elfin 20.e/20.ex

The Glider from The Freezer

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Innovation

Worldwide, executives are not prepared for the future. The biggest obstacles are strategic deficits or organizational and management barriers. Lack of customer orientation, operational and competence gaps are further barriers to growth.

Innovation comes from the Latin ***innovatio***: renewal, change. Realization of ideas with the aim to create new values or to gain benefits with a technical, social or economic change.

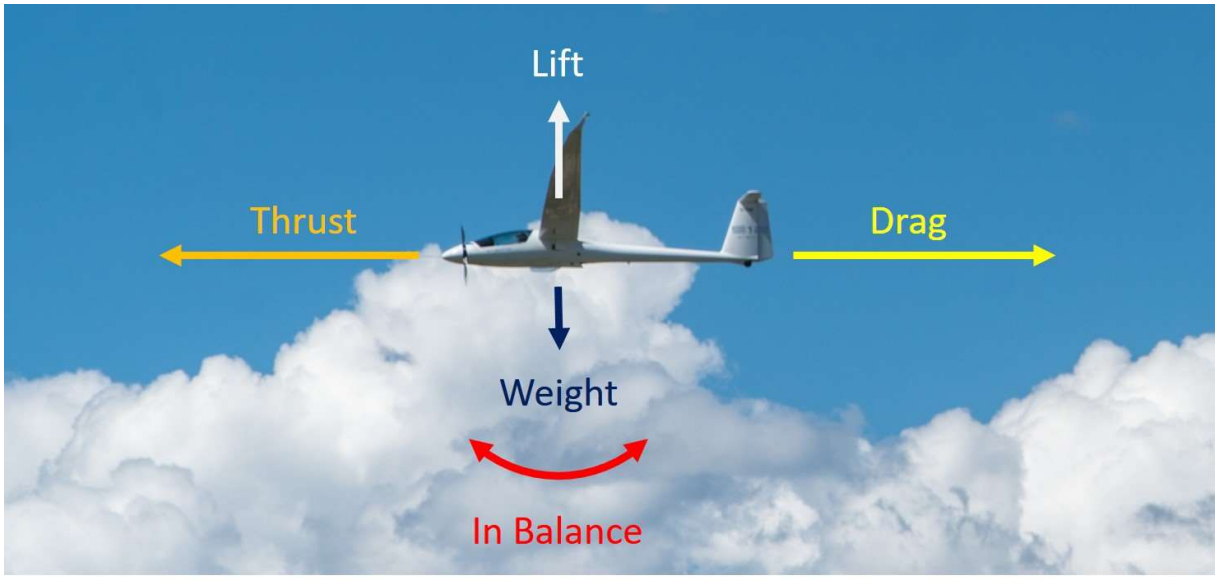
The content of an innovation comes from interacting and communicating with customers, communities of interest, external events, suppliers, competitors, the economy, the state, and even one's own family. It takes a passion and curiosity like a balloon ride. With the launch of the balloon you leave the familiar environment. Unnecessary ballast obstructs the ride, however, discussions with pilots who have similar experiences can bring you further.

Morning ride at the balloon meeting in Metz and an opportunity to share experiences

From 1963 to the S10, S10-V, S10-VT, S6, S15 and S12

Passion, curiosity, renewal and change have always shaped the life of Dr. Reiner Stemme (born 1939). He studied physics at the Technical University in Berlin from 1963 to 1970, built a company for laser technology in Switzerland and received his doctorate in 1975 at the University of Bern. In the years 1976 to 1985 he dedicated himself as managing director of the VDI Technology Center (VDI - Verein Deutscher Ingenieure / Association of German Engineers) in Dusseldorf for the introduction and financing of new technologies.

During this time, the idea was born of developing a self-launching, two-seat glider that optimally meets the laws of physics. To realize this idea in Berlin was a special challenge because at that time all Berliners were forbidden by the victorious powers of World War II to fly or build aircraft.



