Viennese Innovation

Viennese rotorcraft technology research and development has had an outsized contribution to the international community.

By Ian Frain

Earliest Developments

Austria has been involved in the rotorcraft industry for nearly 100 years. Vienna-born Bruno Nagler began wind tunnel experiments on early helicopter design in 1926.

In 1928, while studying at the Technische Universität Wien (TU Wien, "Technical University of Vienna"), Raoul Hafner came up with a design for a single-main-rotor helicopter without a tail rotor that instead used large adjustable vertical surfaces in the rotor downwash for anti-torque. With Nagler, the two built the R.I Revoplane the following year. Overweight and lacking sufficient power, the aircraft was rebuilt in 1931 as the R.II Revoplane, and achieved tethered hops off the ground.

Nagler, Hafner and the aircraft then moved to the UK, where Hafner later developed the AR.III Gyroplane, the first rotorcraft to successfully employ cyclic pitch, using a "spider" swashplate for cyclic and collective pitch control. The restored Hafner R.II Revoplane is now in the collection of The Helicopter Museum in Weston-super-Mare in southwestern England, where it is the world's oldest surviving helicopter.

Hafner's company eventually became the Helicopter Division of Bristol Aeroplane Company, which later became part of Westland Helicopters, where he was the longtime Technical Director for Research. The Hafner-designed Bristol Sycamore first flew in 1947 and was the first British-designed helicopter to enter production, be granted a civilian Certificate of Airworthiness, or serve with the Royal Air Force. Fittingly, the last flying Sycamore is based in Salzburg with the Flying Bulls.

Meanwhile, Nagler continued work in the UK and in Austria. By the end of World War II, he had constructed seven different rotorcraft. In addition to his work with Hafner, he was involved in a program that led to the development of a feathering control version for autogyros. In Austria during the War, he created ultralight helicopters, including the "backpack" portable Nagler-Rolz NR 54 V2, which is in the collection of the Smithsonian Institution.

In Wiener Neustadt, about 25 miles (40 km) south of Vienna, Friedrich von Doblhoff led the Wiener Neustädter Flugzeugwerke (WNF) team that developed the Wn 342, the world's first helicopter to use tipjets to drive the rotor, making its first flight in 1943. After the War, Doblhoff led tipjet and other reaction-rotor-helicopter developments at McDonnell in the US, while fellow Viennese developer August Stepan led tipjet development at Fairey (including the Rotodyne), before emigrating to Germany to become Head of Design and Testing at MBB (now Airbus Helicopters Deutschland), where he contributed to the design of the Bo 105. Theodore Laufer and Paul H.L. Morain went to SNCASO (another Airbus legacy company) in France and supported development of the cold jet reaction-rotor Ariel, Farfadet and Djinn, the world's only successful reaction-rotor rotorcraft.

Blades Over the Alps

After World War II, Austria officially declared neutrality in 1955 and formed a new Federal Army, the Bundesheer. Over the years, the Bundesheer has flown many different rotorcraft, beginning with the Bell 47. This was followed by the Westland WS-55 (based on the Sikorsky S-55), the Aérospatiale Alouette II, then the Agusta-Bell AB 204, the Aérospatiale Alouette III, the heavy-lift Sikorsky S-65Ö (based on the CH-53D), the Agusta-Bell AB 212 and AB 206, and the Bell OH-58C Kiowa.

Today, the central European nation still maintains 21 Alouette IIIs, 23 AB-212s and 10 Kiowas, according to Flight International's "World Air Forces 2022," and has been flying the S-70A Black Hawk since 2002.

In November 2020, the first three Austrian Black Hawks were upgraded by Ace Aeronautics from Guntersville, Alabama. Ace Aeronautics designs and manufactures its ACE DECK VL60 flight deck, which is fitted onto the new Austrian "Ace Hawks." The rest of the 12 S-70s in the fleet are now being similarly modified with the ACE DECK.

An Austrian Bundesheer AgustaBell AB212 and a Sikorsky S-70 at Airpower 2019 in Styria, Austria. (Author photo)

The world's oldest surviving helicopter, the Hafner R.II Revoplane, dates back to 1928, when Raoul Hafner first put onto paper his ideas for a helicopter at TU Wien. (Courtesy of The Helicopter Museum)

A Bundesheer Alouette III rescue hoist demonstration at Airpower 2019. (Author photo)

Austria also leads the way in high-altitude mountain flying, with the Bundesheer running a course that is also open to the UK Joint Helicopter Command, the US Army Europe and Africa (USAREUR-AF) and Italian aircrews. In September 2020, the Bundesheer selected the Leonardo AW169M to replace their legacy Alouette III fleet, with the purchase of 18 airframes, the first of which will be delivered this fall.

