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TAURUS electro.

In 1995, Pipistrel d.o.o. Ajdovščina were the first in the World to present a two-seat ultralight aircraft with a wing-span of 15 meters, aimed also at glider pilots. The aircraft was the Sinus, still going strong in production. The idea for this aircraft grew from the fact there was a large number of glider pilots, who wished for cheaper and independent flying without being stuck to aero-towing.

However, this very idea of producing a microlight aircraft with a 'glider soul' seemed rather bold and everything else but promising. The general opinion amongst the pilots back than was that the glider pilots will not decide to fly an aircraft of inferior category, and that the pilots of existing ultralight were believed not to be capable of piloting a high-performance aircraft that would resemble a glider a great deal. Not even the legislation on this field had been determined then... But as it turned out, the owner of Pipistrel and co-constructor of Sinus, Ivo Boscarol was correct.

One has to know the development of an aircraft is a huge project which requires experts from all branches. To develop a never-seen-before concept of an aircraft was even a great challenge. With the Sinus, the team aimed at the following:

- to present a two-seat composite-built aircraft with 15 meters of wingspan, which requires 100 meters of runway to take-off and reaches 200 km/h in horizontal flight, all on a 50 HP engine;
- the aircraft must be completely safe – intended for gliding it is constructed according to EASA CS-22 rules (classic gliders), although it fits into the microlight category;
- the aircraft must have a comfortable cockpit with seats in side-by-side configuration, since microlight pilots rarely fly alone;
- the aircraft must provide a low stall speed and at the same time be a high speed cruiser – this enables the pilots to go gliding over terrains away from their home base without the need of road transport;
- the L/D ratio of the aircraft must be close to 1:30, which makes it a decent glider and provides extra safety in case of engine failure, since the engines for microlights are not certified;
- the aircraft must present Short Take-off and Landing (STOL) characteristicts. Thus the aircraft is to be equipped with airbrakes, which enable the pilot do descent rapidly and use a high angle of approach onto typical ultralight airfields - short runways with plenty of obstacles below the approach path;
- the aircraft must fully comply with all criteria of a microlight – the reason for this is inexpensive maintenance and the fact also pilots, who cannot be issued an aviation medical certificate any more can fly the aircraft. Many countries issue a microlight license on basis of only a driver's license. This however meant that the empty weight of the whole aircraft must not exceed 285 kgs!
- Special attention must be given to ensuring the fuel consumption stays at the lowest possible level to preserve the environment.

The small Pipistrel team eventually managed to combine all desired features into an aircraft that first seemed impossible. They were able to do it by developing an own airfoil and wing shape as well as an own propeller with feathering capability, all drastically decreasing the drag and providing for a satisfactory glide ratio.

As the Sinus flew for the first time she was a subject of all aviation magazines around the World and despite being doubtful in the published performance figures the glider pilots began placing orders. They were willing to trade the imperfect glide ratio for the low cost of flying, freedom and independence from glider tow.

Sinus became an instant hit Worldwide, she took the World Champion 2001 title, triggered a wave of imitators and set new foundations for a new category within the definition of microlights. She flies on all the Continents of the world and is used by flight schools, national aviation associations and even militaries for training of their pilots.

Sinus 912 gliding over the cliffs of Portugal

After such a success it was quite realistic to expect there is also a market niche for a real microlight two-seat glider, as well as it's version with an auxiliary, fully retractable engine. Hard-core glider pilots were not convinced by the glide ratio of 1:30 that Sinus has to offer. The 'real' quality gliding goes together with glide ratios of 1:40 and more.

This time, the main idea of construction was completely different from the one with Sinus, but the aims remained sky-high. The world's first side-by-side microlight motorglider, later named Taurus was to:
- offer the pilots a REAL glider or it's self-lauchable version with an auxiliary, yet fully retractable engine and glide ratio of at least 1:40;
- make gliding cheap;
- provide a fully equipped aircraft, including a total rescue ballistic parachute system which saves the aircraft and both pilots, all instruments, radio etc. at a reasonable price;
- provide the owner with complete freedom and independence – even the helper holding the wing tip during take-off is now not needed any more by providing two main wheels in parallel configuration;
- have the most comfortable cockpit on the market with a separate ventilation system for each pilot and side-by-side seating arrangement;
- be pilot-friendly oriented without simple & straight-forward systems handling.