Force chart on the example of an S12 in powered flight

To develop an airplane for dual mode gliding/powered flight required a creative process that needs appropriate innovations. If the engine and the weight of two people are in front of the wing, then a counterweight must be created. If the pilots sit behind each other, then the leverage effect to the front becomes even bigger. It was about finding a balance. The pilot and the passenger can hardly be moved because of the necessary visibility. This means that the engine has to be optimally placed as a counterweight and the changing fuel supply must not cause too large change in the centre of gravity. In addition, a solution had to be found for the propeller, because at that time the only variable pitch propellers available for mounting in the nose could not fold out of the airstream. Those impeded optimal gliding with their drag, even when feathered. The breakthrough to a solution was described by Dr. Stemme in his patent of 1979, in which the folding propeller is driven by a low-vibration carbon shaft. After switching off the engine, the propeller blades are folded by spring force for gliding and disappear in the nose cone.

In November 1984, the Stemme company was founded. The first flight of the S10 was in 1986. In 1987, the S10 was first presented at the Aero in Friedrichshafen and received certification in 1990. Continuously the S10 was further developed and received a variable pitch propeller. The resulting new model became the S10-V. By installing the Rotax 914F engine with turbocharger, the S10-VT was born. Klaus Ohlmann proved the excellent qualities of the S10 family in 2000 in the Andes with the record flight "cross country soaring" over 2'463 km in 14h. Other record flights were also made by his wife Sidane Ohlmann. On 01/02/2014, Klaus crossed Mount Everest in the Himalayas with his S10-VT (www.youtube.com/watch?v=ATnNWnlLuT8).

The S10-VT with under-wing pods for measuring equipment was the basis for scientific knowledge about high-mountain turbulence in the Mountain Wave Projects in the Andes to the Himalayas (www.mountain-wave-project.com).

In November 2006, the pure touring motor glider S6 completed the maiden flight and received EASA type certification two years later.

In March 2012, in cooperation with the Technical University of Berlin and the University of Stuttgart, the automatic flight control system LAPAZ (Luft-Arbeits-Plattform für die Allgemeine Zivilluftfahrt -Air Work Platform for General Civil Aviation) was tested.

Before leaving Stemme AG, Dr. Stemme started development of a new model. Based on the S10-VT, it offered several significant improvements based on feedback from owners around the world. These include electric trim, an extra two meters wingspan, a wider landing gear, a baggage area in the tail boom and an autopilot. There is also a water ballast tank in the new wider chord fin. For years Olivier de Spoelberch from Belgium supported the development of the S10/12 series. The Twin Voyager S12 was unveiled in April 2015 at the AERO in Friedrichshafen and is today available in the variants S12, S12 SW and S12 G.

On 2 December 2015, Deutsche Gesellschaft für Luft- und Raumfahrt (DGLR) honoured the work of Dr. Reiner Stemme with the 14th Otto Lilienthal Medal. «Dr. Reiner Stemme has earned outstanding merits in the German aircraft industry», is the statement on the certificate.

elfin 20.e/20.ex: The Vision

Activity instead of resting, implementing further ideas, analysing the environment and actively interpreting the acquired experience is now the basis for the elfin 20.e / 20.ex. New technologies also mean additional challenges. The elfin should not become more complex but carry the good genes of the S10.

We are looking for a **two-seat (side by side) high performance glider with a 50:1 glide ratio of the FAI 20m class with an electric / hybrid drive**. It is supposed to be the first CS-22 glider that has been **designed to meet the needs of electric flying**. In addition to competition

flight, it should be suitable for gliding safaris. By mounting a simple under the wing pod, containing a motor and generator, the elfin will also have long powered range. The elfin is intended to open up broad areas of use with some top performance.

The Flexibility in Operation With 5 Examples

1. **Competition flight**: To optimize wing loading, only the main battery is carried and ballasted with up to 100 kg of water. The take-off takes place by self-launch, towing or winch launch with sufficient capacity for a safe return flight or a nearby airfield.
2. **Gliding**: Installation of the entire battery capacity (main and auxiliary battery). The launch takes place in self-launching up to 500 m, tow or winch and a remaining battery capacity of 1 hour at 100 kts, with up to 200 kg in the cockpit and 20 kg of luggage.
3. **Sightseeing flight or distance flight**: With the main battery installed and the pod mounted (range extender, elfin20.ex), you can fly more than 6 hours and have a range of 1,000 km.
4. **Training**: Due to the side-by-side seating arrangement, the flight instructor can observe the student during the flight or the student can see the actions of the instructor directly. The electric drive reduces the noise pollution around the airfield. The easy and rapid replacement of the 2 battery packs will not interrupt training. For introductions to cross-country soaring, off-field landings can be avoided. The tow hook also allows launch training with tow or on the winch.
5. **Without motorization and without batteries**: The elfin 20.e remains a high-performance glider, which is towed for take-off or pulled up by the winch. It is characterized by a very low wing loading (31-42 kg / m2 instead of 38-55.5 kg / m2) and again becomes highly competitive with water ballast.

