FES FLIGHT MANUAL

Version 1.15

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Table of Content

1. General

1.1 Introduction.

The FES flight manual has been prepared to provide:

1. Pilots with information for the safe and efficient operation of the sailplanes equipped with Front Electric Sustainer/Self-launcher system.

2. Sailplane manufacturer of specific type of sailplane equipped with FES, with all the information necessary to prepare flight manual of the sailplane after FES installation.

Chapters of this manual are written as it is requested by CS-22 requirements.

1.2 Certification basis

This type of powered sailplane has been designed in accordance with CS 22 Certification Specifications for Sailplanes and Powered Sailplanes, and in accordance with Special Conditions for electric powered sailplanes.

1.3 Warnings, cautions and notes

The following definitions apply to warnings, cautions and notes used in the flight manual.

Warning: *Means that the non-observation of the corresponding procedure leads to an immediate or important degradation of the flight safety.*

Caution: *Means that the non-observation of the corresponding procedure leads to a minor or to a more or less long term degradation of the flight safety.*

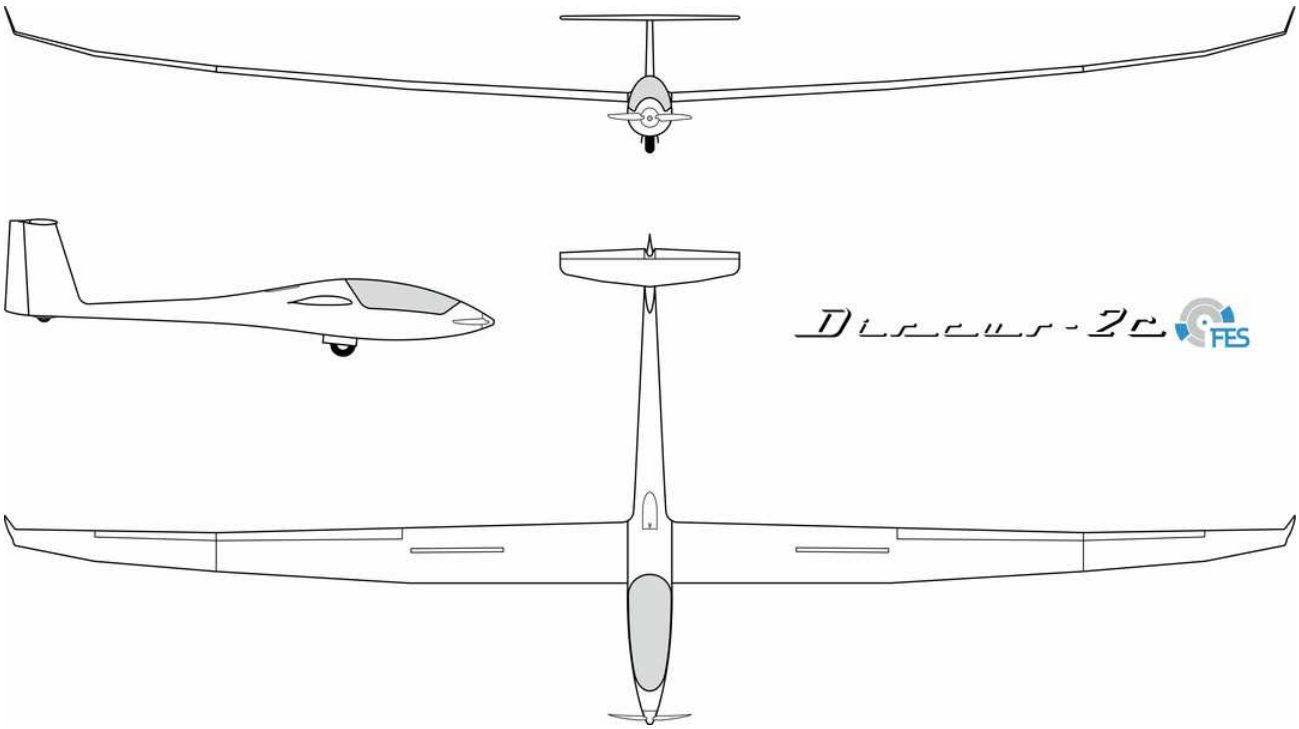
Note: *Draws the attention on any special item not directly related to safety by which is important or unusual.*

