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Maximum vertical integration: Isar Aerospace develops and tests almost every part and component of its Spectrum rocket in-house. (Pictured here: an early prototype rocket motor, nine of which are used in the first stage.)



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PC-based control and EtherCAT in aerospace technology

Rocket technology on the test bench

Isar Aerospace in Ottobrunn has made a name for itself as a real game changer in European space travel. Founded in 2018, the company is opening up low Earth orbits for commercial applications with payloads of up to 1,000 kg thanks to its Spectrum launch vehicle. There's no doubt about it that every last component is put through its paces on a space mission. This is where PC-based control and EtherCAT Terminals make an invaluable contribution, from the development and quality control of virtually all rocket components through to the launch operations at the launch pad.

Based in the German town of Ottobrunn, just outside of Munich, Isar Aerospace develops and builds launch vehicles that can be used to place one or more satellites with a total weight of up to 1,000 kg into low Earth orbits.

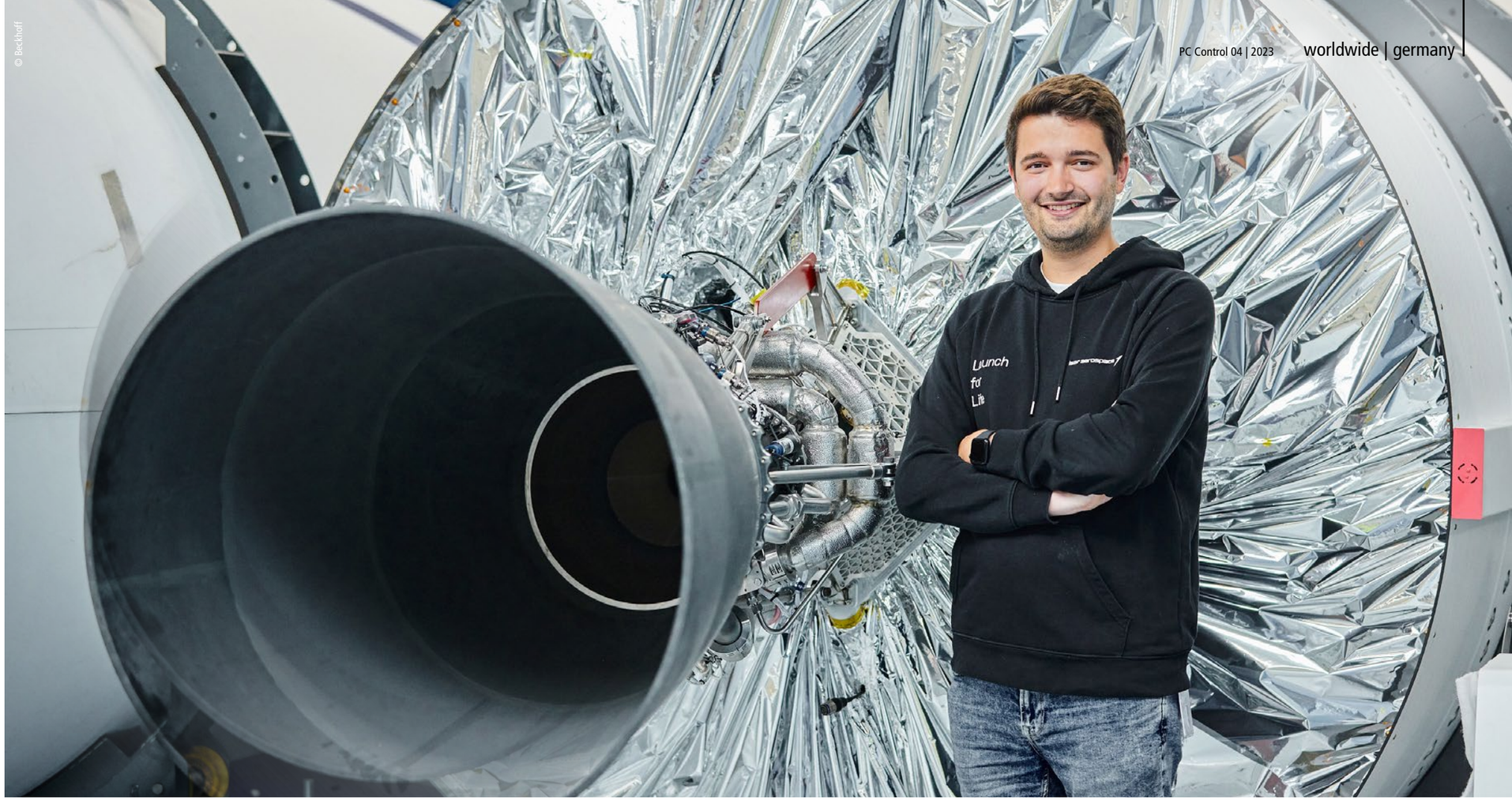
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It's unsurprising that Isar Aerospace would be less than impressed with the typical three or four rocket launches per year when it has its sights set on 20 to 30 economical flights into low Earth orbits. Around 350 employees develop the necessary technologies and systems almost entirely in-house, from the design and optimization of the individual rocket components through their industrial production and testing, to the final assembly of the rockets and launch pads.

