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Position of influence

THE IDEA THAT THE COCKPIT IS A POWERFUL PURCHASING MOTIVATION HAS SPREAD TO LIFT-TRUCK CABS. THE LATEST CANBUS DEVELOPMENTS WILL ONLY REINFORCE THAT TREND

LEFT: **Intuitive armrest assembly using fingertip controls for lift-truck applications**

BELOW: **Multifunction grip and joystick armrest controls customised for lift-truck applications**

What was the primary factor that influenced your decision to purchase your car? Was it the power of the engine? The low fuel consumption? Its looks? Most probably all of these and a few more, but there is one factor that should not be underestimated: the car's interior.

How do the cockpit instruments look? How do the controls feel? The cockpit is an important part of the OEM's face to the customer. It is often possible to tell – just by looking at a car's cockpit – the manufacturer's identity, even if the logo on the steering wheel is not visible.

This idea has also become more important for industrial vehicles in recent years, and the trend is expected to continue.

Forklift functionality today

Today's advanced operator control interfaces in lift-truck applications typically use CANbus to communicate with the vehicle control system; the CANopen protocol being the most common communication standard in materials handling. There are different profiles describing the 'frame' for the information to be transferred between the control interface and the machine. There are already generic profiles for joysticks (CiA DS401, Annex A) and application-specific profiles describing the vehicle function represented by a specific interface device.

The operator's workspace features common devices such as joysticks, foot pedals, switch panels, indicator lights, displays, regulators and much more, all of which have to fulfil different functions, depending on the type of vehicle. In a forklift truck, for example, a dual-axis joystick could control the functions of the fork and mast (up/down/tilt in/out). Compare this with a mobile crane, where there are typically two main dual-axis joysticks: a left-hand joystick that controls boom in/out and left/right rotation of the slewing platform, and a right-hand joystick that controls hoist up/down and boom angle up/down. These functions may be controlled alternatively by other devices as single-axis joysticks or fingertip controls.

This is mainly dependent upon the type of vehicle, the ergonomic situation, and the OEM's philosophy of how best to meet the operator's expectations and to make his daily work as smooth, intuitive and productive as possible. The joysticks are usually equipped with handles that include several additional functions. There are various versions of those multifunctional grips. Their shape is adapted to the application for which they are used, and they may include push buttons or rocker-switches, proportional rollers, or FNR switches.

Concentration of functions

In traditional cockpit designs, the arrangement of the vehicle control elements was dictated mainly by available space and existing standard components. Now the trend is to concentrate these functions within reach of the driver's hand, positioned to involve the least movement of his or her body or arm. Ideally, the controls would be integrated into an armrest, providing good support to the arm during operation of the vehicle functions.

These armrests enable the building of functional clusters, giving a good overview of the vehicle functions and status. It is an art, based on experience and a development-partnership between supplier and OEM, that enables these concepts to be realised in a successful manner.

To reach the ergonomic approach as described above, a trade-off between the usage of standard off-the-shelf products and customer- or application-specific components has to be made. DeltaTech Controls is specialised in the integration of standardised base components into a customer-specific application. This is accomplished by the addition of application-specific elements to the standard bases, and implementing them into the armrest design. From a marketing perspective, this gives the vehicle a face to the customer, unique to the particular vehicle OEM.

If the OEM is planning the same control philosophy as a platform over a range of vehicles, a modular approach should be considered to make the investment in such an armrest design more effective and

Fendt modular armrest assembly for large (top) and small (above) agricultural tractor applications

to introduce a brand identity to the OEM's vehicle fleet. This is backed up by a user-friendly interface, always providing the same functional logic to the driver.

One pertinent example can be found in the area of agricultural equipment. Fendt, a premium German brand, created a family of multifunctional armrests for its full range of machines, ranging from a highly integrated design for its biggest tractors to a simpler version for its smallest tractors. The family of armrests uses a modular approach on the controls, so the small machine armrests are based on the same modules that are on the big machines. Each of these armrests is available in different configurations, supporting different machine variants.