The Austrian aerospace industry is well represented by companies serving the helicopter community, such as Braunau-based Air Ambulance Technology GmbH, which designs and manufactures VIP and emergency medical service (EMS) interiors and equipment. On the opposite side of the country in Wiener Neustadt, airborne surveillance experts Airborne Technologies GmbH fits helicopters for the police role.

Two Centuries of Academica

On the academic side, Austria's contribution to aerospace research and development within the rotary-wing industry comes largely from TU Wien, especially in the area of innovative transmissions for aviation. It was in June 2016 that TU Wien held its first Vertical Lift Day for rotorcraft professionals to discuss the future of the helicopter. The areas covered included air transport systems, helicopter emergency service (HEMS), and drivetrain technologies.

TU Wien has been a place of higher learning in one form or another for more than two centuries. In 1815, the Imperial and Royal Polytechnic Institute of Vienna was established. It was also during this time that military and technical colleges began to be established in Austria and across Europe. The Habsburg Empire wished to emulate and compete with other countries, such as England, which at the time was leading the Industrial Revolution. In France, the newly established École Polytechnique in Paris gave the Austrians the model for the creation of an institution in Vienna. In 1872, the school was officially converted into a Technical University, and academic freedom was re-introduced into academic life. In the 20th century, the departments survived the two World Wars, plus post War re-structuring of courses and degree awards. In 2004, the Technische Universität Wien was granted full legal independence, along with all other academic institutions in the country. Since then, the number of academic departments has increased from five to eight.

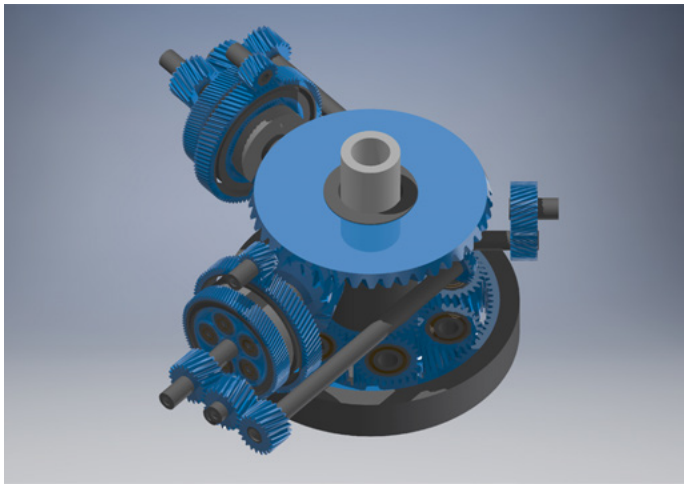
Innovative Transmission Research and Development

The advent of advanced helicopters and tiltrotor to push faster and higher presents a new set of challenges with mechanical drivetrain technology. With these issues in mind, a research unit was established in 2008 under Prof. Michael Weigand called Transmissions for Aviation, part of the Institute of Engineering Design and Product Development at TU Wien. The aim is to identify new methods of designing and assessing mechanical drives. Another goal is developing innovative mechanical drivetrain solutions for novel rotorcraft and engines. TU Wien offers special lectures about transmissions for aviation; the laboratory fully complies with the European Union Aviation Safety Agency (EASA) CS-27/29 requirements (learn more at **www.ikp.tuwien.ac.at/mel**).

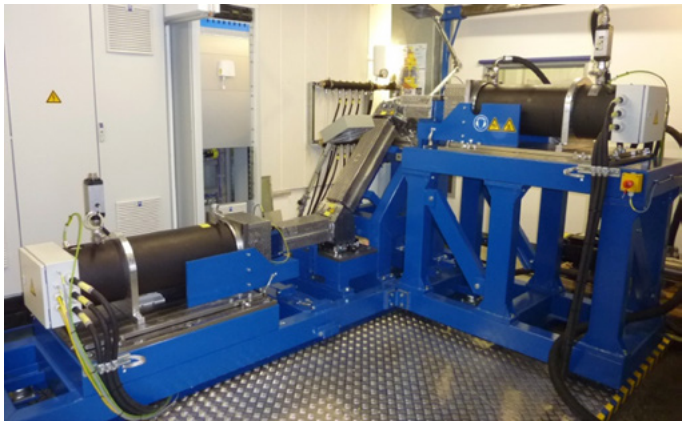
The international expertise with which Transmissions for Aviation can draw and/or partner include EASA, the Research Association for Drive Technology (FVA), and the International Forum for Aviation Research (IFAR); TU Wien leads the Vertical Lift Working Group discussions with research organizations from 16 nations on how new vertical lift concepts can contribute to new transport systems.

