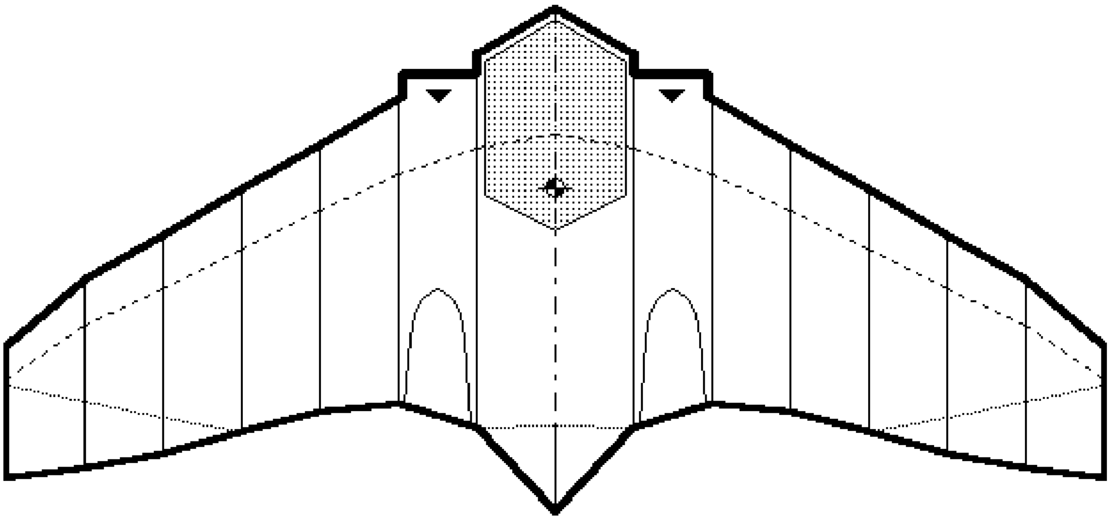
Aircraft Operating and Flight Manual



Experimental Flying Wing ScV13e

(X-Plane™ Simulation)

Designer, Author, and Pilot: Dipl. Ing.(FH), Kapt.(AG) Wolf Scheuermann

Forschungskontor für angewandte Mathematik

Hamburg, Germany

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Certificates and Approvals

Note:
The version 1.0 of this manual contains aircraft and performance data as calculated and simulated in X-Planes™. The data are to be verified with the real thing.

General Description

Aircraft Designator:
Flying Wing ScV13e.
Version 13 of the Scheuermann flying wing design, electric propulsion.

Design:
The slow flying aircraft ScV13e is a short range ultra-light tailless single seat flying wing of non-expensive wood and fabric design. Designer is Dipl. Ing (FH) Kapt. (AG) Wolf Scheuermann from Hamburg, Germany.

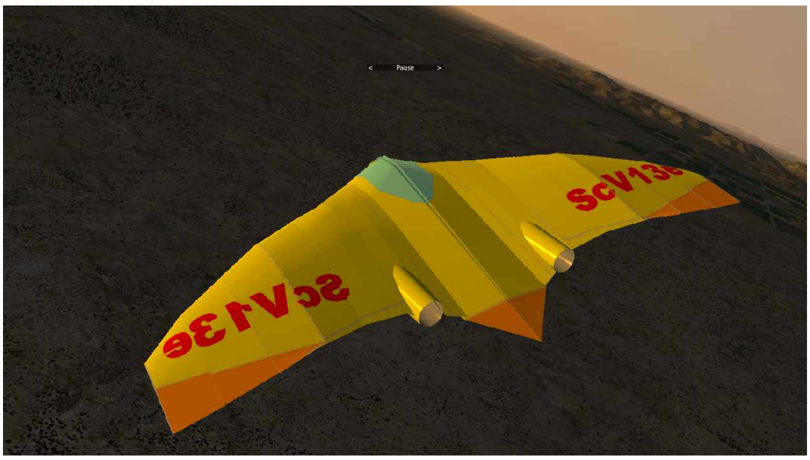
Wing:
This lightweight plane comprises a large swept wing of stubby aspect ratio with a multifunctional flap. The flap is aileron, elevator, and lifting device in one. The center tail of the wing root is split and acts separately activated as a rudder.

Airfoil:
The thick zero moment airfoils have a large camber. The root airfoil is belly-shaped. It has the function of a fuselage.

Engine:
The internal twin engines consist of normal powered electrical motors of high power to weight ratio. The electric energy is stored in NiMh batteries or other modern state of the art batteries.

Propeller:
The propellers are two 4-bladed impeller metal or wooden fixed props.

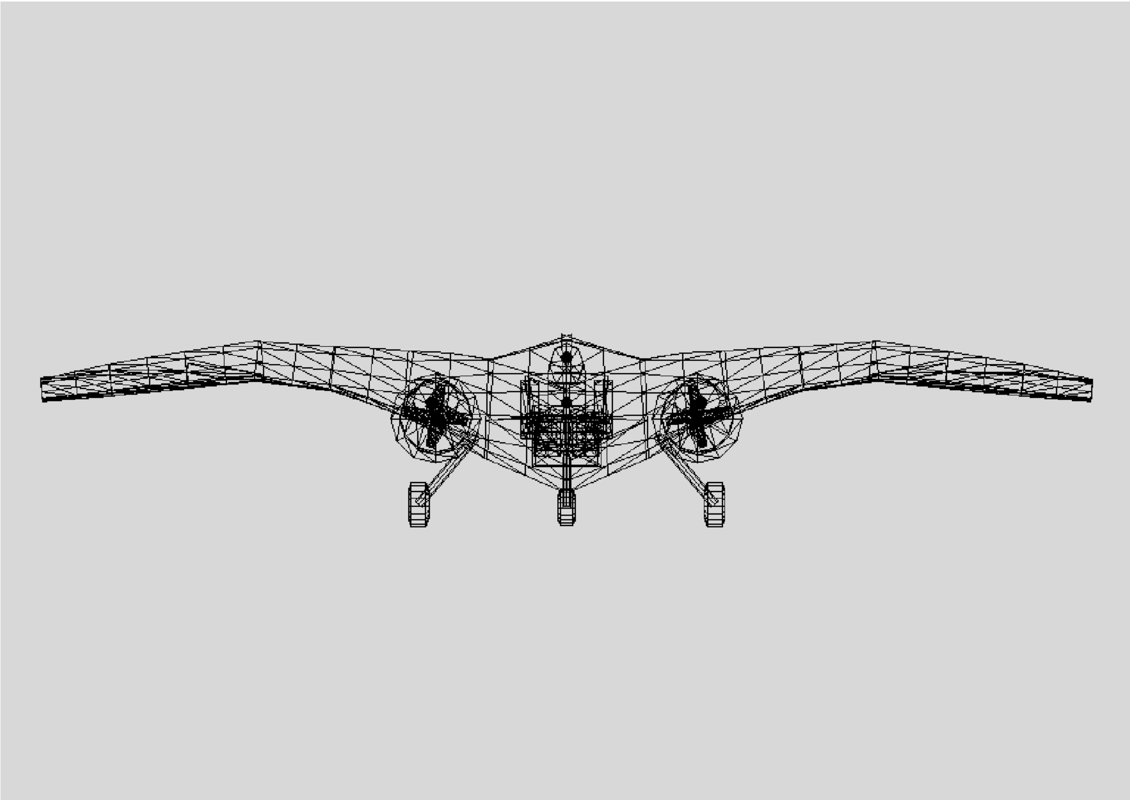
Landing Gear:
The landing gear is retractable.