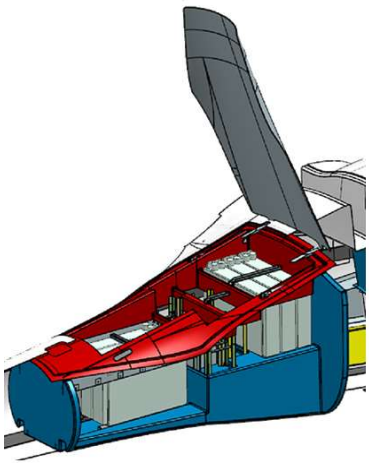
The Needs of Electric Flight

The S10 has been a platform for experimentation several times. The Eco Eagle Stemme S10 of the Embry-Riddle Aeronautical University participated in the NASA Green Flight Challenge in 2011. In December 2013, the first flight of the Sunseeker Duo, the first pure electric glider with solar cells on the wings, took place. The S10 fuselage shells were used for the construction of the Sunseeker fuselage (www.solar-flight.com/sunseeker-duo).

The challenges for electric flight lie in the weight of the batteries and the compensation by a weight-reduced fuselage and the time required to charge the batteries. The energy density of the battery packs available today is in the range of 0.15 - 0.25 kWh / kg. A 220 V power outlet delivers 3 kW in one hour. An increase of up to 0.40 kWh / kg is targeted by the automotive industry in the medium term and this would allow electric flight times of more than 2 hours.

Batteries

With the weight of the batteries, the question of the equilibrium for optimizing the gliding ratio arises again. The main battery and the control of the electronics (left in the picture) form the counterweight to the pilots and the electric motor. The auxiliary battery for replacement or weight reduction is closer to the centre of gravity and is easily accessible. The fire protection of the batteries complies with the current requirements of the EASA / FAA.

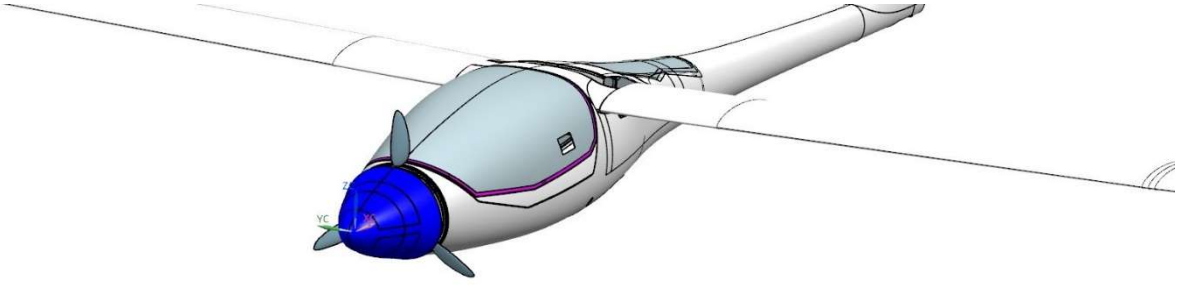


Two packages of 54 kg each with 400 V, each consisting of 3 modules of 18 kg each

An internal charger (5.5 kg) provides 3 kW and allows charging up to 85% of the capacity in about 6 hours. If only 3 hours is available before the next launch a climb of 1500 m will be possible. A part of the delivery package is a 20 m cable (2.8 kg) to charge the battery at the next hangar or house power connection (3 kVA - 110/220 V) and can be carried on board the aircraft. An external fast charging device for full capacity charging on the ground in under 2 h is being developed.