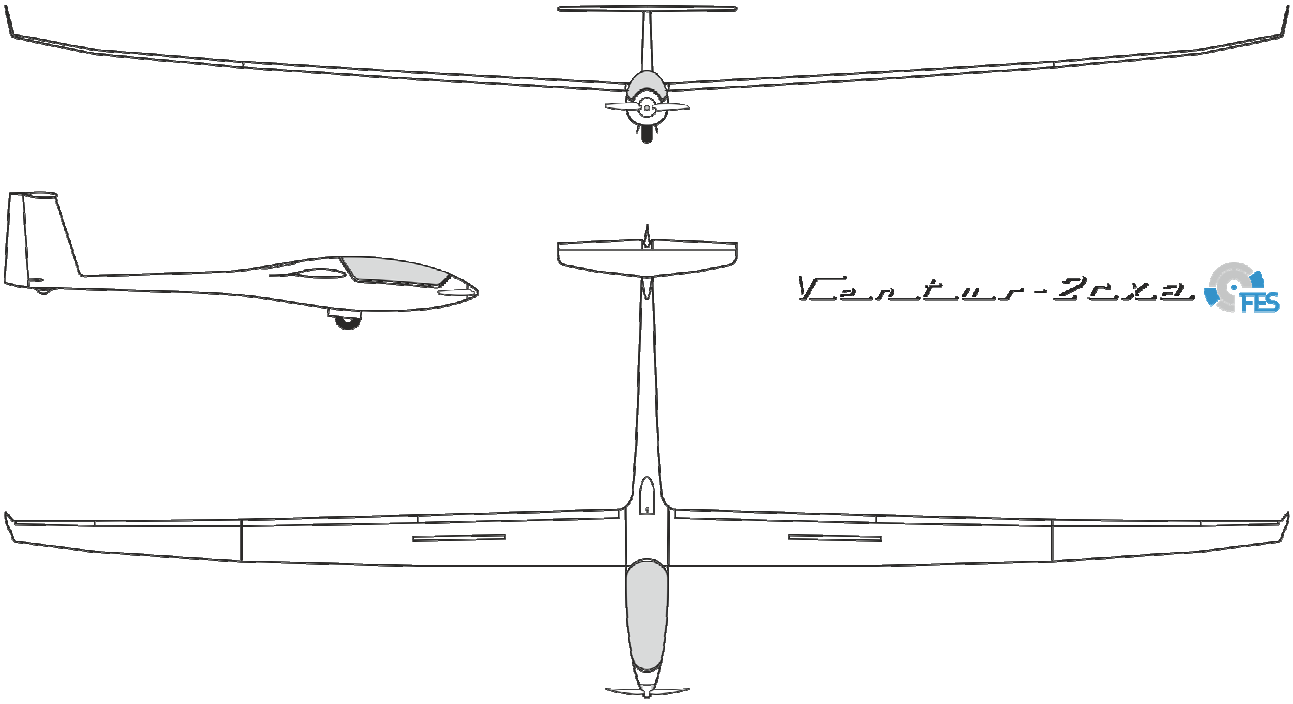
1.4 Descriptive data

Sailplane is equipped with a high-tech powerful FES front electric propulsion system developed for high performance powered sailplanes. Main parts of the FES system are:

- Brushless electric motor
- Controller for motor
- Foldable propeller
- FES GEN 2 Battery packs, with internal BMS (Battery Management System)
- Charger (1200W or 600W)
- FCU (FES control unit) instrument
- LXUI box with Shunt (for current and voltage measurements)
- FCC box (FES connecting circuit)
- Power switch
- DC/DC converter (converts high voltage to 12V)

1.5 Three-view drawing





Typical FES equipped powered sailplanes are Discus 2c FES and Ventus 2cxa FES

1.6 Abbreviations

CAS - calibrated airspeed means indicated airspeed of a sailplane, corrected for position (due to position of pressure ports on sailplane) and instrument error. Calibrated airspeed is equal to true airspeed in standard atmosphere at sea level
C.G. - center of gravity
daN - decanewton
H - hour
IAS - indicated airspeed means the speed of a sailplane as shown on its pitot – static aircraft indicator and is uncorrected for the system error
M - meter
Kg - kilogram
Km - kilometer
S - second
Ltr - liter

1.7 Unit conversions

1 bar = 14,5 pounds per square inch (psi);
1 decanewton (daN) = 2,25 pounds force;
1 kilogram (kg) = 2,2 pounds (lbs);
1 meter (m) = 39,4 inches (in.) = 3,28 feet (ft.);
1 millimeter (mm) = 0,0394 inches (in.);
1 liter = 0,2642 U.S. gal;
1 square meter (m^2) = 10,764 sq.ft;
1 kg/m^2 = 0,204 lbs/sq.ft;
1 m/s = 1,944 knots (kts);
1 km/h = 0,5396 kts;
1 kW = 1,34 HP.

2. Limitations

2.1 Introduction

This chapter includes operation limitations, instrument markings and placards, necessary or safe operation of the sailplane equipped with Front Electric Sustainer system.

2.2 Airspeed

Airspeed limitation for the use of FES system and their operational significance are shown below:

Speed		IAS; km/h / (kts)	Remarks
V_{PO}	Maximum speed with rotating propeller	160 / (86)	Do not exceed this speed with rotating propeller (at any power setting)
V_{POmin}	Minimum speed to start motor	80* / (43*)	Do not start rotate motor below this speed
V_{POmax}	Maximum speed to start motor	160 / (86)	Do not start rotate motor above this speed

*** Warning:** *select your motor start/stop speed correctly:*

- flaps must be at positive position; (depend on glider type)
- make sure your selected speed for motor start / stop is at least 8…10 km/h (4…5 kts) higher as if stall speed for your flight configuration.

2.3 Airspeed indicator markings

FES equipped sailplanes do not have any special markings compared to pure gliders. Blue line marking on airspeed indicator can be added representing range of best rate of climb speeds but it depends on glider type. Usually is between 80-90km/h, with positive position of flaps.

Marking	(IAS) value or range	Significance
Blue line	80-90km/h	Best rate-of-climb speed

2.4 Powerplant

Warning: *When FES is installed on 18m class sailplanes like Ventus 2cxa or Discus 2c, it is a **sustainer system**, and it is prohibited from taking-off solely, if not specified differently in flight manual.*

*On lighter UL sailplane like Silent 2 it is a **self-launch system**.*

2.4.1 Motor

Motor manufacturer: LZ design d.o.o.;

Motor model: FES-xxx-Myyy;

xxx - represent version of motor for specific glider type
yyy - represent motor length

More detailed data about motor which is used on specific type of FES powered sailplane are described in separate **FES motor manual**!

2.4.2 Propeller

Manufacturer: LZ design d.o.o.
Model: FES-xxx-Pv-yyy;

xxx - represents type of sailplane for which the propeller is designed
v - represents version of propeller for specific glider type
Xxx - represents propeller diameter in mm

2.4.3 Battery packs

FES needs two Battery packs wired in serial. Each Battery pack has 14 LiPo cells, so altogether there is 28 cells.

Maximum allowed total voltage of both Battery packs	118 V
Minimum allowed total allowed voltage of both Battery packs	90 V
Nominal capacity of each cell	40 Ah
Energy storage capacity	4,2 kWh
Maximum voltage per cell	4,16 V
Middle voltage	3,7 V
Minimum voltage of each cell	3,2 V

More detailed data about battery packs which is used on specific type of FES powered sailplane are described in separate **FES Battery pack manual**!

2.5 Power-plant instrument markings

FES power plant has a FCU instrument with high resolution sunlight visible color display. More detailed data about FCU and its operation can be found in separate **FES FCU INSTRUMENT manual**!

