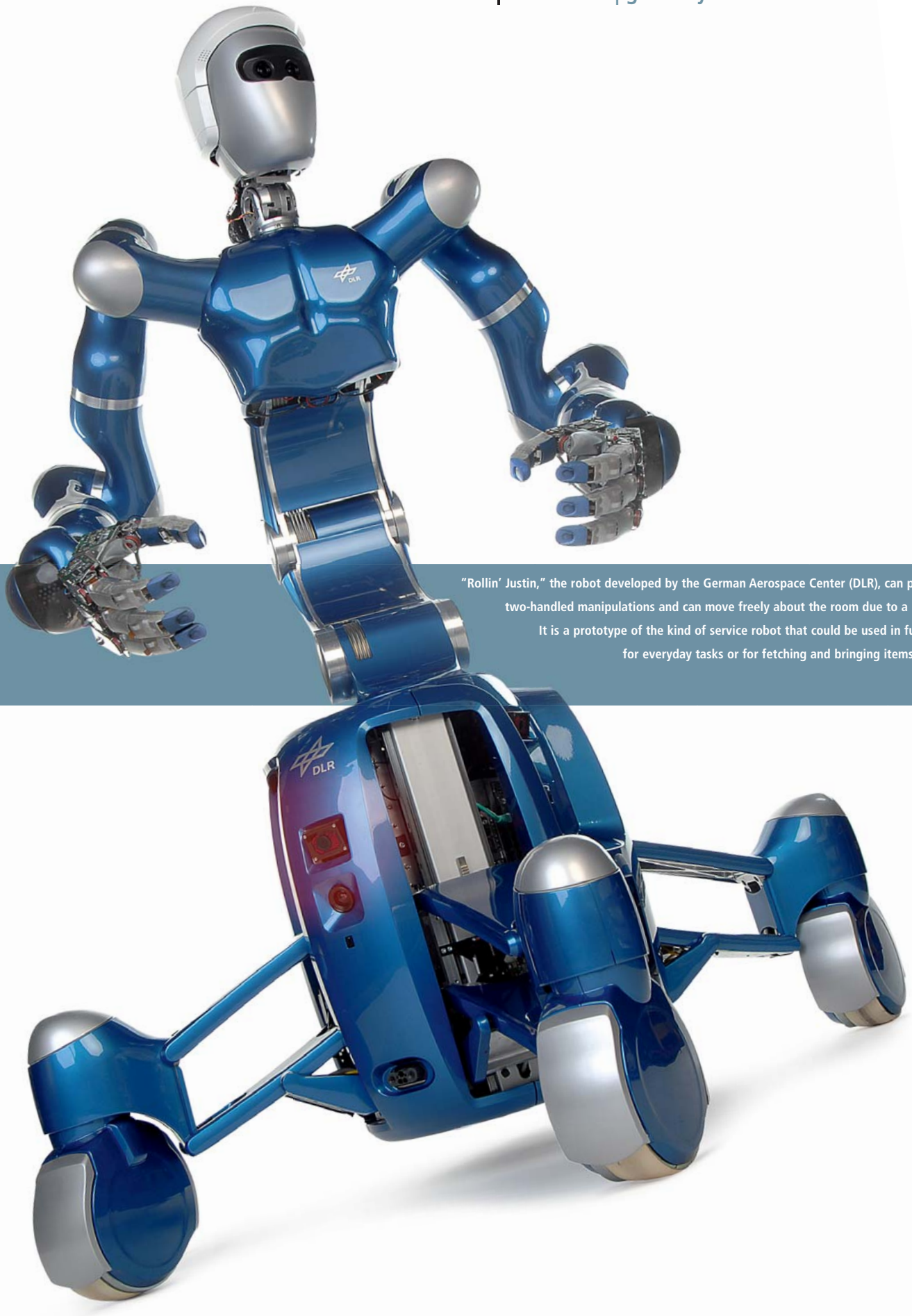


"Rollin' Justin," the robot developed by the German Aerospace Center (DLR), can perform complex, two-handled manipulations and can move freely about the room due to a mobile platform. It is a prototype of the kind of service robot that could be used in future households for everyday tasks or for fetching and bringing items in a warehouse.

EtherCAT as a uniform communication platform for mobile service robots of the future