Drive system

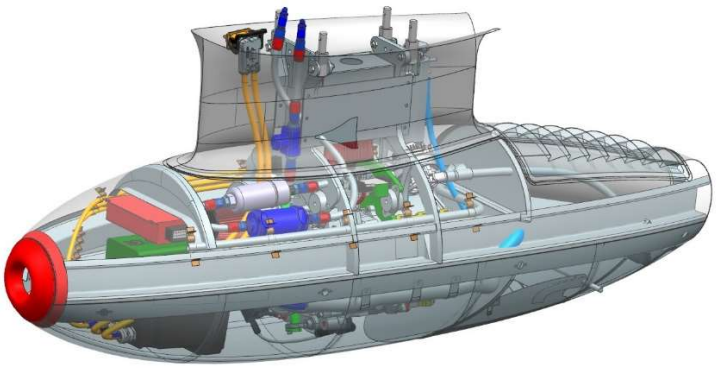
A motor is evaluated for launching with power in the range of at least 70 kW or about 100 hp and a continuous power of 50 kW about 70 hp. Both values are more than sufficient and in contrast to internal combustion engines, independent of altitude!



Foldable 3-blade propeller with a diameter of 1.45 m

With the new 3-blade propeller, ground clearance compared to a 2-blade propeller is significantly increased. This reduces the potential for ground contact and also lowers the cockpit entry level to only 0.96 m. At the same time the three bladed propeller achieves a lower noise and vibration level. The leading edges have metal protection. The three blades ensure that the maximum potential of the electric drive system is exploited. The propeller dome is automatically opened or closed within seconds with a single-lever operation which is coupled to power on/off switch. The process is independent of the position of the propeller blades.

Range Extender



Electric generator system with 30 - 45 kW engine power

With the Range Extender, the glider becomes a touring glider. The e-generator system with 30 - 45 kW continuous power weighs about 65 kg and can be mounted by one person using a built-in lifting device. The fuel tanks are located in the centre wing. The range at FL 100 is 1,000 km (550 NM), depending on cruising speed between 120 km/h (65 kTAS) and 215 km/h (115 kTAS).

The glider from the freezer that has to be put into the oven

The weight of the batteries forces the manufacturer to continuously reduce the structural weight. The entire structure of the elfin 20.e / 20.ex is therefore made of innovative carbon fibre prepregs.

Out-of-autoclave (OoA) prepreg materials and processes have gained acceptance in the last decade, and so components of consistent quality can be made using the vacuum-bag-only (VBO) method. The main advantages of OoA prepregs are: weight reduction and improved manufacturing quality compared to wet laminate designs, as well as cost reduction compared to autoclave prepreg designs. The achieved structural performance corresponds to the autoclave prepregs.

Three freezers with the prepreg raw material in front of the curing oven of 11 m length

The key to weight reduction is the higher allowable design values compared to wet laminates. Greater parts repeatability also results. The achievable quality allows lower tolerances for the for smaller bonding gaps and thus facilitates production. OoA prepregs ensure uniform resin distribution and avoid the usual dry or resin bulges during infusion of wet hand laminates. Part properties such as thickness or strength are less dependent on the skills of the worker and are therefore much more reproducible. Manual labour costs can be significantly reduced due to the following factors: No mixing of the resin, less cleaning and preparation, less rework and extended durability of the molds.

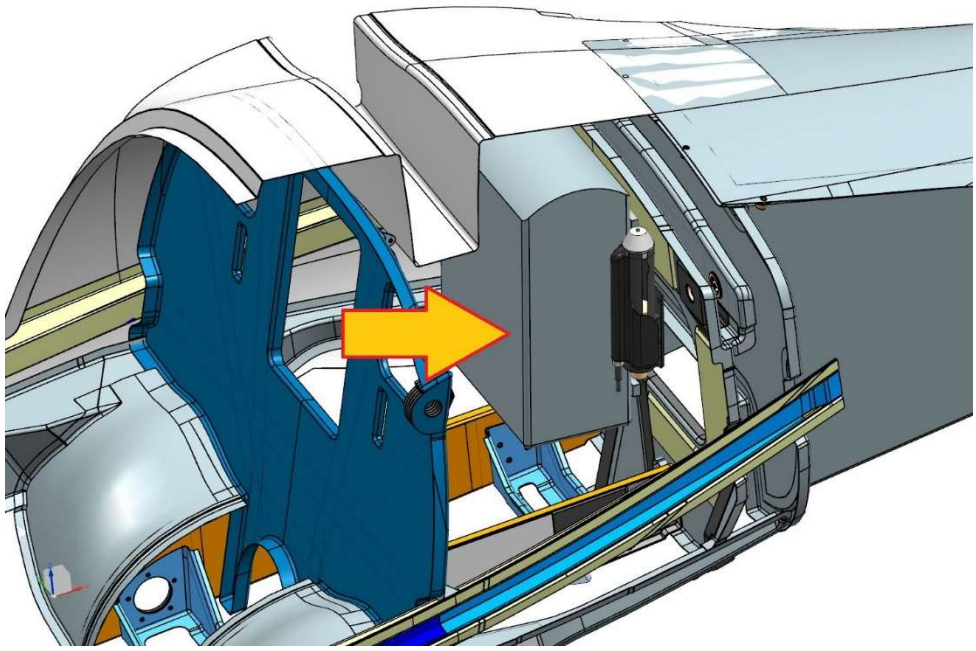
Goal achieved: 25% weight reduction compared to wet laminate and previous designs. One side of the fuselage constructed in prepreg, including reinforcement parts and integrated