2.6 Weight

FES system can be installed only on such type of sailplanes which have enough margin in maximum weight of non lifting parts. Total weight of all FES components including reinforcement ribs for battery compartment box is about 50kg. However 12V batteries are not required any more, so they can be removed from a glider to save some weight (2 pcs of standard 12V-7Ah Pb battery have total weight about 5kg).

Exact FES weight depends on type of sailplane, and installed FES components.

2.7 Centre of gravity

Components of FES system are positioned so that after FES installation C.G. position remains as much as possible on the same position as with pure sailplane. After installation sailplane C.G. must be checked and corrected if necessary.

Warning: *Flying with removed motor is not allowed, if not specified differently for certain type.*

Warning: *Flying without battery packs is not allowed, if not specified differently for certain type.*

2.8 Approved maneuvers

Aerobatic maneuvers with FES equipped sailplanes are not permitted, unless it is specified differently for a certain glider type.

2.9 Maneuvering load factors

Depends on type of sailplane.

2.10 Flight crew

Depends on type of sailplane.

2.11 Kinds of operation

Flights must be conducted under Day / VFR conditions.

Warning: *Flying under power in strong rain is not allowed! Make sure that cover of battery compartment is sealed with plastic tape.*
Warning: *For sailplanes equipped with sustainer system it is prohibited from taking off solely by the means of its own power.*

2.12 Minimum equipment

As specified in flight manual of pure sailplane.

2.13 Aero-tow, winch and auto-tow launching

As specified in flight manual of pure sailplane.

2.14 Other limitations

As specified in flight manual of pure sailplane.

2.15 Limitations placards

Additional limitation placard needs to be added for FES equipped sailplanes:

Speed IAS:		km/h	kts
Power-plant operation	V_{PO}	160	86
Max. engine start	V_{POmax}	160	86
Min. engine start	V_{POmin}	80	43

3. Emergency procedures

3.1 Introduction

As in flight manual of pure sailplane.

3.2 Canopy jettison

Warning: *Before canopy jettison, stop motor and switch OFF power switch, if there is still enough time to do that.*

3.3 Bailing out

Warning: *Before you bail out, stop motor and switch OFF power switch, if there is still enough time to do that.*

3.3.1 Ballistic parachute

If sailplane is equipped with a ballistic parachute, a special switch is installed which stops motor automatically in case of activation!

3.4 Stall recovery

As specified in flight manual of pure sailplane.

3.5 Spin recovery

As specified in flight manual of pure sailplane.

3.6 Spiral dive recovery

As specified in flight manual of pure sailplane.

3.7 Motor failure

3.7.1 Motor fail to start

In the event that the motor fail to start, continue flying as a pure glider.

Note*: Check if you maybe forgot to switch the Power switch* ***ON****. Reminding message (on the FCU)"Check power switch" should appear if there was high enough throttle set.*

3.7.2 Power loss during flight

If power is lost during flight, push the control stick forward gently, to sustain desired airspeed! Than you can do next actions:

1. Check first if you maybe unintentionally switched OFF power switch!

Warning: *This can happen during retraction of landing gear on some glider types (LAK17A&B FES) where "Power switch" (toggle switch with red protection cover) is located on the same side of cockpit like landing gear retraction handle.*

If this actually happened, just switch Power switch ON again and adjust throttle knob.

Note: *On earlier software versions (below v2.13), it was necessary to manually reduce throttle bar to zero, otherwise motor did not start due to safety. When throttle was reduced to zero than motor started normally.*
On new versions (from FCU v2.13) throttle bar goes to zero automatically!

2. If Power switch was not unintentionally switched OFF, as described in 1st point, proceed with next actions:

- switch OFF "Power switch" and then also FCU.
- turn ON FCU and check it for any strange behavior.
- If everything is Ok switch on Power switch and try to start motor again.

If motor starts and there is any strange behavior under power:

- stop the propeller from the wind milling phase with the electronic brake.
- After propeller is stopped, switch OFF Power switch and FCU as usually.

In case that you are not able to stop propeller, you will need to land with the propeller in wind milling phase. In such situation try to land carefully on both landing wheels simultaneously, to avoid possible damage of the propeller.

Note: *If there is a grass runway in good condition available it is probably better to use it than concrete runway.*
If there is a grass runway with some holes than it is probably better to use a concrete runway if is available.

Warning: *Try to avoid landing into high grass or similar.*

Note: *L/D of sailplane with propeller in wind milling phase is only a little degraded, so you might have enough time to choose a suitable landing place if you have enough altitude.*

Please read **FES FCU Instrument** manual for detailed behavior and necessary actions after appearance of certain messages or LED lights.

3.8 Fire

3.8.1 Fire on the ground

- switch OFF the "Power switch"
- switch OFF all instruments, and master switch of instruments
- get out of cockpit
- extinguish fire

3.8.2 Fire during flight

- stop motor immediately
- switch OFF the "Power switch"
- open front ventilation if not already opened
- open canopy side window
- land as soon as possible (or bail out if appropriate)
- extinguish fire after landing

3.9 Other emergencies

3.9.1 Loss of 12V electrical power in flight

During soaring flight:

If electronic instruments (radio, flight computer, FCU etc) stop working, during soaring flight, than continue to fly as a pure sailplane. In such case you will not be able to start FES.

However in case that FCU still works, you can try to start motor if necessary.

During powered flight:

If FCU stop working during powered flight, than also motor stops working. However propeller would still rotate as windmill and it would not be possible to stop it. You will need to land with rotating propeller. In such case try to land on both landing gears simultaneously, to avoid damage of propeller.

If case that only some of the instruments would stop working during powered flight, but motor and FCU would till works fine, than you can continue to use motor.

4. Normal procedures

4.1 Introduction

This chapter provides checklists and explanations of procedures for conducting normal operating procedures. Normal procedures associated with optional equipment can be found in Chapter 9.

4.2 Rigging and de-rigging, charging, battery pack installation

4.2.1 Rigging and de-rigging of sailplane

Same as described in manual of pure sailplane.

