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From the editors' desk:

Cross-media, multi-media, and social-media – we are in the middle of the jungle

Since March 2012, we have been publishing both: The CAN Newsletter, which you are reading right now, and the CAN Newsletter Online, which you might visit from time to time. The printed version, available on paper as well as PDF-format, focuses on technical and background information. The online version is rather product-oriented, providing news and reports as well as features and dossiers on designated topics. Both publications are linked to our other publications: CiA's website, CiA's Product Guides, CiA's conference proceedings, and CiA's Weekly Telegraph, which is an email sent periodically to the subscribers, informing them briefly about all published news.

All these publications are cross-media linked, which means that they cross-reference each other and also provide external links to other publications (e.g. Wikipedia, other magazines, companies' websites). The benefit for the user and visitor: Wherever you enter CiA's cross-media landscape, you can find your way to more product-related information, published in the CAN Newsletter Online and the CiA Product Guides. If you are looking for technical in-depth articles you will be guided to the printed CAN Newsletter or CiA's conference proceedings. By the way, the proceedings of the 13 international CAN Conferences (iCC) comprise more than 480 papers. Its little sister, the international Mobile Machine Control (MMC) conference, took place for the first time in June this year. The 22 MMC presentations are documented in the related proceedings, which are available at the CiA office.

Besides the cross-media strategy, we are also committed to multi-media solutions, meaning we present information in text, images, and in future also in audio as well as video content. We, the editors, have lots of ambitious ideas when it comes to cross-media. Even though we learn something new every day, quite often we are financially limited. Since our magazine is available for free we do not always have the resources we wish we had. Sometimes, this limits the realization of our ideas.

Social media has been getting more important for quite a while now. That's why we provide each article in the CAN Newsletter Online with a link to Facebook, Google+1, and Twitter.

The resonance has been modest but growing and we hope for further interaction through these possibilities. ▷

The editorial team of the CAN Newsletter at work on the current edition (from left to right: Nickel Plankermann, Cindy Weissmüller, Annegret Emerich, Holger Zeltwanger)

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Definitions

Cross-media is a media property, service, story, or information, which is distributed across media platforms using a variety of media forms. It refers to the journey or linkage across devices and through forms. Cross-media invites the readers and users to crossover from one medium to another (e.g. reading this magazine you are invited by means of hyperlinks or QR (Quick Response) codes to online media.)

Multi-media includes a combination of text, audio, still images, animation, video, or interactivity content forms. It is usually recorded and played, displayed, or accessed by information content processing devices, such as computerized and electronic devices, but can also be part of a live performance in a conference. Multimedia devices are electronic media devices used to store and experience multimedia content.

Social-media refers to the means of interaction among people in which they create, share, and exchange information and ideas in virtual communities and networks. This includes internet forums, weblogs, social blogs, micro-blogging, wikis, social networks, podcasts, etc. Well-known examples are Facebook, Twitter, YouTube, and LinkedIn.

The other link to social-media that we are working on is the discussion forum, which we have established on LinkedIn (CAN Newsletter group). In the group, we would like to discuss the published articles and news with our readers and users. Of course we are not only looking for a discussion between the editors and the users. It is our intention that the readers and visitors use the articles and news as a spark for discussions between themselves.

We, the editors, will use these discussions as prompt for our editorial work, in order to incorporate the interests of the readers in our article selection.

Modern media, in particular online media, is sometimes described as a jungle: The new economy of media is like the ecology of the rainforest – small plants like ferns, which are close to the ground, are in good shape, and the giant trees, which benefit from the sunshine, are growing properly.

Nothing can grow in the middle! We regard our publications as small plants growing on the tropical rainforest's ground.

We are working on developing blossoms and not just stems and leafs. If the readers and advertisers help to foster our media, we have a good chance of surviving in the new media jungle.

So please invite your business friends and partners to use and to visit CiA's publications.

Holger Zeltwanger

MMC 2013: Focus on functional safety

About 80 participants came to the Meistersingerhalle in Nuremberg for the 1st international Mobile Machine Control (MMC) conference on June 12 and 13.

The 22 speakers talked about challenges and solutions of mobile machine control. Various companies displayed their productsand innovations in the accompanying tabletop exhibition.

The MMC attracted numerous visitors to Nuremberg, who wanted to hear about new ideas when it comes to safety in mobile machines. Device manufacturers, researchers and an expert from TÜV Rhineland (Germany) presented their applications, products, their research, or their experiences regarding functional safety. After a couple of theoretical presentations, several presentations about practical applications drew interest among the listeners.

On the first day, L. Fraccaro from Autec Safety (Italy) fascinated with his "Mowers to the limits" and their application on steep slopes or mine fields. The included videos of the adaption of mowers to hazardous areas gave rise to interested comments from the audience.

E. Lautner from Hydac (Germany) managed to captivate his listeners with "System and software design for a modern grape harvesting machine fulfilling state of the art functional safety requirements and implementations". He also showed a short film about the usage of harvesting machines and the challenges the machine builder has to face during the construction of the self-driven grape harvester machine.

On the second day, Uwe Koppe from Microcontrol (Germany) started the conference with his speech about hints and kinks for properly using CANopen communication in mobile machines. Among other interesting presentations was also the talk from Yves Legrand working with Freescale Semiconductors (France). He presented application ideas for 77-GHz radar technology and functional safety for advanced driving assistance. In total, most of the papers were of high quality and not overly marketing oriented. All presentations, except one, are documented in the printed proceedings. The 250-pages booklet in DIN A4 format can be purchased from the CiA office.

Between the presentations, the visitors took the opportunity to socialize and to talk to the exhibitors at the open tabletop exhibition next door. Softing (Germany) presented the SMT, a universal measuring and automation system for mobile and stationary applications. Also interesting were the shown PLCs supporting functional safety by Hirschmann (Germany), Inter Control (Germany), and Sensor-Technik Wiedemann (Germany). The CAN-to-WLAN gateway by Sontheim (Germany) also got some attention. Sponsored by Hirschmann, Inter Control, Sensor-Technik Wiedemann, Softing Automotive and Sontheim, the conference worked with media partners Automa (Czech Republic), Mobile Maschinen (Germany), and SPS-Magazin (Germany). The next MMC is scheduled for 2015. "Hopefully, we will see a growing interest in machine control and a growing number of participants," said Gisela Scheib from CiA, responsible for the conference organization.

Cover story

The CANopen-Diag hand-held diagnostic tool by Embedded Systems Academy is based on the PCAN-Diag hardware by Peak-System Technik. It complies with the CiA 301 (version 4.2) application layer specification. In addition, it supports the CiA 305 Layer Setting Service (LSS) specification (version 2.2). The add-on software module for the CiA 447 car add-on devices application profile complies with the version 2.0.

Editorial

CANopen

Mobile machines

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It's done
Once again it's done. The September issue of the CAN Newsletter got published. We have got quite a lot of interesting articles about CAN and CANopen, which we are happy to share with you. We also would like to thank all authors for their ideas and applications.

Upcoming next ...
Unfortunately we couldn't publish all articles in the current issue of our Newsletter. Though we will release them in the December issue:
- *V-model development of safety application*
- *Encoders make mobile elevating work platforms flexible*
- *Walking excavator using J1939-linked hydraulics*
- *Electric servo drives prove themselves in outdoor use*
- *CANopen for Chinese product quality*

We are always looking for "unusual", fancy, CAN-related applications. You think yours would perfectly fit in our magazine? Then don't hesitate to contact us and share your article with over 6000 CAN Newsletter readers.

Thanks for your support.
We hope you will enjoy this issue of the CAN Newsletter.

The editors

PS Your comment on this issue to pr@can-cia.org helps to improve this magazine.

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Introduction
The CANopen Diag hand-held diagnostic tool by Embedded Systems Academy is based on the PCAN-Diag hardware by Peak-System Technik. It complies with the CiA 301 (version 4.2) application layer specification. In addition, it supports the CiA 305 Layer Setting Service (LSS) specification (version 2.2). The add-on software module for the CiA 447 car add-on devices application profile complies with the version 2.0.

Literature
CANopen Diag User's Manual, Embedded Systems Academy, Barsinghausen (Germany), 2013.

The stand-alone CANopen Diag tool offers various operation modes. In one mode it communicates with a single CANopen NMT slave device under test (DUT). In this use case, the tool acts as the SDO client for the SDO default server of the DUT. The user can write and read to the DUT's entire object dictionary.

When using the tool to access a CANopen network with several devices, it can optionally ask the SDO Manager in the network for permission before using a slave device's default SDO server. Alternatively, there is a listen-only mode to guarantee pure monitoring access. Either approach will avoid any CAN collisions.

Network monitoring and event history

When the tool monitors the network traffic and shows the selected events, it does not actively generate any CAN messages by itself.

This function is used to get a first impression of what is currently happening in the network. The screen shows the messages and provides some additional information (e.g. node 3 boot-up message). The event history list collects dedicated CANopen messages and records them to be analyzed later with the CANopen Diag Manager Software.

The reported events include EMCY messages of individual nodes, NMT messages with a specific content (e.g. start all nodes), SDO abort messages with a specific error code, and many other detailed CANopen and LSS messages.

The tool could also be used to scan the network and the connected CANopen devices.

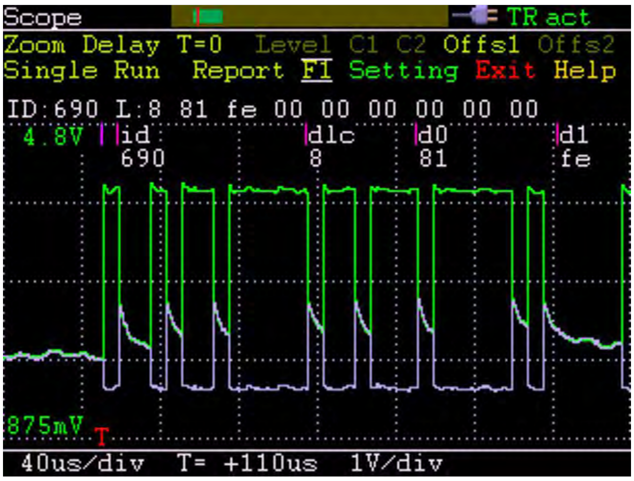

Figure 1: The scope function shows the signal as an analog value

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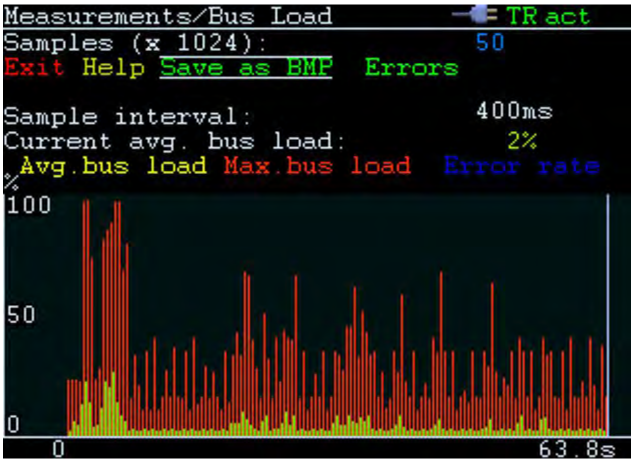


Figure 2: The tool measures the busload (average and maximum) as well as the error rate

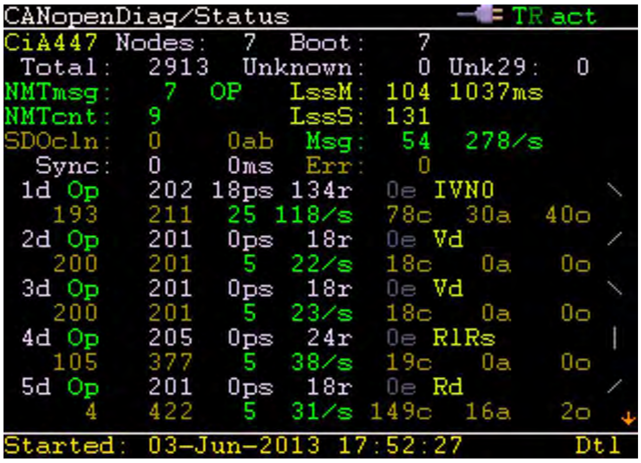


Figure 4: The status screen informs about the number of nodes detected ant their NMT status