stringers on the shell weighs only 25 kg! This is impressive for an aircraft with a VNE of more than 280 km/h!

In the centre of the fuselage, extremely strong stringers protect the airframe in an emergency landing. The centre wing span is 9.9 m and the outer wing mass is less than 30 kg. A 100 kg (220 lbs) water ballast tank and a fuel tank (alternatively also water 80 kg / 176 lbs) for the Range Extender are included in the centre wing.

Safety

As early as 1995, a patent relating to the "Rescue System for Aircraft" was issued to Dr. Stemme. In the case of the elfin, theory becomes a reality. Thus, the aircraft is equipped with a complete emergency parachute system to improve the survivability in ground-level emergencies. In addition, the seats are designed for the use of individual pilot safety parachutes.

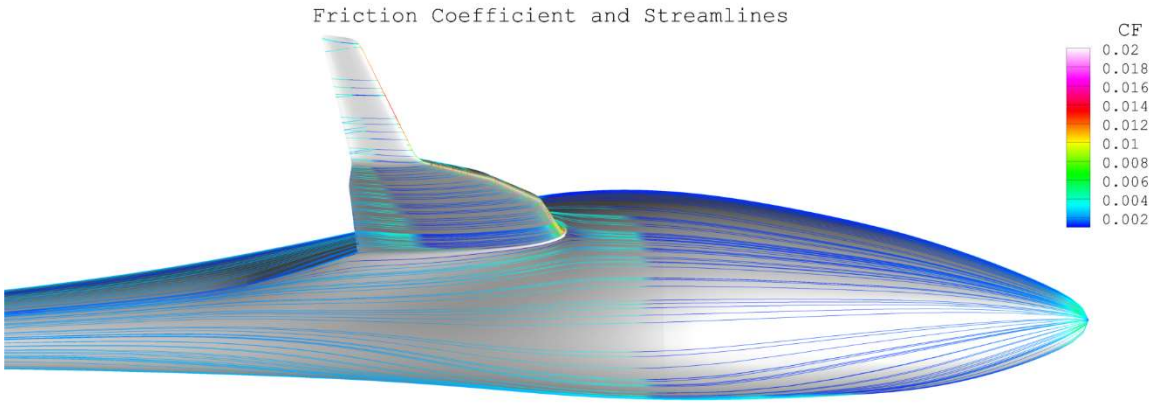


Rescue system behind the seats with rocket

The above-mentioned load-bearing stringers not only protect against landings without a landing gear, but protect the entire cockpit from impact. The construction meets the increased requirements of CS-22. The canopy can be ejected in an emergency with a one-handed grip thanks to a "Röger hook" design. An audio-visual warning will alert you to extended air brakes, the source of many accidents. Integrated position lights; Anti-collision and ELT systems are combined with 2 holders for oxygen cylinders provide additional element of the built-in safety.

Often the ergonomics in the cockpit are considered for comfort. But it is also an active element of security. Pilots in a suitable environment make fewer mistakes. Thus, the cockpit is designed for pilots from 1.6 to 2.0 m and offers the appropriate panoramic view for each size. The minimum payload of 70 kg and the maximum of 200 kg allows almost every combination of two pilots to comply with legal regulations.

Aerodynamics



The most beautiful thing about gliding is to fly with solar energy - be it in circles in the thermals, the dolphin flight under a cloud street, in the rising air, in wave flight or in the fast glide on the final approach to the home base.

