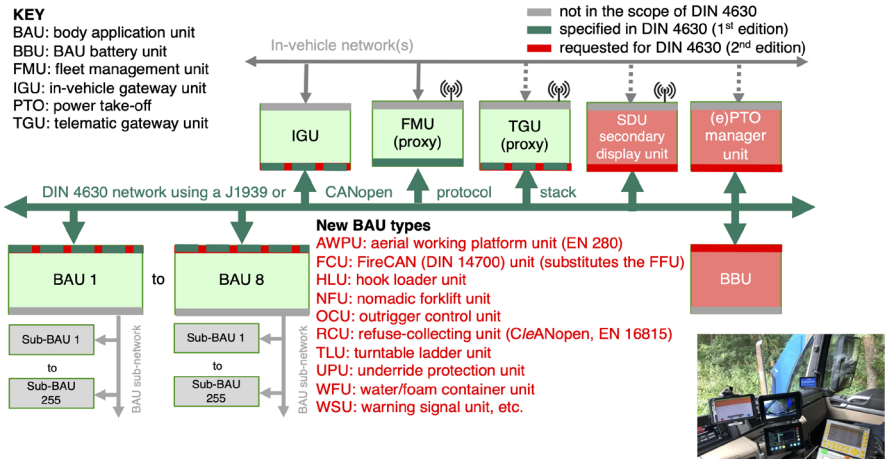


Figure 3: The body application network as standardized in DIN 4630 specifies several units including an in-vehicle gateway unit (Source: CiA)

(artificial intelligence) software running in the back office. They are connected by means of telematics and have thus access to the refuse-collecting equipment with CiA 422 communication capability. C*le*ANopen feeds so-to-say the AI computer. C-Trace offers telematic solutions for its own bin-classification and measuring/weighing units as well as for third-party C*le*ANopen products.

Abbreviations in text

AI: artificial intelligence
AWPU: aerial working platform unit
BAU: body application unit
CAN/CANopen CC: CAN/CANopen classic
ECU: electronic control unit
EMCY: emergency message
ERR: error message
FCU: FireCAN unit
FFU: fire-fighting units
FIU: frequency inverter unit
FMS: fleet management system
FMU: fleet management unit
GND: ground
HC: host controller
HLU: hook loader unit
IGU: in-vehicle gateway unit
ISO: International Organization for Standardization
IVN: in-vehicle network
LMU: light mast unit
NFU: nomadic forklift unit
NMT: network management
SDO: service data object
SDV: software-defined vehicle
SIG: special interest group
OCU: outrigger control unit
OEM: original equipment manufacturer
PTO: power take-off
RPDO: receive process data object
TGU: telematic getaway unit
TPDO: transmit process data object
UPU: underride protection unit
WSU: warning signal unit
WU: winch unit

DIN 14700: The second edition in some detail

The 2nd edition of DIN 14700 is written in English language. It is a single document comprising the twelve predecessor parts of the 1st edition. The new document specifies the CANopen dictionary and the pre-defined PDOs. The implementation of the CANopen dictionary is optional, due to backward-compatibility reasons. Nevertheless, it is recommended to implement it.

The CANopen application profile for fire-fighting equipment is a network system approach. It defines virtual devices, the so-called functional units. Such virtual devices are the frequency inverter unit (FIU), the light mast unit (LMU), the winch unit (WU), the warning signal unit (WSU), and further ones. Some of these units have multiple instances.

The pre-defined PDOs have a length of 8 byte. When the in a PDO mapped data objects (parameters) do not need 64 bits, they are filled up with bits indicating that no function is available. It is done by setting these bits to 1_b. All these PDOs have a fixed assigned CAN-ID, in order to achieve an off-the-shelf plug-and-play capability. This avoids a double-use of CAN-IDs.