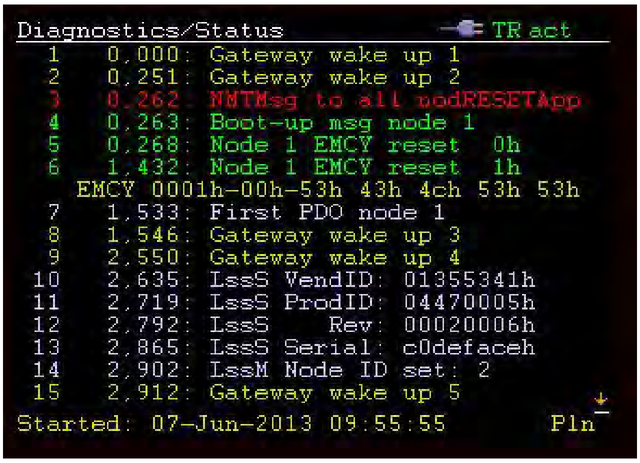


Figure 3: The event list shows the messages in the order transmitted on the network

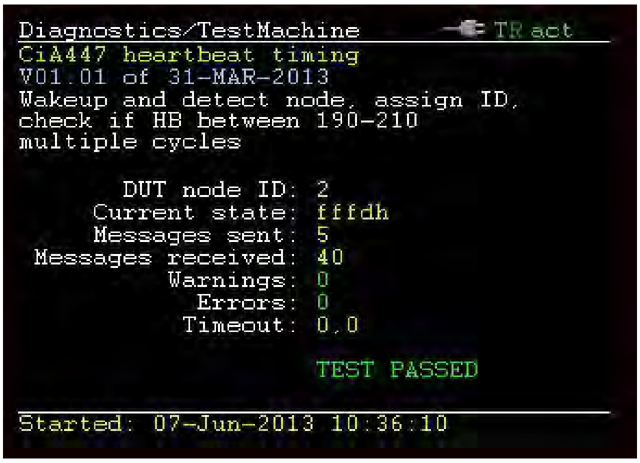


Figure 5: The tool provides dedicated test procedure for CiA 447 (the Heartbeat test for the CiA 447 device with the node-ID of 2 was successful)

The Node Viewer functionality allows browsing through the object dictionary. With the Write-to-node function it is possible to configure a device or to download a software update. The tool also implements the CANopen Test Machine engine, which can execute complex test sequences with an accuracy of 1 ms. For each executed test sequence, a report is generated and stored. Pre-defined test sequences include LSS testing, Heartbeat producer time, periodical PDO (event-timer), and PDO inhibit time measurements.

CiA 447 option

The tool comes optionally with a CiA 447 module. CiA 447 is the CANopen application profile for car add-on devices as used in taxis, police cars, ambulances, and other special-purpose cars. This also includes passenger cars for handicapped drivers. This module supports several specialties of the CiA 447 profile. For example, the user can set the trigger on the sleep request command or the gateway wake-up command. The tool can also trigger on specific SDO client abort messages, because the CiA 447 devices are fully "SDO-matched", meaning there are SDO clients and SDO servers from and to all other nodes in the network.

The Test Machine engine provides additional sequences for CiA 447 devices such as SDO server function and stress testing as well as sleep and wake-up testing. For CiA 447 gateways, the tool implements specific test sequences.

For more complete functional testing of a CiA 447 network, in particular the CiA 447 gateway, the module also adds a tester node, which is a simulated, actively communicating CiA 447 slave implementation running inside CANopen Diag. A special stress test mode allows executing up to 14 virtual tester nodes in parallel.

CAN measurements

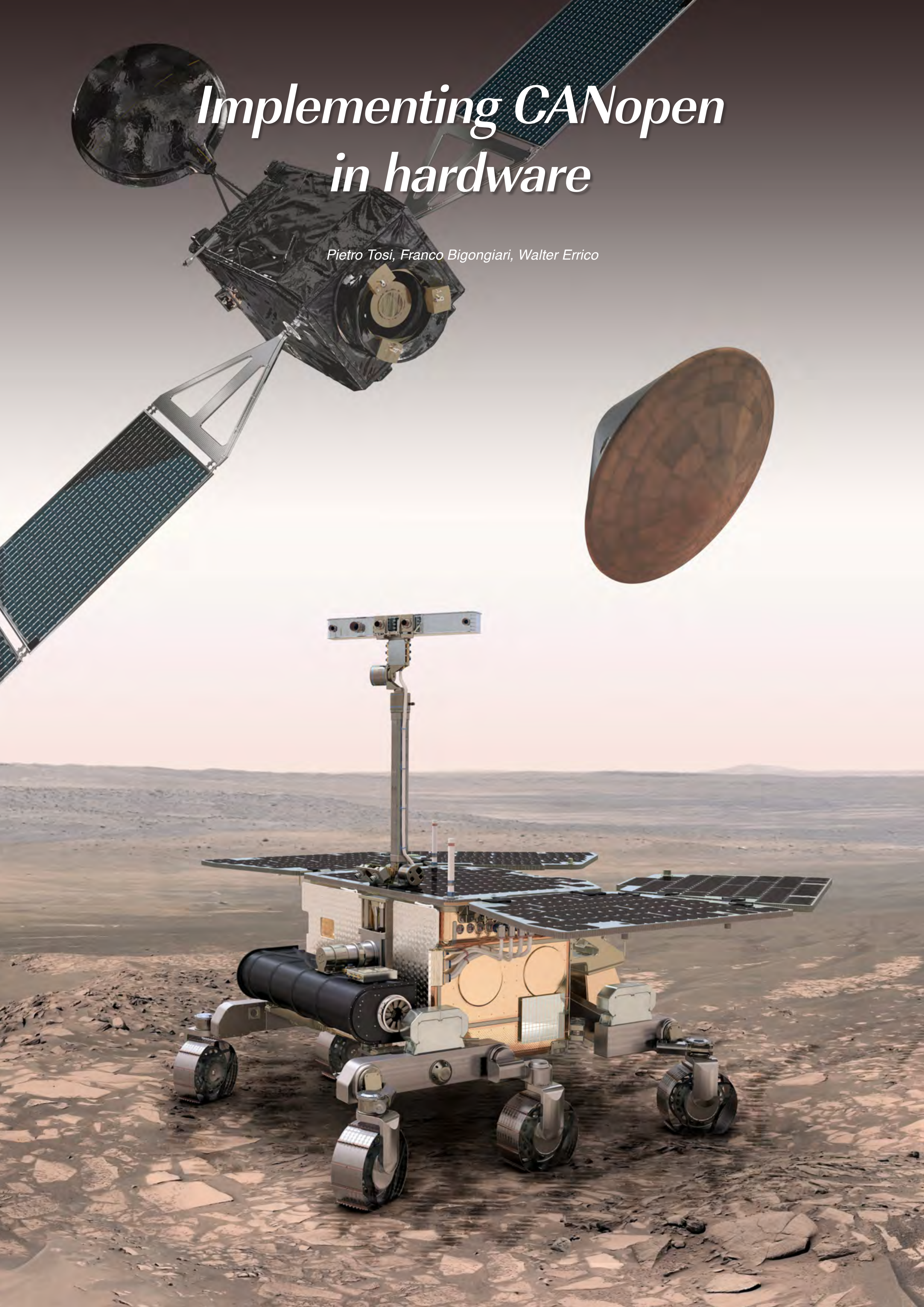
CANopen Diag is also able to measure the busload, the termination resistance and the voltage levels on the bus. The busload diagram shows a short history for the overall bus utilization of a running CANopen network. Momentary peaks are indicated in red. Of special interest is the average busload, which should stay as stable as possible. While the tool doesn't provide latency measurements for individual messages (e.g. delay of PDOs), it does show the occurrence of error frames.

The built-in oscilloscope provides measurements of the signal quality. There are two independent channels with a sampling frequency of up to 20 MHz. The memory depth is 64000 samples. The timer resolution is up to 50 ns. Triggering options include start of data/remote frame, end of data/remote frame, start of error frame, and on specific CAN-IDs.

Holger Zeltwanger

Implementing CANopen in hardware

Pietro Tosi, Franco Bigongiari, Walter Errico



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Introduction
It has been a long time since the CAN network was adopted as one of the possible spacecraft onboard networks for control and remote sensing data communication. To promote the use of CAN and to be more similar to structured data networks like MIL-STD-1553B, in the framework of ESA ExoMars program (launches scheduled for January 2016 and May 2018) and under a contract with Turin premises of Thales Alenia Space Italia has developed a CANopen Controller IP Core (CCIPC).

The CCIPC is a hardware solution for CANopen implementation in charge of managing CAN physical, data link and application layers simultaneously. It is capable of managing the main CANopen protocol aspects (NMT, PDOs, SDO, etc.) with additional features as bus redundancy and error correction and detection (EDAC) algorithms for high-reliable communication. The CCIPC has been designed with a lot of configurable and customizable parameters and it can be implemented both in ASIC and FPGA technologies.

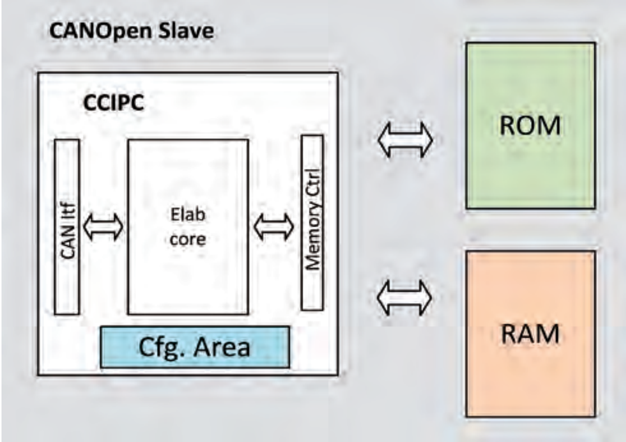

Figure 2: CANopen slave node

Architecture of the CANopen core

Within a CAN network, the CCIPC takes the role of a CANopen slave node. CCIPC implements the following CANopen services:

- PDO handler (synchronous and asynchronous RPDO and TPDO)
- SDO handler (expedited, segmented and block)
- Network Management
- Synch consumer
- Heartbeat consumer and producer

The CCIPC also supports a specific service, called Redundancy Manager, in charge of executing redundancy algorithm and managing CAN network multiplexing.

Figure 1 presents the CANopen Controller IP core architecture. The CAN controller module is the manager of the CAN interface and it's able to transmit, receive and filter CAN messages.

The Bus manager module is part of the Network Manager block; it is represented as a separate block in order to explicitly show the CCIPC capability to implement the Bus Redundancy management protocol. The two CAN queue blocks (MsgIn and MsgOut Queue) are used to temporaryly store messages received and messages to be transmitted, using a FIFO mechanism. The Network Manager is the module that controls and coordinates all system functionalities. It performs the Network Management and the Heartbeat Error control services. The event handler module is in charge of enabling the different CANopen functionalities (SDO, RPDO and TPDO) according to the state of its input trigger signals. The OD (object dictionary) handler is the module that has direct access to the CANopen Object Dictionary area in order to implement the different CANopen communication services (PDO and SDO protocols).

The Object Dictionary area has been split in two main subsets:

- Internal area (communication parameter), which stores the PDO communication parameters area;
- External area (mapping parameter & application objects), which includes the PDO mapping parameters area and the manufacturer-specific profile area (2000_h to $5FFF_h$).