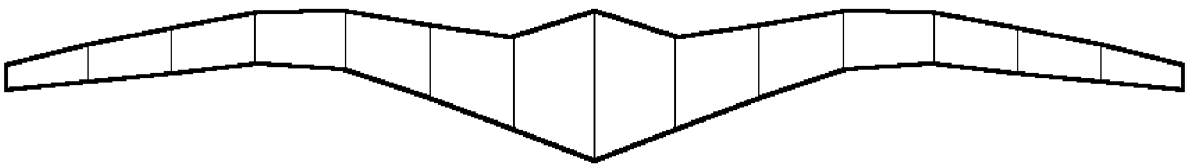


Three View

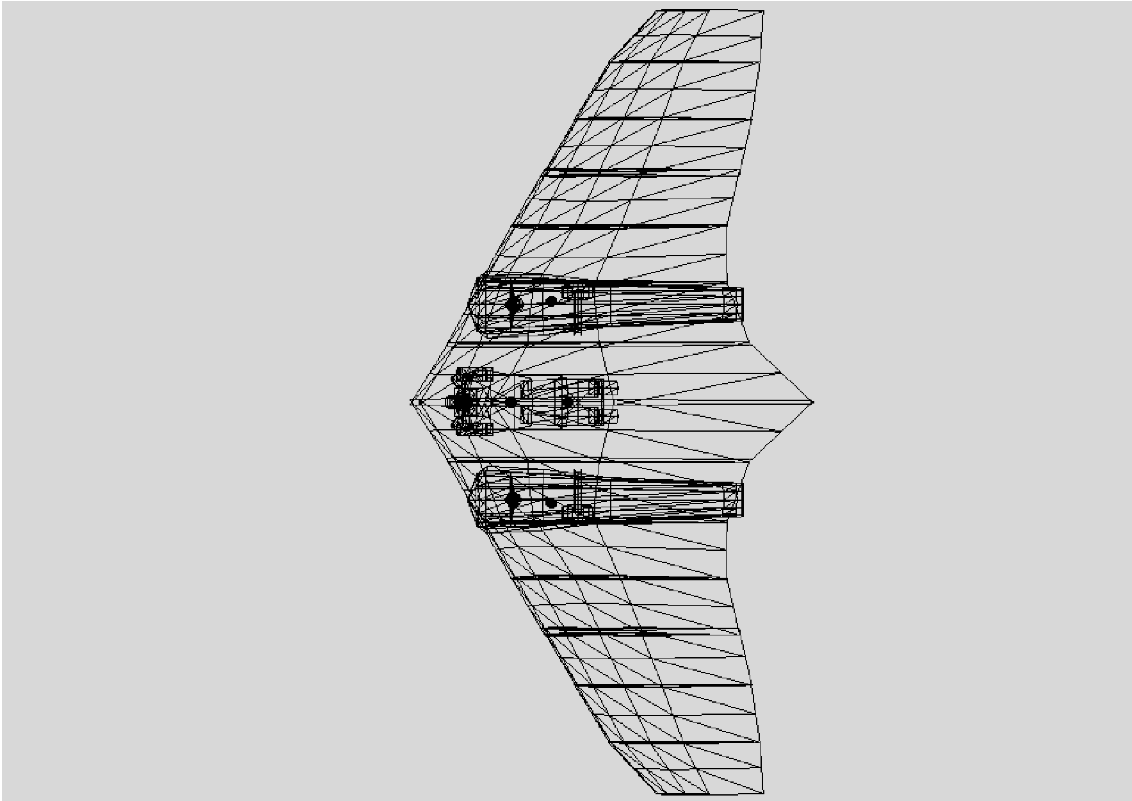
Flying Wing ScV13e

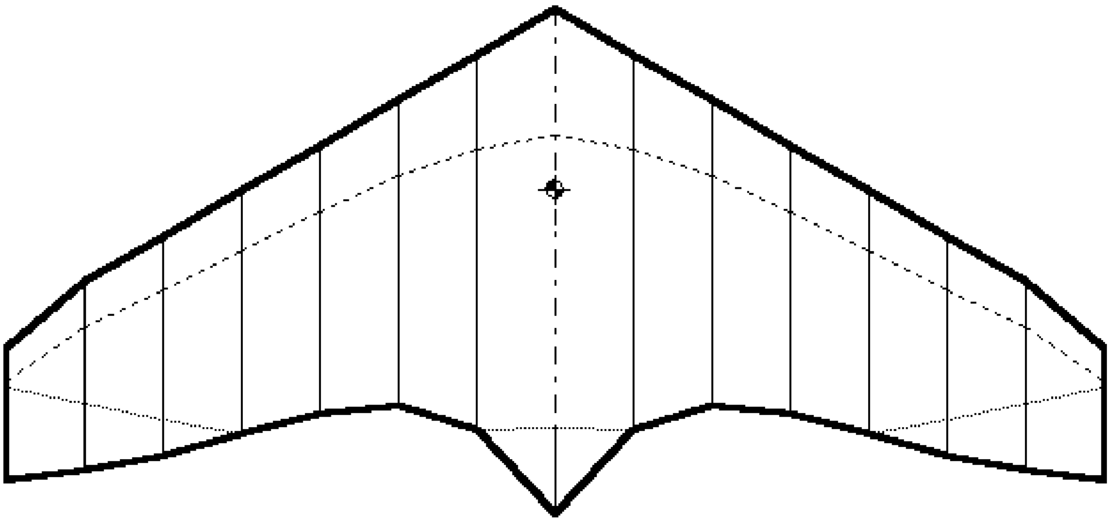
Front View



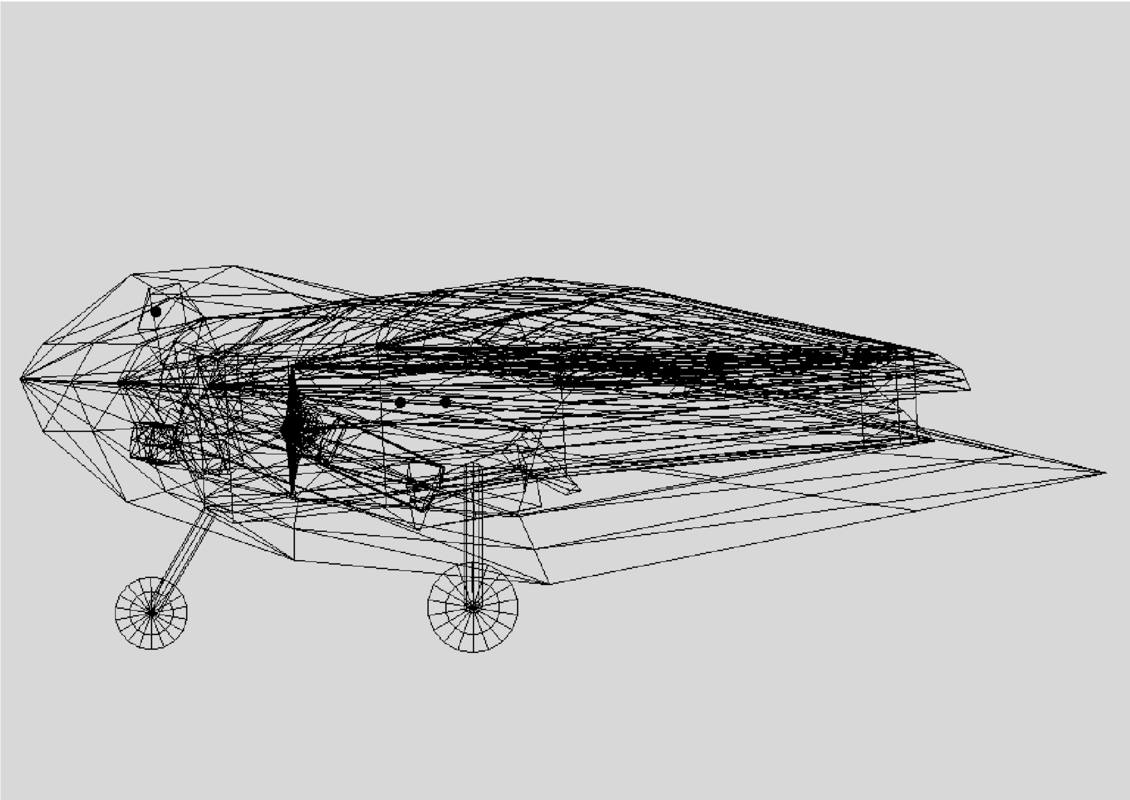


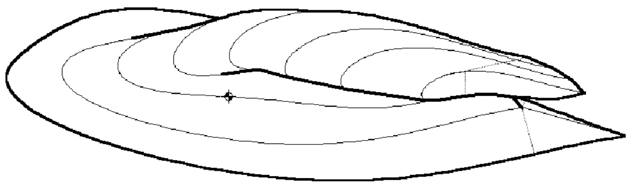
Top View





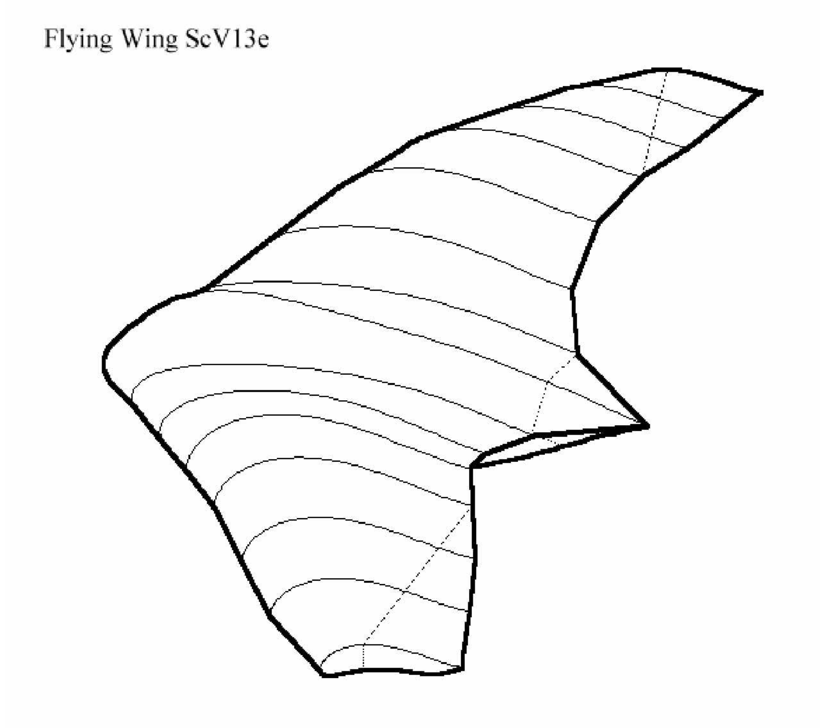
Side View



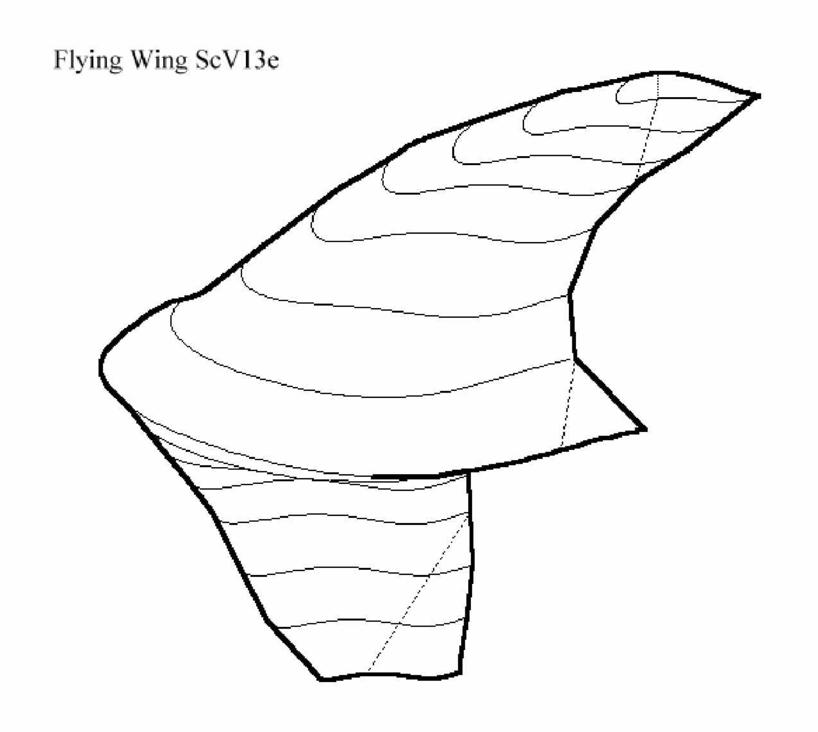


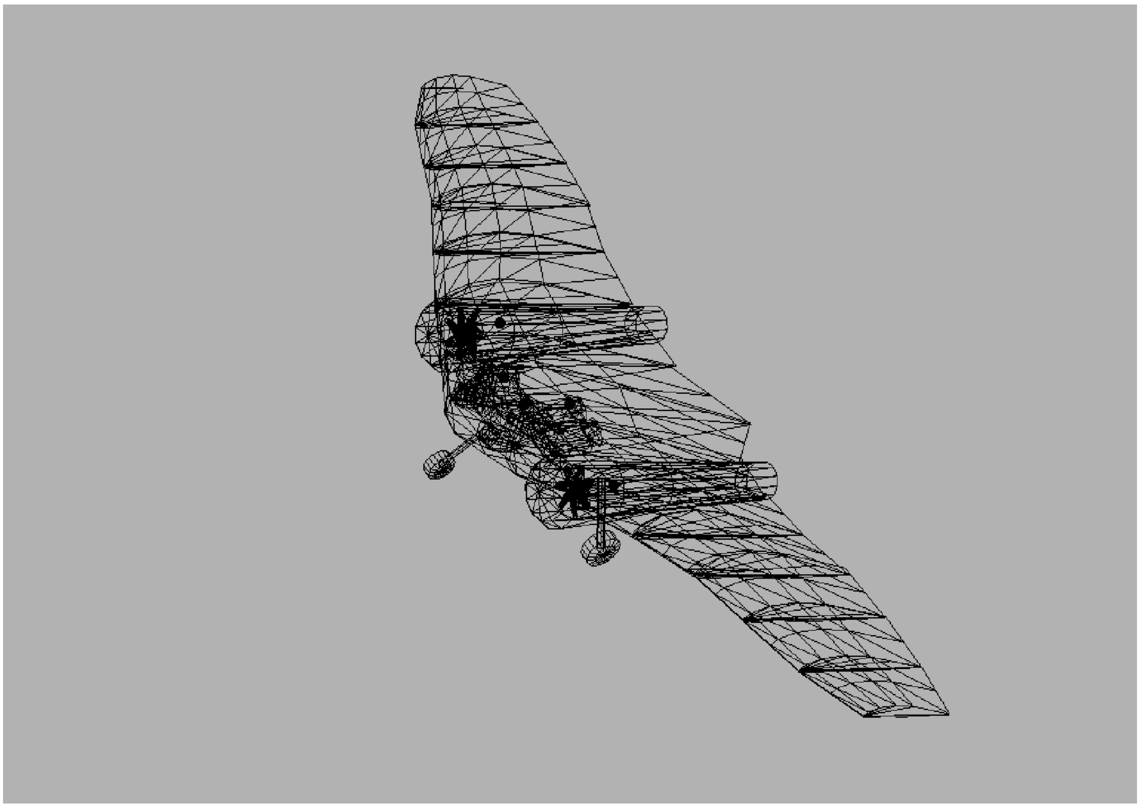
Perspective Views

Top View



Bottom View






2:22.17
RECORD MOVIE FROM REPLAY

History

Design Concept:
Designer's statement: I wanted to learn more about aerodynamics, aircraft design, and flying.

I wanted to create an original aircraft design that is simple, stable, and safe, easy to build with everywhere available material and affordable because there is no cheap aircraft around just for fun flights with a little comfort. The aircraft should be comparable to a little town car, mainly used for short distances but able to go on tour now and than. I want to fly within the limits of my budget.

The aircraft should be easy to fly with good mannered slow flight characteristics but high maximum speed. The design should be tolerant against average craftsmanship. It will be no aerobatic aircraft but able for extreme slow flight with maximum T/O weight and maximum Range. It should comprise space for one or two persons and baggage. To not disturb the aerodynamics the aircraft will have an internal propulsion system, preferable an electrical engine.

I used the following

Design Principle:
It has to be a pure and simple slow flying single seat Flying Wing with jet or rocket or impeller or other internal propulsion.

This reduces the possible solutions.

Therefore:

1) All functions of a plane for the desired mission have to be fulfilled by the wing.
2) I use optimized zero moment airfoils to reduce the moment induced drag and make the stabilization around the abeam axis easier.
3) It is a single flap plane. The flap, slot-free located at the trailing edge of each wing tips, has the functions of ailerons, elevators, and trims flaps.
4) The straight leading edge has mainly 30° sweep, to get the CG forward and get a lever for the flaps. So my design gets the directions ahead and aft.

5) The trailing edge is curved to give the wing an optimal elliptic lift distribution and reduce the induced drag to its minimum. This allows slow flight with the lowest glide angle.
6) The cord length has its maximum at the wing root. It is continuously decreasing towards the wing tip and is coordinated with the incidence angle of the airfoils.
7) The use of a special root airfoil (with a belly) gives an aerodynamic twist between root and wing tip, reduces the necessary geometric twist, and determines aerodynamically the upper and lower side of the wing. So I get stability around the axis abeam.
8) To get stability around the longitudinal axis the inner wing has a positive dihedral.
9) To reduce the dutch roll effect during turns and increase the stability around the vertical axis the outer wing has a negative dihedral. So the wing looks like a seagull wing. Because the wing is now no longer plane but has a vertical extension it enhances also directional stability.

The plane looks like a bird but only because birds know the design principle and its solution (at least the biological evolution does). The plane exists at the moment only in models and computer simulations, but I plan to build the real thing when I have the time and the money. I want to encourage everybody who wants to build it to do so! I only want to fly it some day, slowly and just for fun - that's the main design goal. The design may also be used for UAVs.

The ultralight flying wing ScV13e (it is the 13th design version already) has a span of 22 ft, a max take off mass of 730 lbs and needs a take off thrust of 130 lbs to get a speed range from 35 kt to 140 kt in level flight. The pilot is placed in a prone position.

The shape of the flying wing is entirely mathematically determined. One may see it as a lifting body with the wings of a flying wing. The used airfoils and the shape of the flying wing are my registered designs.

The Flying Wing ScV13e is unique and I own the rights of the registered design (Bundesrepublik Deutschland Gebrauchsmuster Nr. 20 2005 020 011.5).
Also I own the rights of the registered design of the unique airfoils for the flying wing (Bundesrepublik Deutschland Gebrauchsmuster Nr. 20 2005 018 086.6).

Test Flight

I will build and test fly the aircraft by myself.

The taxi tests and test flights will take place in early morning hours at best weather conditions with no wind on dry lake beds. On such lakes like Roach-Lake in California, just south of the Nevada-California border south of Las Vegas.

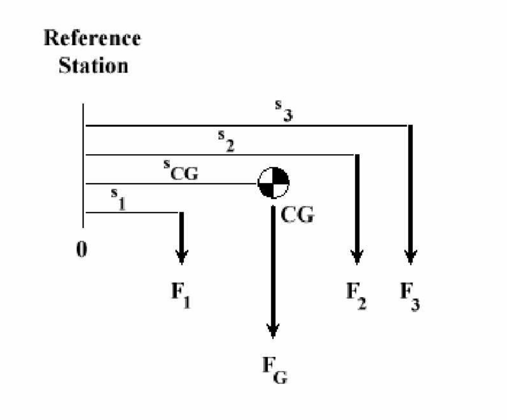
First, I must get approval for the ScV13e as experimental aircraft by the FAA. Also permission of the county authorities must be granted before any flight might take place.

Taxi test and test of the ground steering may take place before the approval of the FAA. Don't forget to ask the county sheriff in any case first!

Before any test intensive weighing of all parts of the aircraft and measuring of the location of the longitudinal center of gravity shall take place.

Weighing Procedure

Under every wheel put a cheap person scale of the same type. Take the readings and calculate the following:



- Measure the forces $F_1,\ldots,F_3$ with similar scales.
- Measure the horizontal distances $s_1,\ldots,s_3$ from the Reference Station.

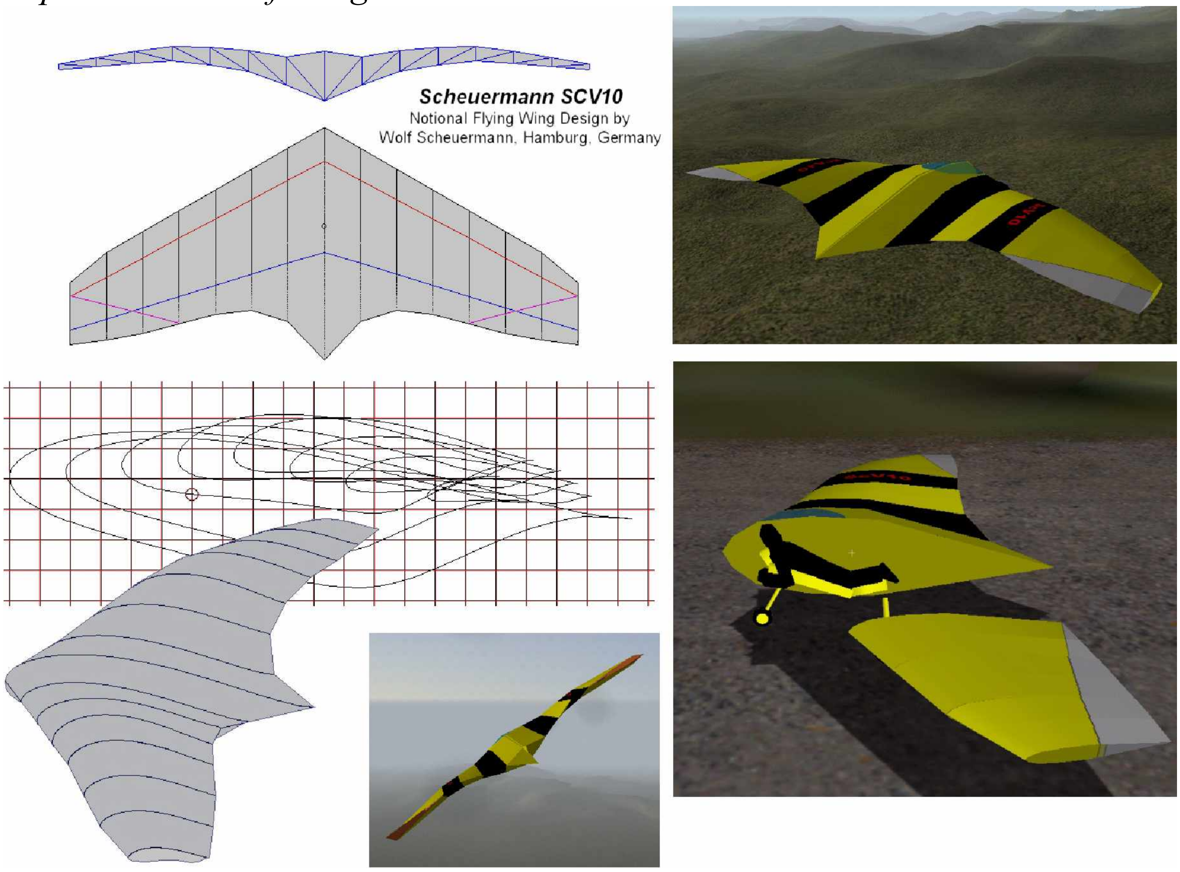
Sum of Forces: $$F_G = \sum_{i=1}^{3} F_i = F_1 + F_2 + F_3$$

Sum of Moments: $$M_{CG} = s_{CG} \cdot F_G = \sum_{i=1}^{3} s_i \cdot F_i = s_1 \cdot F_1 + s_2 \cdot F_2 + s_3 \cdot F_3$$

Calculate the horizontal location of the Center of Gravity:

$$s_{CG} = \frac{M_{CG}}{F_G}$$

Predecessor design ScV10 published on Dan Raymers aircraft design page:
http://www.aircraftdesign.com/



Technical Data

Flying Wing ScV13e

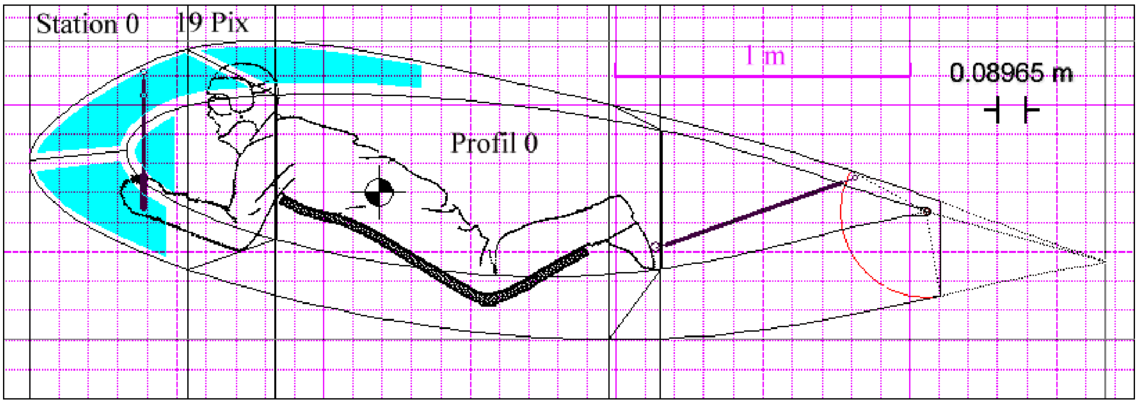
WING
Geometry

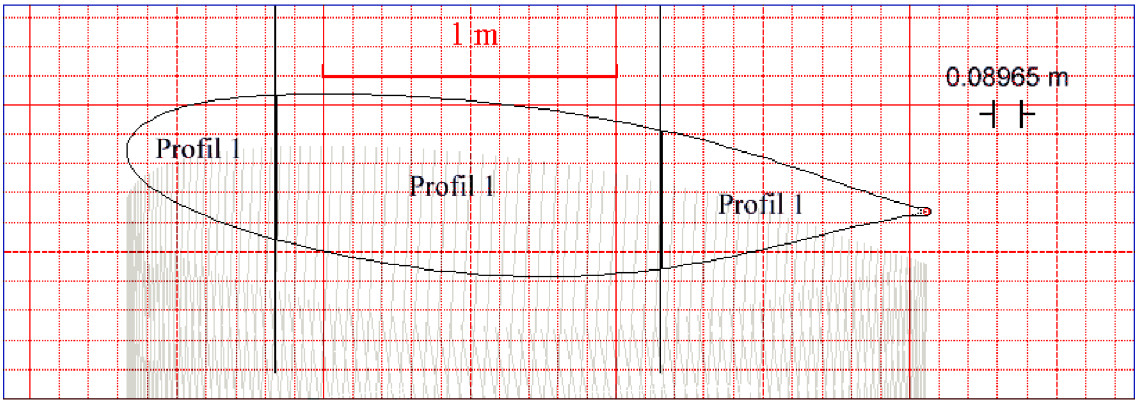
y	x	t	Sweep	Airfoil	Sehnen-	Dihedral-	Pfeilwinkel
0.00	0.000	3.671	30°	ScCanopy2	2.5°	2°	23°
0.57	0.329	2.725	30°	ScCenter2	4.0°	2°	23°
1.14	0.658	2.223	30°	Straak	-0.2°	2°	23°
1.71	0.987	1.949	30°	Sc718	0.5°	2°	23°
2.28	1.317	1.767	30°	Straak	-0.35°	2°	23°
2.85	1.645	1.596	30°	Straak	-0.4°	-6°	23°
3.42	1.975	1.368	30°	Straak	-0.5°	-6°	23°
3.99	2.453	0.969	40°	Sc715	-1.0°	-6°	30°