Warning: *Make sure that connecting cable is not installed, between Battery packs (if they are fixed inside the fuselage)*

4.2.2 Charging the Battery packs

Detailed instructions about charging of Battery packs are described in separate **FES battery pack manual**.

Note: *It is recommended to charge Battery packs fully just a day or two before flight is planned. However plan charging so that there will be enough time for properly completed charging process!*

4.2.3 Installation of Battery packs into sailplane

Warning: *Make sure that both battery packs are fully charged before installation into sailplane. Both battery packs **must have** approximately the same voltage level of each cell (close to 4.16 V per cell). There should be less than 0,4V difference, between total voltage levels of each battery pack!*

1. Open cover
2. Check that Power switch (Key) is OFF
3. Check that FCU instrument and all other instruments (Flight computer, Flarm, Radio, Transponder, PDA...) are switched OFF
4. Check that BMS switch of each battery pack is OFF
5. Put one pack into the fuselage so that contacts are facing forward
6. Slide it back to rear position
7. Put another pack into the fuselage so that contacts are facing rearward
8. Place fixation plates
9. Tighten battery pack fixation knobs
10. Insert and secure temperature sensor connectors, to each battery pack
11. Insert RED (+ contact) pin on cable to front pack, and BLACK (– contact) pin on cable to rear pack power connectors
12. Close cover

4.3 Daily inspection

Please keep in mind the importance of the inspection after rigging the glider and respectively each day prior to the first take off. As a minimum check the following items. If any problems are found they must be corrected before flight.

- Check the sailplane as required for each type.
- Check the FES system visually especially propeller blades condition

4.4 Pre-flight inspection

- Check the sailplane itself as requested before a flight
- Perform short FES test run as described below

4.4.1 Motor starting on the ground

1. Remove propeller covers and a tail dolly
2. Open battery compartment cover
3. Check that Power switch is OFF
4. Insert connecting cable between the battery packs
5. Switch ON BMS switch of each battery pack
6. Seal battery compartment cover with glider tape
7. Seat into the glider, and close canopy
8. Check that no one is around propeller zone, in front of glider or in line of propeller
9. Switch on FCU instrument
10. Switch on Power switch
11. Wait about 8 second, for FCU to show all battery bottles
12. Start motor but use only low power to check proper operation

Caution*: In case that you would like to test, system at maximum power, somebody must hold a fuselage tube down, so that glider can not lift tail, which could result in damaged propeller blades.*

Warning*: Do not run the motor for longer time, on the ground, especially not at high power! When motor is stopped, also cooling is stopped, and so motor temperature can rise very quickly, which can lead to damaged motor!*

13. Check if propeller braking and automatic positioning are working fine
14. Switch OFF Power switch
15. Switch OFF FCU

4.5 Normal procedures and recommended speeds

As described for a pure sailplane, but have in mind that with installed FES your glider has higher wing loading, so you have to adjust speeds accordingly.

4.5.1 Aero tow launch

Before take-off, always switch ON the FCU instrument. Double check that "Power switch" is OFF before somebody approach front area of the glider in order to attach tow rope to the hook. All the time during tow, "Power switch" should be OFF!

Warning: *It is not allowed to start FES motor during aero tow!*

4.5.2 Winch launch

Before take-off, always switch ON the FCU instrument. Double check that "Power switch" is OFF before somebody approach front area of the glider in order to attach towing cable to the hook. All the time during winch launch, "Power switch" should be OFF!

Warning: *It is not allowed to start FES motor during winch launch! Towing rope must be always released before running FES motor.*

4.5.3 Auto tow launch

Before take-off, always switch ON the FCU instrument. Double check that "Power switch" is OFF before somebody approach front area of the glider in order to attach towing rope to the hook. During tow, "Power switch" should be OFF!

Warning: *It is not allowed to start FES motor during auto tow launch! Towing rope must be always released before running FES motor.*

4.5.4 Taxiing procedures

Warning: *Taxiing is **not allowed** when FES is installed as sustainer system!*

Your sailplane needs to be factory equipped with steerable tail wheel, and small wing tip wheels to be suitable for taxiing. Do not try to use tail dolly for taxiing!

For taxiing, use only concrete or good grass runways with short grass. Do not try to taxi if runway is with a holes, otherwise propeller blades can be damaged!

To start moving, use a little bit more power, but then decrease it quickly, so that you will not be taxiing too fast. Try not to use a wheel brake, or use it very carefully, to avoid damaging propeller!

4.5.5 Self-launch and climb

Warning: *Self-launch is not allowed when FES is installed as sustainer system!*

Before a self-launch be always prepared, what actions you will do in case of motor failure, during different stages of take-off. Take into account wind conditions, airfield altitude, length of runway, obstacles at the end of runway, outside temperature etc.

If runway is very short, with a lot of obstacles and without alternatives in case of motor failure, than simply do not fly there!

Caution: *Always avoid performing take-off with tail wind!*

Self-launch procedure:

1. Check that tail dolly and propeller covers are removed
2. Seat into the glider, fasten your seat belts and close the canopy
3. Check that airbrakes are closed, and trimmer set to proper position
4. Position flaps to proper position for take-off (depending on type of sailplane)
5. Check that ventilation is opened
6. Check that no one is around propeller zone, in front of sailplane or in line of propeller (call "clear prop")
7. Switch ON FCU instrument
8. Switch ON Power switch, and wait until all parameters become visible
9. Ask for take-off permission by radio, and wait for approval
10. Start motor with rotating throttle knob in clockwise direction to low RPM
11. Gently rotate throttle knob clockwise to maximum power
12. Accelerate, adjust flaps position and gently lift off at suitable speed
13. When safe altitude is reached, reduce power and continue with climbing
14. Retract landing gear

During Self-Launching, pay attention to any other traffic in the circuit – which may not be familiar with electric self-launching sailplanes (and may not expect your aircraft to launch unassisted)

4.5.6 Free flight

As described for a pure sailplane, but have in mind that with installed FES your glider has higher wing loading, so adjust speeds accordingly. FCU instrument should be always ON during soaring flight.