The Index pointer RAM internal memory block contains the tables of pointer, keeping the cross references between the ▷

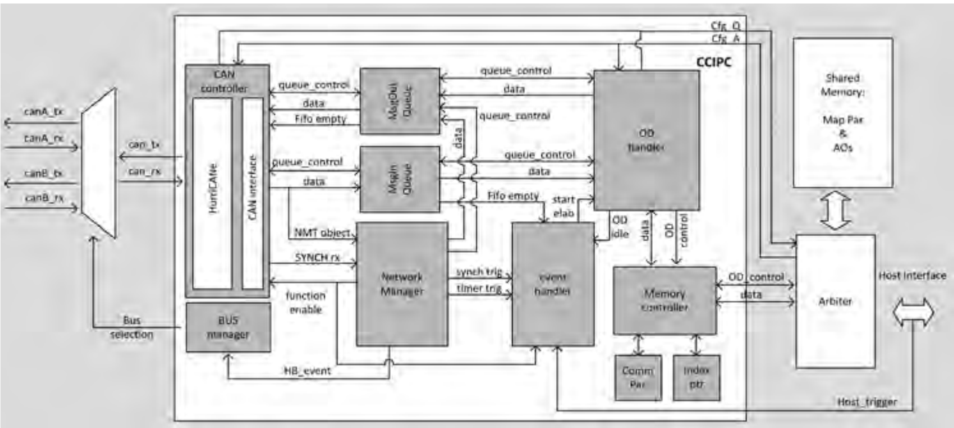

Figure 1: Architecture of the CCIPC

CANopen

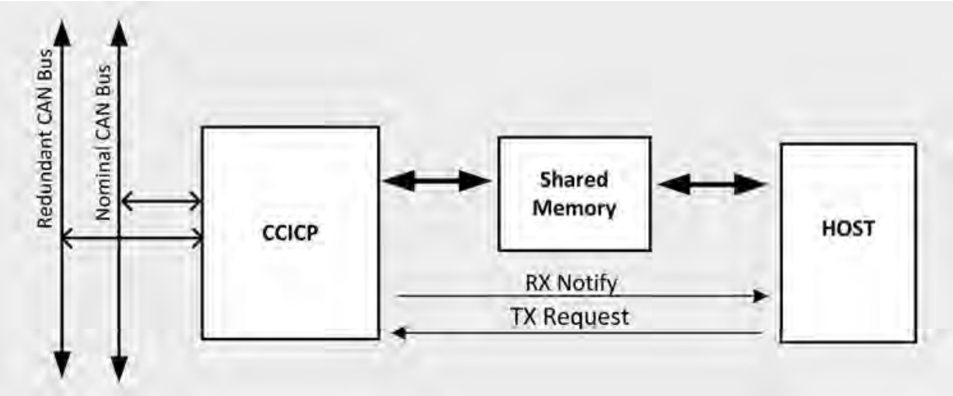

Figure 3: CCIPC host interface

Figure 4: CCIPC graphical user interface

OD application objects and their physical addresses in the external shared-memory. The memory controller is the unit that handles the access on the core's internal and external memory areas. An auxiliary arbiter module allows sharing of the external memory between CCIPC and the host device.

Host interfaces

The CCIPC is designed to cover all aspects of the protocol, exposing the CANopen object dictionary to the user as a shared-memory area with additional received messages notification (interrupt) signals and transmission request triggers.

In order to work as a CANopen slave node in accordance with the Network Management (NMT) “reset node” and “reset communication” services, the CCIPC needs to access two external memory areas, hereafter simply called ROM and RAM.

The ROM area is assigned to store the default values for TPDO/RPDO communication/mapping parameters and for application objects that have to be loaded after power-on or when the “reset node” or “reset communication” requests are received. Depending on the specific instance and in case of a FPGA implementation, this area can be realized with different solutions:

- Internal implementation as a LUT circuit (for example in case of 1-2 node with application objects limited to a few hundred bytes),
- Internal RAM macro-cell. A dedicated internal FPGA memory has to be preloaded before releasing the CCIPC Rst_n signal (e.g. the case of an external microprocessor or a serial link connected to a remote server/memory devices),
- External EEPROM memory. This is a simple (and costly) solution achievable with an external non-volatile memory,

The RAM area is assigned to keep TPDO and RPDO Mapping Parameters and Application object data. This area is shared between the CCIPC core and the External Device. Depending on the number of Node supported and Application Object defined, this area can be implemented exploiting the internal macro-cells (in case of implementation on FPGA) or as part of an external RAM device.

The CCIPC also includes an additional memory area, called configuration area that collects all CCIPC configuration and status registers.

Three different interfaces are available to realize the memory sharing between the CCIPC and its Host Device depending on the different CAN network user categories (CPU-less, micro-controller and CPU) and also different OD structure size:

- The generic I/O interface is the more general solution, where an external arbiter module is in charge of managing the sharing of the memory device between the CCIPC and host device according to request/lock signals coming from the two interfaces;

```
EB(0) :=  D(0) ^ D(1) ^ D(2) ^ D(4) ^ D(5) ^ D(7) ^ D(10) ^ D(11) ^ D(13) ^ D(16) ^ D(20) ^ D(21) ^D(23) ^ D(26) ^ D(30) ;
EB (1) := D(0) ^ D(1) ^ D(3) ^ D(4) ^ D(6) ^ D(8) ^ D(10) ^ D(12) ^ D(14) ^ D(17) ^ D(20) ^ D(22) ^ D(24) ^ D(27) ^ D(31) ;
EB (2) := D(0) ^ D(2) ^ D(3) ^ D(5) ^ D(6) ^ D(9) ^ D(11) ^ D(12) ^ D(15) ^ D(18) ^ D(21) ^ D(22) ^ D(25) ^ D(28) ;
EB (3) := D(1) ^ D(2) ^ D(3) ^ D(7) ^ D(8) ^ D(9) ^ D(13) ^ D(14) ^ D(15) ^ D(19) ^ D(23) ^ D(24) ^ D(25) ^ D(29) ;
EB (4) := D(4) ^ D(5) ^ D(6) ^ D(7) ^ D(8) ^ D(9) ^ D(16) ^ D(17) ^ D(18) ^ D(19) ^ D(26) ^ D(27) ^ D(28) ^ D(29) ;
EB (5) := D(10) ^ D(11) ^ D(12) ^ D(13) ^ D(14) ^ D(15) ^ D(16) ^ D(17) ^ D(18) ^ D(19) ^ D(30) ^ D(31) ;
EB (6) := D(20) ^ D(21) ^ D(22) ^ D(23) ^ D(24) ^ D(25) ^ D(26) ^ D(27) ^ D(28) ^ D(29) ^ D(30) ^ D(31) ;
```

Figure 5: Error detection and correction algorithm

- The AMBA network interface is designed for complex System on Chip (SoC) solutions. It is composed of an AMBA AHB master module used to request read or write operations on the external memory device and an AMBA AHB slave module to access the CCIPC configuration & status area;
- The direct interface is used for small CCIPC solutions in which application objects are directly mapped into FPGA or ASIC, exploiting its register and pins resources

Additional features

The first feature regards the CCIPC behavior when a failure occurs in a CAN network. CCICP utilizes the Heartbeat protocol receiving and transmitting Heartbeat messages to detect failures on the net. When CCIPC does not receive the Heartbeat message from the NMT master node, it generates a "Heartbeat event". This event is used by CCIPC to implement the "Bus Redundancy Management" protocol. Through this protocol, CCIPC is able to control two CAN networks (nominal and redundant). CCIPC periphery is furnished with a bus selection flag that allows defining which is the CAN network that is currently active.

Two parameters are available to control the redundancy protocol:

- T-toggle counter defines the maximum number of Heartbeat events before switching the bus;
- N-toggle counter defines the maximum number of network toggling before stopping the redundancy process.

Another characteristic of the CCIPC is the implementation of the EDAC algorithm, based on the Hamming code shown in Figure 5, in order to detect and correct single-bit errors and detect double-bit errors in internal and external memory devices.

Graphical user interface

A CCIPC-oriented GUI (graphical user interface) leads the user during the configuration phase of the main CCIPC configuration parameters and also to edit the object dictionary compatible with the EDS (electronic data sheet) standard.

The following items can be set:

- System frequency in the range of 10 to 16 MHz;
- CAN network bit-rate (1 Mbit/s, 500 kbit/s, 250 kbit/s, 125 kbit/s)
- Host Interface;
- PDO communication & mapping parameters;
- Application objects;
- CCIPC configuration objects:
  - Synchronous Window Length;
  - Heartbeat consumer and producer time;
  - Redundancy Manager parameters. ◀

Goldhofer axles shoulder the USS Coronado

Figure 1: 2800 tons under one-man control; the complete 104-axle vehicle combination was steered by a single operator using a remote control

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In addition to heavy-duty transportation specialists around the globe, the Pentagon also trusts in the transport technology from Goldhofer. The US Navy turned to Berard Transportation, an old-established Goldhofer customer, to handle the project of the launch of the USS Coronado, which is latest in the independence class of vessels, costing like 440 million dollars. Berard, a leading specialist for heavy haulage in the USA, makes consistent use of Goldhofer's heavy-duty technology and for the Coronado mission deployed a total of 104 axle lines in the form of Goldhofer PST/ES-E and PST/SL-E heavy-duty modules with multiway steering. A CAN network was used for electronic synchronization of the hydraulic functions of the two types of vehicle. That made it possible for the complete configuration to be handled by a single operator using remote control.

The first step of the project was to load the 2800-ton navy ship onto Goldhofer's self-propelled PST/SL-E modules in the Alabama shipyard belonging to the Australian shipbuilder Austal and transfer it to a floating dock. That way it could be moved to a dry dock further downstream. There the Goldhofer axle lines were used to move the 127-meter-long and 30-meter-wide colossus, mainly built of aluminum, into the dock for the actual launch.

Chief Operating Officer Braedon Berard: "For us, it is a great honor to be entrusted with a highly prestigious job of such importance for our country. It was an amazing experience and also a great pleasure to cooperate with the specialists from Austal. We had just two days to handle the project, and thanks to our long years of experience with special transportation work and the reliable equipment from Goldhofer, we completed the job in time and without any incidents. We can always rely on our Goldhofer axle lines.

Figure 2: Safe and reliable transportation on land; the USS Coronado on Goldhofer PST/ES-E and PST/SL-E heavy-duty modules

We are very happy to have such a strong partner as Goldhofer for handling challenging assignments," said Braedon.

The Goldhofer PST/E-SE and PST/SL-E modules employed to move the USS Coronado have hydrostatic drive and electronic multiway steering and offer flexibility. In addition to the standard steering modes (normal, diagonal, transversal and carousel), the company's self-propelled modules can be operated with special steering programs without the need for major modifications to the vehicle combination. The heart of the affair with any self-propelled vehicle is the power pack, which is available in a 155 kW and a 360 kW version. This is the drive unit for the hydrostatic drive and houses all the controls and instruments for the self-propelled vehicles.

"The US Navy contract is an excellent reference for our company too, and I'm very pleased we were able to help Braedon and his great team handle such an impressive project. In Memmingen, we are very proud to see the world's most expensive and important vessels traveling on Goldhofer axles before they are launched," said Stefan Fuchs, CEO at Goldhofer. ◀

USS Coronado

The USS Coronado is the latest addition to the US Navy's fleets. It is a littoral combat ship, a type of warship that the USA wants to deploy as it intensifies the fight against terrorism. The USS Coronado will be commissioned this year and will be stationed in San Diego (California).

More than devices for road construction machines

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Figure 1: Grader working on a sports court in Southern Germany using the 3D-matic leveling system

Providing only CAN-connectable devices for road construction machines is not sufficient to be successful in mobile machine automation. You also need to understand how to pave and compact. Moba, established more than 40 years ago, develops and manufactures electronic control devices in close cooperation with its customers not only for road construction machinery. This includes on-board host computers, leveling and positioning sensors, human machine interfaces (HMI), and software for these devices. Of course, the devices provide CAN and CANopen connectivity. The host controller, programmable in IEC 61131-1 languages (Codesys), features up to three CAN/CANopen interfaces.

The company, headquartered in Limburg (Germany), was an early bird in CAN technology. CiA member since 1992, engineers of the company participated in the CiA technical groups, which standardize higher-layer protocols and associated profiles.

The company has developed electronic control systems dedicated to graders (a machine with a long blade to create a flat surface), pavers (a machine laying asphalt), compactors (a machine compacting the asphalt), or other mobile machinery. Some of these devices are used in different kind of machines. HMI devices, for example, are integrated in most of the machine control networks. This is why the company has developed a modular HMI series.

Graders need to be leveled

The grader precisely distributes the material in the blade over the surface, fills holes, and flattens bumps. Via tachymeter or by means of GNSS, position and height of the machine are constantly determined and the blade is adjusted accordingly. The operator has an overview of all operations on the display in the vehicle cab. This is possible due to the 3D-matic leveling system. This system, which was developed for graders, dozers, and blades, pro- ▷

Figure 2: "The system is really simple to operate," stated Wendelin Schneider

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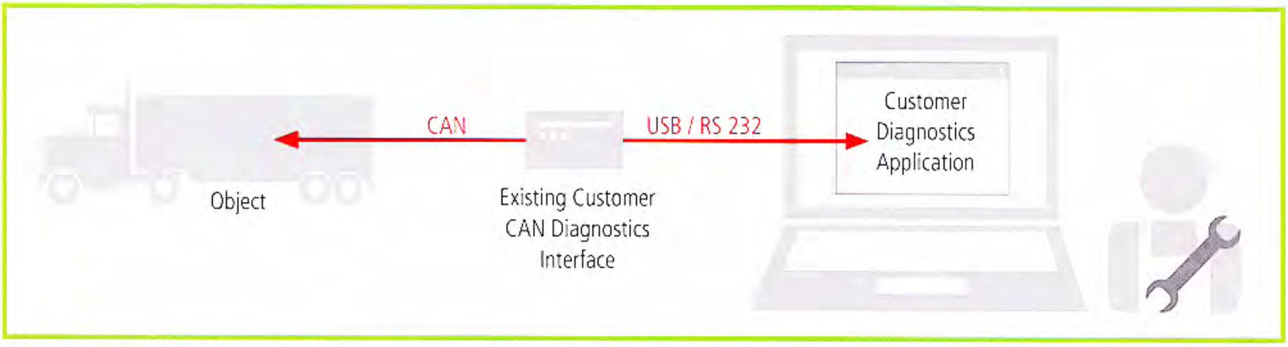

CAN data is read via cable connection – remote diagnosis is not possible.