The result is a strong, premium brand identity for Fendt; with easy-to-use, intuitive controls for its customers, regardless of which model they are using.

CANbus enables the easy implementation of this modular approach into the vehicle – the mechanical and electrical interface between the armrest and the vehicle is always the CANbus. The data from all the elements of the armrest, which may vary according to the equipped options, is collected by an integrated ECU and transmitted via the CANbus. It is therefore only a question of the application software, which can be easily adapted to distinguish between the variants. No change in mechanics or wiring are necessary to achieve this.

Tomorrow's approaches

Future operator controls could lift this trend to the next level. For vehicles with a steering wheel, such as a forklift truck, it might be useful to replace the steering wheel with a control element in the left armrest. This could lead to a more ergonomic way of steering and a clear view to the front side.

An example where this approach was followed successfully is the Caterpillar M-Series motor grader. For decades, operating this machine type has been one of the industry's most difficult jobs, involving up to 15 hydraulic levers and a steering wheel. Not any more: just two ergonomic, armrest-mounted joysticks now drive, steer and control blade functions on M-Series graders equipped with electrohydraulic control systems. Studies performed by Caterpillar show much improved performance and very high operator acceptance.

An additional, very useful, feature is the introduction of active force feedback. This can help drivers keep track with the motion controlled by their activity in a closed-loop control, especially in applications needing fine adjustment of the controlled equipment, or where the equipment will change its state of operation, for example, such as a hydraulic valve that would change from the proportional operational state into the float mode).

An example of such force feedback in bulk materials handling is the new 950K/980K Caterpillar K-Series wheeled loader, where the steering function is realised by a left-hand joystick, with active force feedback mounted to the armrest. In other materials handling applications, the force feedback could be used to adjust the actuation force according to the load, to give the driver a 'feeling' for the load he is handling. It would be quite possible to set up a proportional haptic control via CANbus to realise this feature.

The use of the haptic channel could also be used to alert the driver in the event of critical situations, or even block movements that are 'not allowed' in a special situation. If the load, picked up with the extended boom of a machine, is so high that the machine could tilt if the boom is lowered, the driver could be warned through a pulsing pattern induced in the driver's handle.

Safety considerations

The architecture of control devices is now being directly influenced by the increasing level of machine operation depending on electronic operator's control equipment along with the functional safety requirements. The architecture and performance must fit with the functional safety requirements defined by the OEM.

RIGHT: **Custom armrest module combining fingertip and joystick controls for construction vehicle applications**

As a result, these requirements are leading to different levels of redundancy, from diagnostic features up to hot standby redundancy to continue the operation of the safety-related functionality in the event of a failure, such as vehicle steering functions). CANbus communication between the vehicle and the operator control devices needs a CANbus protocol that will also fulfil the necessary safety requirements such as transmission failure protection, reliable data transmission, real-time data, and distribution of diagnostic and status information.

Although some of these requirements are already part of the CANbus datalink layer, others need to be part of the upper protocol layers. The CiA 304 CANopen standard (EN50325-4) defines how to implement safety-relevant data transfers in a CANopen network by use of SRDOs (safety-relevant data objects). This method enables safety-relevant data communication up to SIL3. The safety-relevant data transfer can be added 'on top' of a normal CANopen network, running non-safety-relevant communication tasks. So no special infrastructure is therefore needed to set up the safety-relevant communication.

Flexible cockpits

CANbus is the gateway to flexible cockpits featuring complex and automated vehicle functions through the combination of data from various sources. So the CANbus as the vehicle communication bus is becoming increasingly important as it has to carry much larger data volumes than in the past. Therefore, the trend is leading to higher data rates to increase the data capacity.

Consequently, the requirements for wiring and EMI protection are rising and becoming more complex because CANbus networks, including subnetworks, have to be redesigned.

Alternatives are on the horizon: the Flexray bus for example. This has been designed for automotive applications, is providing higher data rates and is already prepared for safety architectures. This may be a bit of future music for the next few years – at least for use in industrial vehicles. But we will listen to the music! **ALT**

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LEFT: **Fully integrated operator controls within arm's reach enable optimised cab design for the OEM**