4.5.7 Low speed flight and stalling behavior

As described for a pure sailplane, but have in mind that with FES, your glider has about 5kg/m2 higher wing loading, and as result of that minimum speed is higher.

4.5.8 Cruise and climbing with running motor

FES can be used for long continuous cruise at low power settings, or climbing at higher power settings!

Caution: *During motor operation, ventilation must be fully opened (depends on type of sailplane; usually ventilation lever must be pushed fully forward).*

Warning: *I case that you forget to open ventilation; warning message "Check ventilation" will appear on the FCU screen. FCU monitors temperature rise gradient, and when gradient is more than usual with opened ventilation such message will appear!*

Motor starting procedure during flight:

1. Check that all values on the FCU instrument are in normal range (FCU must be always switched ON during flight)
2. Turn ON Power Switch
3. Check if there is green LED ON (left lower LED), check Voltage level
(If there is no green LED or red LED is blinking motor will not run). Read FES FCU instrument manual for detailed FCU description
4. Start motor with Throttle knob rotating in clockwise direction gently.

Use about 4kW of power for horizontal flight, and more for climbing. Maximum climb rate depends on glider type and it is affected by its weight, speed, flaps position etc.

Available maximum power is reducing slowly due to voltage drop, during discharging of battery packs. Maximum power can be used only until any of temperature values reach yellow warning. (motor and controller at 70 deg, battery packs at 45 deg)!

Note: *You can reduce power in thermals, and use more power in sinking air*

Do not use high current at lower voltages; this mean below 95V.

Always try to fly as much as possible on lower power settings where efficiency of complete system is the highest!

During powered flight always keep the FCU turned ON. Switch OFF Power switch if motor is not running.

4.5.8.1 Propeller stop with electronic braking

To stop propeller with electronic braking, you need to rotate Throttle knob in counter-clockwise direction for 1 step, from zero throttle, so that throttle line on display starts blinking red!

Note: *For successful stop the motor should reach about 1500 RPM, otherwise braking will not work, due to* ***insufficient induced voltage*** *(regeneration function of controller is used for propeller braking).*

In the air there is nearly always enough RPM. But if you want to test electronic braking on the ground, make sure you set at least 1500 RPM, and then rotate throttle knob quickly in counter clockwise direction!

4.5.8.2 Propeller positioning

1. FES installations **without** automatic positioning:

If propeller stops in such position that pilot can see one of the blades trough the canopy, just start motor again to about 1500 RPM and then stop it again. Repeat this procedure until blades are randomly positioned in suitable position!

2. FES installations **with automatic positioning**:

If your system is equipped with automatic positioning of blades, the electronics will rotate them in horizontal position.
After electronic braking stops motor, wait for 2-3 second, until RPM data shows zero RPM. After that automatic positioning will start! You can always stop automatic positioning by pressing throttle knob.

Note: *Positioning does not work if Canopy message is active, or if throttle is set to zero power instead of braking!*

In settings it is possible to adjust:
-time between steps from 50ms to 1 sec
-power used for positioning at 115V and at 90V
-number of steps after hall sensor for position is detected

4.5.9 Approach

As pure glider, but have in mind that with installed FES your glider have higher wing loading, so increase landing speed for 5 to 10km/h.
Check that propeller blades are parked in horizontal position and "Power switch" is switched OFF.

4.5.10 Landing

As pure glider, but have in mind that with installed FES your glider have higher wing loading, so increase landing speed for 5 to 10km/h.
Land always with propeller blades in horizontal position, or propeller blades might be damaged during landing, or during opening of the canopy.

4.5.10.1 After Landing

Caution: *Always remove connecting cable between the packs after landing. (At older packs with external BMS: Always remove Power fuse after landing and put safety covers on free terminals.)*

Warning: *Make sure that "Power switch" is OFF before removing connecting cable; (or Power fuse)*

If motor was used during flight, take out both batteries and recharge them according detailed charging instructions in FES Battery pack manual.

4.5.10.2 Taking Battery packs out of sailplane

1. Check that Power switch (Key) is OFF
2. Check that FCU instrument and all other instruments (Flight computer, Flarm, Radio, Transponder, PDA...) are switched OFF
3. Open cover
4. Take out connecting cable between the packs
5. Take out RED + and BLACK - power connectors
6. Fix supply cables to the side of battery compartment box
7. Remove both temperature sensor connectors, from each battery pack
8. Fix temperature sensor cable to the side of battery compartment box
9. Un-tighten battery pack fixation knobs
10. Take the fixation plate out
11. Firmly grip the front battery by a carrier strap
12. Lift it out of the fuselage and put it on safe place
13. Firmly grip the rear battery by a carrier strap and slide it forward along the bottom of the battery compartment
14. Lift the Battery pack out of the fuselage and put it on safe place
15. Close cover

Caution: *Make sure you put battery packs on a dry and safe place. Read FES Battery pack manual for further instructions*

4.5.11 Flight with water ballast

As described for a pure sailplane.

If you want to achieve maximum climb rate performance or range under power, then drop water ballast.

4.5.12 High altitude flight

As described for a pure sailplane.
Check also chapter 5.3.4.3 Maximum operational altitude.

4.5.13 Flight in rain

Always avoid flying trough heavy rain and thunderstorms. It is recommended to close ventilation, to prevent entering water into the spinner. Before flight seal battery compartment with a glider tape, to prevent water entering.

Warning: *Avoid flying close to lightning activity!*

It is allowed to fly trough light rain, with running motor if necessary. However use only lower RPM settings, suitable for horizontal flight, to avoid damaging propeller blades. Stop motor if rain becomes stronger.

4.5.14 Aerobatics

Aerobatic maneuvers are in general not allowed with a FES equipped sailplanes, if is not specifically allowed for a certain FES equipped type!

5. Performance

5.1 Introduction

This Chapter provides data for airspeed calibration, stall speeds and take-off performance and some further information. The data in the charts have been computed from actual flight tests with the sailplane in good condition and using average piloting techniques.