Almost all components of modern sailplane designs have been optimized to a point where very little improvement is possible. The goal of the engineers was, however, to design a modern, powerful and competitive sailplane with unique and superior soaring characteristics. As a consequence, we tried to reduce drag wherever possible to obtain our goal. The aerodynamic design of the elfin 20.e was done very carefully using modern CFD methods. Special emphasis was put on the wing-fuselage junction which has not been as carefully analysed in modern sailplane development up to now.

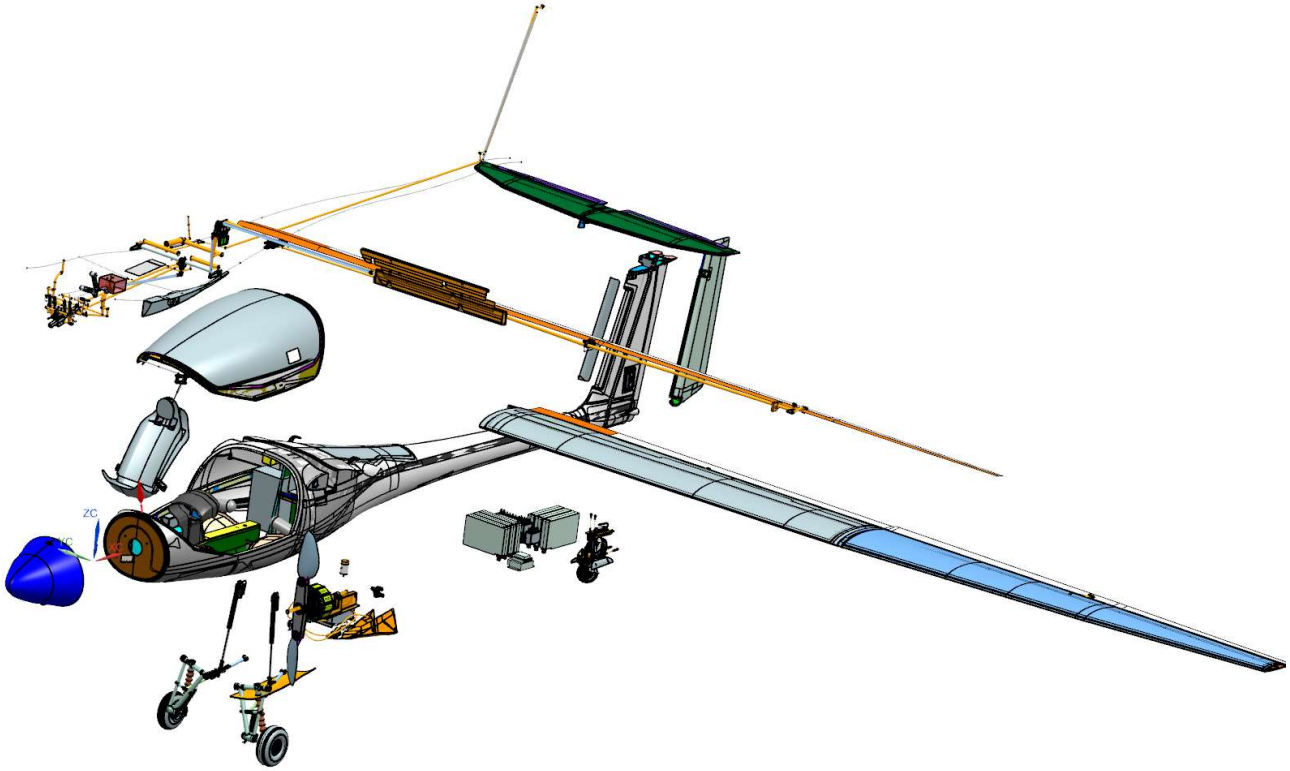
In the proximity of the fuselage the almost elliptical circulation distribution of sailplane wings is disturbed, increasing induced drag. Therefore, the elfin 20.e was designed with a high-wing configuration from the beginning. The high-wing configuration is, in general, aerodynamically superior to compared to the mid-wing configuration, often used in sailplane design. With a high-wing configuration the lift reduction due to the fuselage is minimized. Furthermore, a positive twist was applied to the wing root section of the elfin 20.e, also compensating for the lift loss in the fuselage region and resulting in a close to elliptical lift distribution and minimized induced drag.