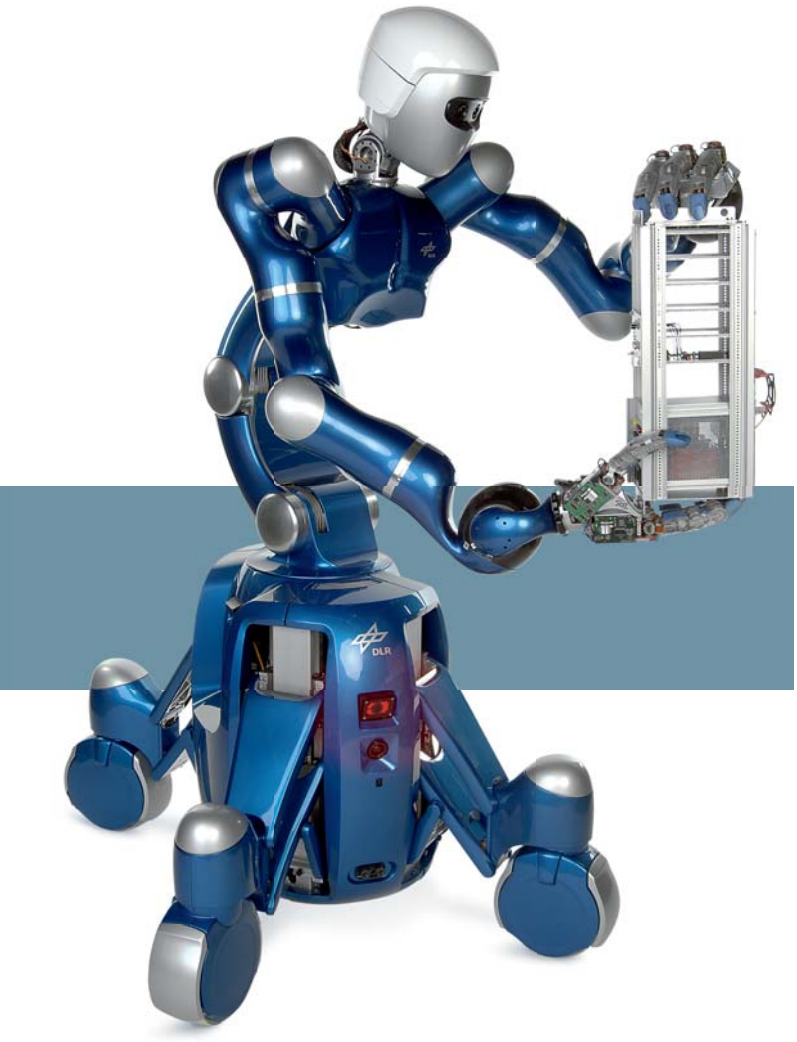
"Rollin' Justin" robot drags crates and serves tea

The development of humanoid robots has made significant progress in recent years. "Rollin' Justin," developed by the German Aerospace Center (DLR), can perform complex, two-handed manipulations and can move freely about rooms due to a mobile platform. "Rollin' Justin" is a prototype of the kind of service robot that could be used in future households for everyday tasks or for fetching and bringing items in a warehouse. The fast communication necessary for the movement sequences takes place via EtherCAT, while the Beckhoff TwinCAT PLC automation software takes care of control.

"Rollin' Justin" is the result of over 10 years of research at the German Aerospace Center (DLR) in Weßling. The lightweight robot arms and hands developed by the DLR like those used, for example, for maintenance work in space are the basis for the development of a mobile robot in the shape of a human being. The robot's grasping range can be extended by means of the torso and the mobile platform with four separately retractable and extendable legs mounted on roller bearings, analogous to the trunk and leg movements with which a human extends his radius of action. The upper body alone has 43 degrees of freedom equipped with torque sensors; a total of 51 joints make "Rollin' Justin" a highly mobile automaton that can manipulate and interact sensitively. The robot skillfully manipulates objects with two hands and is able, for example, to carry a crate or prepare instant tea. The latter requires complex coordination of movements. The robot must grasp the tea caddy with one hand, in order to unscrew it with the other hand. Then it fills instant tea granulates into a drinking glass, whereby it meters the quantity exactly by tapping the plastic container lightly with a finger. Finally, it pours water into the glass from a decanter.

Torque sensors permit sensitive manipulations

A looser or tighter coordination of arms and hands is required, depending upon the kind of manipulation: for instance the grasping of large objects, such as a crate, requires the tight coordination of both arms. The opening of a screw cap, on the other hand, requires the synchronous movement of hand and arm. However, "Rollin' Justin" also interacts with humans and its environment: if it knocks against something or touches an object or a person, it notices that and aborts the movement, or it asks whether it should continue working. Via an integrated speech recognition system, the robot knows approx. 100 words and can combine them into meaningful phrases. Apart from that, it uses built-in cameras to collect information from its environment and can identify objects in order to be able to orientate itself accordingly. The equipment with torque sensors, e.g. in the fingers, ensures that "Rollin' Justin" can also grasp sensitive objects, such as strawberries, without crushing them. The robot's footprint is variable: when performing highly dynamic actions or actions requiring a particularly long reach, "Rollin' Justin" stabilizes its upper body



by enlarging its footprint; to do this it extends its legs. If it needs to traverse a narrow passage, it retracts the legs again.

"We have found the ideal communication system in EtherCAT."

"The utilization of proven hardware components from third-party suppliers allowed us to save time-consuming development work when building 'Rollin' Justin'," explains Klaus Kunze from the Institute of Robotics and Mechatronics, Robot Systems Department, DLR. "Our selection was primarily determined by the desired functions and the necessity of a compact design."

However, this presented the DLR with the challenge of having to integrate the most diverse real-time protocols. The components used communicate via CAN, CANopen, SERCOS, SpaceWire and EtherCAT. These different fieldbuses are mapped via the Beckhoff TwinCAT PLC automation software on an EtherCAT slave. All data necessary for control are available synchronously via a single real-time capable bus protocol in a Matlab®/Simulink® environment on the separate real-time computer that controls the entire platform, including the upper body. "We needed a solution that, on the one hand, would support the communication technology of the components, while on the other not limiting their performance capability, such as the 1 ms cycle time of the SERCOS drives and the short dead times. We have found the ideal communication system in EtherCAT," says Klaus Kunze. The force sensors and the servo drives are connected via standard EtherCAT Terminals from Beckhoff. Beckhoff SSI terminals acquire the data from the position sensors of the robot legs. The SERCOS drives of the arms and the torso are connected via Beckhoff SERCOS master PCI plug-in cards. "Rollin' Justin" represents an optimal experimentation platform for the DLR to test robust control strategies and intelligent action planning for the realization of complex, two-handed manipulation tasks. The employment of the mobile service robot as a crate-dragging or tea-pouring household aide, for the time being, remains a dream of the future.

German Aerospace Center (DLR) **www.dlr.de/en**
EtherCAT **www.beckhoff.com/EtherCAT**