Through the Austrian Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology (Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, BMK), the Transmissions for Aviation department is the country's representative in the Advisory Council for Aviation Research in Europe (ACARE). The university is also a member of the Austrian

TU Wien Prof. Michael Weigand (right) and Zoerkler Gears project manager Ralph Germin with a Bo 105 gearbox. (TU Wien)



Design of a drivetrain with a compound split for a helicopter in a main and tail rotor configuration. (TU Wien)



The universal test stand for helicopter drivetrains at TU Wien. (TU Wien)

Aeronautics Industries Group (Interessensgemeinschaft der Österreichischen Luftfahrtzulieferindustrie), the German Aerospace Society (Deutsche Gesellschaft für Luft- und Raumfahrt, DGLR, and the American Gear Manufacturers Association (AGMA). TU Wien is the only university and the only European representative on the AGMA Aerospace Gearing Committee and actively contributed to the AGMA standard 911-B21, "Design Guidelines for Aerospace Gear Systems," released late last year.

TU Wien is also an Educational Member of the Vertical Flight Society, and Weigand is a member of the VFS Propulsion Technical Committee (and is currently the only European member).

Driven Concepts

Improving traditional gearboxes and drivetrain safety is a critical area for the development of future helicopter platforms, as well as reducing fuel consumption and noise emissions. Some of the work carried out includes innovations for variable-speed drivetrains that dynamically improve the rotor speed in flight. One area of research is the friction, wear, lubrication and design of bearings, especially as far as lubrication loss is concerned. The helicopter gearbox is a complex tribological system and, despite the high standard of components within, there is an area of unpredictable behavior if lubrication is no longer available. State-of-the-art Transport Category rotorcraft are expected to continue to fly for at least 30 minutes after the loss of oil, as now specified by the US Federal Aviation Administration (FAA) Part 29 and the EASA CS-29.

The TU Wien test laboratories conduct mechanical tests and evaluations, along with metallurgical investigations. Sometimes the university also works with TÜV Austria, the leading testing, inspection and certification agency in the country. The test facilities of TU Wien are also suitable for verification runs that are required according to certification specifications. Under this, all manufacturing and development work complies with both EASA and FAA requirements. The school also collaborates with the Climatic Wind Tunnel in Vienna, the largest climate wind tunnel in the world capable of testing aircraft with running engines.

One of a number of successful projects to come out of the Transmissions for Aviation effort was done with Zoerkler Gears GmbH for the development of the complete drivetrain for the Russian Helicopters JSC Kamov Ka-62. The Ka-62 is a new medium helicopter powered by twin Turbomeca Ardiden 3G engines; it was derived from the military Ka-60 Kasatka (Killer Whale). The Ka-62 has a shrouded anti-torque tail fan built into the vertical fin — similar in design to the Airbus Helicopters Fenestron — and the helicopter development benefitted from the special test equipment that TU Wien developed for Zoerkler.

Gearing Up

In November 2021, at the first EUROPEAN ROTORS safety conference and trade show in Cologne, Germany (see "Inaugural EUROPEAN ROTORS Reunites Vertical Flight Community," *Vertiflite*, Jan/Feb 2022), TU Wien presented highlights of their helicopter research and the exciting development of new gears. This included a brand-new type of transmission for changing between the different gear ratios of

two coupled gear sets, which does not need another coupling, but allows for the continuous variation of the engine and rotor gear ratio.

This innovative new concept opens up many other opportunities. Although some upgrades and improvements will have to be made to existing rotors and gears in order to take full advantage of the new transmission, this will lead to increased performance, greater energy efficiency, a quieter and greener flight, and an overall increase in safety.

This year, TU Wein will be exhibitors at the Farnborough Airshow in the UK in July, and Weigand will again be part of the VFS technical presentations at EUROPEAN ROTORS in Cologne, Germany, in November.

Another area where TU Wien is leading the way is in tribology, the science of friction and mechanical wear. The wear and tear on moving parts in helicopter transmissions is very high, and research used to rely on the records of previous experiments to determine present, and predict future, results. Advances in computer software have led to great advances in how mechanical wear is measured, even on a microscopic level. The development of "2D" materials, such as graphene, and specialized solid lubricants — known as MXenes and MAXenes — are potential game-changers, as their extremely thin layers can glide over each other, almost imperceptibly, creating a wear-free, minimal movement.

Working with ÖAMTC Air Rescue's technical services division, HeliAir, Weigand's group has also developed a completely new concept of interiors for EMS helicopters, called "Kokon" (Cocoon). Trumpeted as "aviation's first ever self-supporting interior trim," a partnership agreement between HeliAir and Airbus in 2020 makes this a standard option for Airbus's helicopter catalogue.

Future research focuses on microsensors for measuring electric fields, smart detection of metal fatigue, and the development of climate-neutral aircraft concepts.

All in all, the future of innovation and design of rotorcraft technologies looks to be in very good hands with TU Wien.

About the Author
Ian Frain runs an aviation research consultancy from Cambridge, United Kingdom, as well as having a base in Austria/Germany, called Helian. He has a BSc in Engineering — aerospace and mechanical — from University of Hertfordshire, and has worked in offshore and parapublic helicopter maintenance, and as a researcher in an aviation publishing company. He can be reached at **ian@helianinternational.com.**