

ANYbotics' ANYmal C robot is a multi-module machine

Rugged four-legged robot with three brains

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ANYbotics provides solutions for robot applications with the most advanced mobility and autonomy requirements in challenging terrains. The massive embedded computing performance for the key tasks – situational awareness, motion control and mission fulfillment – is delivered by three COM Express Computer-on-Modules from congatec.

Due to the advancements in computer-based intelligence and sensor technology, previously stationary robots unaware of their environment are now evolving into smart autonomous mobile robots. This will not only help to relieve humans of potentially dangerous tasks but also to optimize repetitive tasks in real life environments from an economic point of view. Such robots can autonomously fulfill many jobs that previously required human labor and significantly extend the list of feasible tasks.

With such a perspective, it is not surprising that robot applications are a booming market. The overall global smart robot market is expected to grow with a CAGR of 23%ⁱ. Yet growth varies depending on the specific subsegment of the robot market. The autonomous delivery robots market, for example, is expected to register a CAGR of over 49.5% during the next 5 yearsⁱⁱ, while the agricultural robots market is projected to grow at a CAGR of 22.8% in the same period.ⁱⁱⁱ The global civilian autonomous mobile robots market including Unmanned Aerial Vehicles (UAV), Unmanned Ground Vehicles (UGV), and Unmanned Maritime Vehicles (UMV) has already matured and is thus expected to grow somewhat slower but still at a quite attractive rate of 15.9%^{iv} from 2019 to 2025. End users for such robots can be found in markets such as energy, process, logistics, transportation, manufacturing in collaborative environments, agriculture and mining, and many more. With its four-legged ANYmal C robot for most advanced mobility and autonomy requirements in challenging terrains, ANYbotics is one of the developers that targets these markets.



The ANYmal C from ANYbotics is a rugged robot that's designed to operate in the same environments as humans. That includes demanding and rugged terrains like off-shore wind parks, oil rigs, mines, and industrial facilities with many obstacles in the pathway.

What distinguishes the ANYmal C autonomous mobile robot from other smart robots is that it performs tasks with a high degree of autonomy in dynamic human environments, not just in highly defined settings such as automated warehouses or factory production cells. The robot reacts to moving or unexpected obstacles as well as to changing environmental conditions (lighting, rain, snow, etc.). Furthermore, it adopts a problem-solving behavior without external guidance or a simple stop to avoid casualties. Instead, autonomous mobile robots have to plan an alternative optimal route to the designated target location and successfully fulfill their mission.

In order to safely and reliably navigate through industrial plants, Autonomous Robotic Systems (ARS) need a wide range of sensors to collect and interpret equipment and environmental data. The ultimate goal is that these ARS fulfill complex tasks just like skilled human workers by leveraging the most advanced mobility and autonomy in challenging terrains such as large-scale industrial plants and construction sites. This is the only way for them to relieve their human co-workers from exposure to potentially hazardous environments and to optimize the precision and reliability of data acquisition.

To obtain comprehensive situational awareness data, ARS need to be packed with various perception sensors that enable a safe operation. This simultaneous localization and mapping (SLAM) must work even in complex and dynamic environments. In its ANYmal C robot, ANYbotics uses a wide range of sensors for navigation and path planning. For obstacle detection and terrain information, the ARS is equipped with stereoscopic optical cameras on all sides to provide a 360-degree field of vision with depth information. A sophisticated light detection and ranging (LIDAR) system provides additional environmental data for navigating in a range of up to 100 meters. For teleoperation as well as a teach-in operation mode for dedicated pathways, ANYmal C is equipped with two wide-angle

cameras at the front and rear to provide the operator with a clear view. For outdoor operation, ANYmal C can additionally be equipped with a receiver for global navigation satellite systems like GPS.

But situational awareness for localization and mapping is only one part of the task to get the autonomous four-legged robot moving. Another highly important function is real-time control of the advanced locomotor system that enables omnidirectional movement and allows ANYmal C to overcome up to 25 cm high steps, climb industrial stairs up to 45°, and crawl into spaces tighter than 50 cm.