The fuselage of Taurus uses a special lifting body shape concept and features enough room for an auxiliary, yet fully retractable engine and an incredibly spacious cockpit. It was not easy to decide how to shape the pilots workspace, but in the end the fact that World's population is growing in all measures prevailed. The pilots in the Taurus are placed side-by-side for comfort and ease of communication.

Taurus is also intended for training, therefore all control levers must be within reach of both pilots. Both pilots have individual control sticks and rudder pedals. The landing gear operation lever, flaps, airbrakes, tow rope release and trim levers are there for common use to both pilots and therefore found in the middle, between both seats. For added comfort pilots enjoy adjustable headrests, in-flight adjustable rudder pedals, separate vent window and nozzle for each pilot and along with a central ventilation system for efficient de-fogging of glass surfaces.

The version of Taurus with an auxiliary retractable engine comes with a ROTAX 503 which is modified and redesigned by Pipistrel. The engine is twin carbureted engine and drives a Pipistrel's own developed propeller. This power configuration provides the aircraft with short-field takeoff and very decent climb performance.
The system for extending and retracting the engine and propeller is fully automated. The pilot takes advantage of a dedicated interface on the instrument column and all he/she has to do is to flick the switch to 'engine IN' or 'engine OUT' position – everything else is done completely automatically. When retracting, the propeller is first positioned vertically, the engine then gets retracted and the engine bay covers close. To restart the engine on ground or in-flight the pilot selects the 'engine OUT' option and the engine extends and is ready for start-up in only 12 seconds. The entire engine retraction system is incredibly light and reliable, all switches and sensor used to monitor the operations are electromagnetic-induction type and as such not sensitive to vibration, mechanical damage and/or dirt. This system has also been developed in-house by the Pipistrel team.

The same goes for the undercarriage retracting system, which is fully mechanic but needs very light force on the cockpit lever during operation. There are two main wheels in parallel configuration which ensure for comfortable taxiing despite the fact they are not suspended. The tail wheel is not retractable but fully stearable instead, which makes taxiing a walk in the park. The airbrakes, flaps and the elevator trim are all mechanical pushrod type. Upon customers wishes a tow-rope release mechanism can be fitted as well.

The next interesting step in further-development of the Taurus is definitely the substitution of the internal combustion engine with its electric counterpart. Several teams and research laboratories around the World have been researching the possibility of producing and electric-powered aircraft. Using the latest findings in the fields of batteries and charge storage as well as the recent developments of synchronous electric motors with small mass and high specific torque, the flight of electric-powered aircraft can now become a reality.

However, to achieve electric powered flight, and doing this for a two person crew for the first time ever, there are quite a few hurdles to overcome. To name just a few:
- the specific weight of the batteries is still high and the number of charge cycles (life span) relatively low (measured in thousands of cycles)
- specific capacity of the batteries could be higher
- low efficiency of the existing solar cells and their current price
- aviation legislation, which is very slow to follow the advancements in this field
- customers being skeptic to the new type of propulsion.

The electric-motor propulsion has been tested successfully on four light aircraft until the Taurus Electro – as an auxiliary engine on self launching gliders Apis, Antares and Silent and on the MCR light aircraft where a full-cell based propulsion was used. Mentions of Sonax using an Electric engine as a means of propulsions also exist, but no proof of flying has yet been published. Recently a French-made single seat Electra also flew under electric power.

Because of all of the above the direct substitution of the classic aircraft engine with internal combustion on powered aircraft is not yet possible. The most plausible application of electric-motor propulsion however points to the powered-gliders.

Pipistrel's Taurus is a two-seat glider with higher approved take-off mass than the single seat gliders where the electric-motor propulsion has been tested so far. Therefore the Taurus requires a more powerful electric motor.

The motives to develop an electric-powered Taurus self-launching glider were the following:
- to offer the customers with a new, high-tech and innovative aircraft propulsion
- to reduce the pollution to the atmosphere
- to reduce noise when flying under engine power
- to reduce the cost of flying because of ever higher oil prices
- to become the first truly useful two-seat electric powered self-launching glider (aircraft).