5.2 Approved data

5.2.1 Airspeed indicator system calibration

The airspeed indicator is to be connected to the pitot source from the fuselage vertical stabilizer and static source (detailed location of ports depend on specific glider type).

5.2.2 Stall speeds

As pure glider, but have in mind that with FES installed your glider has higher wing loading, so stall speeds are higher.

5.2.3 Take-off performance (only for self-launch approved types of sailplanes)

During aero tow, winch launch, or auto tow take-offs is like at pure glider, but due to additional weight of FES, sailplane has slightly higher wing loading, so lift off must be performed at higher speed.

During self-launch, take off run distance and climb performance are greatly dependable on sailplane take-off weigh, its glide performance, quality of runway, air density (airfield elevation, and outside temperature).

Important factor is also the temperature of Battery packs. If they are very cold they will not provide the same power as at normal temperatures.

Warning: *Do not try to self-launch if temperature of the Battery packs is below 5 degrees Celsius!*

Note: *To avoid such situation, store the Battery packs at normal room temperature during the night (not in a glider outside or in a trailer) and then install them to the glider just before self-launch.*

Caution: *Always take care, that propeller blades are cleaned, before self-launch, as bugs reduce propeller efficiency, and thrust, so take-off run is longer, and climb rate reduced!*

5.2.4 Additional information

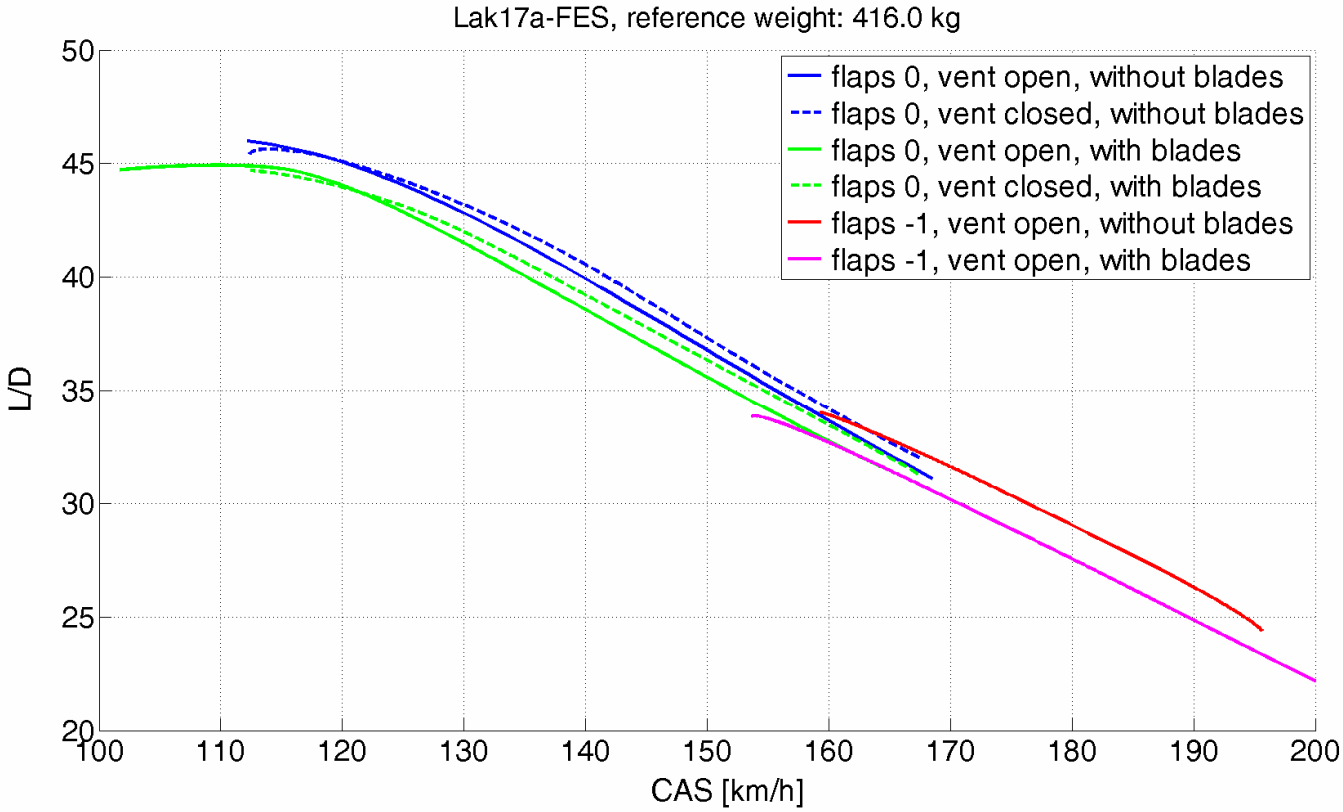
5.3 Non-approved further information

5.3.1 Demonstrated crosswind performance

FES equipped sailplane have the same crosswind performance as a pure sailplane.