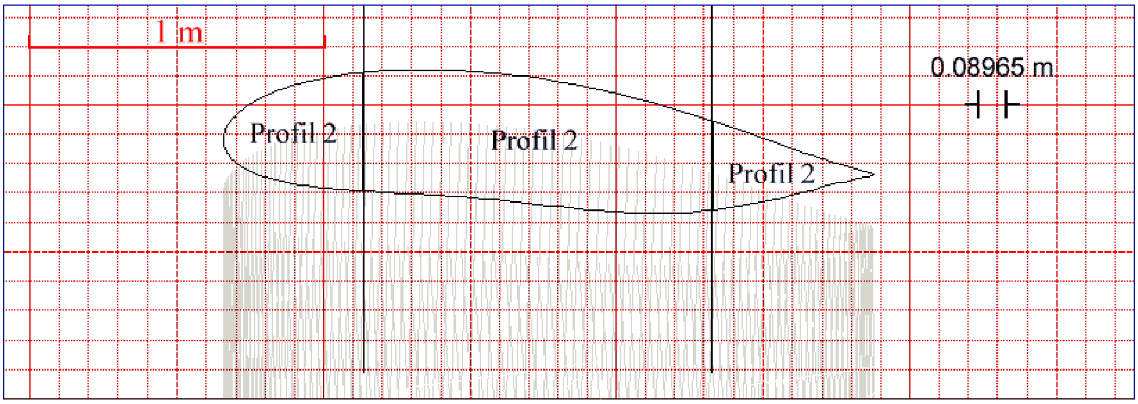
Wingspan 7.98 m
Wing Area 15.90 m²

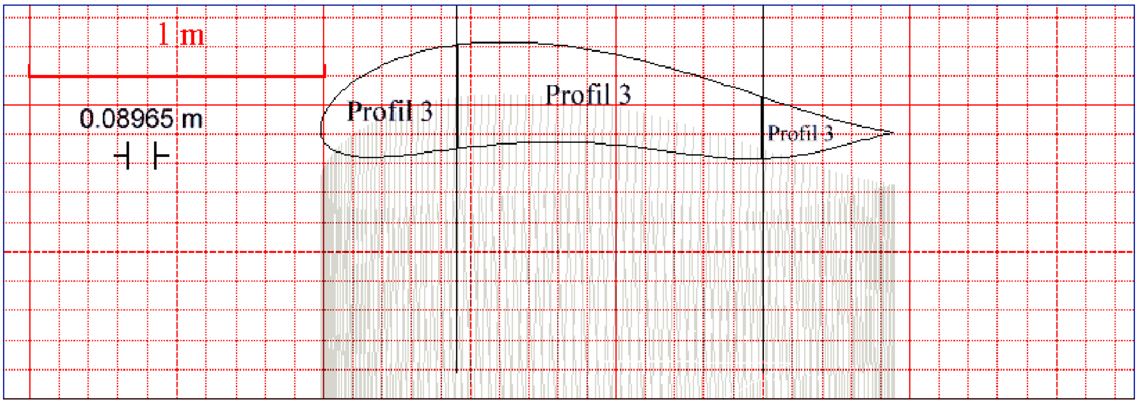
SECTIONS

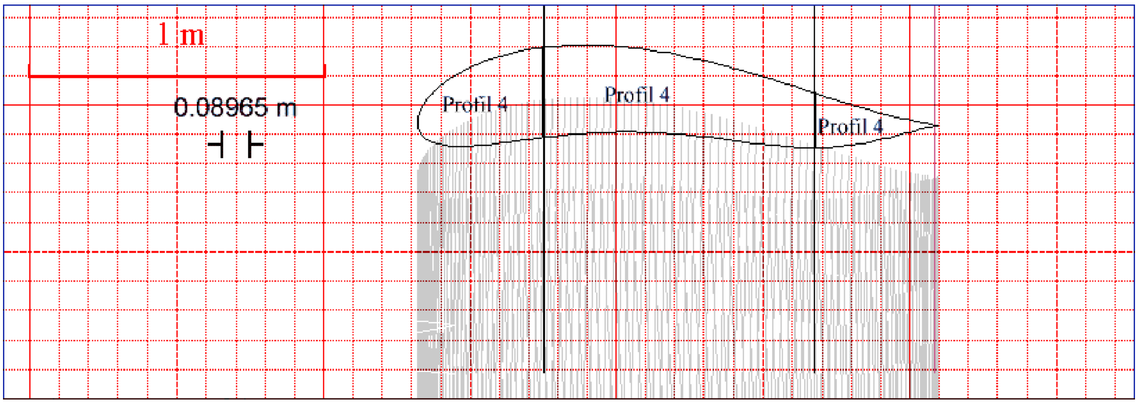
Airfoils

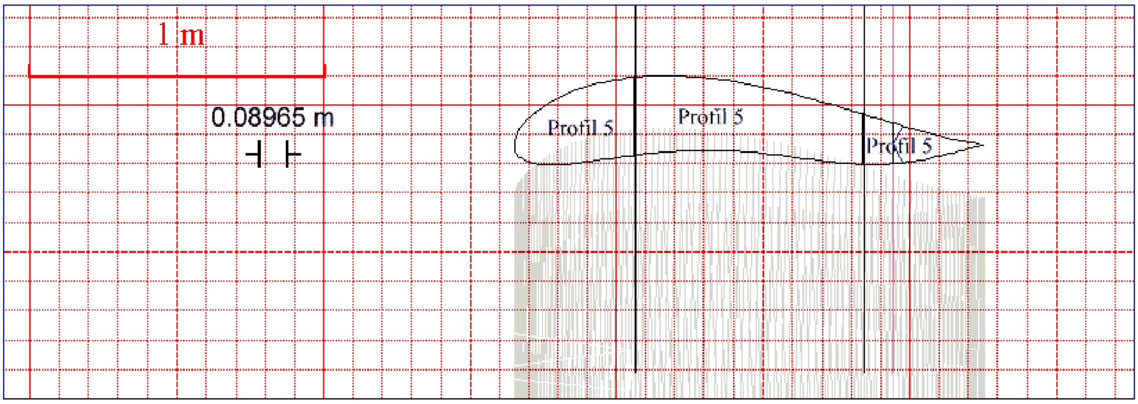


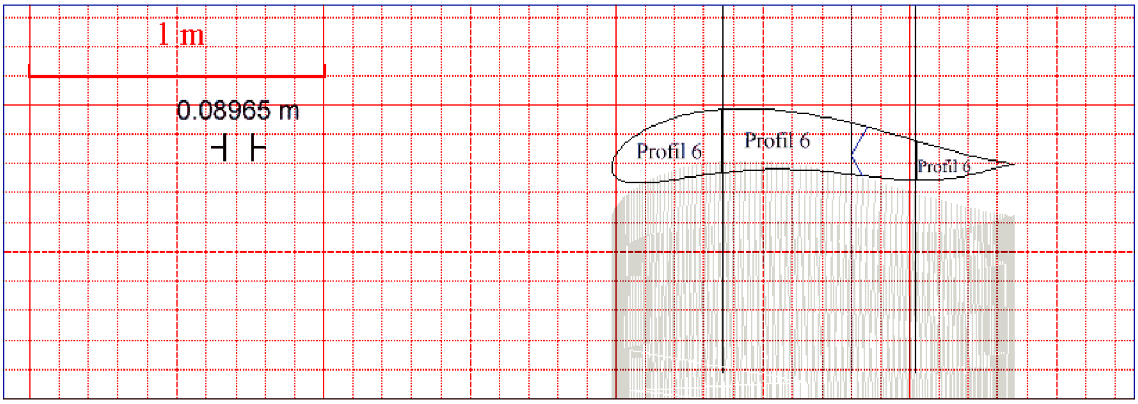


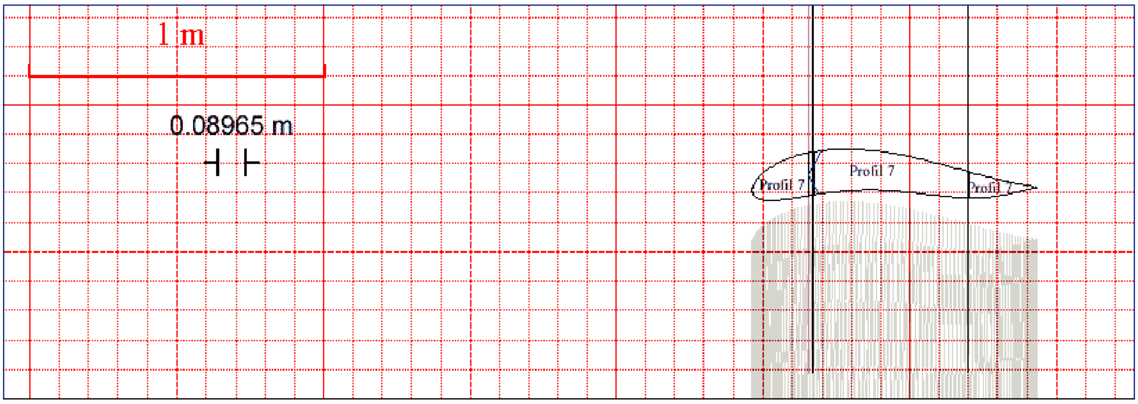




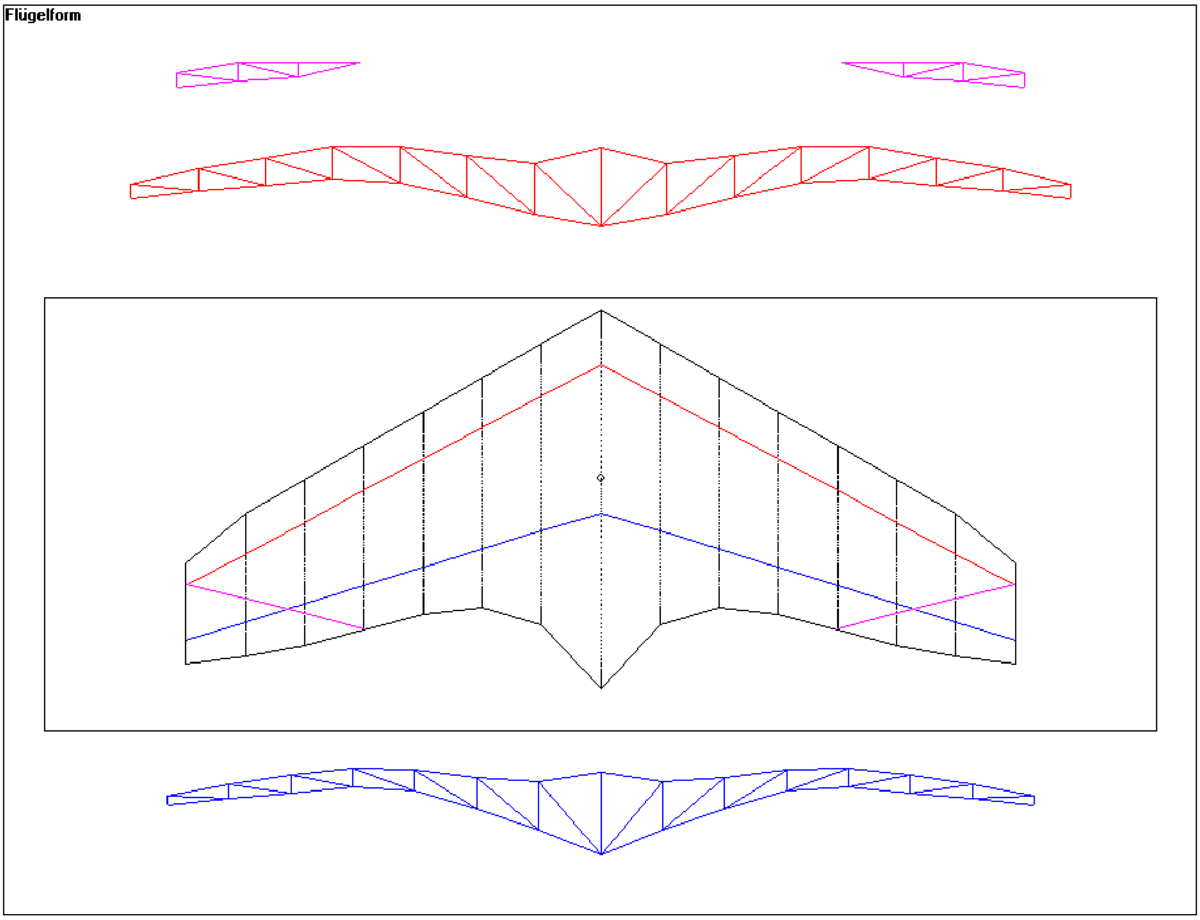

1 m
0.08965 m
Profil 4
Profil 4
Profil 4

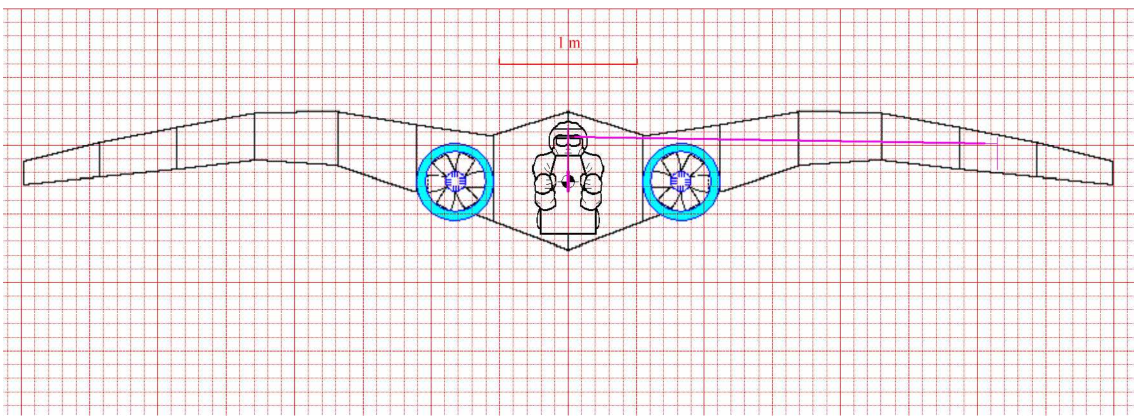

1 m
0.08965 m
Profil 5
Profil 5
Profil 5


1 m
0.08965 m
Profil 6
Profil 6
Profil 6

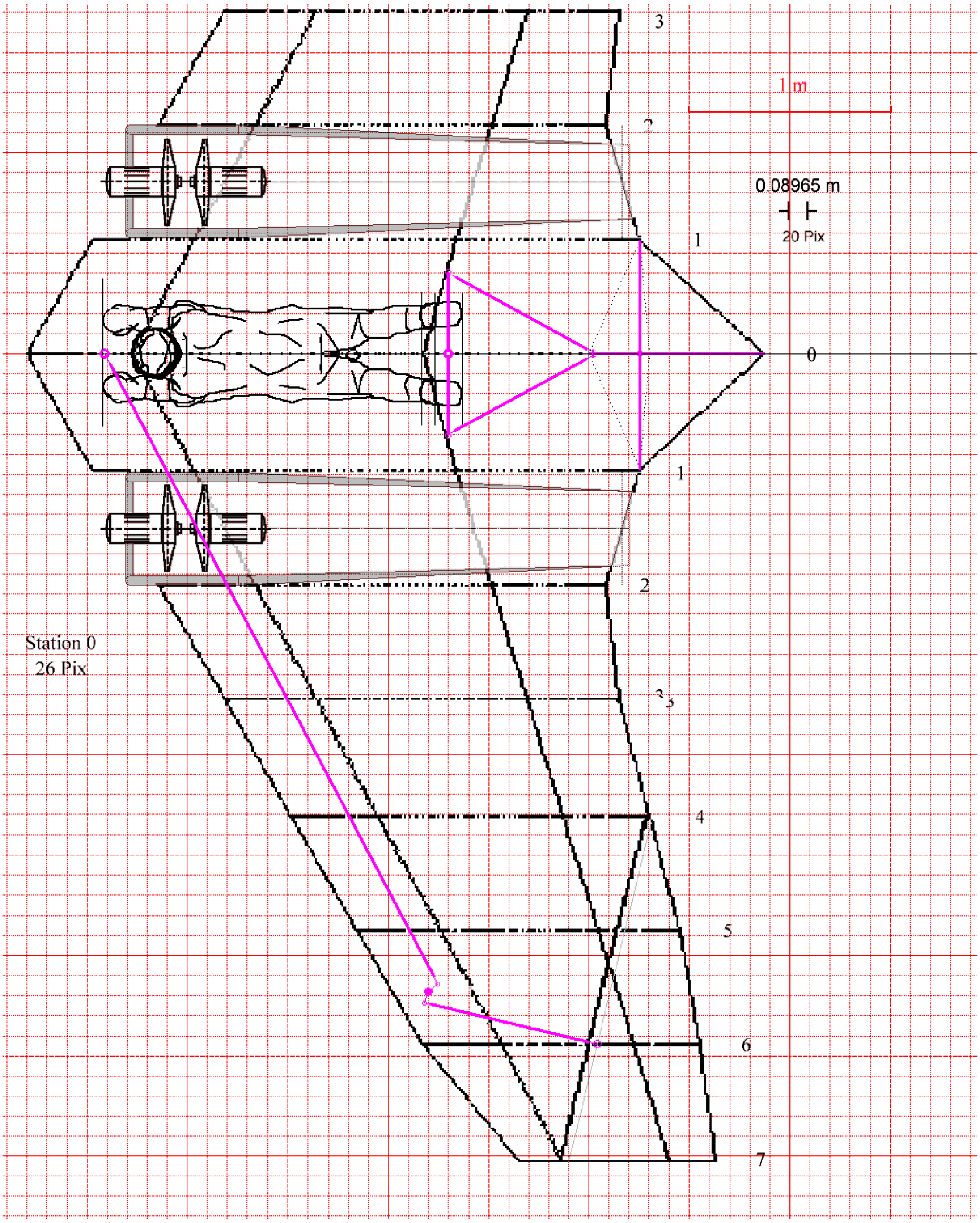

1 m
0.08965 m
Profil 7
Profil 7

Planform, Spars, and Flaps

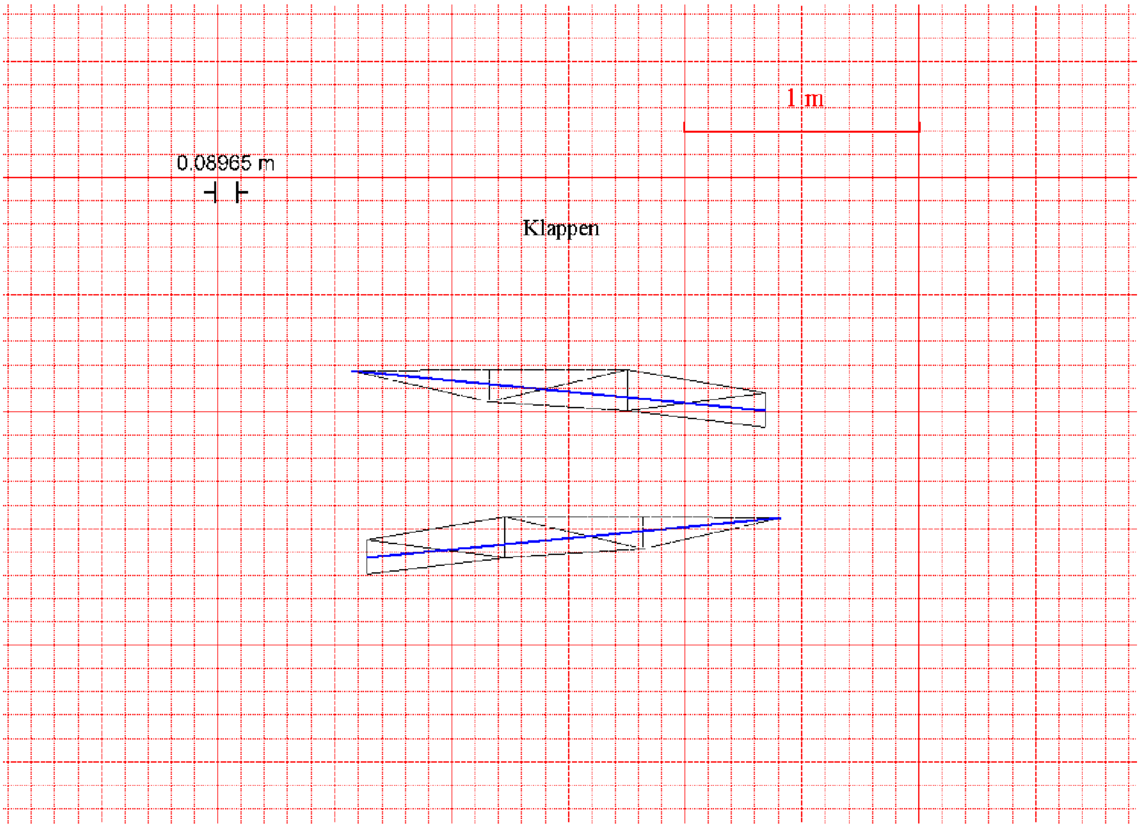




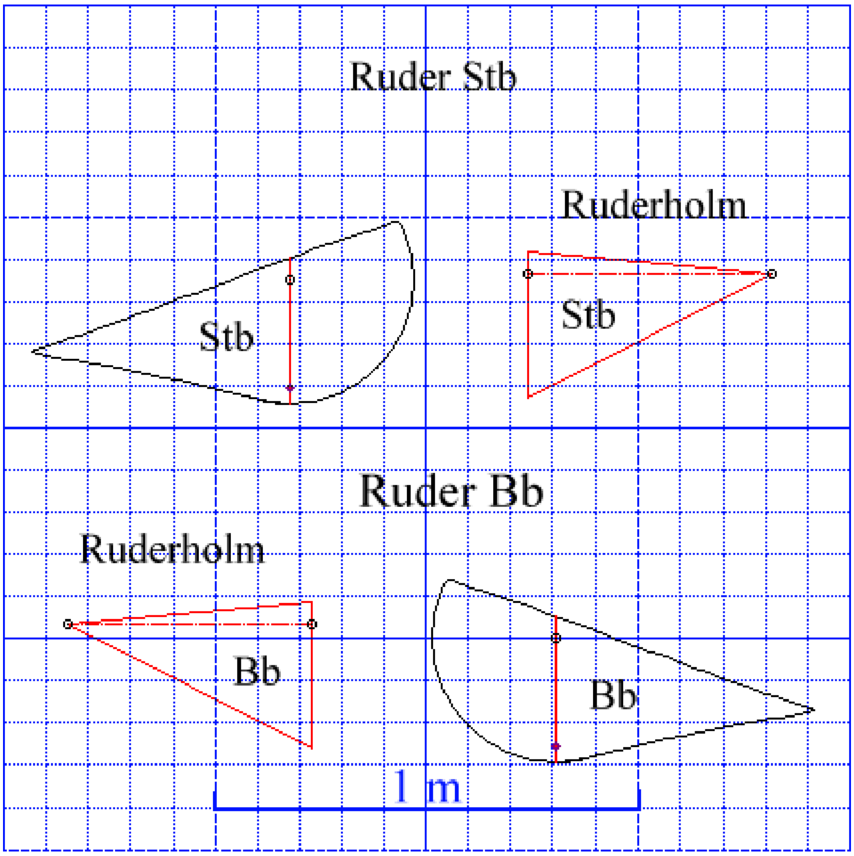
Wing Planform



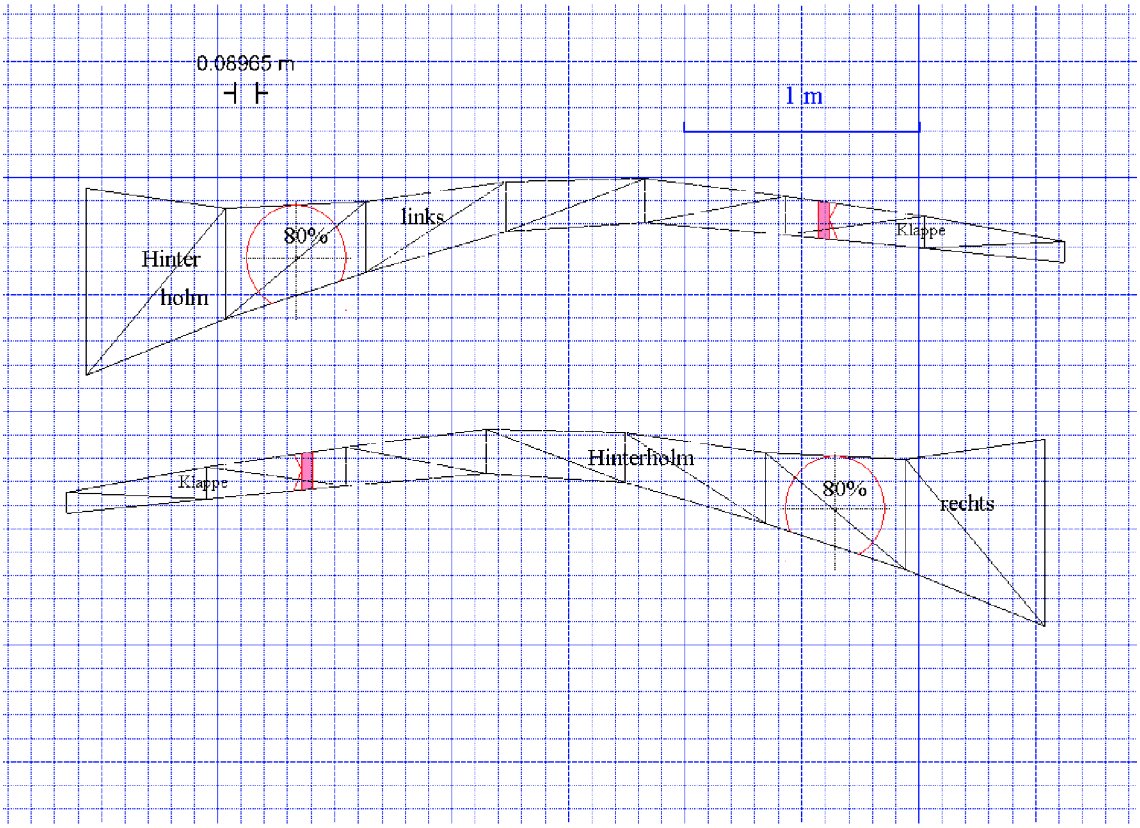
Flaps



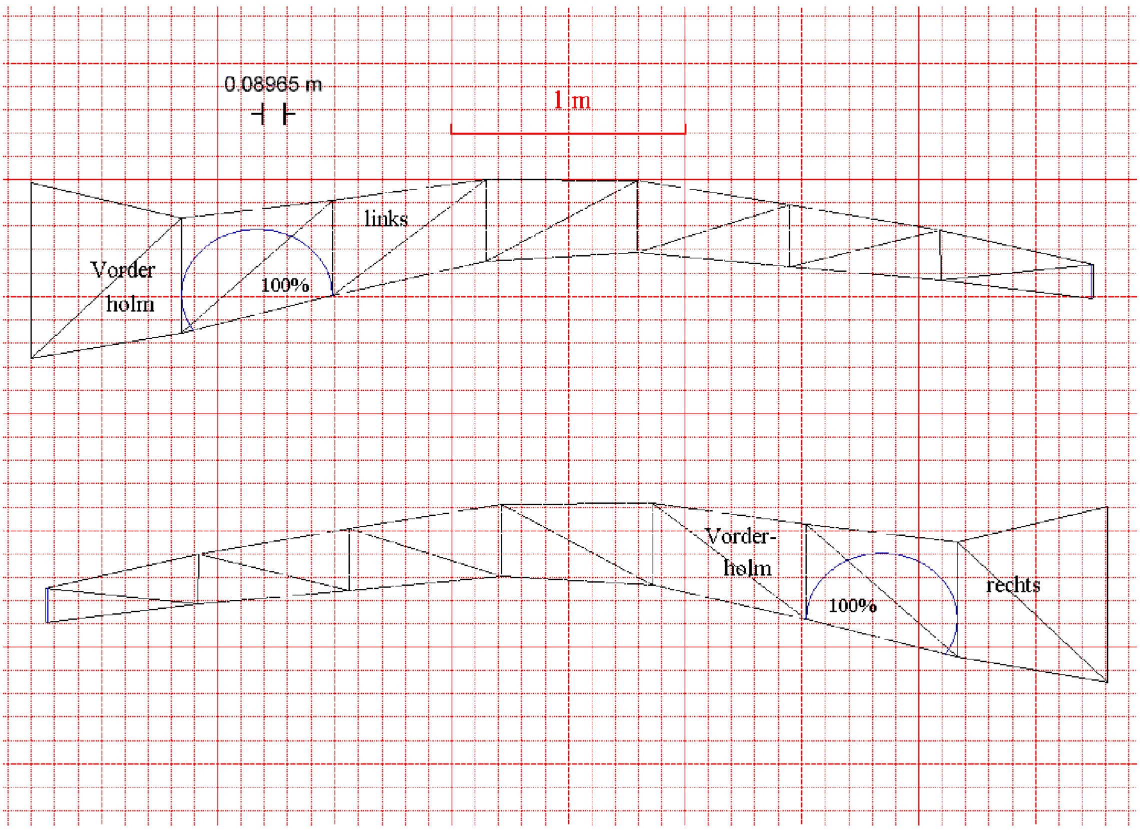
Rudder



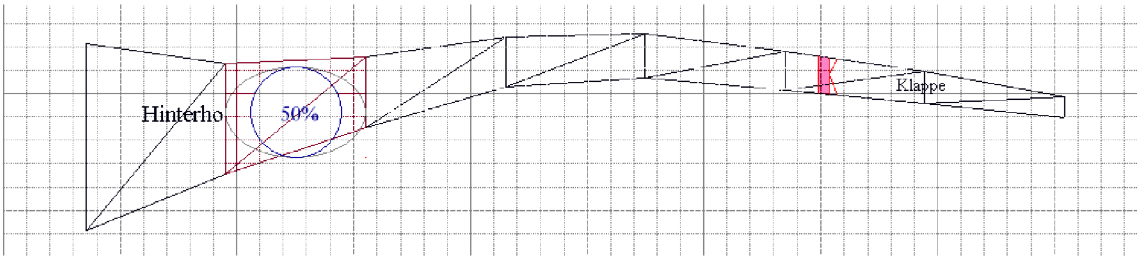
Aft Inner Spars



Fore Inner Spars

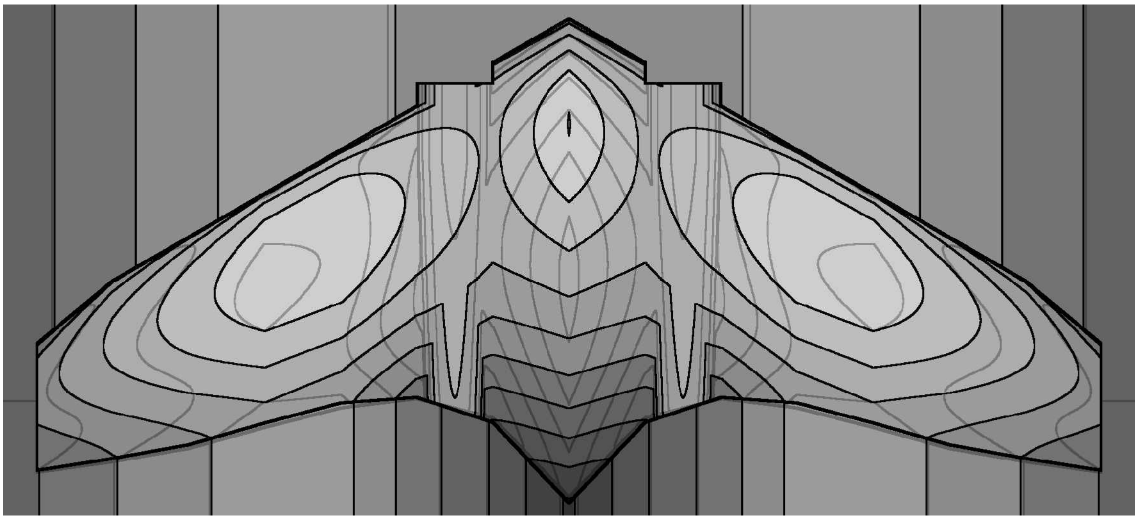


Alternative Aft Inner Spars

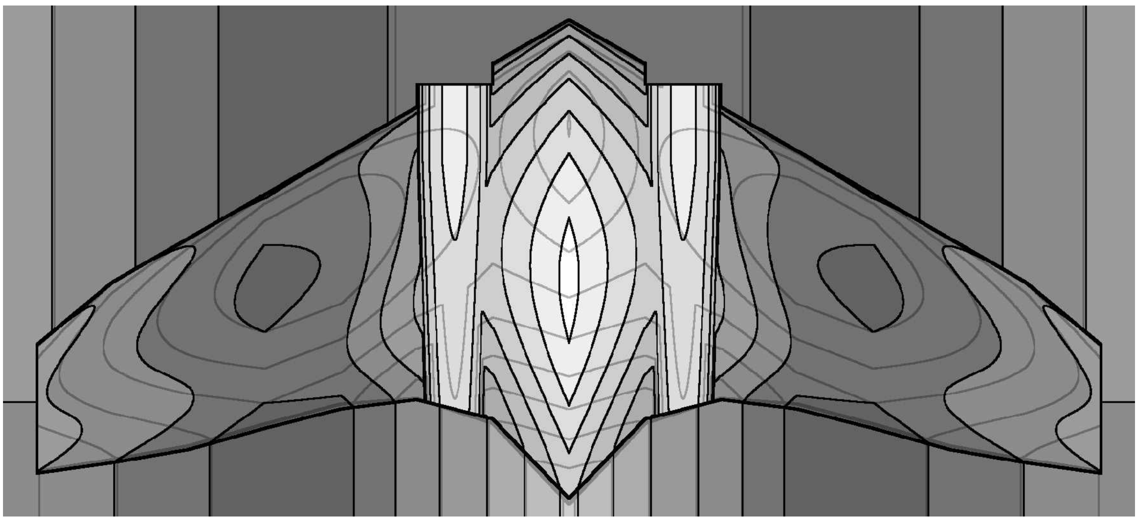


Layer Model

Upside



Downside



Material
Red Spruce, Modulus E=11.1 GPa
Specific Gravity 0.40 (weight/volume)
Density ~ 35 lbs/ft³ (bei 30% Moisture) = 618 kg/m³

Load Factors
Belastung 4g
Dauerbelastungsfaktor 0.9 (-10%)
Druckbelastungsfaktor 0.667 (-30%)
Sicherheitsfaktor 1.5
max Zugkraft -1761.65N
→ Lastäquivalent 0.1t

WEIGHT
Truss:
mittlere Stablänge 1m
mittlere Stirnfläche eines Stabes A=3 cm * 5 cm =15e-4 m²
2*170 Stäbe mit 2cm² Stirnfläche = 80 kg
Wing ohne Fahrwerk und Ausbau, mit Bespannung, geschätzt: 100 kg
Wing ohne Fahrwerk und Ausbau, ohne Bespannung, gerechnet:
Wing weight = 2 x 34.57831 kg = 70 kg
Total Wing Weight = 290.0102 lbs = 131.5486 kg

Weight Distribution:
Aircraft Weight = 1/3 Wing, 1/3 Pilot, 1/3 Engine + Energy Storage (Batteries)