The requirements upon designing the Taurus ELECTRO were mainly to:
- develop a system, that will enable the aircraft to climb to altitudes in excess of 2000 meters on a single battery charge
- keep the current market price of the aircraft
- keep the current take-off distance
- keep the empty weight of the aircraft within the values of the internal combustion engine powered Taurus 503 with fuel
- keep the current climb profile of the aircraft

Because of the fact that all current systems/aircraft only managed to succeed in the first of the above points they are not interesting on the market and even less as subject of serial production. They remain on the level of expensive piloting projects.
Pipistrel is aware that the development reaches its goal only when the customers' orders confirm the idea as the correct one. Market research has undoubtfully shown a vast sales potential for this kind of aircraft, but only if all the mentioned conditions were met entirely.

We have therefore decided to focus on the development and strive to meet the other four requirements. The task is of course unbelievably difficult as we are the first to attempt anything like this. We are fully aware that only (almost) unrealistic goals lead the way in a course of development.

To be able to make our vision a reality we need to:
- modify the existing Taurus aircraft for the application of the electric-based propulsion
- modify the existing system for extension / retraction of the engine
- develop a cheaper system to control the charge and discharging phase of the batteries
- develop a purpose-built propeller to maximize the efficiency at given constant torque
- organize an innovative way of serial production to reduce production costs
- use high-performance Lithium-polymer batteries with specific capacity touching 200Wh/Kg
- develop and use of a very light highly efficient electric motor with high specific torque
- develop a system to recuperate (charge) the batteries in flight

This kind of a project is highly complex and we have therefore decided to collaborate with third party manufacturers (in alphabetic order). Special thanks go to:

Enstroj – Sušnik Roman s.p. – Integration of electric propulsion system into the aircraft
Piktronik d.o.o. – Development of tailor-made power controller
Sineton d.o.o. – Development of tailor-made electric motor

Involved in the development were also the following companies, entrepreneurs and instititions (in alphabetic order):

Aeroklub Josip Križaj Ajdovščina
Aerodynamicist – Orlando Franco
Aerotech - Sašo Kolar s.p.
Albastar d.o.o.
Albatross Fly, Radovljica, d.o.o.
Avtomehanik – Kodelja Branko s.p.
Avtomehanik – Kosta Igor s.p.
Cosylab d.o.o.
Galaxy High Technology S.R.O.
Ibis – Štrumbelj Igor s.p.
Lupina – Kikelj Radivoj s.p.
LX Navigation d.o.o.
Multitech d.o.o.
Sistem WE d.o.o.
Strojno ključavničarstvo Popit – Popit Janez s.p.
University of Nova Gorica

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Developmental costs of the Taurus Electro project reach over 1 Million Euro. The project was partially funded by the EU for the sum of 354,824.89 EUR.

Electric propulstion tech sheet

Electric motor type	*permament magnet synchronus three-phaes brushless*
Electric motor dimensions (excl. propeller flange)	*diam. 250 mm x 150 mm*
Electric motor mass (excl. propeller flange)	*14 kg*
Max. continous shaft power	*30 kW at 1800 RPM*
Efficienty at max. continous power	*95%*
Max. continous torque	*160 Nm*
Peak torque	*200 Nm (0 – 1500 RPM)*
Max. motor RPM	*1800 RPM*
Nominal voltage	*140 V*
Propeller diameter	*2040 mm*
Batteries: Lithium-polymere	*42 cells, 3.7 V each*
Storage capacity	*6 kWh*
Battery weight	*46 kg*
Charger / battery voltage balancer	*Built into aircraft*
Power / RPM controller	*SAC 40 modified for aviation use*

A30K016 Motor powering the Taurus Electro

Taurus Electro

Empty weight (incl. Batteries)	*320 kg*
Top-of-climb	*2000 m / 6500 ft AGL*
Take-off distance at MTOM (472.5 kg)	*170 m / 560 ft*
Climb rate at MTOM (472.5 kg)	*2.8 m/sec / 560 fpm*

Gliding performance matches Taurus 503, technical data available at www.pipistrel.si

The project itself has quite some very innovative solutions, which Pipistrel plans to patent, unlike some solutions on previous projects. The first flight of the prototype of Taurus Electro was made in December 2007.

Targets for 2008

- Establish a serial production and incorporate the experts from the field of electrical engineering.
- Initiate an aggressive world-wide marketing campaign to present the benefits of the electrical-motor propulsion to the customers – pilots.
- Persuade the general authorities that an electrical-motor propulsion is in fact low-noise and completely emissions-free, therefore being friendlier to the nature and community and should therefore be a subject to tax deductions, similar to the automotive industry.
- Prove that an electric-motor driven aircraft can indeed have the same performance specifications than its internal combustion engine counterpart.

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