5.3.2 Glide performance

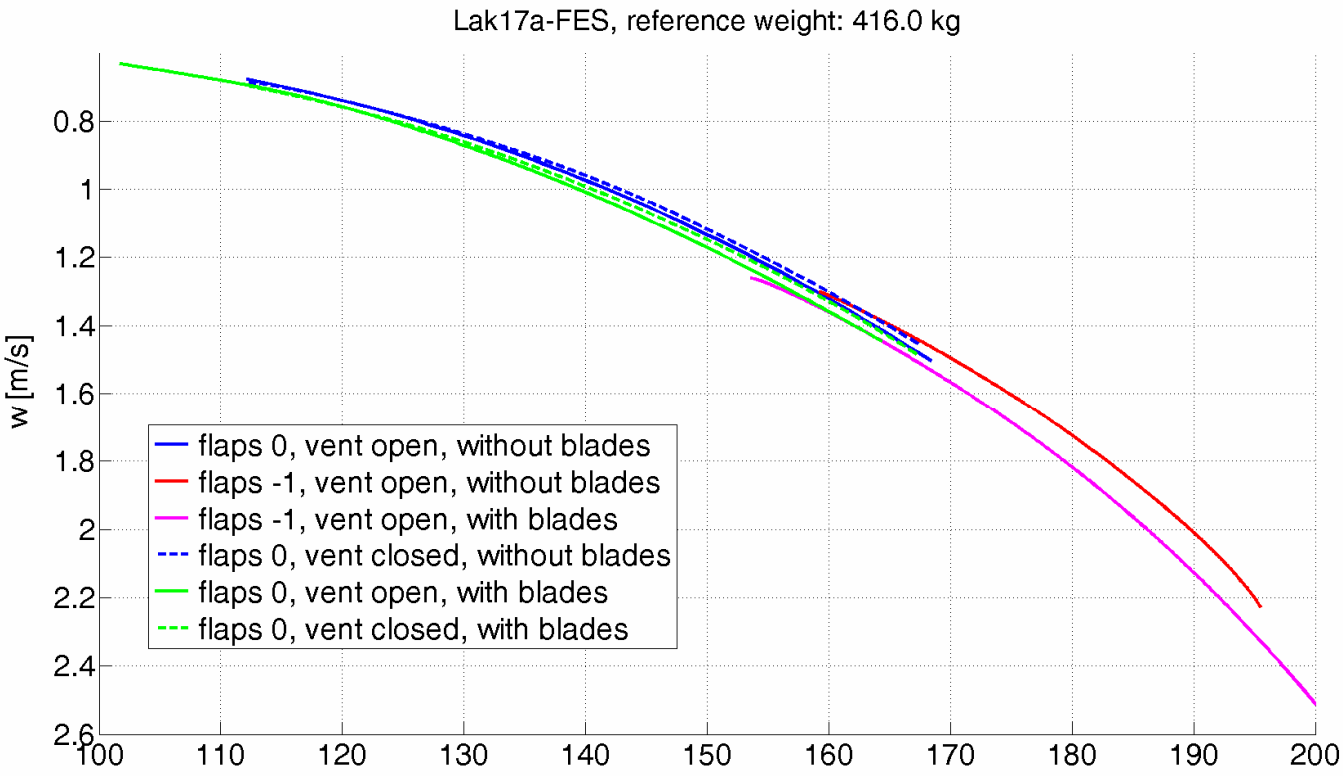
Idaflieg flight comparison measurements results (LAK17A FES, August 2012), showed only minor effect of propeller blades to glide performance which is only about 1 L/D point in entire speed range.



As you can see from the graph above, even cockpit ventilation has some effect on flight polar (about 0,5 L/D point).

5.3.3 Flight polar

FES equipped sailplane has about 4-5kg/m2 higher minimum wing loading, compared to about 45kg lighter pure glider. This has the same effect on flight polar as adding water ballast (moving polar to the right). So best L/D is at about 5km/h higher speed, and minimum sink rate is also at about 5km/h higher speed, compared to pure glider.



Graph above shows flight polar of LAK17A FES in 18m configuration, at 416kg take-off weight (without water ballast, but with about 20kg of measurement equipment!).

5.3.4 Powered flight performance

5.3.4.1 Rate of climb

Maximum rate of climb is available only for a few minutes with fully charged Battery packs. As voltage is reduced, than also maximum a rate of climb is reduced.

Average rate of climb depends on many factors but mostly on type of sailplane and its take-off weight.

Maximum altitude gain that can be reached at a standard atmosphere conditions is greatly dependable on type of sailplane, its weight and aerodynamic qualities. To achieve maximum altitude gain you should use about 15kW of power (not full power, as total efficiency is better at lower power settings. Usually suitable climbing speed it is about 80-85 km/h at positive flap position (as used in thermals). Here are rough numbers:

- 1600 m (5200 ft) for UL sailplanes at 300kg take off weight; Silent 2 Electro
- 1400 m (4500 ft) for the 18m class sailplanes at 400kg take off weight (without water ballast); LAK17A FES

- 1200 m (3900 ft) for the 18m class sailplanes at 450kg take off weight (without water ballast); LAK17B FES, Ventus 2cxa FES, Discus 2c FES, HPH 304ES

Caution: *Always take care that propeller blades are cleaned. Unclean leading edge reduces propeller efficiency, and climb rate.*

5.3.4.2 Cruising flight

The maximum range of powered cruising flight, without water ballast is about 100km (62 miles), depending on lift-sink conditions.

The optimum cruising speed and flap position depends on type of sailplane. Usually it is about 90 km/h (48 kts) at around 3000-3300 RPM and 4kW of power, at positive (as used in thermals) position of flaps.

5.3.4.3 Maximum operational altitude

There should be no problem to fly with FES equipped sailplane on high altitudes, due to low pressure. According UN transport regulations such cells which are used in FES battery packs had to pass 8 different tests. First test is altitude simulation where cells were tested at reduced pressure of 11.6kPa which is equivalent of about 15.000m.

Cold outside temperatures down to -20 °C do not represent a safety issue for Battery packs (as they usually stay much warmer), or for other components of FES system. However if Battery packs have very low temperature their performance is reduced, but it is unlikely that you will need to use FES at high altitude.

5.3.5 Noise data

Measurements of noise level of motor are lower than levels of noise compared to sailplanes equipped with combustion engines.
Measurement was performed for certification purposes of Silent 2 Electro, where noise level was measured to be 57 db, according requirements.

For sustainers there are no requirements regarding maximal noise level.

Regarding ENL (Engine Noise Level) signal for Flight recorder:

It should be emphasized that for the ENL signal to be significant when the FES is running, the Flight Recorder must be mounted in the instrument panel or equally close to the FES unit. Mounting of the FR elsewhere in the cockpit will require a separate MOP sensor in the same way as for other quiet electric engines.
Annex B to the IGC Sporting Code refers.

5.3.6 Electromagnetic interferences

Good construction of motor does not leak magnetic field outside of its housing. With high power cables going below instrument panel, we did not find any strange behavior of any instruments (including magnetic compass) during motor run or stop.