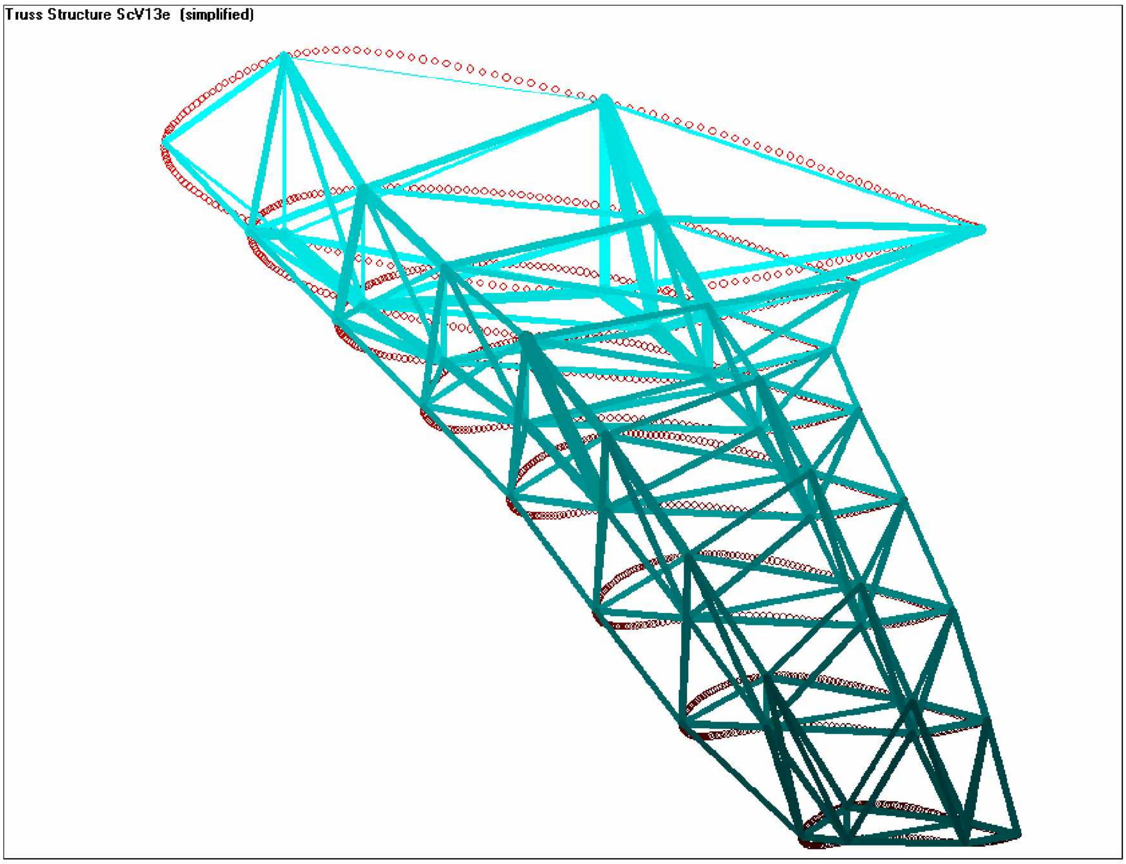
Wing Load:
W/S = 4.486497 lbs/ft² = 21.90487 kg/m² = 2.190487 g/cm²

Empty Weight:
We = 500.9755 lbs = 227.2425 kg

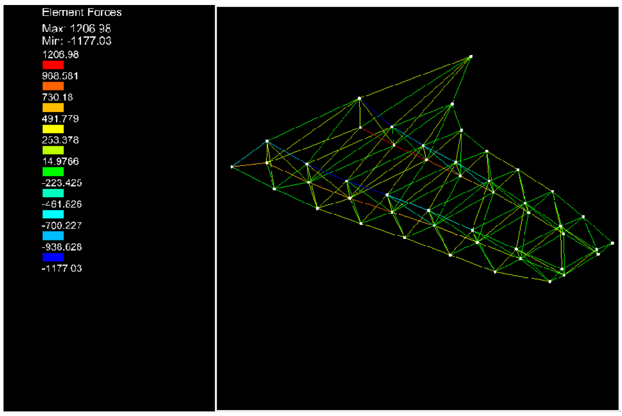
Battery Weight:
(fuel) Wf = 49.39497 lbs = 22.40556 kg

Take Off Weight:
total Weight W0 = 765.3704 lbs = 347.172 kg

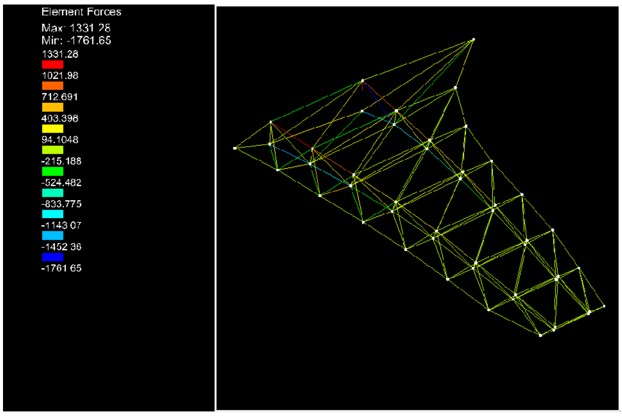
Internal Wooden Structure



Wing Loads



In Flight



At Landing

PROPULSION

Thrust
Thrust needed: 200 lbs - 500 lbs
Total Thrust = 300 lbs
One Engine Thrust = 138.7415 lbs

Electric Motor
Piston Engine Analogon:
W/hp = 12.47487 lbs/hp = 7.588305 kg/kW
Power = 61.35299 hp = 45.75093 kW
desired Power = hp0 = 55 hp0 = 41.0135 kW

Twin Electric Engine
Power per Electric Motor: 27.93 hp = 22.875 kW
Max power: 27.93 hp
Engine start fuel intro time: 0.1 sec
Throttle advance time from idle to maximum: 1.0 sec
Red line: 6000 rpm
Idle. 0 rpm
Top of green arc: 5000 rpm
Bottom of green arc: 0 rpm
Jet Engine Specs
Thrust 100% N1: 65 lbs
Minimum N1 for fuel intro: 10%
Compressor area: 2.0 ft²
Maximum efficient inlet mach. 0.10 Mach
Turbine start fuel intro time: 10.0 sec
Turbine spoolup time: 0.5 sec

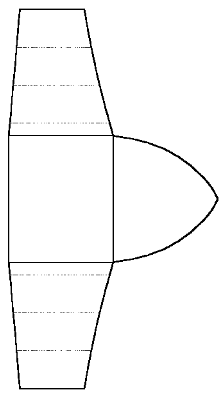
Batteries
NiMh
Battery energy content: 5933 watt-hours
Battery location: forward of aircraft CG

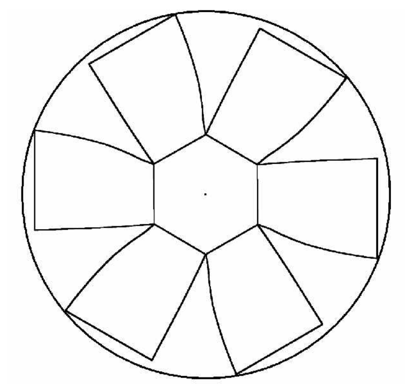
Prop Specs
Ducted unswept prop
Prop area: 0.60 ft²
Prop radius: 30 cm
Root and tip chord: 10.0, 10.0 cm
Design RPM: 10000 rpm
Aircraft design speed: 77 kt

Impeller
4-bladed impeller

Construction of an un-tapered, un-swept, impeller blade

The impeller has a multibladed rotor designed for the design speed of 77 kt. It is driven by an electrical step motor with electronic or digital power control.