The flow at a wing-fuselage junction is generally turbulent. Thus, along with the wing root twist we designed a new turbulent root air foil specially for the elfin 20.e. It is optimized to reduce friction and pressure drag in the root area. Several iterations on the root twist and on the air foil, were done to ensure a separation-free root junction. In addition, adequate fillets between wing and fuselage of the Elfin 20.e prevent the so-called diffusor effect

Needless to say, the elfin 20.e also features all other qualities of high-performance sailplane design:

- Five different air foils are used in the wing for maximizing the performance of the Elfin 20.e. All are derived from the main air foil RS10-143, optimized at each spanwise section for the specific chord length and Reynolds number.
- The air foils feature a well-balanced and steady lift slope, without a premature lift plateau or local maxima as it is characteristic for other air foils (e.g. HQ17, DU89, DU97)
- The shape of the elfin 20.e fuselage was optimized to ensure laminar flow over the largest possible area in order to minimize drag.
- The fuselage is tilted nose down compared to the wing in order to match the incoming streamlines.
- The fuselage contraction ratio is well adjusted to reduce the wetted surface area and avoid separation.
- Winglets were optimized to ensure maximum cross-country performance.

elfin 20.e/20.ex: A Dream?



No. The prototype is being developed piece by piece and there are many more details to mention – see www.reinerstemme.aero. The elfin 20.e /20.ex is expected to see its maiden flight at the beginning of 2020 and to be ready for delivery by 2020. It will be presented at the Aero in April 2020. The best wishes should accompany the team in baking and creative ideas for emerging challenges.

elfin 20.e/20.ex: Eckdaten / Specification

Äußere Abmessungen / External Geometry		
Spannweite / Wing Span	20 m	65.6 ft
Flügelstreckung / Wing aspect ratio	24.7	24.7
Flügelfläche / Wing area	16.2 m²	174 sqft
Länge gesamt / Length overall	8.7 m	28.5 ft
Höhe / Height over tail plane	1.7 m	5.6 ft
Spurweite Haupt-Einziehfahrwerk / Wheel track	1.2 m	3.9 ft
Radstand zu Einzieh-Spornrad / Wheel base	5.5 m	18.0 ft
Innere Abmessungen / Internal Geometry		
Cockpitbreite / Cockpit width	1.25 m	4.1 ft
Cockpithöhe / Cockpit hight	0.98 m	3.2 ft
Einstiegshöhe / Cockpit entry sill height	0.96 m	3.1 ft
Massen und Zuladung / Weights & Loading		
Leermasse / Operating empty weight	540 kg	1'190 lbs
MTOW / MTOW	900 kg	1'984 lbs
MTOW ohne Wasser Ballast / without water ballast	820 kg	1'808 lbs
Max. Zuladung Cockpit / Max. cockpit load	200 kg	441 lbs
Min. Zuladung Cockpit / Min. cockpit load	70 kg	154 lbs
Flächenbelastung / Wing loading	38 – 55.5 kg/m²	7.8 – 11.4 lbs/sqft
Flächenbelastung (ohne Antriebseinheit) / Wing loading without engine	31 – 42 kg/m²	6.3 – 8.6 lbs/sqft
Max. Wasser Ballast / Max. water ballast	100 kg	220 lbs
Flugleistung (Segelflug) / Gliding Performance		
Gleitverhältnis L/D / Glide ratio	1:50 Klasse	1:50 class
Flugleistung (mit beiden Batteriepacks) / Performance (both batteries installed)		
VNE Höchstgeschwindigkeit / Never-exceed speed	280 km/h	151 kts
VA Manövergeschwindigkeit / Manoeuvering speed	210 km/h	113 kts
VSO Minimalgeschwindigkeit / Stalling speed	78 km/h	42 kts
Reichweite / Range (elfin 20.e)	T/O auf 500 m + > 1h motorisierter Flug	T/O to 1'640 ft + > 1h powered flight
Flugleistung mit Range Extender / Performance with Range Extender		
Reichweite / Range (elfin20.ex)	1’000 km	540 nm
Reisegeschwindigkeit /Cruise at FL100 (elfin20.ex)	215km/h TAS	115 kTAS

All design and technical data subject to change without notice