Besides navigation and movement tasks, ANYmal C also needs to fulfill its mission, and for that purpose it can be freely configured with a sensor payload of up to 10 kg and act autonomously for 2 to 3 hours. The first application-specific design of ANYmal C is optimized for inspection tasks on in- and outdoor industrial plants and other demanding environments. For this, the robot is equipped with a pan-tilt inspection unit comprised of an optical zoom camera, to read measurements from analog gauges and meters and check valves. This is accompanied by a thermal camera, to check machinery and other equipment for unwanted excess heat or thermal anomalies. For gas leakage detection, ANYmal C is equipped with gas sensors, while an ultrasonic microphone for acoustic inspection helps identify machine anomalies at an early stage.

In order to execute all three tasks in parallel with the highest reliability and at full performance, ANYbotics utilizes a modular design that is based on two Intel i7 hexa-core and one Intel i7 dual-core processors with virtualization to further separate the different subtasks on single cores. These processors provide the computing power for the advanced motion control, the real-time mapping and autonomous navigation, and the sophisticated on-board customer applications. This flexible design makes it possible to balance the price and performance of each task, and serves as a basis for any future performance upgrades. All features are enclosed in a user-friendly, ruggedized, and fully water- and dustproof IP67 design. This groundbreaking design also qualifies the ANYmal C for many other tasks, including search and rescue (SAR), security controls, rescue after earth quakes, or simply parcel delivery.

For the design-in of the computing power, ANYbotics leveraged COM Express Computer-on-Modules from congatec. Computer-on-Modules enjoy great popularity for such embedded system designs due to providing ready-to-use, easy to integrate and standardized platforms that include all necessary drivers and firmware. These modules combine all key building blocks such as CPU, RAM, high-speed

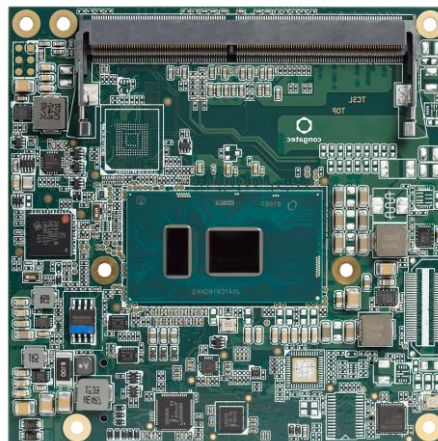
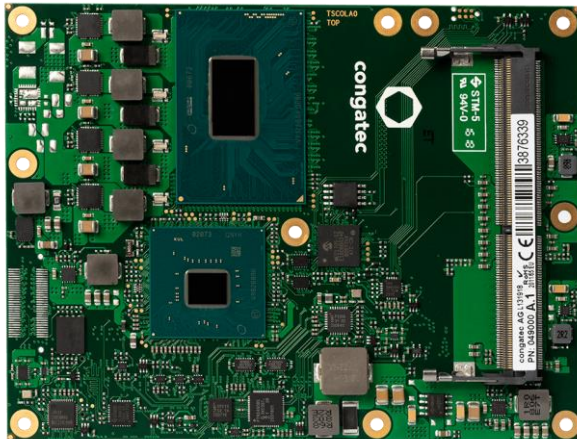
interfaces and often also the graphics unit in a single and validated package. Another advantage is the fact that Computer-on-Modules of the same form factor and standard are scalable, both across processor generations and manufacturers. This gives OEMs full flexibility when scaling and upgrading their solutions with the latest processor technology even after several years. The customer can concentrate all time and resources on designing the carrier board and making sure that all functions and interfaces exactly fit the application without having to take care of the complex processor design-in.

Although standardized COM Express modules are easily interchangeable, the services and quality provided by module vendors can differ significantly. OEMs should look for the optimum total cost of ownership (TCO). Besides the module price itself, there are many other aspects that play a role in this. Firstly, design quality should be checked to ensure that the module offers high thermal, mechanical and electrical resistance. Reliable embedded vendors can provide extensive test documentation to prove a compliant design. Secondly, the modules should come with a comprehensive board support package for all required hardware-near software to simplify OS and software integration. The long-term availability of individual modules is another key factor to reduce the TCO in the long term. Last but not least, the design service offered by the embedded vendor is an important factor. Even though Computer-on-Modules are application-ready components and all the above features are part of the offering, the design and development requires close cooperation between vendor and OEM. This is where specialized distributors and technology partners come into play, providing comprehensive and individual design-in service and technical support in order to help OEMs to bring their solution to market as quickly as possible. The Swiss company [Fabrimex Systems](#) is an authorized sales partner of congatec, both looking back at 7 years of successful cooperation. [Fabrimex Systems](#) offers all congatec products adding their technical expertise and providing additional components, engineering services and customized system level products. And in this respect, ANYbotics gave [Fabrimex Systems](#) and congatec full marks as “the cooperation was excellent, reliable and a lot of fun”. The customer appreciated the local support and service provided by [Fabrimex Systems](#) and the congatec product portfolio including comprehensive software tools, technical documentation and a broad line card offering a 10-15 year product lifecycle with a consistent upgrade path for Computer-on-Modules and single board computers for future designs and compatible upgrades.