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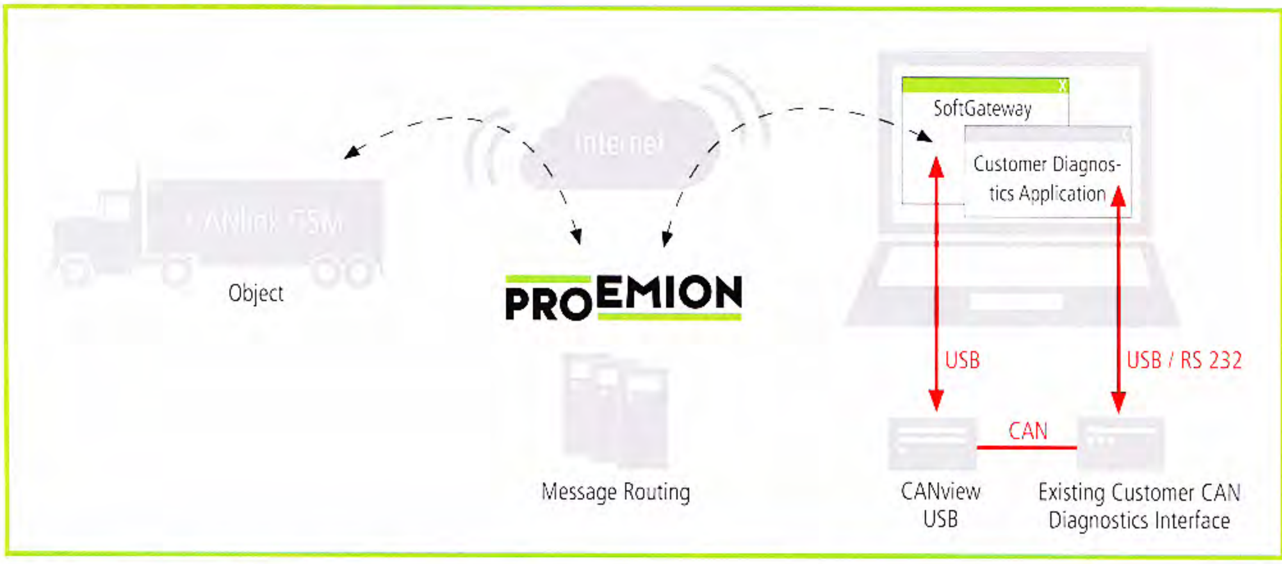

The PROEMION Real-Time remote diagnosis solution enables access to vehicle operational data, machines or remote objects in real time – anytime, anywhere. With conventional diagnostic systems, such data is only available on site. PROEMION Real-Time enables wireless connectivity with remote objects – regardless of distance. Global availability of diagnostic data not only facilitates error detection and prevention, but also allows a timely response to critical values. Errors can be rectified without costly and time-intensive on-site repairs, downtime is reduced or even avoided.

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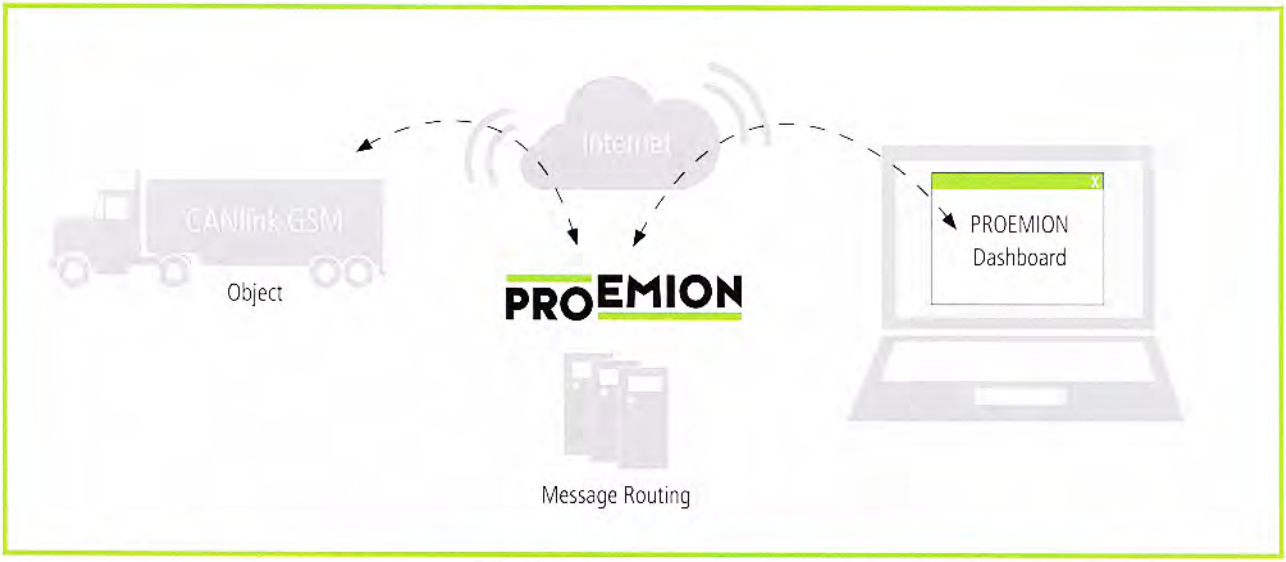
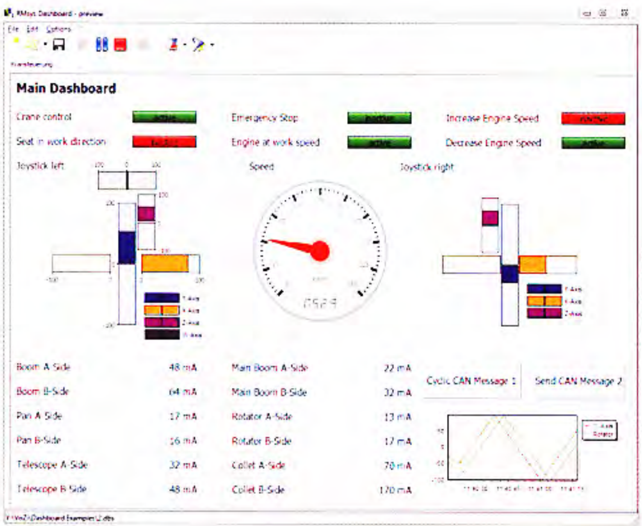


As an advanced version of our established PROEMION Real-Time solution, "Dashboard" – a new desktop application – provides optimal, extremely user-friendly representation of globally retrievable CAN data. Upon installing the PROEMION CAN-link GSM / UMTS module no additional hardware modules are required for reading the accessed data.

PROEMION Real-Time can quickly process and clearly illustrate "Dashboard" data received via GSM / UMTS bridging. Results are individually configurable, no specific programming skills are required.

Dashboard Software



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The device includes all required accessories and software, such as the SoftGateway.

CANview® USB (optional)

The CANview USB is connected to the PC's USB interface and converts all received messages to local CAN, so that the information transmitted to your existing CAN diagnostics device is equal to the source CAN messages.

Security Token (optional)

The Token generates authentication data for online identification when accessing the vehicle or machine via a direct Real-Time connection.

PROEMION Real-Time Server

The PROEMION Real-Time Server is for communication handling and message routing.

SoftGateway

This software allows for authentication and connection establishment. Further, it receives CAN data from the PROEMION Real-Time Server and sends it to the local CAN via the CANview USB.

New Dashboard Feature

The "Dashboard" desktop application displays data in real-time.

Cockpit instrument representation is individually configurable.

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Figure 3: "The machine and the corresponding values are depicted clearly," said Wendelin Schneider

cesses 3D data (when that is not available, it can use 2D data, as well). It combines so-to-say 3D and 2D computers in a single housing. The displays as well as the necessary sensors are also suitable for 3D and 2D applications. The benefit: Depending on the project, the operator can thus work with 3D or 2D.

The leveling system is also usable in smaller projects such as the renovation of a soccer court. Wendelin Schneider used the 3D-matic system in his grader, when he renovated a sports field in the stadium of Bahlingen (Germany). His task: The hard court from the 1960s had to be reconstructed and converted to a grass court. This meant that an area of 7000 m^2 had to be re-worked and re-leveled. He generated the terrain model with Autocad, and transferred it as a DFX file on a USB stick from the PC to the CAN-based leveling system. After he removed the red sand layer, he re-leveled the subgrade as specified by the model. Wendelin Schneider installed the leveling layer — a total of 600 t of material — using the 3D system.

To prevent rainwater from collecting on the court and to instead allow it to drain uniformly, the surface must not be completely flat, but should rather have specific inclines. For the above-mentioned soccer court, this was realized through a hipped profile. That means that multiple inclines were necessary on this surface and a uniform gradient of 0,8 % to 1 % incorporated on all four sides from the middle to the edge of the court. And the advantages of the 3D system came into play. "With the 3D-matic, I can travel the entire length in one pass, and the system automatically regulates the height and incline angle of the blade depending on which part of the court I am currently traveling over with the grader," explained the grader operator. "If one was to use a system with a laser, it would be necessary to exit the cab intermittently and adjust the laser transmitter accordingly for the various inclines." In addition, the grader does not need to travel in lanes, but can instead be driven in any direction, since the receiver on the machine constantly captures the tachymeter signal and adjust the blade accordingly. Passes can even be made over the corners without problem.

Over a distance of up to 200 m, the receiver captures the signal with an accuracy of less than 5 mm. Even at the edge of the curb, where deviations frequently arise when working with a laser, the grader with the 3D leveling system operates with precision, since the terrain model can be implemented according exactly to the specifications and the existing conditions.

The grader can be operated via the touch-screen display as well as the keyboard. Processing the surface with the 3D system saves time and fuel and improves the quality in the construction process. "Using the system, I can attain time savings of two thirds over manual processing. No stakes need to be set, no wires tensed and no measurements performed," said the contractor. An upgrade from 2D to 3D was no problem, as Wendelin Schneider confirmed, who also worked with the 2D System GS-506 from Moba. After processing the subgrade and the leveling layer, an approximately 2 cm plastic coating was applied with a surface finisher and the irrigation and the turf installed. The ball is rolling again, sooner as expected. ▷

Figure 4: Paving machine controlled by the Big Sonic-Ski leveling system

Moba community

Moba has established an online community website for people interested in construction machine development. The intention was for it to be company-independent. However, this has not been achieved yet. Most of the contributors are the company's employees and customers. Nevertheless, sometimes valuable postings and discussions can be found on the website.

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Figure 5: In cab display shows the progress of the paving

When working with GNSS, the 3D leveling system ascertains the machine position with its GNSS sensor. The control unit compares the machine position with the design data and calculates the deviations. Corrections for these deviations are performed in the blade controller. The CANopen-based leveling system scores with the straightforward menu navigation on the 7-inch touchscreen display.

Pavers need to measure asphalt temperature

Quality is a top priority in road construction — that includes not only the optimum composition of the material, but also an optimum process flow during the construction work. One aspect that plays an important role in the entire process chain — from the asphalt plant to compaction – is the temperature of the asphalt. Temperature differences and the paving of asphalt that is too cold lead to road damages, which result in additional costs of up to 46 % due to a shorter lifetime of the road.

The CANopen-based Pave-IR system provides in addition to the established temperature-bar a new way to use a temperature scanner to monitor the temperature during asphalt paving and document it for the entire project. As a result, contractors can optimize their processes and verify the quality of the paving process. The system uses a micro-controller based temperature scanner over the entire paving width of up to 8 m to measure the temperature of the asphalt. The measurement width can be set individually. With up to 31 measurement points, the scanner achieves an accuracy of ±2 °C at typical asphalt temperatures. The temperature profile is displayed in real-time on the display. As a result, the operator can react at any time if irregularities occur. In addition, the profile is stored with the GPS position data and transferred to a USB stick. With the Pave Project Manager software, the user can evaluate and document the data in the office. Alternatively, the data can be sent to a server via GSM, where it can be called up at any time with a web application.

