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Custom linear motion solution drives hydro research project

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When a project to model hydro-morphological processes as part of a river restoration research project required the smooth motion of a gantry across a scaled sediment bed, the designers turned to Thomson Industries, working with automation expert König Lineartechnik.

As part of its initiative to restore the natural functions of anthropogenic impaired rivers, the Federal Office for the Environment FOEN, Switzerland, has contracted with the University of Stuttgart Institute for Modelling Hydraulic and Environmental Systems to run a physical model experiment to gain insights into hydro-morphological processes. In the model, a pair of belt-driven linear units move a gantry of sensors across a 20-metre-long bed of scaled sediments to measure hydro-morphological changes for varying hydrological and geometrical conditions.

The need for the sediment study dates back to more than a century ago when humans started to settle at rivers, and a large share of the population was involved in agricultural processes. At that time, river modifications were implemented to prevent floods and increase arable land. Throughout the decades, larger and larger dams were built to store water and produce electricity.

Today, however, as environmental scientists know more about river ecosystems, they have found that measures such as riverbank fixations, damming and river straightening do not always protect from flooding, but also disrupt natural habitats and leave a monotonous pattern of rivers. Hoping to reverse the damage, the Swiss federal government policy aims at restoring river ecosystems and their natural functions. Understanding the behaviour of sediment transport and river morphology is hence critical to this objective.

Sediment plays a crucial role in shaping the river's physical structures and hence the ecology of a river. It contributes to the formation of various river habitats but may also influence flooding. Sediment and associated nutrients also impact water quality and aquatic life and connects different downstream and upstream regions.

"Bringing rivers back to their natural state requires sufficient sediments, and our role is to help determine just how much sediment is necessary for given hydrological and geometrical boundary conditions. This is challenging because we are dealing with a very dynamic system, with ongoing changes of the riverbed such as erosion, deposition and bank formation," said Dr Stefan Haun, who heads the hydraulic laboratory at the Institute.

To model the dynamics of the riverbed, Haun and his team augmented their own experience in modelling hydraulic and environmental systems with reviews of available literature on hydro-morphological systems and visiting other projects. They concluded that they would need a large-scale experiment that would enable investigations of the riverbed before, during and after flooding it with water.

The model in their laboratory was 20.4 m long and 4.5 m wide. To observe changes in the bed and to monitor the water levels with a high spatial resolution, the team mounted 14 high-precision ultrasonic sensors for point measurements and one laser scanner with a measurement resolution of 2 to 3 mm for larger spatial areas on a gantry that spanned the width of the bed. Two linear units are connected via a cardan shaft and propelled synchronously by a stepper motor to carry the imaging structure across the simulated riverbed.

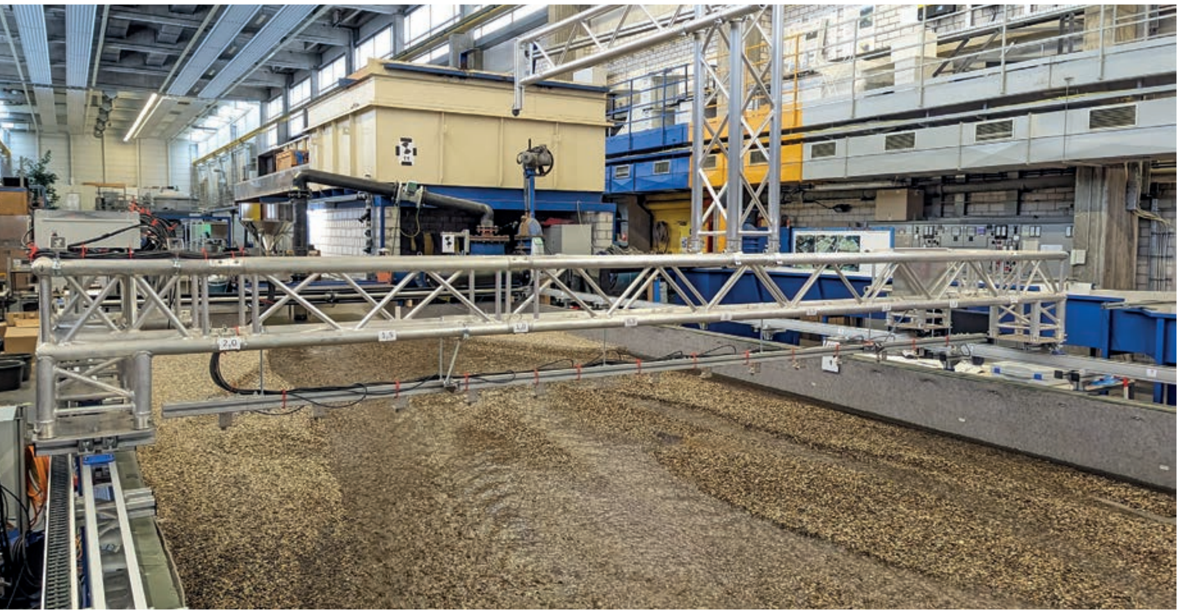
The gantry would not have to move extremely fast but would require smooth, uninterrupted motion. This meant that each guide unit, which was delivered in two pieces, had to get end-to-end joint-mounted to a single, backlash-free unit, which would then provide the smooth, uninterrupted movement needed. But there was one problem: no motion control vendor offered a linear unit that met the 20m length requirement.

"It was a coincidence that we had seen a label for Thomson's distributor König Lineartechnik on some of the other linear units used in the laboratory of the Federal Waterways Engineering and Research Institute (BAW) in Karlsruhe, Germany," said laboratory electrical engineer Steffen Hägele. "When we contacted managing director Heinz König, we found that there would not be a standard product that long, but that he would investigate with the Thomson engineering department the possibility of building a custom linear unit for this project.

"Because this would have been a large purchase for us, we set out to get additional bids in line with university policies. However, we could only find one other manufacturer that would even produce such a long linear unit, but at a price that was far outside our budget for this product."

Heinz König added: "Due to the long length required, the Movopart MG07B belt-driven linear unit from Thomson was the right option to choose. Though being a challenge, we achieved a safe and cost-effective transport from the manufacturing facility in Sweden to Germany and assembled backlash-free, end-to-end mounted units on site."

The final selection was a very long version of the Thomson Movopart MG-B slide-guided belt-driven linear unit, which handles light loads at medium application speeds with low friction. The 20.4m units flank the right and left of the test riverbed to guide sensors.



Manually starting the system sets the gantry in motion along the riverbed length. The ultrasonic sensors bounce sound waves off the surface to give insight into the water levels. After rinsing the water, a second scan is initiated, which provides data on the riverbed. By using these datasets, the research team can evaluate water depths and bed level changes by comparing data sets from previous days.

Completing the digital image of the dynamic state, however, requires a higher spatial resolution of the riverbed, which the researchers get by using just the laser scanner. The laser scanner provides not only a point but works like a camera, providing a high-resolution digital image of the entire scanned area. This gives the researchers the data points they need to triangulate the surface changes digitally. The result is a high-resolution model of the whole surface with some twenty million data points in which the team can analyse and compare many morphological details, including variations in volume for certain parts of the model, bank erosion or sediment deposits.

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