Images



Besides its extensive sensor array with stereoscopic cameras for a 360-degree field of vision, LIDAR for environment mapping can carry a 10 kg payload of additional sensors for inspection.



ANYbotics uses three congatec Computer-on-Modules in each robot with two different processor types: Intel® Core™ i7 hexa core and low power dual core ULT processors. The workload is consolidated using dedicated processor cores for mapping, path planning and real-time motion control. In addition to this, a third segment is reserved for individual customer applications.

Development Concepts in Comparison

 COM & Carrier Designs	 Full Custom Designs
 One supercomponent	 Complex BOM
 Open standard	 Proprietary processor implementation
 Application ready BSPs	 Complex implementation of hardware-related software
 Comprehensive design-in support	 Limited support options
 Large ecosystem	 No community
 Efficient re-use of existing building blocks	 Wheel reinvented every time
 Long term availability	 Complex lifecycle management
 High design security	 Greater risk of design errors
 Low development costs	 High NRE costs
 Short time-to-market	 Long development cycles
 High scalability	 Each variant a new product
 Easy upgrades	 Always a new design
 Ideal for small to medium series	 More complex than COM & carrier fusion
 COM & carrier fusion for large series	

Compared to full-custom designs, Computer-on-Modules offer many advantages for autonomous mobile robots that require compact and rugged embedded computing components.

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About ANYbotics

ANYbotics was founded in 2016 as a spin-off from ETH Zurich (Switzerland) to lead the way in developing mobile robotics for industrial applications. Their autonomous legged robots solve customer problems in challenging environments so far only accessible to humans. ANYbotics consists of a team of 45 employees and has successfully tested their legged robot ANYmal in various applications such as the world's first deployment on an offshore plant in the North Sea. To learn more on ANYbotics, please visit <https://www.anybotics.com>

About Fabrimex Systems

For over 30 years, Fabrimex Systems is a leading Swiss company with experienced specialists in the field of Embedded Computing, Industrial PC Systems, Panel-PCs and Displays, Machine-Vision- and Deep-Learning-Software as well as customized hard- and software. Fabrimex Systems has been a total solution provider - so all your projects can be timely realized with a competent partner at your side. Our highly motivated team consists of experienced specialists who are continuously trained on leading edge technology. In addition, we do have access to a large network of partners from all over the world and keep a close contact to technical/scientific institutes and universities. This also allows our customers to get access to future technical developments and trends. After all, the decisions of today are shaping the products of tomorrow. With many years of project management and consulting expertise, we support and guide our customers in making the right decisions for their success.

About congatec

congatec is a rapidly growing technology company focusing on embedded computing products. The high-performance computer modules are used in a wide range of applications and devices in industrial automation, medical technology, transportation, telecommunications and many other verticals. congatec is the global market leader in the Computer-on-Module segment with an excellent customer base from start-ups to international blue chip companies. Founded in 2004 and headquartered in Deggendorf, Germany, the company reached sales of 126 million US dollars in 2019. More information is available on our website at www.congatec.com or via [LinkedIn](#), [Twitter](#) and [YouTube](#).

ⁱ <https://www.businesswire.com/news/home/20200414006063/en/Global-Smart-Robot-Market-Expected-Grow-CAGR>

ⁱⁱ https://www.marketwatch.com/press-release/the-autonomous-delivery-robots-market-is-expected-to-register-a-cagr-of-over-495-during-the-forecast-period-2020---2025-2020-03-03?mod=mw_quote_news

ⁱⁱⁱ <https://www.marketsandmarkets.com/PressReleases/agricultural-robot.asp>

^{iv} <https://www.marketwatch.com/press-release/global-autonomous-mobile-robots-market-2020-cagr-status-future-demand-growth-factor-analysis-top-key-players-regions-and-industry-size-and-forecast-to-2025-2020-04-14>