At Bauma 2013, Moba presented its Big Sonic-Ski leveling system dedicated to pavers. It now features four ultrasound sensors. With them, the system can even smooth road waves that occur in regular intervals of 5 m to 7 m. Those cannot be detected when using a smaller number of sensors. Using ultrasound sensors, the subgrade is scanned over an area extending up to 13 m. By calculating an average during the height measurement, a virtual reference level is determined and the screed of the paver controlled accordingly. The leveling system thereby evens out bumps in the subgrade and achieves a verifiably greater smoothness during asphalt paving.

Rollers need to be leveled and need to measure temperatures

The quality and thus longevity of an asphalt road can be improved considerably through homogeneous and high-quality compaction. The MCA-2000 roller system facilitates controlled compaction during asphalt paving. With the recently introduced additional function of wireless data transfer, data can now be exchanged quickly and conveniently between machine and office, eliminating the need to travel from the office to the construction site.

The CANopen-based roller control system uses temperature sensors to measure the asphalt temperature and uses GNSS positioning of the roller to ascertain the number of passes. By means of the combination and visualization of this information on the display, the operator can immediately identify where sufficient compaction has already been performed and where additional passes are still necessary. By means of the temperature display, the system allows compaction to be performed in the optimum temperature spectrum. This prevents the compaction of asphalt that is too cold, which can damage the material and lead to subsequent road damage.

The Kaliningrad motorway "Primorsk Ring" is one of the prestige projects currently under construction within the scope of infrastructure improvements in the Russian exclave. With a total length of approximately 180 km, the ring road will encircle the city of Kaliningrad in a broad arc around the Samland peninsula. ZAO VAD, the construction consortium for this project, and OOO SMD Balt Avtomatika, a dealer of leveling and control systems, have chosen the MCA-2000 control system. "The requirement in this project was to make the compaction more controllable as in the past," said Yuri Dolgilevitch from Balt Avtomatika. "With the MCA-2000 roller control system, the material system can be compacted in a more controlled manner." The compaction information appears directly on the display and the roller operator can use it to compact those areas where the temperature is in the optimum temperature range from 100 °C to 140 °C. "During comparison measurements, the temperature displayed by the system was identical to the temperature that we measured and thereby ▷

Figure 6: Roller in Russia implementing the MCA-2000 control system

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NEW

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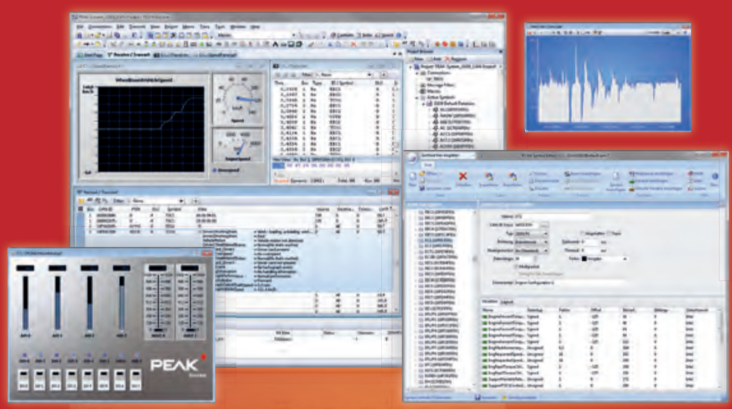

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facilitates a reliable temperature measurement," explained the Russian dealer of leveling and control systems. This prevents asphalt that is either too cold or too hot from being compacted.

In addition to the temperature, the system also records the passes of the roller by means of GNSS positioning and compares target and actual passes. The current status is visualized in real-time on the touch-screen using a color scheme. This way, the roller operator can identify where a sufficient amount of compaction has been performed and which sections still require passes. The recorded data is compiled for a report and read out using a USB memory stick. This allows optimizing the compaction process and leads to fuel reductions of about 20 %. The operators are pleased that Russian is available as a language option.

Matthias Limbach, working with Moba, described in his presentation at the MMC (Mobile Machine Control) conference the future of compaction controlling. "The use of a GNSS receiver is undisputed: It actually builds the basis for most reliable ▷

Alfons Horn (Moba)

"Sooner or later a CANopen profile for asphalt quality will be required."

Alfons Horn, Moba's Vice President of Engineering and Development answered some questions by the CAN Newsletter editors.
He joined the company in 1983. Today, more than 70 engineers belong to his department.

Q Moba has used CAN networks for its products quite early. What was the main reason for that?

A Yes, we started very early using CAN as an interface connection for our products. It was about the same time when CiA was founded. In fact, at that time we considered various possibilities to build up a sensor network, which is more reliable, stable, easy to use and cost efficient at the same time. As soon as we analyzed the CAN protocol in more detail, it was clear "CAN" will be the right choice for the future, with all the functions implemented in hardware like bus arbitration, CRC, Stuff bits and so on. Furthermore CAN was intended to be the future network system for the car industry, and therefore, high production numbers and low cost per node were quite obvious at that time.

Q You are in favor of open communication standards. Are you not afraid that competitors are invited to copy your solutions?

A Not really, because the main product features and the selling points are derived from the product core functionality. Considering a sensor for a road construction machine, the customer is focusing on the product properties and characteristics, like working accuracy, stability over a wide temperature range, robustness in general and in particular features for controlling the construction machine tooling. Nowadays CAN and CANopen networks are the de facto standards on these construction machines. Furthermore, when designing a new machine control system, the main discussion is about the CAN network structure, safety aspects and redundancy and for these points we also have to offer our expertise. So our customers get more than just a sensor or controller.

Q In the beginning Moba was focused on paving machines. In the meantime, you provide solutions for many other mobile machines. What is coming next?

A Right, in the very beginning we learned a lot from paving machines and found out that it's a must to know the machine technology and specific features in detail, in order to develop the right products and being able to constructively support a new system design. Based on this principle, we would like to extend the various machine functionalities for our customers. Next steps are: machine-to-machine communication via radio link, internet connection, safety concepts for critical machine functions. In particular internet connection and Web-based technologies could significantly increase the overall machine functionality.

Q Are you missing dedicated CANopen profiles?

A Over the years, CiA did a really good job in promoting and supporting various CANopen profiles. So there are already a large number of different profiles available, everybody can participate. Considering CAN FD and it's possibilities I'm sure there will be further profiles and updates of profiles required. For the road construction industry there are a lot of ongoing discussions on how to increase road quality. Sooner or later an asphalt quality profile will be required.

Q What is your opinion on the acceptance of the recently introduced CAN FD data-link layer in mobile machines?

A Even today, road construction machines, or more general mobile machines, require (or it would be desirable) higher communication bandwidth for CAN networks, if we consider ECU flashing, diagnostics of complete mobile system, or applications where we have to transfer a lot of user data. For example, in 3D machine control we use embedded Ethernet to transfer the digital terrain model to the main leveling controller, although we would have preferred a CAN-based solution. With the support of 64-byte payloads and higher CAN speed, CAN FD will give us the opportunity to handle these requirements without introducing a total new technology. Overall, using CAN and CAN FD will lead to a more consistent, homogenous and easy to handle network system concept for mobile construction machines.

Modular HMI series

The modular design allows creating machine-specific operating units even with small production quantities. The CAN-connectable HMIs are configurable regarding the display, the buttons, and the joysticks. They are built of up to six modules, which are linked together and to the machine network via plug connections.

The display module is available as a black-and-white display, or as a programmable color display. The programmable version implements Codesys, which is an IEC 61131-3-compatible PLC runtime software. In addition, the module is equipped with three softkey buttons and the encoder, which can optionally be attached to the side of the module, in order to facilitate menu navigation. An additional cover protects the display from damage. The joystick module is available in two versions: one lockable, the other one non-lockable and equipped with a railing. The joystick mechanics and evaluation electronics are contact-free and assembled separately. This functionality allows the joystick to be exchanged within seconds and prevents the ingress of moisture. The button module with up to nine buttons, which can be assigned to any function, offers flexible application in different construction machines. All modules are also available as blanco-modules, which means they are available in a neutral white design and the customer can add his own design-foil. Optionally, customers can integrate up to four of their own operating and display elements, implementing, for example, a key switch. Furthermore, an emergency stop switch with a special protective housing can be attached to the module.

The robust housing and the modules, sealed with potting compound with a special casting technique, protect the electronic components from dust, moisture and vibration. Each module can be controlled separately with CANopen. Due to the square form of the modules, the HMI can be assembled flexibly and applied both vertically and horizontally.

The modular HMI family can be used in different kinds of machines

Figure 7: Displaying the passes in real-time and color

Figure 8: "Compaction of the paved material is one aspect that plays a key part in a successful result," said Ronald Brinks from ZAO VAD compacting the ring road for the 2018 Football World Cup venue in Kaliningrad (Russia)

systems." However, position accuracy is a matter of price. Using filters would reduce costs, but they provide just relative accuracy, meaning that after restarting the roller, there might be an offset in positions.

Most of today's roller controllers measure the surface temperature. Even though this is valuable, other environmental factors influence the asphalt mat, too. Therefore, the core temperature of the asphalt mat is likely to be the more reliable information for the roller operator. "Currently, there is no way to measure the core temperature directly," explained Matthias Limbach, "therefore, an estimation of this temperature is necessary." There are different cooling models, which use the estimated core temperature to predict the remaining time for compaction under optimal conditions.

Roller control systems also use acceleration sensors to measure the stiffness of the underground. "In soil compaction applications, there is a high correlation between the stiffness and density of the underground," reported Matthias Limbach. "However, this correlation is not found in hot mix asphalt." Further research is needed.

In order to improve the compaction, that is avoid over- or under-compaction, a roller-to-roller communication is considered. By means of these vehicle-to-vehicle links position, temperature, and stiffness data can be exchanged. This machine-to-machine communication should also enable the paver to achieve optimal results in estimating the core temperature of the asphalt mat.

Holger Zeltwanger

SI-Unit and scaling management in CANopen

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TKE Engineering, CiA member since 2006, focuses on CAN education and training, engineering, application-specific developments, and import as well as sales. The offered products include CAN PC-interface modules, data-loggers, displays, network infrastructure components, and tools as well as software.

Various kind of inconsistencies have been typical problems in design of distributed control systems. The first solved issue was an automated generation of signal and parameter abstraction from CANopen project avoiding the inconsistent names between application software and communication [1]. The use of meta information of signals and local parameters, such as name, minimum, maximum and default values has already been implemented to avoid the most common inconsistencies [2].

Producers NMT state is used for monitoring the status of signal producer devices [2] and connections between the devices [5]. Name, network and node identifiers, object index and sub-index are included into meta information of remote parameters to avoid inconsistent parameter accesses [2]. A method for management of CANopen emergency error codes has been introduced to fill the main missing feature of CANopen [4].

One of the most significant remaining source of inconsistencies in system designs is, how to apply the SI-Units and scaling used by the sensors, actuators and I/O devices to the application programs. Main challenge during the design is that both SI-SI-Unit and scaling may need to be adjusted during the development and it shall be guaranteed that same values will be used by both producer and consumer devices.

CANopen provides an excellent basis for systematic management of the SI-Unit and scaling information by defining representation of SI-Units with prefixes [6]. Some device profiles already support definition of the signal physical units via object dictionary [11], [13] or fixed unit with adjustable scaling [12], [14]. Support of more detailed scaling than just a prefix varies between the device profiles and implementation, because optional objects may also have an effect on SI-Unit and scaling details.

Though there is not dedicated meta information for SI-Unit and scaling of object dictionary objects, such information can be synthesized from various parameter object values.

The approach cannot cover all signals and parameters, but provides an excellent workaround while better support is included into corresponding CANopen standards.

The most commonly used device profiles are reviewed and basics of CANopen projects are presented first. Then, an example implementation using combined pressure and temperature transmitter is described in more detailed level. After description of the implementation, discussion of the results and notices are presented. The conclusions are set as a last topic.