The momentum theory of ducted propellers implies that the required power P equals for an m-bladed propeller (m > 2)

$$P_{MP} = \frac{(1+\sum_{i=1}^{m-3} 0.6^{i})\cdot 1.6}{\sqrt{2}} \cdot C_p \cdot \rho \cdot (\frac{n}{60})^3 \cdot D^5$$

to produce a thrust F_S

$$F_S = (1+\sum_{i=1}^{m-3} 0.4^{i})\cdot 1.4 \cdot \sqrt[3]{\rho \cdot \pi \cdot D^2 \cdot {P_{MP}}^2}$$

where
D = 0.60 m diameter of the rotor
H = 0.24 m advance of the rotor
so that

$\frac{H}{D} = 0.4$ is in the usual range of propeller parameters.

$\rho = 1.24$ kg/m³ is the density of the accelerated air just behind the rotor plane. It is usually $\rho = \rho_0 + 1\% - 5\%$ where $\rho_0 = 1.225$ [kg/m³]

A good approximation for the power coefficient of normal real propellers is

$$C_p = 0.0856 \cdot \frac{H}{D} - 0.0091$$

To obtain the desired thrust of

$$F_S = 618 \text{ N} = 139 \text{ lbs}$$

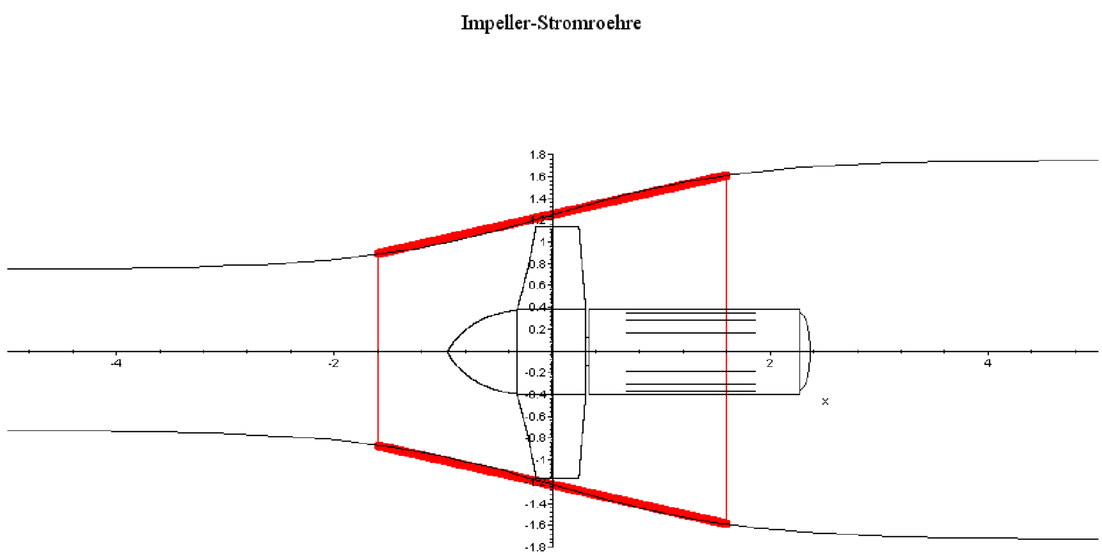
for one engine with a ducted 4-blade rotor – which seems to be the optimum number of blades – it is required to have a rotation of

$$n = 8417 \text{ RPM}$$

and the necessary power will be

$$P = 12.11 \text{ kW}$$

With this data the streamtube can be calculated and from this the shape of the duct can be obtained:



Electromotor

The electromotor has to be chosen accordingly.

If one single rotor is used a stator is necessary to reduce the spin of the airflow. Instead, a second counter-rotating rotor can be used with its own electromotor. The location of the second rotor downstream of the first requires it to be of smaller diameter.

To get a power to weight ratio comparable to petrol motors the electromotor has to be electronically controlled. A three-phase stepping motor promises the best output result in power, rotation, and torque and the maximum power-to-weight ratio.

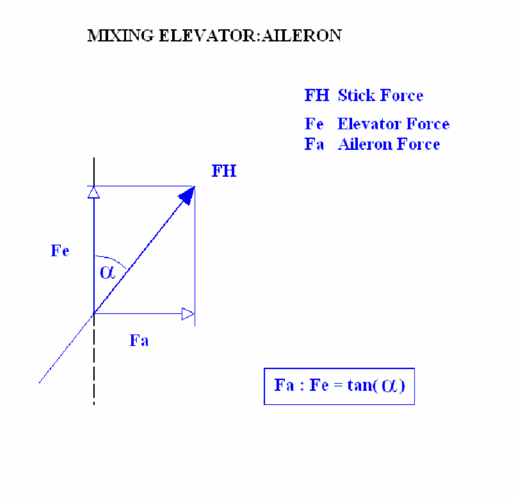
The higher the input voltage is the lower the thermal losses. The battery pack should therefore be connected accordingly to obtain at least 400V DC and an inverter put to use.

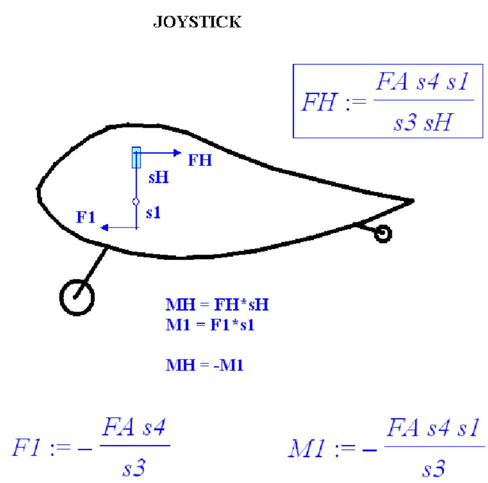
FLIGHT CONTROLS

The wing flaps are multifunctional. They work as aileron, elevator, and lifting devices.

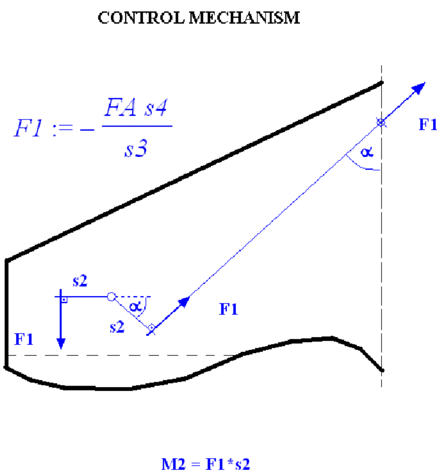
Operated via the joystick a pushrod and double lever system works as a mixer for aileron and elevator function.

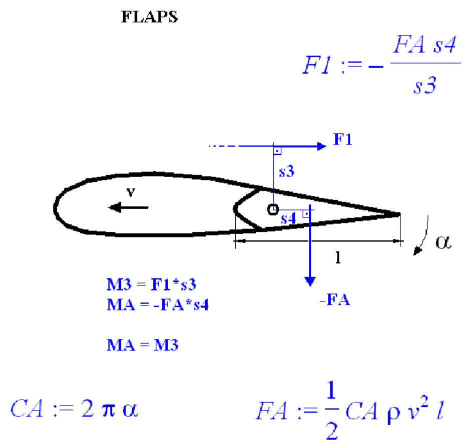
To work as a lifting device both flaps are trimmed upward simultaneously to lift the nose of the whole flying wing and increase the angle of attack. So the lift is increased at constant speed. If the flaps are trimmed down the nose of the aircraft is pushed down and the lift is decreased while the speed remains constant.





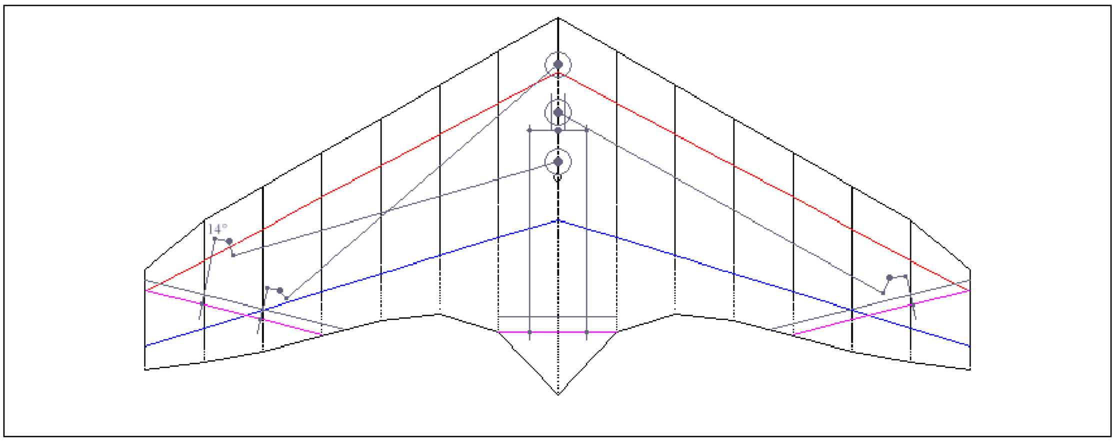
Elevator stick forces have to be double the amount of aileron stick forces. If necessary enhanced by springs!





The split tail has the function of a rudder. To stabilize a turn and avoid the dutch roll effect the turnside tailflap is deflected down and the opposite up.

The control layout of the pushrod control of rudder and ailerons:



Control Forces

The length of one elevon flap is 1.71 m and the maximum depth 0.65 m. Due to the triangular shape the area is $A_F = (1.71 \cdot 0.65)/2 = 0.556\ m^2$. The maximum excursion angle is $\alpha = 30°$. The design speed in MSL is v = 80 kt = 40 m/s. The drag coefficient $CD_{\eta 30°} = 0.9$ and the air density at MSL $\rho_0 = 1.25\ kg/m^3$. Therefore the maximum control force is

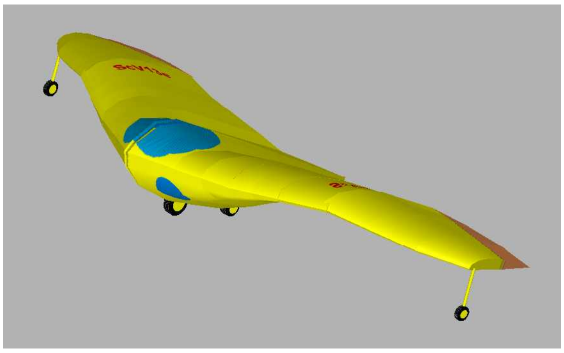
$$F = CD_{\eta 30°} \cdot \rho_0/2 \cdot v^2 \cdot A_F \cdot \cos(\alpha) = 250\ N \text{ entsprechend } 25\ kg$$

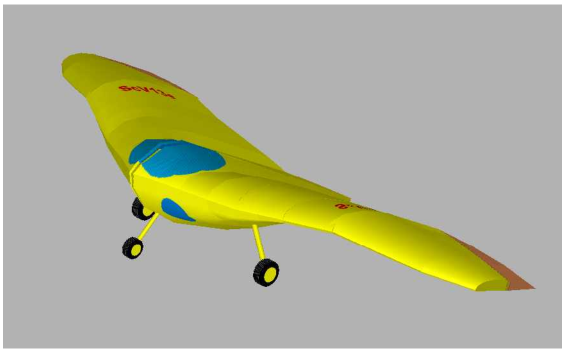
This would be the maximum aileron force due to the compensating effect of opposite flap excursion. For the elevator force this would double at the maximum to 500 N due to the same flap excursion in this case.

GROUND CONTROLS

The landing gear is a trike design. The main gear below the wings is equipped with brakes. The bow wheel can swivel freely.

Alternatively a quadruple design may be cheaper: a tandem center main gear where the aft wheel is steerable and connected with the rudder pedals, the front whell has brakes, and there are two small retractable wing tip supporting wheels.


Landing Gear Tandem Design


Landing Gear Trike Design

Brakes

In case of the trike design the main gear below the wings is equipped with brakes. The brakes are not connected and can be operated separately. The rudder pedals are equipped with brake functions to make differential braking possible. The parking brake arrests the brakes in the ON position: push both brakes and lock them by setting the parking brake.

Steering

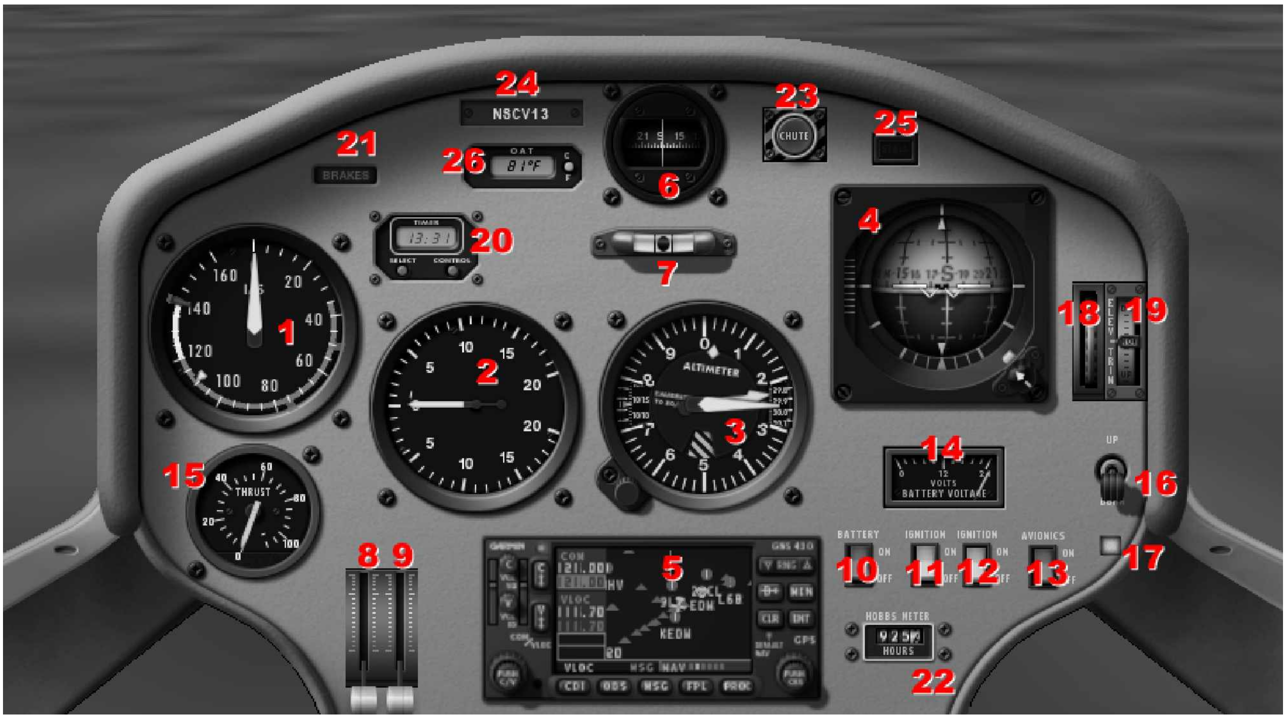
To steer the aircraft on the ground below any aerodynamic speed differential braking is applied. To slow down symmetric braking is applied.

Parking

After the aircraft is pulled into the parking position the parking brake shall be set, the ropes fastened, the blocks placed at the main wheels, and eventually the tarpaulin pulled over the aircraft.

Cockpit Equipment List

OPTIMIZED COCKPIT PANEL LAYOUT:
Flying Wing ScV13e



DIALS

Airspeed Indicator	(1)
Magnetic Compass	(6)
Artificial Horizon	(4)
Altimeter	(3)
Variometer	(2)
Thrustmeter	(15)

INDICATORS

Operation Hours Indicator (Hobbs Meter)	(22)
Stall Indicator	(25)
Outside Air Temperature Indicator	(26)
Gear Position Indicator Light	(17)
Battery Voltage Indicator	(14)
Brake Indicator	(21)
Bank Coordinator	(7)
Elevator Trim Indicator	(19)

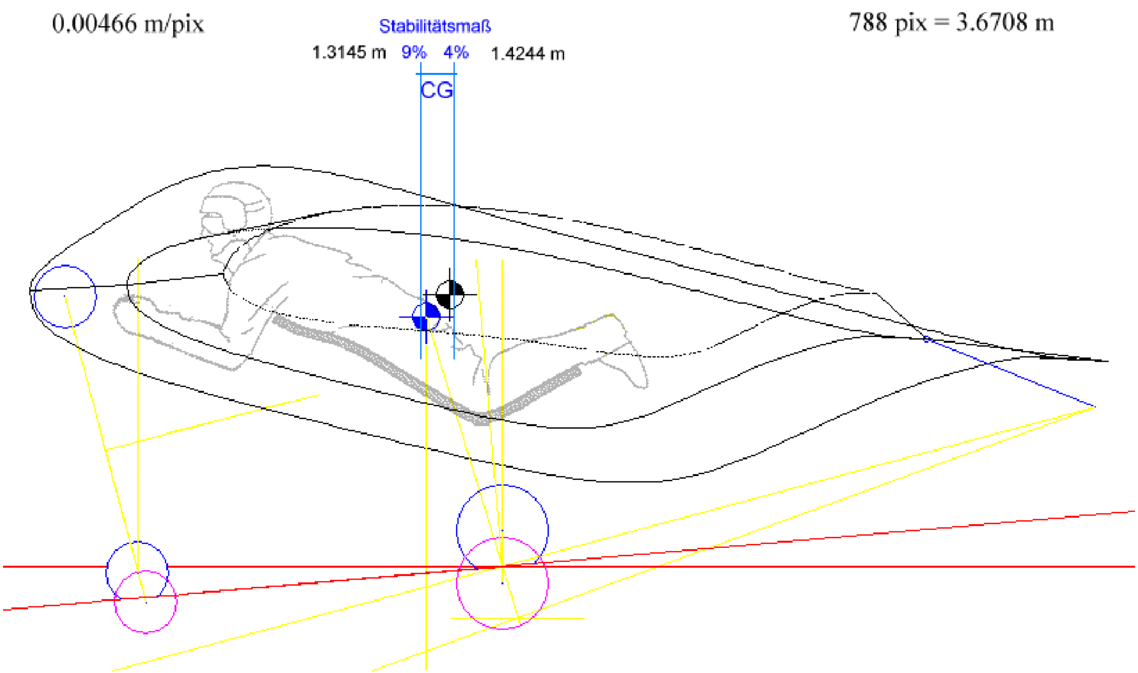
LEVER	
Elevator Trim Wheel	(18)
Throttle Lever	(8), (9)
Gear Lever	(16)
SWITCHES	
Battery Switch	(10)
Avionics Switch	(13)
Ignition Switch 1	(11)
Ignition Switch 2	(12)
Emergency Chute Release Button	(23)
NAV	
GPS for Waypoint Navigation	(5)
COM	
VHF-COM	(5)
CLOCK	
Timer	(20)
OTHER	
Call Sign Plate	(24)

