

# **Final Report on MODU78 Experiment Booster Program ETH Zurich**

## **1. Short Description of the overall status**

In 2016 the ETH Spinoff company ANYbotics was founded with the goal to commercialize outcomes of the ECHORD++ MODUL experiment, both Series Elastic Actuators (SEAs) and quadruped robots. In the meantime, the company sold over 100 separate ANYdrive SEA TRL7 prototypes (excluding the ones used in the quadruped robot ANYmal) and over a dozen quadruped robots to beta customers, however with a number of disclaimers such as no qualification and no guarantees. The TRL8 version of ANYdrive is currently in production, after a number of optimizations, redesigns, and tests were successfully completed during 2018 by ETH and ANYbotics.

## **2. Status before the beginning of the experiment booster program**

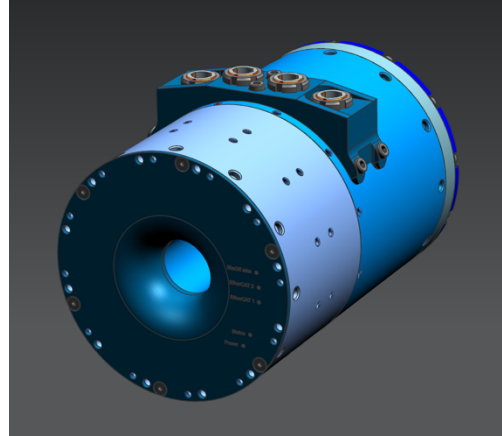
The TRL7 version of ANYdrive resulting from the ECHORD++ MODUL project was available end of 2017 and had been sold as prototypes, both as a separate product and as a component in the autonomous robot platform ANYmal. However, systematic lifetime tests were still missing and the cost was still very high. Certification had not been addressed yet.

## **3. Achievements during the experiment booster program**

During 2018, lifetime tests were conducted which clearly showed that the fastening of the elastic element in the SEA was not strong enough to withstand more than around 100'000 load cycles. This required a redesign. At the same time, a cost reduction study was performed with an external engineering house to identify cost reduction potentials. The commercial motor was replaced by a cheaper and stronger inhouse design and for the gearbox less costly alternatives were identified and tested. This resulted in an overall cost reduction of at least 40% (probably close to 50%, still to be verified). At the same time, the nominal and max torque was doubled, and the redesigned fastening of the elastic element was tested to withstand more than 1 million load cycles. Product documentation was completed, a new website was created by ANYbotics (<https://www.anybotics.com/anydrive-robotic-actuator/>) and the CE marking certification was prepared. As a result, the redesigned ANYdrive is now prepared to be sold as a commercial product with twice the torque specifications from before at the same speed and for a price approximately 40% below the prototype price. The commercial product is now being produced in a zero series and will again be tested extensively during the coming months, including preparation for the necessary certification. The product will finally be ready for customer deliveries towards end of 2019.

## **4. How the experiment booster program helped us with the exploitation of results**

The experiment booster program MODU78 helped us to develop the necessary steps from TRL7 to TRL8 together with ANYbotics. The good results achieved were made possible through the combination of knowhow from ETH and from the spinoff company. The results of the original MODUL project and of the experiment booster program resulted in a robust and well tested ANYdrive: a completely integrated compact robotic joint incorporating motor, gear, elastic element, position encoders, and all necessary motor electronics and controls – everything arranged around a hollow shaft and built into a compact IP 67 aluminum housing.



*ANYdrive versions before and after the ECHORD++ MODU78 project*

## **5. General outcome, conclusion, gains from the program**

The experiment booster program helped us to proceed with the ANYdrive product from a TRL7 to the TRL8 level. It allowed us to finance the efforts at ETH that were needed to make that step together with the ETH spinoff company ANYbotics. The main goals of the booster project were achieved, the product is now basically ready for commercialization. The redesign and testing efforts took somewhat longer than anticipated, this is why commercial sales of the redesigned version have not yet started.