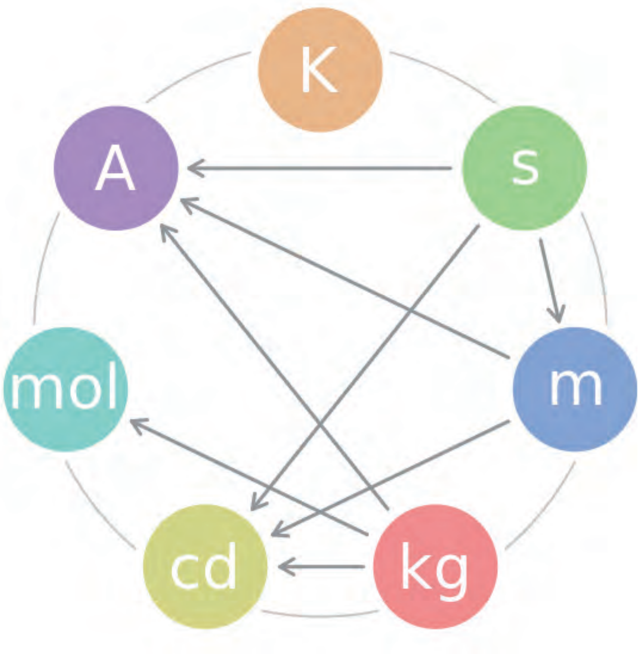

Figure 1: The seven base SI-Units and their interdependencies (clockwise from the top: Kelvin (temperature), second (time), meter (length), kilogram (mass), candela (luminous intensity), mole (amount of substance, and Ampere (electric current)

SI-Units in CANopen device profiles

Only some the most common device profiles are covered by the review of this article. The presented concept also applies for other profiles. The purpose of the review is to briefly summarize the objects, where SI-Unit and scaling information is available. Readers are advised to read the device profile documents for further details.

I/O devices according to CiA 401 can support units only if an optional objects are supported [9].

Unit for analog inputs is located at 6430_h and for analog outputs at 6450_h. However, because of the general purpose nature of I/O devices, there are significant risks for inconsistency. First, sensors and actuators cannot be unambiguously identified over analog signal path. Therefore it cannot be guaranteed that the connected sensor or actuator supports the signal type, for which the I/O device has been configured. Invalid combinations may look working properly over a wider signal value range, which may lead to incorrect behavior or even safety risk. Furthermore, the mentioned objects define the SI-Unit, but no scaling, which may be implemented differently in different devices. Units are typically not used for outputs of joysticks and pedals. Joystick and pedal devices are indicated by higher word of the device type [10].

Transmitters according to CiA 404 are simple to manage. There are a set of objects defining the units and scalingof each channel [11].

SI-Unit with prefix is located at 6131_h and the number of digits supported by the channel at 6132_h. Scaling and offsets are used for calibration of the sensing element. Transmitters has been selected as a proof of concept because of the simple and unambiguous approach along with the common implementations. Transmitters can be mainly identified based on the higher word of device type – pressure and temperature transmitters support only analog inputs.

Encoders are even simpler, because CiA 406 clearly defines how to configure the encoder output signals. Furthermore, rotary and linear encoders have dedicated objects and the detailed encoder type is indicated in the higher word of the device type [12]. Measuring step is given directly as *μ*m for linear encoders. For rotary encoders, measuring step shall be computed from the number of steps per revolution. Measuring step for linear encoders is located at 6005_h and the number of steps per revolution for rotary encoders is located at 6001_h. The unit of speed information is always measuring units per second. Most common parameters, such as preset and CAM thresholds, use the same unit with scaled output signal. If scaling is disabled, default values of the scaling objects can be used instead. Scaling and preset are activated from operating parameters object, which is located at 6000_h.

Hydraulic drives are covered by CiA 408. SI-Unit with prefix may be defined for each set-point and actual value signal [13]. If unit is not defined, internal resolution shall be used as a relative set-point or actual value. Internal resolution is defined in the device profile and it may be either 16 bit (IR) or 32 bit (IR32). For example, set-point for spool position control is located at 6300_h and pressure control at 6380_h. Sub-index one of each object is used for the value itself.

SI-Units and prefixes are given in optional sub-indexes two and three. Same principle applies for actual spool position and actual pressure located at 6301_h ▷

SI-Units

The International System of Units (SI-Units) represents the physical units of the metric system. It is internationally standardized in the ISO/IEC 80000 series of standards. The standard also specifies the International System of Quantities (ISQ). The SI-Units have been nearly globally adopted: Only Liberia, Myanmar, and the United States of America have not adopted SI-Units as their official system of weights and measures.

and 6381_h respectively. Axis control set-points and actual values are included also as pairs, both with optional SI-Units and prefixes. Set-points and actual values are located at 6500_h and 6501_h for velocity control, at 6580_h and 6581_h for force or pressure control and at 6600_h and 6601_h for position control.

Inclinometers follow device profile CiA 410. Main parameter for inclinometers is just a resolution of the output angles at 6000_h [14].

The first potential source for errors is, that if 16-bit output signals are used, maximum resolution cannot be supported for the full 360 degrees measuring range. Main parameters, presets and differential offsets are using same unit with the output signals.

```
[6131sub1]
ParameterName=P_Physical_Unit
ParameterValue=0x004E0000

[6131sub2]
ParameterName=T_Physical_Unit
ParameterValue=0x002D0000

[6132sub1]
ParameterName=P_Decimal_Digits
ParameterValue=3

[6132sub2]
ParameterName=T_Decimal_Digits
ParameterValue=0

[9130sub1]
ParameterName=TestPres
DataType=0x4
AccessType=rwr
PDOMapping=1

[9130sub2]
ParameterName=TestTemp
DataType=0x4
AccessType=rwr
PDOMapping=1
```

Figure 2: Excerpt of an example transmitter DCF with output signal and SI-Unit

CANopen project and DCF files

Each CANopen project consists of a set of DCF files – one for each device [7]. The DCF-files forming a project are listed in an additional project file, nodelist.cpj [2]. System design tools may use their own file formats, but the main contents is always equal and it is easy to convert the proprietary files into standard format before other conversions. It is presented earlier, how calls to external add-on applications for e.g. code header export can be included into EDS and DCF files [1].

Main information source is included into object dictionary description part of DCF files [2]. All defined meta information of objects may be utilized in application programming. Device commissioning section provides target location information, which may be used e.g. in diagnostics [3], [5] and generating unique variable names. Information of device type and identity may be used for determining the type of target device and required format and contents of the export.

Conversion process

Unit synchronization has been included as part of the IEC 61131-3 communication abstraction generation presented earlier [1], [2]. There has been already a reservation for unit information in the presented code examples. The abstraction generation is divided into three parts – CANopen project parse, project analysis and device specific abstraction export.

CANopen project parser just reads project information into memory as efficiently as possible. Parser independent of the analysis and export enables further improvement

```
(* @GLOBAL_VARIABLE_LIST := TEST_MAIN_Vars *)
(* @PATH := '' *)
 VAR_GLOBAL
  :
  (* Volatile variables from D001.DCF at Thu Jul 04 18:34:35 2013 *)
  TestPres  AT %MD256:  DINT := 0;
  TestTemp  AT %MD257:  DINT := 0;
  :
  (* Variable details from D001.DCF at Thu Jul 04 18:34:35 2013 *)
  dTestPres:  dtDINT := (
    ParName := 'TestPres', Unit := 'mbar', DefVal := 0,
    MinVal := 0, MaxVal := 400000, Status := 0);
  dTestTemp:  dtDINT := (
    ParName := 'TestTemp', Unit := 'deg C', DefVal := 0,
    MinVal := 0, MaxVal := 1250, Status := 0);
 END_VAR
(* @OBJECT_END := TEST_MAIN_Vars *)
```

Figure 3: Excerpt of an example signal abstraction with SI-Units

Figure 4: HMIs may convert the SI-Units to national units for convenience, but the CANopen devices must not communicate non SI-Units

to e.g. support XDC files instead of DCFs when format becomes finalized and commonly adopted in the industry. Optionally nodelist.cpj may be replaced with proposed nodelist.graphml [3], if adopted as part of CiA 311 [8] as proposed. Parameter values are defined during the system design, based on the system requirements. Thus, EDS files cannot be used as a source.

Analysis part is source and target format independent, which enables flexible analysis of the project information and synthesis of information. Information synthesis is required, because a lot of information is distributed either in multiple objects of each DCF file or even in multiple DCF files. PDO connections between the devices can be followed based on CAN-IDs. Connections can be expanded into signal level by reading corresponding mapping information. After finding out signal connections, units need to be determined. As described earlier, supported device profile shall be read first. Then the supported units and scaling can read and computed from corresponding objects and added to the meta information of the signals. A simplified excerpt of a source DCF is presented in Figure 2.

The use of independent export enables device specific outputs. It is required because different formats are used by different IEC 61131-3 development environments and because the exact contents of the export requires some target API specific declarations. In the future the variation will be reduced, because PLCopen has defined an XML-based standard information interchange format [15]. The target may be automatically detected based on the values of device type and identity objects. An excerpt of target signal abstraction with full meta information is presented in Figure 3. Scaling is embedded as a part of the unit in the example, because a standardized approach does not exist.

Discussion and conclusion

Internal configuration affects on the units in most of the devices and therefore it is best to retrieve the units and scaling from the system project into abstraction layer of application software. Configuration is stored in standard DCF-files, where it can be accessed in a vendor, tool and device independent way. One interesting topic for future research is, how the device parameterization can be simplified.

The concept may be expanded to cover parameters and other device profiles, too. Main parameters ▷

Prefix multiple codes

01_h: 10^1 = deca (da)
02_h: 10^2 = hecto (h)
03_h: 10^3 = kilo (M)
06_h: 10^6 = mega (M)
09_h: 10^9 = giga (G)
$0C_h$: 10^{12} = tera (T)
$0F_h$: 10^{15} = peta (P)
12_h: 10^{18} = exa (E)

Prefix fraction codes

FF_h: 10^{-1} = deci (d)
FE_h: 10^{-2} = centi (c)
FD_h: 10^{-3} = milli (m)
FA_h: 10^{-6} = micro (μ)
$F7_h$: 10^{-9} = nano (n)
$F4_h$: 10^{-12} = pico (p)
$F1_h$: 10^{-15} = femto (f)
EE_h: 10^{-18} = atto (a)

of CANopen encoders, preset and CAMs are using the same SI-Unit and scaling with the position signal. CANopen transmitters use the same scaling for primary output signal, net output after tare function as well as optional controller and limit functions using input signals. Same defined scaling is used for all signals and parameters in CANopen inclinometers. Drive profiles are the most complex and will need to be analyzed further.

All device profiles support objects using predefined format, from which type definitions may be defined in code header modules. In the future, along with the CiA 311, such information may be included into the XDD and XDC files. Such objects are e.g. polarity, filter enable, output error mode control and transmission event control objects for I/O devices. Transmitters support additionally sensor type, filtering and operational mode controls. Encoders support operational mode control and status in a fixed format. Both supported and pending warnings and alarms are clearly indicated in a predefined format. Hydraulic drives support fixed format objects for various device and program control purposes. Resolution and operating parameters are available in a predefined format for inclinometers.

SI-Unit and scaling information may also be added into system design tools to enable they to include such information into communication databases (DBC) to improve network analyses. Both DBC and many analyzer programs already support signal scaling and physical units. One approach could be standardization of the presentation of signal and parameter meta information – especially scaling – in IEC 61131-3 as co-operation of CiA and PLCopen.

Following the CANopen device profiles and standard storage formats is essential, also to get SI-Unit and scaling management working. Traditional CANopen concepts provide good basis for unit management, without dependencies on system tools, device vendors or types. The approach may be easily improved further. The most essential is to get the XDD/XDC formats finalized and into use because of more complete support of object units and enumeration.

Systematic and automated SI-Unit and scaling management will increase the design process performance further by reducing a need to read written manuals and enter such parameter values manually as a raw values. However, the most significant benefit is an avoidance of system configuration inconsistencies in projects, caused by the human mistakes.

Especially ever increasing functional safety requirements demand the realization of designed safety integrity level in system assembly and service. Systematic information management has a key role, because most of the design information inconsistencies potentially decrease the safety performance of systems.

There are fixed values for units and scaling in the simplest devices and it is wasting of memory to include corresponding constant information in read-only objects.

The information is mostly needed only in design time, one approach could be to introduce a totally new access type – info – for objects, for which the EDS files contain important constant value information for design tools but which are not implemented in the devices. Another approach could be to introduce a new object flag to indicate that an object is for information only and not implemented in the device. Modern systematic and automated design information management requires all possible meta information to be able to provide maximum efficiency. ◀

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Working towards Industry 4.0 with CANopen

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Figure 1: Single-drive roller conveyors and installed Mono-Switch Fieldpower drives; thanks to their internal control logic, the devices can be operated without an overriding control system

MSF Vathauer Antriebstechnik is supplementing its family of fully electronic motor starters and frequency converters for decentralized automation with the Mono-Switch Fieldpower for logistics systems and the p&f Energy Saver Controller for power and free conveyor systems. As drive system partner, MSF Vathauer Antriebstechnik uses the Fieldpower power network system by Weidmüller for its drive solutions.