Despite the relatively small size of the launch vehicle, it easier to transport, flexible, and specifically designed to deploy small satellites into the Earth's orbit in an incredibly timely and cost-effective manner. A typical communications satellite weighs between 100 and 200 kg, although much lighter variants have been in development for quite some time. Once in orbit, several of these satellites form 'constellations' and serve to provide the communications infrastructure, among other uses. The Isar Aerospace Spectrum can transport several of these satellites, which significantly reduces costs.

Rocket production with industrial methods

Given the sheer volume of rocket launches, it is clear that production processes have to shift closer toward industrial series production. This is why Isar Aerospace takes a different approach to the design and production of launch vehicles compared to other suppliers: Many of its components, such as the combustion chambers for the rocket engines, are produced much faster using modern 3D processes than with conventional methods. This allows the company to achieve cost-effective rocket production and correspondingly economical launch costs per kilogram of payload. An equally essential part of development and production are the comprehensive quality controls and functional tests. "We test virtually every rocket component on our various test benches, almost all of which we developed ourselves," explains Philipp Lüning, Lead Engineer Control Systems at Isar Aerospace. This is because enormous forces act on the rocket and its components during launch and its flight into orbit. The aerodynamic load of the rocket reaches its peak at a point known as Max Q. Another load peak occurs when the rocket stages are cut off. "We



simulate these loads in production on test benches using hydraulic units," notes Philipp Lüning. The electronics (including power supply and batteries), avionics, and the valves of the rocket engines are again tested under the most realistic space conditions possible in special thermal vacuum chambers – i.e., in a complete vacuum at extremely low temperatures. The fuel and oxygen tanks are not released unless they first pass special compressive strength and leak tests. Virtually no component or part is bolted to a rocket that has not gone through comprehensively testing first.

Large and medium-sized test benches comprising several hundred EtherCAT Terminals can be found at the company headquarters in Ottobrunn and at the rocket test bench in Esrange, northern Sweden. There are also another 20 or so test benches in Ottobrunn, some of which are mobile. "We chose Beckhoff because they support all the signal types we need, including hazardous areas and safety," enthuses the automation expert. This flexibility and modularity was important and represented a decisive factor alongside the excellent value for money of the control technology.

The test benches often have to process a large number of different signals, sometimes at high sampling rates, while the control system has to process sophisticated switching sequences. Typical automation tasks include the control of rocket engine ignition sequences or the automatic control of test facilities to maintain the required test conditions. The wide range of terminal variants and the synchronized acquisition of all control and measurement signals via EtherCAT help with setting up and operating the test benches. The automation expert adds, "This is incredibly important for us, as the fact that there is only one system for control and measurement technology means we do not have to waste any time synchronizing the data."

The control and monitoring cabinets for the Isar Aerospace launch pad in Esrange, northern Sweden, – with EtherCAT, TwinSAFE and numerous ELX Terminals – are also being designed, assembled, and extensively tested in Munich.



Modular test benches in hardware and software

Isar Aerospace has built its own data acquisition system with TwinCAT and EtherCAT, which the automation experts can use to automate the test sequences. "With other control concepts, it would have been much more difficult, if not impossible, to reconcile all of this," notes Philipp Lüning. What's more, as all data is available in a single system, it can be easily displayed and archived in the visualization. Philipp Lüning estimates that he and his team now use around 150 different EtherCAT Terminals: In addition to EtherCAT Terminals from the EL series, which offer a perfectly adequate level of accuracy for most measurements, they are increasingly also using measurement terminals from the ELM series for high-resolution strain gauge measurement strips and vibration measurements, as well as many other products from the Beckhoff range.

Nevertheless, Isar Aerospace has some very special requirements that even the extensive Beckhoff range cannot meet. Philipp Lüning solved this problem by finding a supplier whose measurement technology equipment is available with an EtherCAT interface: "Using distributed clocks, we were able to synchronize these few channels without any problems and map the data synchronously into our TwinCAT-based measurement and test system."

The core of each test bench is a TwinCAT framework that runs on every part of the plant. This generic PLC code is sufficient to control the test bench and record all data. The template is controlled and configured via the company's own user interfaces (GUIs), which not only offer all control functions, but also enable real-time charting, data recording, and the programming of additional process sequences, such as special controllers, step chains, and state machines.

The metrological effort at Isar Aerospace is enormous. Accordingly, the concentration of analog EtherCAT Terminals and precision measurement terminals of the ELM series at the test benches is high.



Philipp Lüning, Lead Engineer Control Systems at Isar Aerospace, in front of the prototype of the second rocket stage: "We owe a lot to Beckhoff, because Beckhoff technology has allowed us to created robust, state-of-the-art test benches that can be adapted to our needs in no time."

Access to all the parameters and signals of a rocket helps with seamless quality assurance from production, through functional testing of individual components and assemblies, to the finished rocket on the launch pad. "Without PC-based control, it definitely would not have been so easy for us to achieve communication and synchronization between avionics and controls," Philipp Lüning is convinced.

More information:
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