Mass and Balance

Flying	**Wing**	**ScV13e:**							
Weight	budget:					längs [m] Station 0	hoch [m] (Nasenspitze)	MomentV	MomentH
Furnishings		=	8.13	kg	x	1.240	0.233	10.07	1.89
Avionics		=	4.88	kg	x	0.191	0.000	0.93	0.00
Electrical		=	8.13	kg	x	0.652	-0.019	5.30	-0.15
instruments		=	3.25	kg	x	0.238	-0.014	0.77	-0.05
flightcontrols		=	5.53	kg	x	1.806	-0.098	9.98	-0.54
Engineinstallation		=	16.90	kg	x	1.123	-0.019	18.98	-0.31
Engine	(calculated)	=	47.72	kg	x	0.825	-0.019	39.36	-0.89
landinggear	Up	=	16.90	kg	x	1.184	0.089	20.01	1.50
landinggear	Down	=	16.90	kg	x	1.254	0.713	21.19	12.05
Wing	Weight	=	130.20	kg	x	2.040	-0.044	265.65	-5.69
1	Crew	=	83.92	kg	x	1.151	0.070	96.59	5.87
Fuel		=	22.59	kg	x	1.131	-0.121	25.55	-2.74
Baggage		=	4.54	kg	x	0.881	0.186	3.99	0.85

					ttl CG				
Total Weight	Gear up	=	352.67	kg	x	1.410	-0.001	497.19	-0.26
	Gear down					1.413	0.029	498.37	10.29

Takeoff	Weight	=	325.08	kg	(final +/-10%)

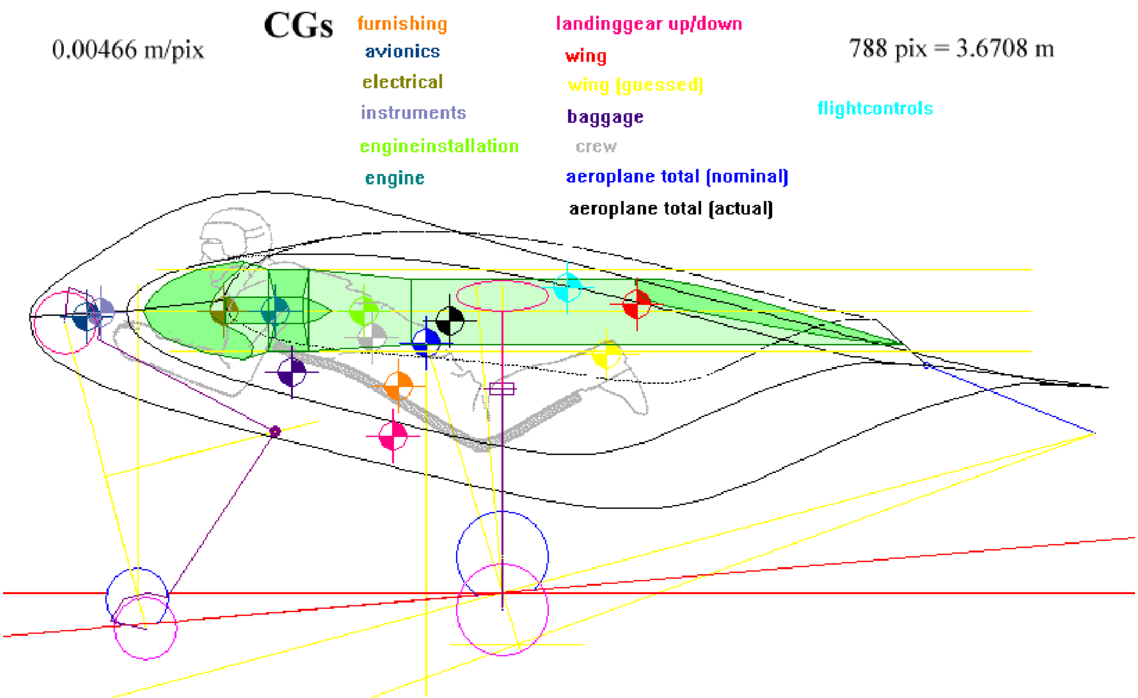


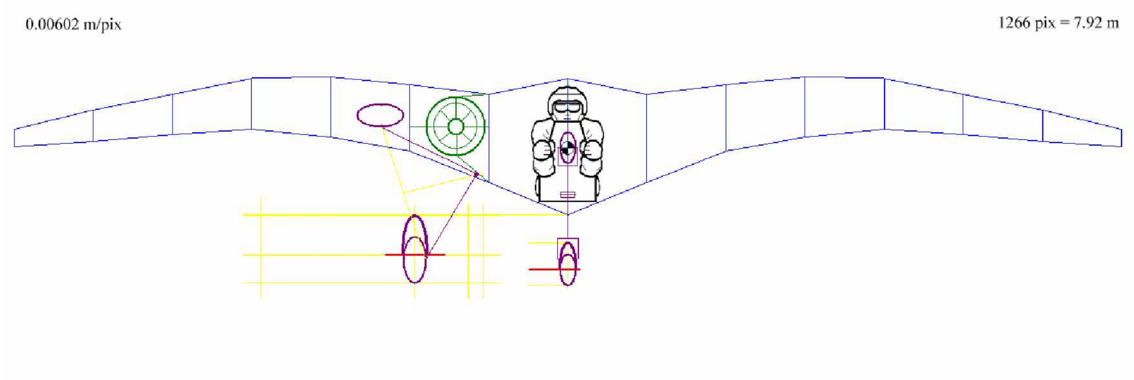
Calculation

Mass and Balance Calculation Sheet		ScV13		Längs [m]	CG	Moment
				Station 0	(Nasenspitze)	
Operating Weight	=	264.22	kg x	1.506	=	397.79
1 Crew	=		kg x	1.151	=	
Baggage	=		kg x	0.881	=	
				ttl CG		
Total Weight	=		kg x	.	=	

NOTE:

- The total weight must be less then 350 kg .
- The center of gravity must be within the limits of 1.30 m and 1.42 m off station 0 (nose point).


0.00466 m/pix
CGs
furnishing
avionics
electrical
instruments
engineinstallation
engine
landinggear up/down
wing
wing (guessed)
baggage
crew
aeroplane total (nominal)
aeroplane total (actual)
788 pix = 3.6708 m
flightcontrols


0.00602 m/pix
1266 pix = 7.92 m

Performance Data

SPEEDS

Flying Wing ScV13e

Stall Speed

Requirement FAR 23:	Vstall < 61 kt
Vstall	25 kt - 60 kt
desired Vstall:	60 kt
calculated stall speed: Vstall:	35.44028 kt
demonstrated Vstall:	25 kt

Takeoff Speed

Pulled Takeoff Speed:	40 kt
Natural Takeoff Speed:	60 kt

Maximum Speed

Vmax

desired Vmax = 90 kt - 120 kt

Cruise Speed

Vcruise = 77.23188 kt

Landing Speed

Trim 0: Vland = 65 kt
Trim +2: Vland = 45 kt
Trim +3: Vland = 35 kt
Minimum safe landing speed: Vland = 40 kt

Speed for Best Glide

Best glide at 53 kt

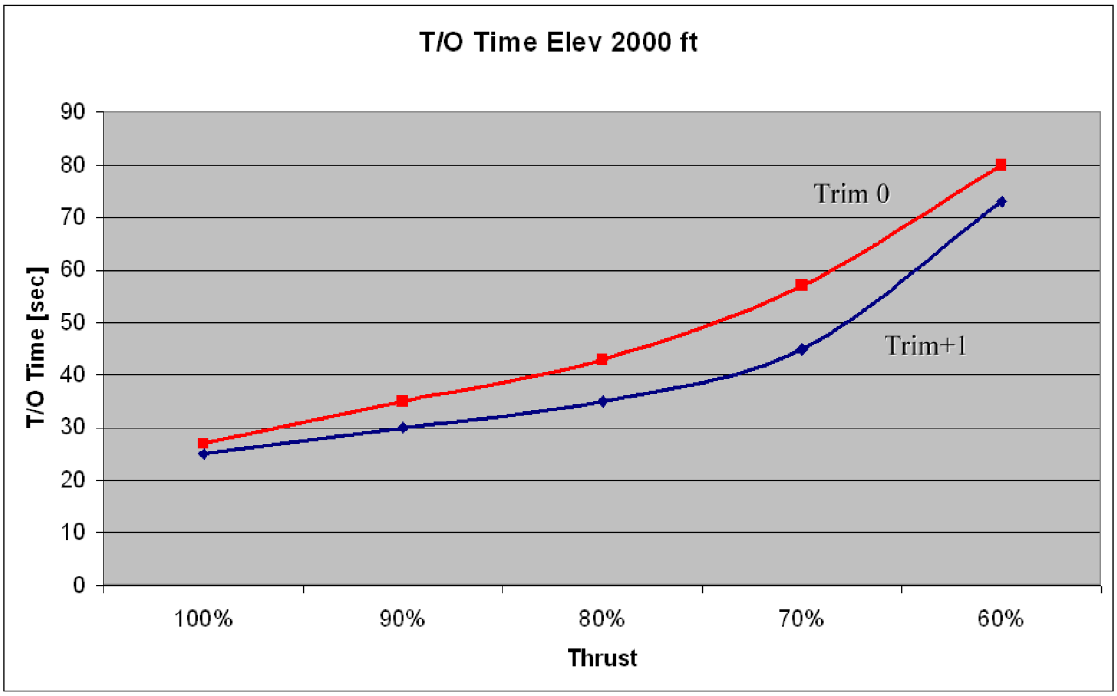
SPEED LIMITS

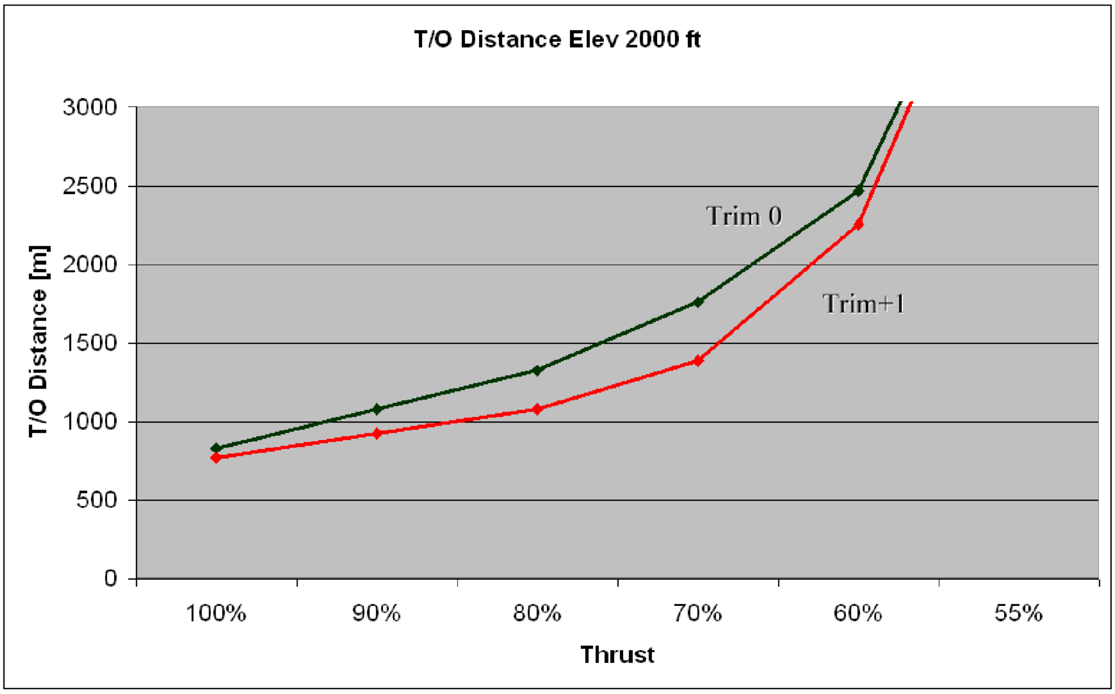
Vs	25 kt
Vmca	40 kt
Vyse	60 kt
Vfe-m	110 kt max dep
Vfe-1	110 kt 1st dep
Vle	110 kt
Vno	120 kt
Vne	140 kt
Mmo	0.08 (Mach)

G-Limits

pos G +10.0 limit
neg G -10.0 limit

Takeoff Data





Takeoff shall be performed with power setting 100% Thrust and trim neutral or 1 pitch up.

Is the Flying Wing ScV13e a STOL-Aircraft?

m:	aircraft mass	m = 347.2 kg
S:	wing area	S = 15.90 m²
ρ:	air density	ρ = 1.225 kg/m³
F:	thrust (two engines)	F = 2·139 lbs = 1276 N
μ:	roll friction constant	μ = 0.25
c_{A0}:	lift coefficient at takeoff (ca 1/272)	$c_{A0} = c_{Amax}$-15% = 0.130186
g:	gravitational acceleration	g = 9.81 m/s²
AR:	wing aspect ratio	AR = 4.005
b:	wingspan	b = 7.98 m
t:	wing reference depth	t = 2.20 m
v_{TO}:	takeoff speed	v_{TO} = 55 kt
s:	takeoff distance	

STOL criterion

The wingspan and the aspect ratio gives the wing reference depth:

$$AR = \frac{b}{t} \quad \rightarrow \quad t = \frac{b}{AR}$$

The reference depth and the wingspan gives the wing area:

$$S = b \cdot t = AR \cdot t^2$$

The wing area, mass, and takeoff speed gives the lift coefficient at takeoff:

$$v_{TO} = \sqrt{\frac{2mg}{S \cdot c_{A0}}} \quad \rightarrow \quad c_{A0} = \frac{2mg}{S \cdot v_{TO}^{\ 2}}$$

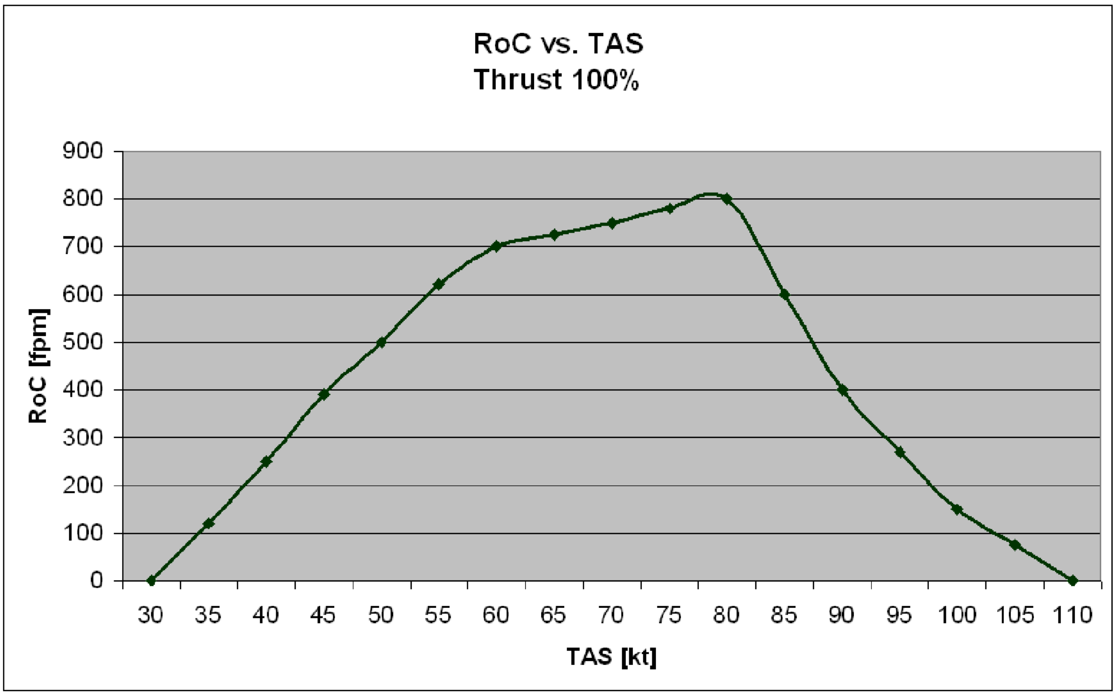
This allows to check the STOL criterion and to calculate the takeoff distance s:

$$Kr_s = \frac{1}{52.3} \cdot \frac{m^2}{c_{A0} \cdot s \cdot F} < 1$$

s > 14 m

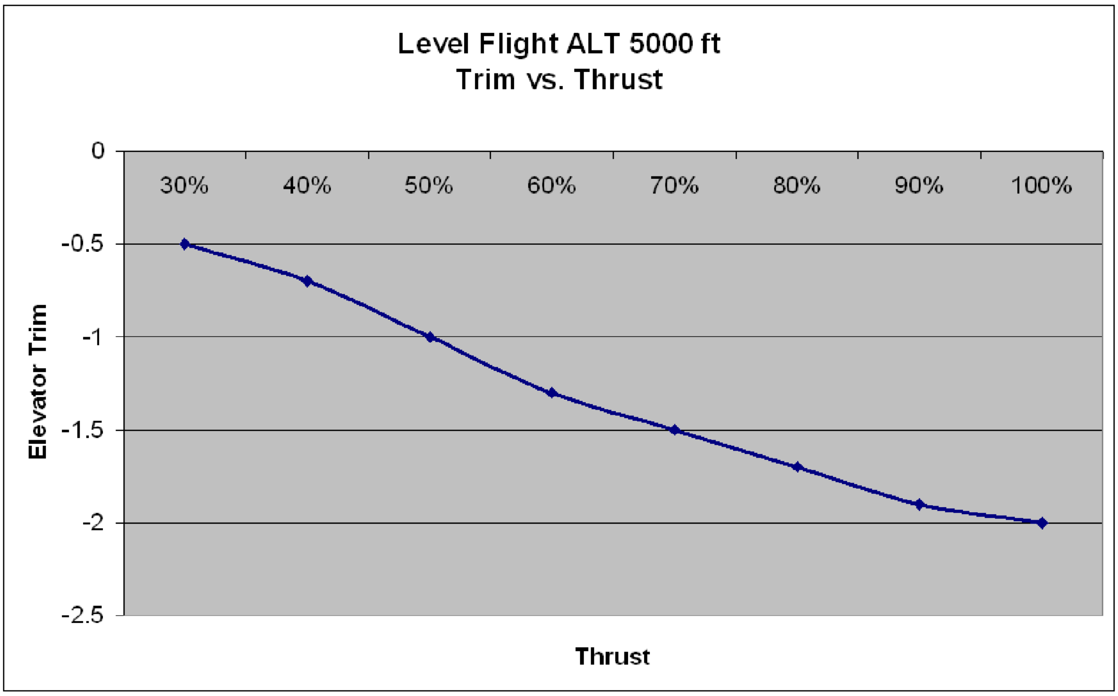
Therefore the ScV13e is not a STOL aircraft.