6. Weight and balance

6.1 Introduction

At each FES equipped sailplane, positioning of FES elements should be arranged in such a way, that C.G. position remains in nearly the same range as at pure sailplane.

6.2 Weight and Balance Record and permitted payload-range

As it is valid for a pure version or powered version of specific sailplane type.

6.3 Weight of all non-lifting parts

Weight of non-lifting parts of the sailplane includes weight of pilot, fuselage with rudder, horizontal stabilizer with elevator, instruments and equipment and weight of FES installation (everything except wings).

Maximum weight of non-lifting parts for specific type of sailplane is set by manufacturer.

6.4 Maximum weight

The maximum approved take-off and landing weight is set by sailplane manufacturer.

Warning: *Do not use full amount of water ballast as there is already about 45kg of additional weight due to FES system installation.*
Adjust maximum amount of water ballast, so that you will not fly above allowed maximum take-off weight, otherwise you can overload your sailplane, resulting in structural damage of airframe.

7. General sailplane and systems description

7.1 Introduction

This Chapter provides a description of the sailplane, its systems and provided standard equipment with instructions for use.

7.2 Cockpit controls

Apart from standard controls of pure sailplane, FES equipped sailplane, has only additional Power switch, located on right side of cockpit (toggle switch with cover), or on instrument panel console (key switch), depending on type of sailplane.

7.3 Instrument panel

Apart from other instruments located on instrument panel, FES equipped sailplane, has only additional FCU instrument, which should be located on easily accessible location on left side of panel. Most suitable location is dependable on specific glider type and other installed instruments.

Detailed description of FCU can be found in separate **FCU instrument manual.**

7.4 Landing gear system

As written in flight manual of pure sailplane!

7.5 Seats and safety harness

As written in flight manual of pure sailplane!

7.6 Pitot and static system

The airspeed indicator is to be connected to the pitot source from the fuselage vertical stabilizer and static source from the aft fuselage part (detailed location of ports depend on specific glider type).

At FES equipped sailplane, pitot source can not be located on the fuselage nose!

Note: *Consult with sailplane manufacturer, regarding optimal configuration of pneumatic sources for specific FES equipped type of sailplane.*
For more info about measuring probes visit www.esa-systems.com.

Total energy compensation source is normally from the fuselage vertical stabilizer, below pitot source.

When FES is installed into used sailplane and there is only one tube available (for total energy compensation but not for pitot), than this tube is taken for pitot source. In such case, electronic compensation can be used.

7.7 Air brakes system

As written in flight manual of pure sailplane!

7.8 Baggage Compartment

As written in flight manual of pure sailplane.

Warning: *If you are heavier pilot, than weigh of non lifting parts on a FES equipped sailplane are already close to the approved limit of manufacturer, especially if you are using also tail water ballast.* ***So heavy pilots should avoid using any additional weight in baggage compartment!***

7.9 Water ballast system

As written in flight manual of pure sailplane.

Caution: *When filling water ballast into wings, make sure, the cover for battery compartment is closed!*

7.10 Power plant

Detailed description of FES power plant can be found in separate **FES maintenance manual,** where are also listed other manuals for specific type of FES equipped sailplane.

7.11 Battery packs

Detailed description of FES Battery packs can be found in separate **FES Battery packs manual.**

7.12 Electrical system

Detailed description of FES electrical system can be found in **FES maintenance manual**

7.13 Miscellaneous equipment

Detailed description of FES BMS (Battery management system), FES Battery pack charger and BMS Control software can be found in separate **FES Battery packs manual.**

8. Sailplane handling, care and maintenance

8.1 Introduction

This chapter contains the manufacturer's recommended procedures for proper handling and servicing of the sailplane with FES. It also identifies certain inspection and maintenance activities, which are needed to retain performance and dependability.

8.2 FES inspection periods

The Instructions for Continued Airworthiness as provided in the **FES Maintenance manual** must be followed.

8.3 Sailplane alterations or repairs

As described in manual for pure sailplane version.

8.4 Tie down

Do not leave FES equipped sailplane outside on the rain, unless is covered with high quality all weather covers.

Protect motor and battery compartment from water entering. Take Battery packs out of the glider and store them on dry place!

8.5 Sailplane trailer

A sailplane with FES should be transported and stored in a high quality enclosed trailer constructed of metal or fiber glass reinforced plastics with a proper insulation, and ventilation characteristics.

- For **lighter fuselages** forward and jumping motion of the fuselage restriction could be arranged with a nose cone support in shape of spinner with a big enough recess for propeller blades in horizontal position, covered with a soft thick material.

- For **heavier fuselages** is recomended that support which holds fuselage is aranged behind a spinner, otherwise load on motor and propeller blades could be to high.

It is recomended to use soft cotton canopy cover which goes also around spinner nose of sailplane, which than also prevent opening of propeller blades.

If canopy cover is not used than propeller blades should have fitted a cover with elastic, which also prevent opening propeller blades!

The fuselage should be supported in a fuselage dolly positioned just forward of the main landing wheel opening. Forward stop must be provided for the fuselage dolly Otherwise it will roll forward and leave the fuselage with no support.

8.6 Ground handling

On the ground propeller blades should be protected with a special blade protection covers, which prevents propeller blades from opening. Do not forget to remove propeller covers before flight!

Caution: *Make sure that propeller is in horizontal position when lifting rear part of fuselage to attach tail dolly.*

Warning: *Newer use a propeller or spinner for pushing, pulling or tail lifting!*

8.7 Cleaning and care

Avoid cleaning with water around area of FES motor, and battery compartment. Spinner and propeller blades should be cleaned with a wet sponge or soft cotton towel. Tape adhesives are best removed using pure petroleum spirits or nitro thinner.

9. Supplements

There are no supplements

10. Revision history

April 2013	Initial release of manual v1.0
October 2013	Minor updates, v1.1
February 2014	Minor updates, v1.11
June 2015	Minor updates, v1.12
February 2016	Minor updates, v1.13
September 2016	Minor updates, v1.14
November 2016	New three view drawings, v1.15