The host controller (HC) manages and controls the connected FFUs. The FFUs do not have direct access to the in-vehicle network gateway (IGU). This means, the HC acts as a gateway to the DIN 4630 network, which provides an IGU compliant with DIN 14704, for example. The HC gateway functionality ensures that the FFUs have access to relevant vehicle-related information like engine speed and that data from the attached FFUs can be forwarded to other ECUs or human machine interface devices connected to the IVNs.

The recommendations given in CiA 301 regarding the overall network length and the maximum length of a single stub (0,75 m) are suitable for DIN 14700 networks. A wiring harness featuring 120-Ohm impedance is feasible. Trunk and stub cables providing four wires for fixed-mounted devices and six wires for portable devices are recommended. The cables can be shielded. In case of using shielded cables, ground loops need to be avoided. The red wire connects to V_{cc} and the black wire connects to ground (GND). The white wire connects to the CAN_H wire and the blue wire connects to the CAN_L wire. The pin-assignments of the socket connectors attached to the wiring harness corresponds to those given in DIN 14700 for the plug connectors. Wires for fixed-mounted devices having a cross-section of 0,34 mm² respectively 1,5 mm² for portable devices.

The DIN 14700 document specifies for each FFU a unique CANopen node-ID, which is needed to assign CAN-IDs for the mandatory heartbeat messages and the optional SDO communication. There is also a specific ERR (error) message specified. This is a specific PDO similar to the EMCY (emergency) message in CANopen. The ERR message is transmitted periodically by the assigned virtual device. It contains the current FFU error information. This ▷

includes also warnings. The FFUs and the HC provide error history lists in the CANopen object dictionary accessible by means of SDO services.

The development of the new DIN 14700 standard is supported by Magirus, Rosenbauer, and Ziegler from the OEMs side as well as by some FFU suppliers, for example the WSU supplier Haensch. International companies can also comment the draft standard, which will be publicly available, soon. The ballot of the DIN 14700 document written in English language starts in the first half of 2024. The WSU functionality has been improved and extended significantly. Some WSU functions are the same as specified in the CiA 447 series of CANopen profiles of add-on devices for police cars and ambulances.

There are already some ideas to extend furthermore the DIN 14700 functionality. One of the ideas is to include a local TGU for equipment, which can be operated as a stand-alone unit. With this option, such so-called nomadic devices can be connected to a fleet management system even when the truck with a generic TGU is not available.

DIN 4630: Submitted for ISO standardization

The in-vehicle gateway unit (IGU) standardized in DIN 4630 has not been implemented yet. All truck manufacturers provide proprietary interfaces to their in-vehicle networks. Often these interfaces implement a J1939 application layer with proprietary PG messages and a subset of those standardized in the ISO 11992 series. In order to gain acceptance, DIN 4630 is going to be submitted to ISO for international standardization.

With the submission, an extended functionality is desired. The OEMs like to have a functional safety capability for power take-off (PTO) requests at the IGU. Additionally, some security measures for the IGU are required. The body building industry wants to specify additional BAUs. This includes an EN 280 compliant aerial working platform unit (AWPU), a FireCAN (DIN 14700) unit (FCU), a hook loader unit (HLU), a nomadic forklift unit (NFU), an outrigger control unit (OCU), an underride protection unit (UPU), and a warning signal unit (WSU).

Additionally, the BAU manufacturers like to standardize a secondary display, virtually connected to the body application network. The remote display in the cabin should be provided by the vehicle OEMs. The secondary display would need a standardized interface to download apps. If the download is done via the IGU, J1939 and CANopen provide appropriate services. In CANopen, the SDO service is able to transmit any size of domain data. Another option is the transport protocol specified in ISO 15765-2 and the UDSonCAN services standardized in ISO 14229-3.

But the hurdles for ISO standardizations are high: Five countries must support the project preferably located on different continents. Support means nominating an expert willing to participate in the development of the standard. The body building industry would benefit from an international standard: The body builders can move their systems to different vehicles and integrate TGUs and FMUs from different suppliers or design their own ones. Additionally, standardized BAUs can be combined to achieve a more functionally sophisticated body application.

hz