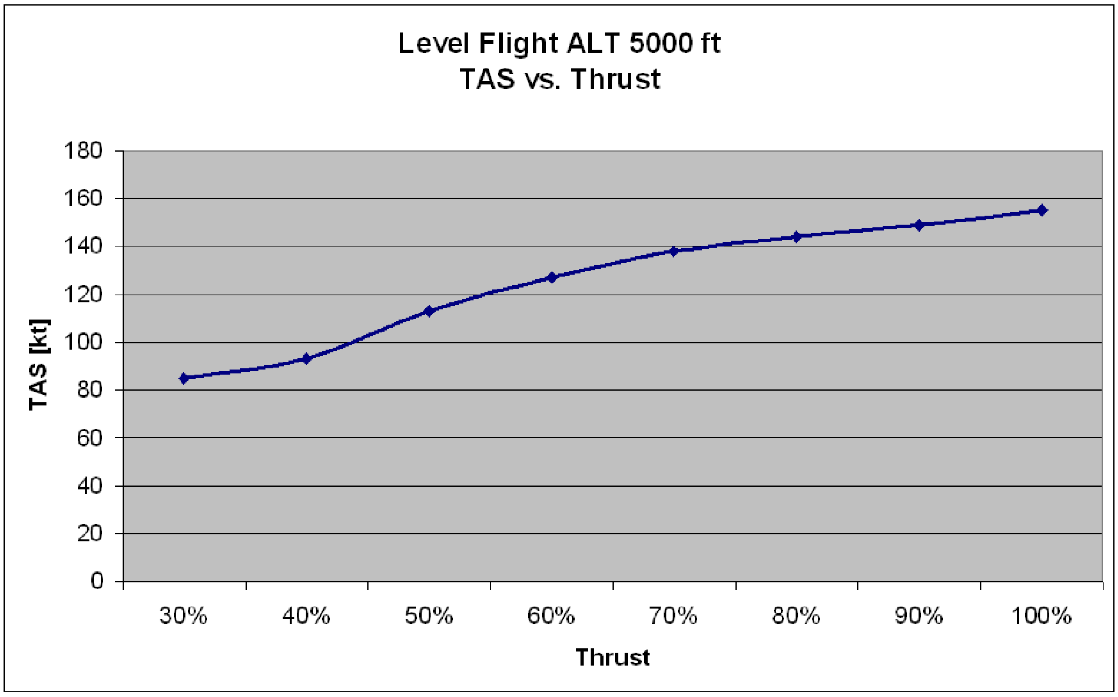
Climb Performance



Best climb performance of 800 fpm is reached with 100% power setting at 80 kt.

Level Flight Data





Level flight shall be performed with trim 1 pitch down and power setting 55%.

Integrated Range

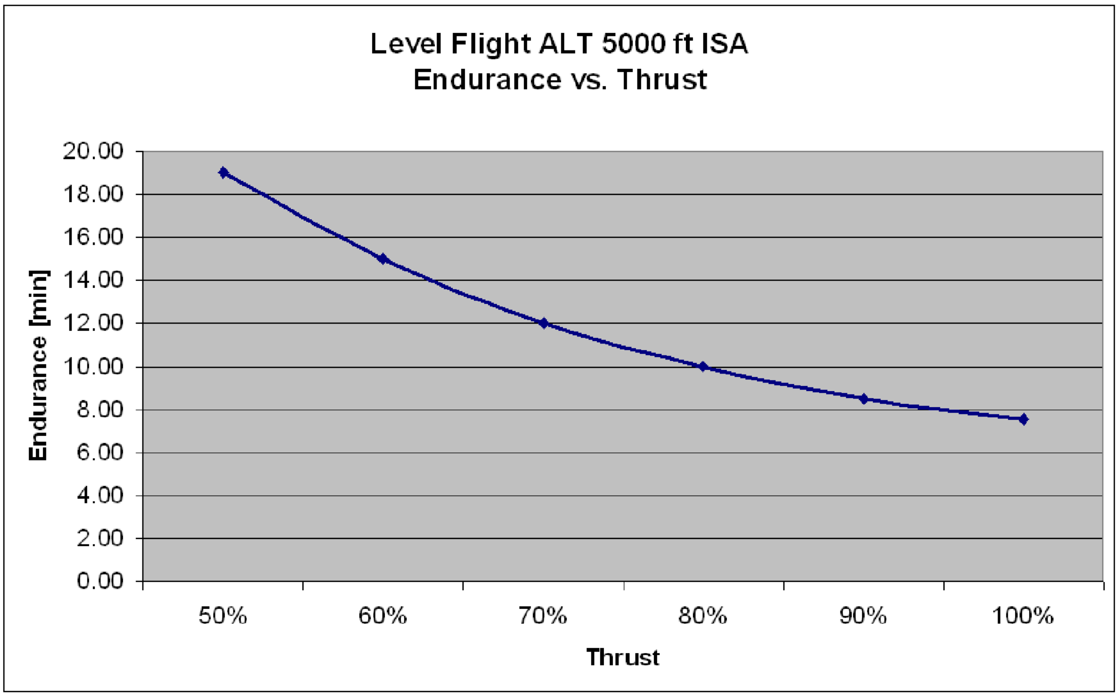
Desired Range 1000 NM - 300 NM

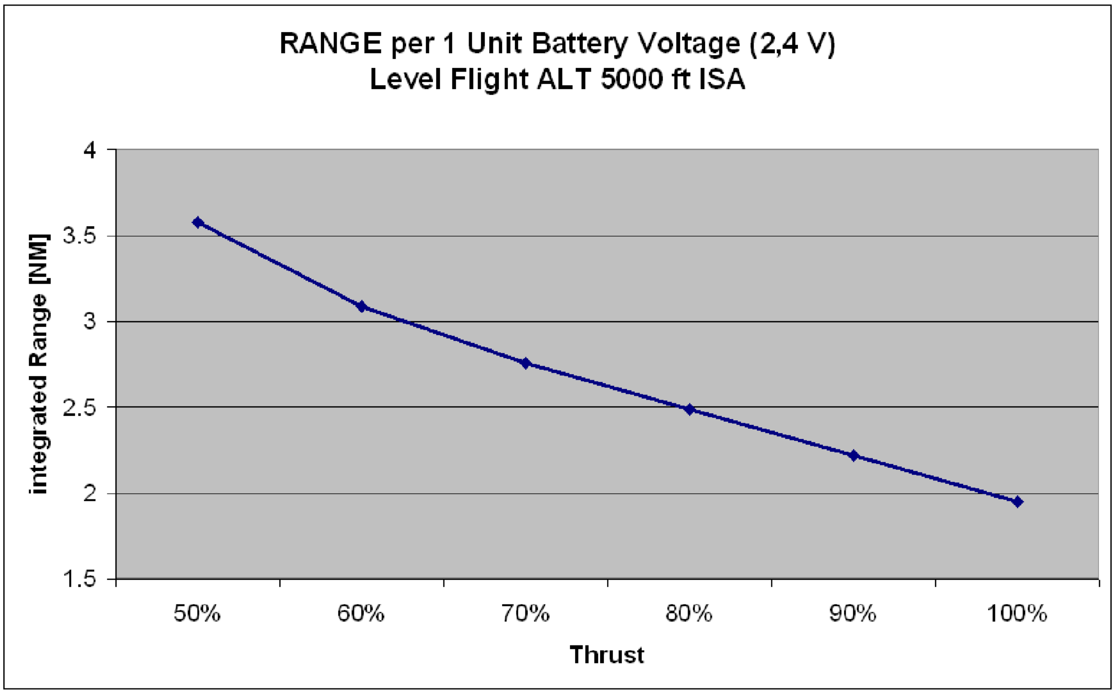
Desired Range = 176 NM

Range = 184 NM

RANGE = 170 NM

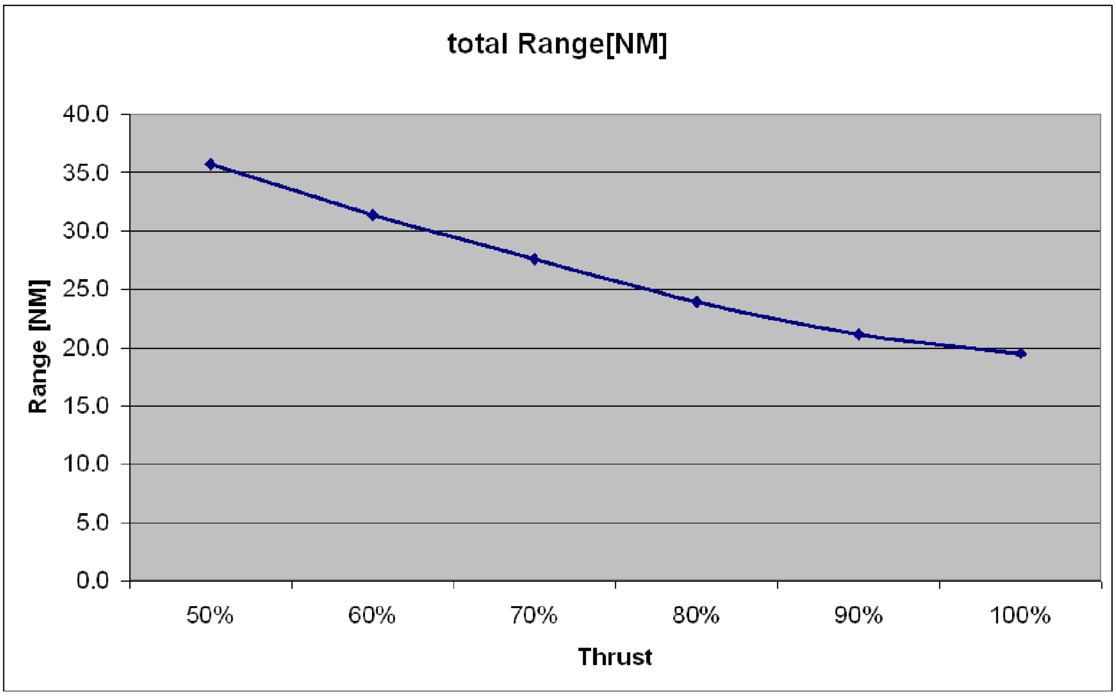
Calculated Range = 109.7195 NM for conventional jet engine



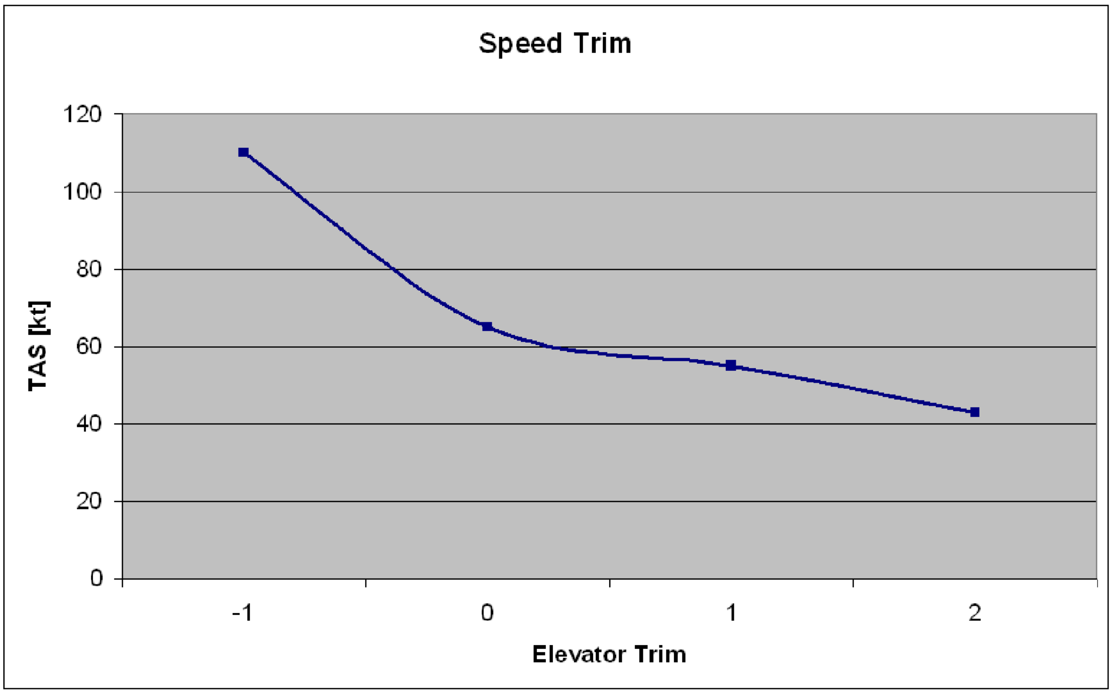


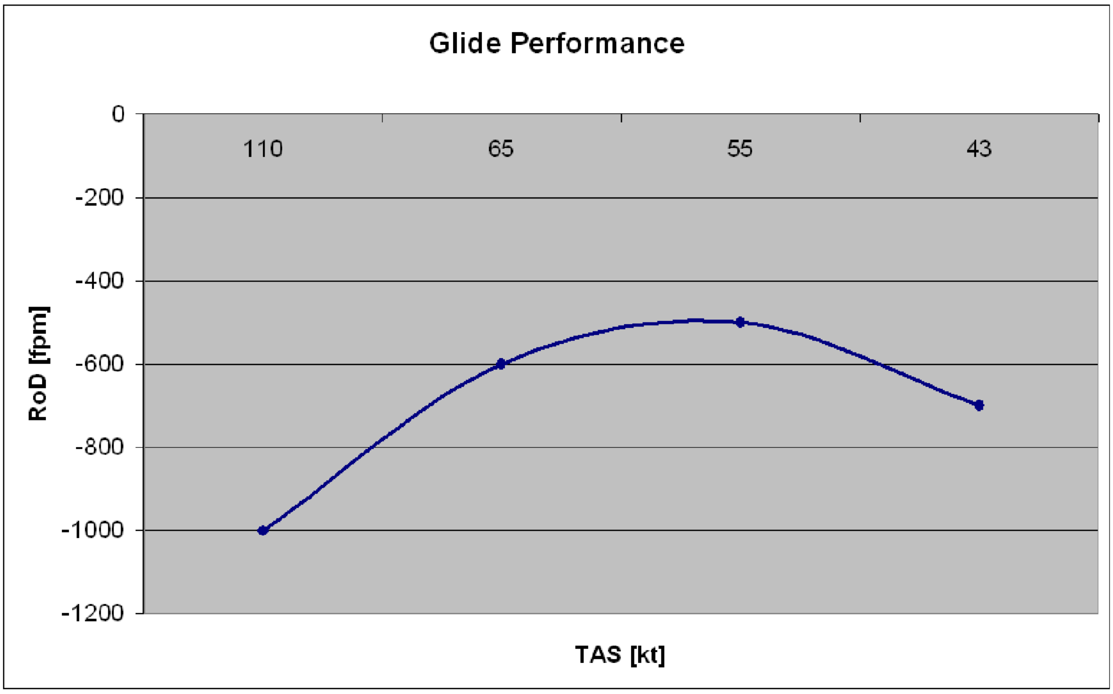
Due to the use of electric impeller engines and the still restricted energy storage in the proposed NiMh batteries the real total range is quite limited.

There may better batteries be available in the near future, with ten times of the present capacity and so ten times of the present endurance.



Glide Data





The best glide speed with engines idle is 53 kt at trim 1 pitch up.

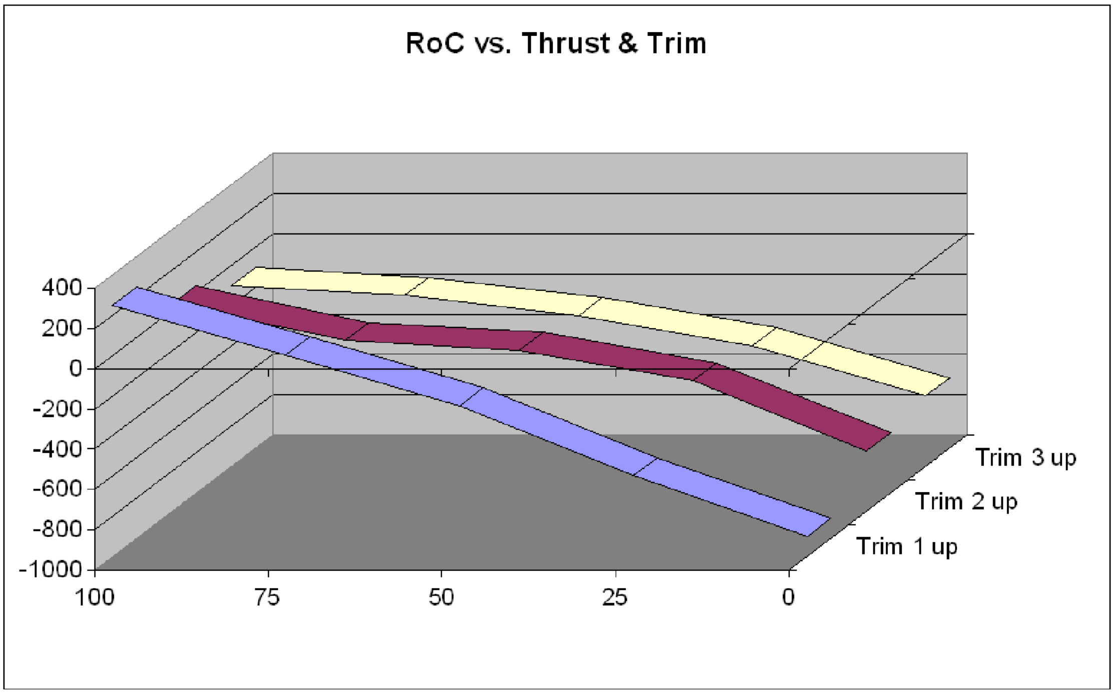
Landing Data

Landing should be performed with the lowest safe speed, that is about 40kt. Also a 3° glideslope should be possible.

Altitude	10000 ft			
RoC/RoD [fpm]	Trim	Thrust [%]	Tas [kt]	GP
-400	6	100	25 Stall	-10
-250	5	100	29	-5
-150	4	100	31	-3
-100	3	100	33	-2

Altitude	10000 ft			
RoC/RoD [fpm]	Trim	Thrust [%]	Tas [kt]	GP
250	1	100	60	3
0	1	75	64	0
-250	1	50	67	-2
-600	1	25	71	-5
-900	1	0	77	-7

Altitude	10000 ft			
RoC/RoD [fpm]	Trim	Thrust [%]	Tas [kt]	GP
30	2	100	38	0
-150	2	75	43	-2
-200	2	50	47	-3
-350	2	25	50	-4
-700	2	0	57	-7



Altitude	10000 ft			
RoC/RoD [fpm]	Trim	Thrust [%]	Tas [kt]	GP
-100	3	100	33	-2
-150	3	75	43	-2
-250	3	50	47	-3
-400	3	25	51	-5
-650	3	0	57	-7

Calculation of Glide Slope:

$$GP_{[\circ]} = \frac{RoD_{[fpm]}}{100} : \frac{TAS_{[kt]}}{60}$$

where $\frac{TAS_{[kt]}}{60}$ are the nautical airmiles per minute and can be assumed constant during one phase of flight.

Evaluation:

RoD[fpm]	Trim [up]	Thrust[%]	TAS [kt]	GP [°]	
-150	4	100	31	-3	
-250	3	50	47	-3	
-200	2	50	47	-3	<- Optimum!
-300	1	40	68	-3	

The 3° glideslope is best maintained by power setting 50% and trim 2 pitch up. The airspeed is 47 kt and the sink rate is -200 fpm. Adjustments are done only by slight changes in the power setting.

The landing flare is performed by slowly reducing the power to zero and simultaneously pulling the elevator to slow down and maintain or reduce the sink rate.

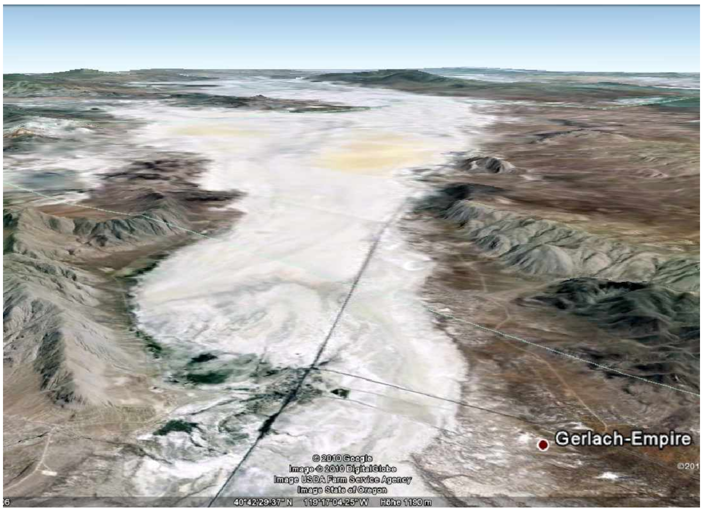
Watch out for ground effect!