With both drive systems, MSF Vathauer is promoting the factory of the future, which will organize itself. This concept is known as the fourth industrial revolution, or simply 'Industry 4.0'. MSF-Vathauer Antriebstechnik is already making a contribution in this area, which will enable autonomous decision processes in companies and entire value creation networks to be managed and optimized in close to real time. The company is presenting a drive automation system that can be used, for example, to automate logistics systems and other industrial applications with or without overriding system control and adapt them to changing production processes. The motor management is distributed in a decentralized manner via a power network cable to the machinery line, with all of the motor management components communicating with each other. Fieldpower by Weidmüller is a modular power network system for decentralized automation. The MSF Vathauer drive components are simply plugged into the installed Fieldpower boxes on location, which has the advantage of greatly shortened installation and activation times, as well as the modular design of the production structures. Facility planning is also accelerated with this integrated and flexible drive solution.

Figure 2: Power & free conveyor systems are robust and reliable material flow systems with a high degree of flexibility for the user

Definition

Industry 4.0 represents a complete realignment of industry. Rigid, inflexible manufacturing systems will be transformed into modular, efficient and non-resource intensive smart factories, in which embedded systems will play a key role.

In what are known as 'cyber-physical systems', which form the core of the new philosophy, each work piece has a digital product memory which defines what it is and what should happen with it next – and this is the case throughout the value chain from the first stage of processing through to logistics. The self-organizing factory with its embedded systems is becoming reality.

Figure 3: The Mono-Switch Fieldpower drive based on the Fieldpower box; the device has its own internal control logic and can therefore be operated without an overriding control system; the sensors are connected directly to the motor starter

For logistics systems, MSF Vathauer offers a new product called Mono-Switch Fieldpower Even Thinking. Thanks to its internal control logic (Even Thinking), the decentralized drive system does not require an overriding control system. As soon as a work piece makes contact, it is identified by a sensor attached directly to the motor starter. The signal is then forwarded to the relevant drives, which ensure that the correct procedure is followed. This process is illustrated by the example of a zero-pressure accumulation conveyor system: as soon as the conveyed product reaches its intended destination, a receipt report is issued, which tells the previous conveyor element that the product has arrived and a new one can be sent if required. If the production or logistics flow changes, motor management can be easily and quickly adapted to the new production and conveying process by adding or removing drive units in the power and communication line. This enables both the conveyor units and the communication between the conveyor elements to be flexibly adapted to new production requirements. It's simple: plug and play. The motor starters, which are directly integrated into the conveyor systems, take care of the entire automation process; the only additional requirement is a mini-switching cabinet for the supply and fusing of the mains voltage. The standard sensors used are also connected to the motor starter directly via standard cables. The benefits are self-evident: the use of standard components and the elimination of system control generate considerable cost savings. In addition, the customer has to spend less time on installation. Thanks to the simple assembly of the power distribution system and the efficient installation of all motor connections and sensors, installation times are reduced by up to 50 %. An additional cost-cutting factor is the power network system, which is installed close to the motor directly in the system field.

Power & free (p&f) conveyor systems are robust and reliable material flow systems with a high degree of flexibility for the user. They are particularly suitable for transporting materials under difficult environmental influences, such as dirt and high temperatures. Using the decentralized p&f Energy Saver Controller enables a high degree of flexibility during the planning and automation phase. The controller can be installed at any point close to the actuators in the machine's vicinity, and with p&f conveyor systems at decentralized locations along the belt systems. The system is supplied and controlled via a power and data network line. To this end, a p&f network interface transforms the generic CANopen signals into p&f CANopen signals. The control signals from the CANopen network and the voltage supply are then combined in a single standard cable. The resulting power and data network is distributed via a single cable along the belts to the controllers, thus initiating the conveying process. CANopen cable lengths of 300 meter and more can be used with this system. Single feeders in line and tree structures can also be installed. Users have confirmed that the generated CANopen network runs stably and without disruptions. The controller has several inputs for initiators and an EIA-485 interface, for instance for an RFID antenna.

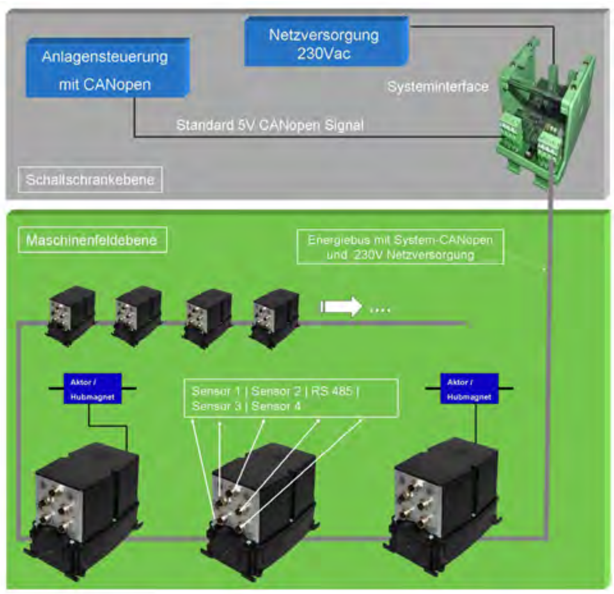

Figure 4: Installation topology of the power and data network in the machinery line

Fieldpower power network system

An integrated drive solution – the Fieldpower box with plugged-in motor starter and frequency converter

Fieldpower is a power network system by Weidmüller that is used as a modular basis for decentralized automation. The system is based on the Fieldpower box and an uncut standard round cable that can be used in cross sections of 2,5, 4 and 6 mm². The box takes care of the supply, bifurcation and distribution of the power. Inside the box are contact units with insulation displacement connectors (IDC technology) and colorful connection points, which guarantee a high degree of accuracy during wiring. MSF Vathauer Antriebstechnik chose the product as a basis for its devices, thus enabling the power and motor controls to be delivered directly to the application site. To do this, the devices are simply plugged into the box on location. Installation and activation times are considerably reduced. In addition, these automation concepts, which combine drive technology and automation, allow the use of very small switching cabinets and a significant reduction in the number of installed cables.

The connection for a manual control system is also integrated. The practical configuration guarantees flexible usage and effortless installation. Power savings at maximum performance are of key importance in modern systems; the system with its integrated power management achieves process-related power savings of at least 30 %.

Conclusion

The realization of Industry 4.0 may appear utopian at first glance, but in fact current technologies are already bringing it to life. MSF Vathauer Antriebstechnik and Weidmüller present the first innovative drive and automation solutions, which will make the factory of the future a reality. ◀

Separating non-safety and safety software functions in ECUs

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Tadano Faun GmbH utilize the ESX-3XL Safety controller with Codesys Safety SIL-2.

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Introduction

In mobile machines often non-safety and safety functions are required. In order to avoid separate ECUs, OEMs demand to use one single ECU for both kinds of tasks. The EN/IEC 61508-3 international specifies technical measures to prevent negative side-effects of software and describes how to reduce the effort for certification of non-safety software modules running in a safety ECU.

The EN/IEC 61508-3 international standard requires that in case of different safety integrity levels, all software parts "shall be treated as belonging to the highest safety integrity level, unless adequate independence between the safety functions of the different safety integrity levels can be shown in the design." This can be achieved either by spatial and temporal domains or by double-checking the independency against violations. Of course, the justification needs to be documented.

Using the Tricore micro-controller

The 32-bit MCU by Infineon provides one core, which is used for the safety and non-safety software. Safety and non-safety software are using the same CPU and the same on-chip memory (ROM and RAM). Merely the micro-controller features a memory protection unit (MPU). The MCU does not provide a complete temporal and spatial separation of its resources. This means, this functionality has to be added by the ECU design.

A watchdog controller and a task system to prioritize the available tasks are needed. These add-ons fulfill the temporal separation requirements. In our ECU design, the spatial separation is ensured through proprietary memory protection mechanism.

Figure 1 shows the software architecture for the C programming application. The green block, denoted as Safety Layer (SL) API, is presenting the memory protection layer. Based on the C application level the safe and non-safe functions are conducted through the SL-API. After the execution there, all functions are passed to the Hardware Abstraction Layer (HAL). Each HAL function has its own SL function. Before executing HAL functions, the additional safety checks and MPU configurations are executed in the SL-API. The described STW task system, which is used by the application code, has the same features as an RTOS (real-time operating system) task system. The task system is fundamentally required for the temporal separation of safe and non-safe code. The linkage of the STW task system with the safety layer is shown in Figure 2.

Global or static functions and data can be stored in three different memory areas with different security levels (system, safety, and non-safety) and each level has different memory access rights. The system level is reserved for internal system functionalities and has access rights to all memory areas and CPU registers. All interrupts will be executed in the system safety level. System functions have read/write access to system, safety and non-safety data. Safety-related data must be protected against access from the non-safe components of the application. Code that will be executed in safety level, usually implements safety-related functionality (for example handling of safety ECU outputs) and must be

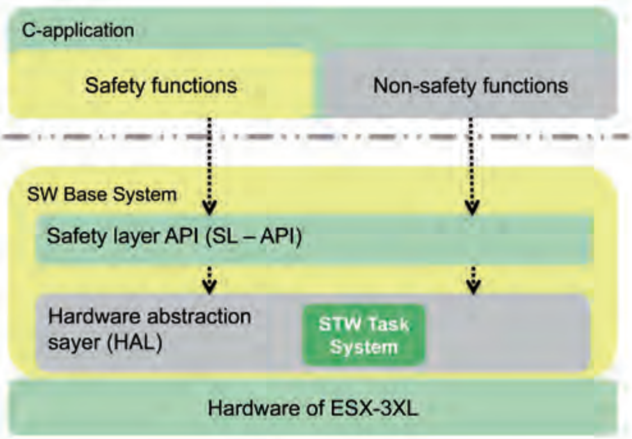

Figure 1: Software architecture

verified and documented according to the required safety standards. This level will have read access to all memory areas and write access to protected and non-safe data. System data cannot be accessed from this level.

The non-safety level has access to application data that is not used for safety-related functionalities. Code executed in this level has no write access to safety and system data. Therefore it can be changed without affecting safety-related functionality.

The task system differs two types of mechanism, safe tasks and non-safe tasks. Managing different code classes and granting write permissions are the key properties. The task system also administrates available memory. Task stack and static data of safety relevant tasks are write-protected; this is achieved by means of the on-chip MPU.

Safety requirements have to be taken into consideration for the configuration of the ECU hardware. For example, an output defined as safe, shall be only accessed by safety functions. The safety layer features the following behavior:

- SL-API is an additional software layer, which is simply placed on top of the HAL;
- SL-API is directly coupled to the STW task system and uses the MPU of the Tricore CPU to refuse writing on global data, if the executed function does not have the required write permission for the task;
- SL-API allows the application to interact between safety and non-safety functionalities.

The SL-API was needed for the Codesys Safety SIL-2 runtime system (RTS) for the ESX-3XL modular Safety controller.

Using Codesys Safety SIL-2

Codesys by 3S is a software platform especially designed to fulfill different requirements of industrial automation projects. The IEC61131-3 ▷

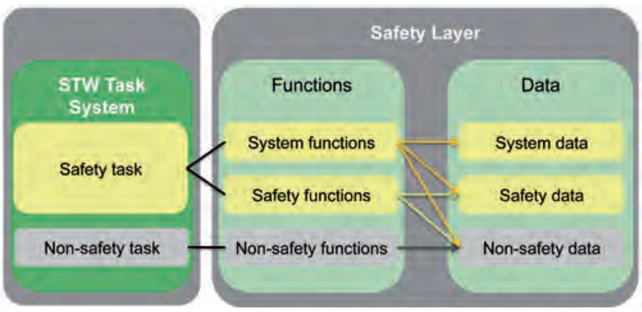

Figure 2: Interaction of memory protection and STW task system

Links

www.3s-software.com

www.infineon.com

www.plcopen.org

www.sensor-technik.de

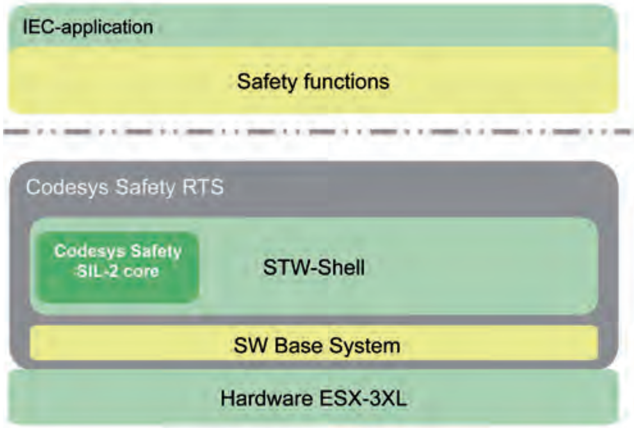

Figure 3: System architecture of the Codesys Safety RTS

development system is the heart of Codesys software approach. It offers integrated, user-friendly solutions to support development tasks. In Codesys several PLC programming languages are available. In accordance to the relevant standards EN 62061 and EN13849, the languages can be divided into two categories:

- LVL (low variability language)
  - Function block diagram (FBD)
  - Ladder diagram (LD)
- FVL (full variability language
  - Instruction list (IL)
  - Sequential function chart (SCF)
  - Structured text (ST)

Codesys Safety SIL-2 is based on Codesys version 3. The system architecture of Codesys RTS is shown in Figure 3. The SW Base System is the lowest software layer in the RTS. Above the SW Base System the STW Shell is placed. The Codesys Safety SIL-2 Core (PLC core) is embedded into the STW Shell. The STW Shell provides the interface between the PLC core, the SW Base System, and the PLC application program (IEC Application). Safety and functional requirements of the SW Base System and the PLC core are considered in the STW Shell. The Codesys RTS specific requirements are all implemented in the STW Shell. The entire PLC application program has to be developed according to the harmonized safety standards.

In accordance with the PLCopen (nonprofit trade organization for IEC 61131) guidelines the safety-related applications can be subdivided into three levels:

- Basic level
- Extended level
- System level

When implementing PLC application software in basic or extended level, only graphic languages (LVL) are allowed including the FBD and LD languages. Non-graphical languages (FVL) are not qualified (for details see EN/IEC 62061 chapter 3.2.49). However, if suitable coding guidelines are applied, almost any programming language can be used for the basic or the extended level. Such coding guidelines have to be approved by safety assessment. If the coding guidelines are approved, certification can take place in accordance with EN/IEC 62061.

In the basic and the extended level the user has to consider linking restrictions, and as an additional requirement only pre-certified modules are allowed. The extended level is usually used for the preparation of pre-certified function libraries. The advantage of both levels is that tests only according to EN/IEC 62061 are required. The system level allows the use of FVL and especially ST languages.

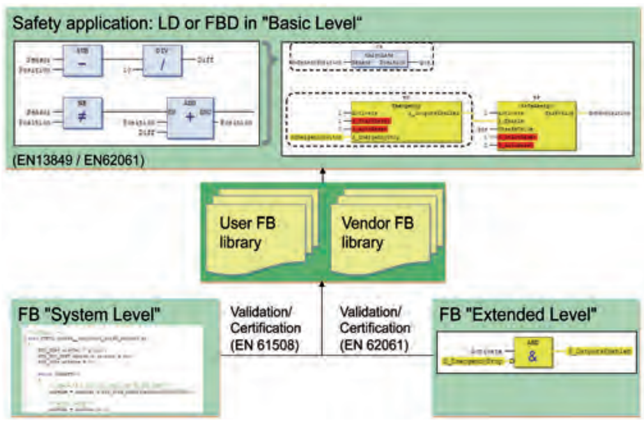

Figure 4: Program structure

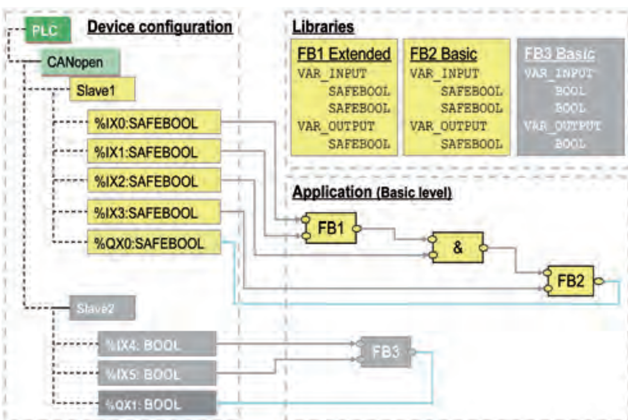

Figure 5: Data flow example

Figure 6: The ESX-3XL modular safety controller implements Codesys Safety SIL-2

If the system level is applied, the EN/IEC 62061 requires that the software must be certified according to EN/IEC 61508.

In Figure 4, the program structure of a safety PLC application program is shown. As mentioned-above, complex libraries can be pre-certified by using the system level or the extended level. After certification, they can be merged and categorized as basic level. This means that only integration tests are required. Another advantage is the reusability of pre-certified libraries. Thereby, the expenses for other application projects can be reduced.

Figure 5 shows a graphical data flow of an IEC application (PLCopen program). The data flow shows the separation between safe and non-safe functions in an easy and comprehensible format.

Codesys offers in addition to the compiler checks, a tool to check the source code based on pre-defined rules. Potential errors can be detected and already removed before the field tests begin. ◀

Summary

Sensor Technik Wiedeman GmbH (STW) has many years of experience in developing safety ECUs. A new mechanism for ESX-3XL ensures temporal and spatial independence of SW functions for different risk ratings. This mechanism can be used in applications, where safety requirements have to be fulfilled. System designers have to focus only on safety software modules during the entire machinery lifecycle.

Non-safety software will not have any influence on safety functions.

Codesys Safety SIL-2 is now available for ESX-3XL customers. An entire IEC-Application has to be designed in accordance with the safety standards. To make it easier for your application to reach certification, pre-certified libraries can be used.

STW offers pre-certified libraries. For on basic-level designed PLC software only integration tests for validation are required.

Kindling with a plan

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Introduction

Mobile machines and units are often used at remote locations. In order for everything to go according to plan regardless, and so that the customer service can react quickly, efficient controls and solutions for remote maintenance must be used. In this industry, they must also be robust and versatile. To achieve this, S&Ü, manufacturer of saw and split machines, counts on products from Wachendorff.

Figure 1: The Ewon router was installed in a small cupboard next to the actual control cabinet; not for technical reasons, but because of the shape of the switchboard; this solution proved to be more economical than a bigger control cabinet

Whoever has seen, maybe during a walk through the woods, the giant machines used to split tree trunks into handy logs, can guess that a lot of power and a sophisticated and robust machinery must be hidden in these machines. One provider of the machines is S&Ü Hydraulik- und Maschinenbau from Marienmünster. For about ten years, the company has been building saw and split machinery. They offer units for stationary use in yards and halls, which are mounted permanently and powered by an electric motor. Beyond that, the company offers mobile solutions, which split the trunks directly at the forest track. Companies that are commissioned by other firms to split wood at changing locations, might use those machines. The machines can either be powered by a diesel motor or by the tractor's PTO.

Nearly all machines by S&Ü, stationary or mobile, have one thing in common: They are equipped with an Ewon router, a remote maintenance module by Wachendorff. "It's a simple game of numbers," explains Christoph Struk, who, as an electrical engineer, is responsible for the supervision/control of the machines. "Depending on the distance, the costs for the remote maintenance module can be redeemed with one single, saved trip." The determining factor for the use of a remote maintenance solution came in 2009, when the company decided to deliver to countries without a local service partner. "We wanted to offer customer service in these countries too – but it had to be affordable and efficient,"

Figure 2: A crane is picking up the trunks, bringing them in the right position

Figure 3: The panel on the right, an operating unit of the Opus series, controls the diesel drive and with the panel on the left, a control panel of the WBG series, the saw and split machine is controlled

Figure 4: The tree trunk is sawed and split into handy logs; the control system calculates the lengths of the logs in such a way that all pieces have the same length and no unusable surplus remains left over

says Christoph Struk. "That's why we looked for a tool that we could use for all units, which had to work equally reliably in stationary machines via LAN as it did in mobile machinery, for example via GSM."

They found their solution at Wachendorff. "They offer different Ewon types, which we can choose from, depending on the particular case of operation.

All of them communicate via the intercalated Talk2M-server, an online service portal, so that we always have the same user interface, no matter via which medium the information is transmitted," explains Christoph Struk.

The possibility for remote maintenance is especially necessary in the first couple of weeks after the delivery. "When someone is standing somewhere in the field with their new machine for the first time, then most of the time questions arise. Sometimes the user doesn't know exactly how to deal with status reports, or some components have to be re-adjusted after the drive and the first couple of hours of operation. In those cases we can have a look at the current user interface of the machine via the Ewon router and we can explain to the customer what reports mean or what they have to adjust for a trouble-free operating state."

But the remote maintenance router is not the only device by Wachendorff that is employed in the units of S&Ü. In mobile units with diesel drives, Opus control panels are used. Because of the necessary compliance with the emission standard control, processes have to be executed according to the CAN protocol. The deployed device of the Opus series is the Opus A3-Standard. The A3 product series offers devices for extreme environmental conditions. Besides a 4,3-inch display, a 32-bit processor with up to 532 MHz and a memory of up to 1 GiB, the appliance features a working temperature of -30 °C to 65 °C and a mechanical capacity of 30 G shock and 5 G vibration. The communication with the control happens via two CAN interfaces. CANopen and SAE J1939 are supported. The latter is used for the visualization and control of the motor data. Furthermore, the possibility to develop a proprietary protocol also exists. Flexibility and versatility is given through the option of programming. Three different ways are open to the user: The first and easiest is the projection with the Wachendorff Projektor. Without in-depth programming skills, the users can help themselves from a pool of pre-made objects, e.g. bar charts, to create a graphical user interface. That's what S&Ü do. The cooperation between Wachendorff and BU Power System, the German distributor for Perkins engines, led to the employment of the Opus A3 in this application. Together, those two companies developed a motor management system with the Wachendorff Projektor. Beyond that, the devices can be programmed via the Codesys version 3.0 programming environment supporting IEC 61131-3 languages. The interfaces of the operator panels are integrated in the Codesys environment as libraries. Last but not least, the Linux operating system of the A3 family offers the option of developing applications under C/C++. This is the alternative that offers the biggest freedom during the development.

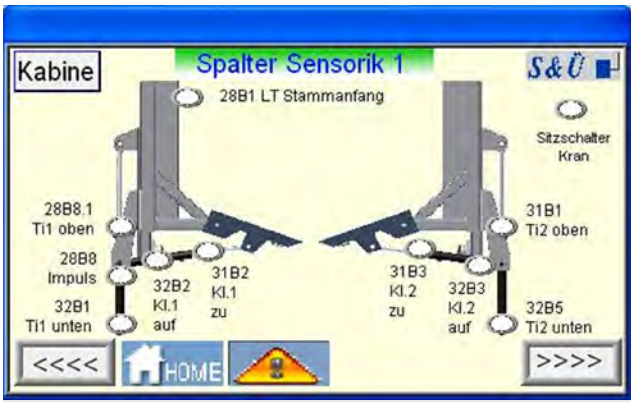

Figure 5: Christop Struk himself has realized the rogramming and the visualization of the operating panel; the projection happened via the included software EasyBuilder

To combine all processes in one control panel would be completely uneconomical," explains Christoph Struk.

On the one hand there are the two different worlds of mobile and industrial application, e.g. CAN and Profinet, which can't be connected easily. On the other hand, S&Ü counts on a modular concept in all their machines, so that the customer only has to buy and pay for those elements that they really need. "Only in mobile units with diesel drive the second panel is really needed."

Christoph Struk is enamored of the devices by Wachendorff, especially their robustness and variability, but also of the costumer service. It is important to always have the same contact person, because "especially for the remote maintenance, the control devices and the remote maintenance solutions have to work together perfectly. Because we are working with a single manufacturer, we prevent interface problems from the beginning."

Ewon routers don't need a gateway in order to directly access the control devices and they depict exactly what the user somewhere in Europe is seeing right now, even from a distance, i.e. on Christoph Struk's display in Marienmünster. Communication in the other direction also works flawlessly. "I can change settings from here, and I can even reprogram the PLC, if that should become necessary," he reports. That way, the service stays economical and efficient at the same time. "Troubleshooting can happen considerably faster than if we had to send someone on a trip." ◀

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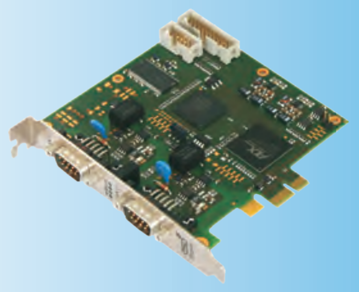

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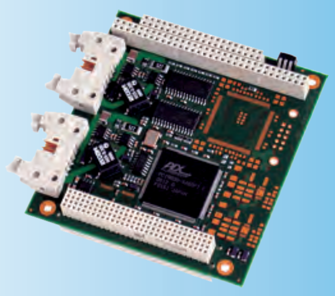

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