Test Sites

Flight tests are planned at locations in California, Nevada, New Mexico, or Arizona, USA. Possible sites may be Roach Dry Lake, CA, near the Nevada and Arizona border. Also Danby Dry Lake 38 miles SE of Amboy, CA, or Broadwell Lake 40 miles NW Amboy may be taken into consideration. The Blackrock desert in northern Nevada is also a possible test site like the desert resort dry lake near Chiriaco Summit in Arizona.

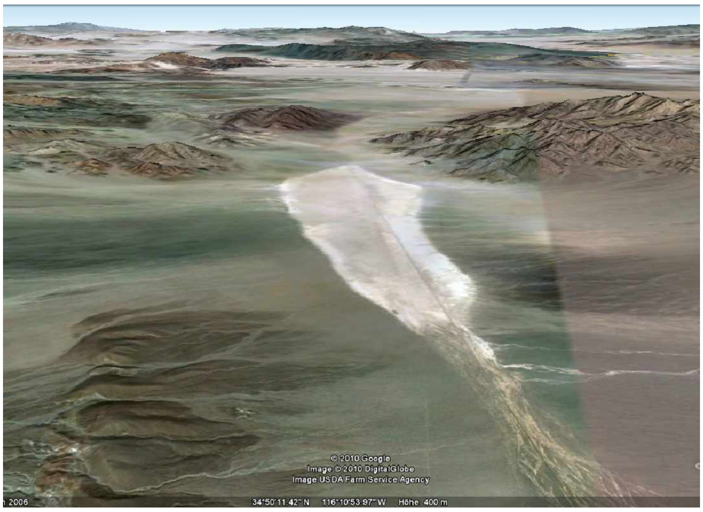
Before any test is performed permits of the FAA and the local county sheriff or the owner of the airfield should be requested.

Roach Dry Lake, CA



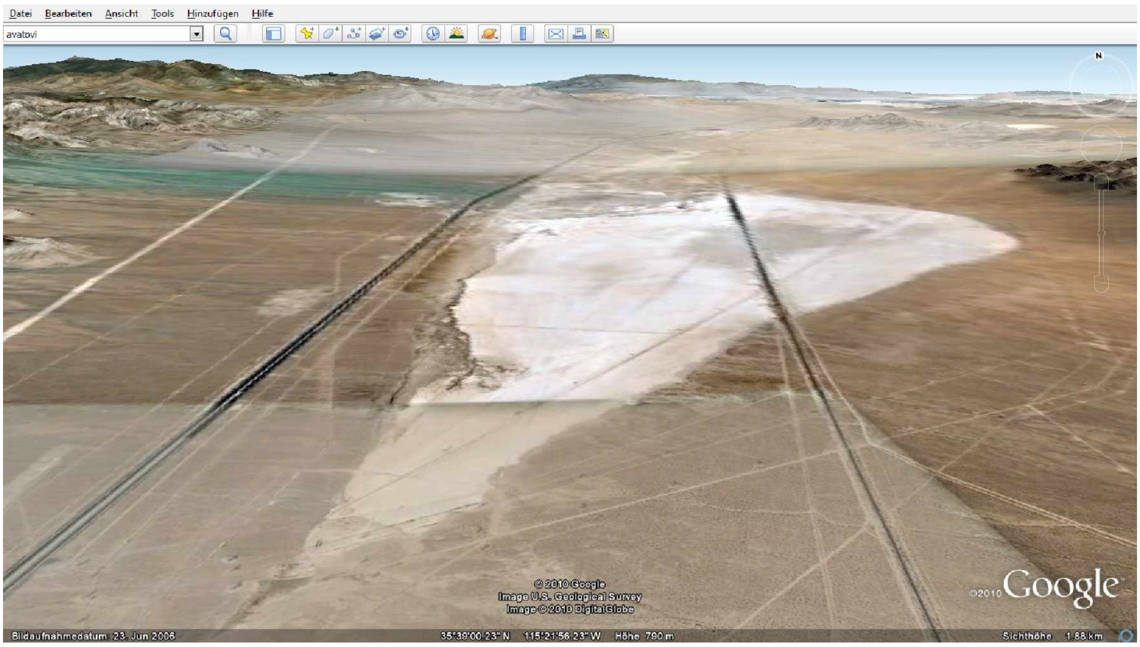
Black Rock Desert, NEV

CA San Bernardino County Sheriff-Coroner's Department
www.sbcounty.gov/sheriff/
655 East 3rd Street San Bernardino, CA 92415-0061, Vereinigte Staaten
(909) 387-8313



Broadwell Dry Lake, CA

Triangle Airpark, AZ50, AZ



Danby Dry Lake, CA

Aerodynamic

Name des Flügels = ScV13e.flg

Flächeninhalt (F) = 15,900726 m^2
Flächenbelastung = 21,822901 kg / m^2 = 218,229018 g / dm^2
Streckung (λ) = 4,004899
Bezugsflügeltiefe (lu) = 2,1985 m
aktuelle Luftdichte (p) = 1,225 kg / m^3 in 0 m Höhe

Rücklage des Geometrischen Neutralpunktes (XC) = 1,502 m
Rücklage des Elliptischen Neutralpunktes (XE) = 1,5172 m
Rücklage des Aerodynamischen Neutralpunktes (XN) = 1,5124 m
Rücklage des Druckpunktes=Schwerpunkt (XD) = 1,3145 m
Stabilitätsmaß (SM) = 9 %

Nullauftriebswinkel des gesamten Flügels (A0) = -1,832 Grad
Nullmomentbeiwert des gesamten Flügels (CM0) = 0,01379
Auftriebsanstieg des Flügels (dCA) = 3,637769
Momentanstieg des Flügels (dCM) = -0,01711

Auftriebsbeiwert des gesamten Flügels (CA) = 0,15316
Momentbeiwert des gesamten Flügels (CM) = 0,01307 <== !!!
Induzierter Gesamtwiderstandsbeiwert (CWI) = 0,00186
Güte (CWI/CWI ell.) = 1
Rollmomentbeiwert des gesamten Flügels (CL) = 0
Induzierter Giermomentbeiwert (CNI) = 0
Giermomentbeiwert (CN) = 0
Geschwindigkeit für den Stationären Flug (v_einsatz) = 47,770999 m/s

Geschätzte Flügelpolare :
Geschätzter Gesamt-Reibungswiderstandsbeiwert (CWR_geschätzt) = 0,00321
Geschätzter Gesamt-Widerstandsbeiwert (CWG_geschätzt) = 0,00508
Geschätzte Gleitzahl (E_geschätzt) = 30,15471
Geschätzte Steigzahl (e_geschätzt) = 11,80123
Geschätzte Sinkgeschwindigkeit (vs_geschätzt) = 1,583999 m/s
Geschätzter Gleitwinkel = 1,9 Grad

Mit Hilfe von Eppler berechnete Flügelpolare :
Profil-Widerstandsbeiwert (CWP) = 0,00643
Induzierter-Gesamtwiderstandsbeiwert (CWI) = 0,00186
Gesamt-Widerstandsbeiwert (CWG) = 0,0083
Gleitzahl (E) = 18,45982
Steigzahl (e) = 7,22436
Sinkgeschwindigkeit (vs) = 2,587999 m/s
Gleitwinkel = 3,1 Grad

Flight Operations

The flight of the ScV13e flying wing consists of

- the definition of the purpose of the mission (test, fun, reconnaissance or transport),
- the VFR flight planning,
- the preparation of the aircraft,
- the outside check, and
- the flight under guidance of the checklists.

The phases of the flight are

- Taxi
- Takeoff
- Climb
- Maneuvers
    - Level flight
    - Turns
    - Step Climbs
    - Step Descends
- Descend
- Landing
- Parking

VFR Flight Planning

Overhead-Overhead Flight Planning

Overhead-Overhead Flight Planning is the preferred method of flight planning: the flight is planned in the chosen altitude from overhead the departure airfield to overhead the destination airfield with the optimum TAS (80 kt). Adjustments are made for climb and descent, the so-called climb and descent additionals.

There are two categories of flights:

Flights with departure and destination at the same airfield:
Standard Test Flight Mission
Standard Fun Flight Mission
Standard Reconnaissance Flight Mission

Flights with departure and destination at different airfields:
Standard Transport Flight Mission

VFR Flight Plan Example

Standard Day Transport Flight Mission

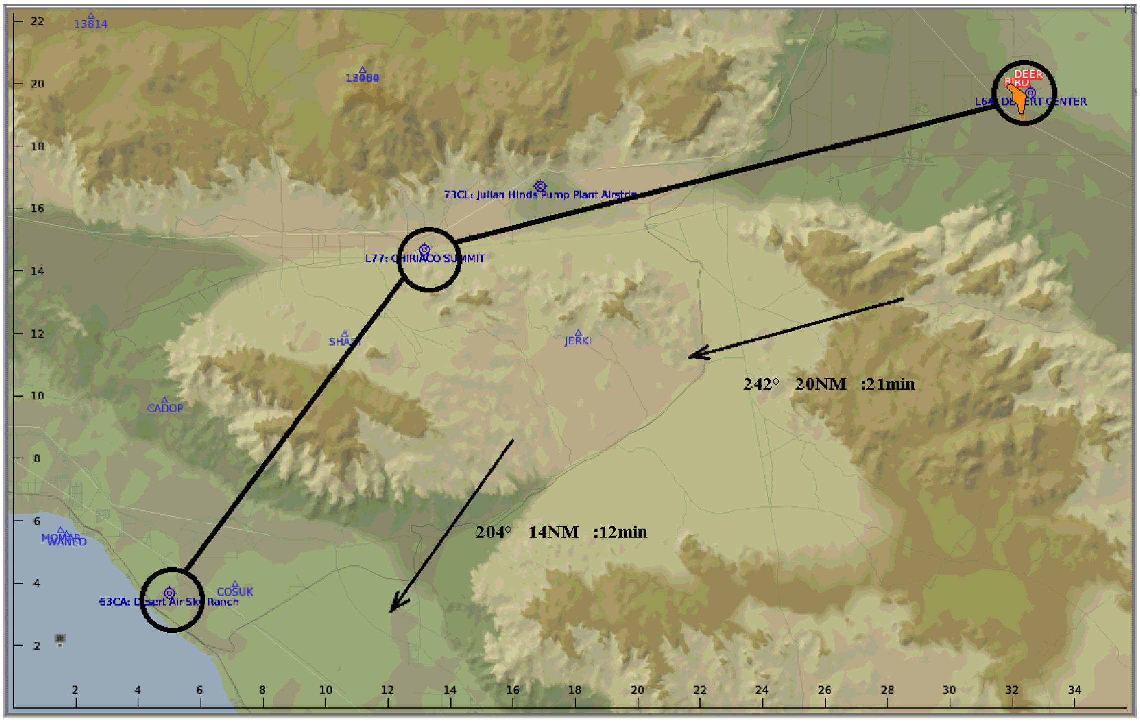
Flight Log:

```
                          VFR-FLUGPLANUNG              12-27-2010
-----------------------------------------------------------------
Experimental Scheuermann Flying Wing:  ScV13e       FLUGZEUGDATEN
Fuel: 100% electric    Energy Flow:   0.655 %/min bei 100% Thrust
avGS  70 kt             Fast 8000 RPM                avALT 6500 ft
-----------------------------------------------------------------
   NAVIGATIONS-FLUGPLAN      VAR 13 ° E
                                   Airwork   00:00  T/O    MSA
 1  Desert Center           L64  MC  Climb   00:04 _____  5900 ft
 2  Chiriaco Summit         L77  242°  20 NM 00:17 _____  5900 ft
 3  Desert Air Sky Ranch    63CA 204°  14 NM 00:12 _____  5900 ft
                                   Descent   00:10  LDG
                                ---------------------------------
                                  Flugzeit   00:43
-----------------------------------------------------------------
   DISTANZ                    Gesamt   34 NM  entspr.   62 km
   FLUGKOSTEN ca.  26.84 EUR = ca.  39.26 USD (incl TAX)
-----------------------------------------------------------------
ENERGIEBERECHNUNG Thrust  Berechnung                 Time
CAF           3.7% <-140% 0.655%*140/100*4 min
TRIP      + 16.9% <- 60% 0.655%*60/100*43 min      00:43 Trip Time
TRIPcorr. = 20.9%
RESERVE   + 11.8% <- 60% 0.655%*60/100*30 min     +00:30
MINTOF    = 32.7%                                 =01:13
EXTRA  diff 65.3%    60% 65.3%/(0.655%*60/100)-> +02:46
TOF       = 98.0%                                 =03:59 Endurance
TAXI      -  2.0% <- 30% 0.655%*30/100*10 min     +00:10
BLOCK      100.0%                                 =04:09
                                                  opHRS end ______
                                                  opHRSbegin______
Verbrauch:  22.9%                                 ttlHRS    ______
-----------------------------------------------------------------
PILOT:      Wolf Scheuermann


WETTER
------
DEP (KBLH)
2010/12/27 08:52 KBLH 270852Z AUTO 36009KT 10SM CLR 12/04 A3011 RMK
AO2 SLP194 T01170039 58003 TSNO

DEST (KTRM)
2010/12/27 09:52 KTRM 270952Z AUTO 00000KT 10SM CLR 11/08 A3013 RMK
AO2 SLP202 T01060078
```

Now the map has to be prepared as follows:
Enter into the map:

- Waypoints
- Course lines
- Course arrows

VFR Map



After the preparation of the flight log and VFR-map calculate mass and balance.

Mass and Balance Calculation Example

Mass and Balance Calculation Sheet					Längs [m]	CG	Moment
					Station 0	(Nasenspitze)	
Operating Weight	=	264.22	kg	x	1.506	=	397.92
1 Crew	=	85.00	kg	x	1.151	=	97.84
Baggage	=	0.70	kg	x	0.881	=	0.62
					ttl CG		
Total Weight	=	349.92	kg	x	1.419	=	496.38

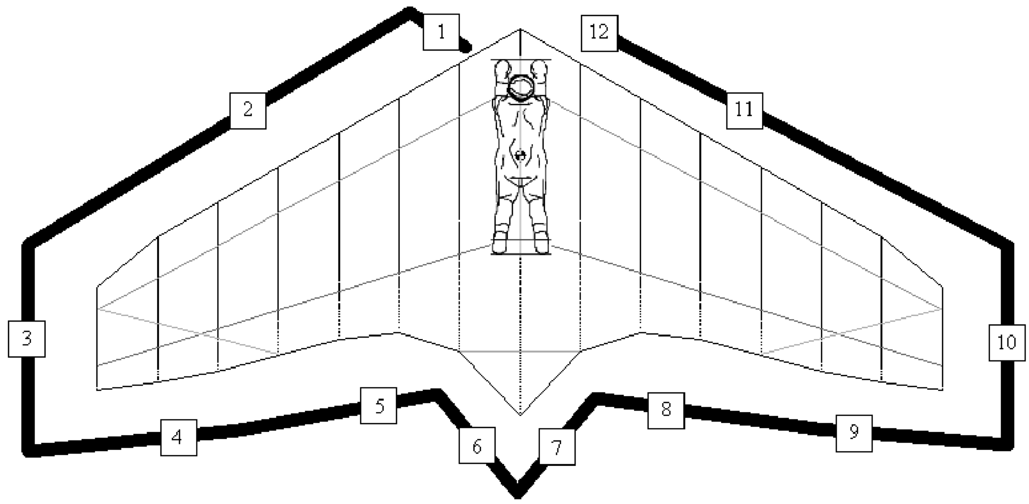
NOTE:

- The total weight must be less then 350 kg .
- The center of gravity must be within the limits of 1.30 m and 1.42 m off station 0 (nose point).

Preparation of the Aircraft

When the tarpaulins, ropes, and blocks are removed release the parking brake and pull the aircraft out of the hangar or shelter. Perform the outside check according to the following checklist.

Outside Check



1. Open canopy and check battery and ignition switch off. Check outboard antennas and sensors. Check left air inlet and impeller.
2. Check left wing and left main landing gear.
3. Check left wing tip and flap hinges.
4. Check left flap.
5. Check left air outlet.
6. Check left rudder and the aircraft rescue parachute.
7. Check right rudder.
8. Check right air outlet.
9. Check right flap.
10. Check right wing tip and flap hinges.
11. Check right wing and right main landing gear.
12. Check right air inlet and impeller. Check outboard antennas and sensors. Check front landing gear. Enter cockpit and close canopy.

Taxi

After the outside check is completed,

- check and put on your personal parachute,
- enter the cockpit,
- settle into the prone position,
- fasten the seat belts, and
- close the canopy.
- Perform the BEFORE TAKE OFF checklist and the Run Up:
    - Check if the controls are free
    - set power to zero
    - switch battery on
    - switch rotating beacon on
    - switch landing light on
    - check if the gear is down and locked
    - start engine1
    - start engine2
    - turn COM/GPS on and tune
    - request ATIS and Taxi clearance
    - set and check altimeter
    - switch transponder to mode standby.
- Taxi to the holding position of the active runway.
    - Check the brakes,
    - the turning instruments and
- Steer the aircraft by differential braking action.
- At the holding position of the active runway
    - Set the parking brake.
    - Check the controls and
    - the engines response the throttle.

Takeoff

Taxi into position and hold. Start the takeoff run according to the TAKE OFF checklist:

- Transponder Mode C or S.
- Trim neutral.
- Timer set.
- Brakes off.
- Takeoff Power full 100%.
- Rotate at 40 kt.

CAUTION:
Be aware of the strong pitch-up tendency at low speeds after rotation! Be ready to push the nose down immediately after takeoff. After gear up try to gain speed at low altitude over the runway to improve the aircrafts behavior.

Enter the take off time in the flight log. The format is local or zulu time.

Climb

Climb according to the AFTER TAKE OFF checklist:

- Climb Rate checked, positive.
- Watch pitch, keep nose down!
- Gear up.
- Takeoff Time recorded.
- Cruise Power set to 60%.
- Trim nose slightly down.

Maneuvers

Inflight maneuvers consist of straight and level flight, turns, step climbs, and step descends.

Level Flight

- Cruise procedure: 50% of total thrust.
- Trim: 1 pitch down.
- When cruising with Full Power trim down until level flight.
- Cruise speed: TAS = 80 kt.
- Keep the wings with small aileron adjustments level.

Enter the passage time of waypoints into the flight log.

Turns

A level turn is performed with coordinated rudder and aileron inputs to reach and maintain a certain bank angle. The woolen string in front of the windshield helps while coordinating the control input.

When the turn starts hold both controls slightly and maintain the bank angle. Watch the vertical speed. It should be steady at zero. Otherwise adjust by pulling or pushing the elevator. Keep an eye outside on the visible horizon!

The air speed during the turn should stay well above 40 kt! At 60° bank the stall speed is 70 kt!

Step Climbs
Step climbs are performed by increasing the power setting to 100%. Just before reaching the new altitude reduce the power setting gently back to cruise level setting.

Step Descends
Step decends are performed by reducing the power setting to 30% or 40%. Just before reaching the new altitude increase the power setting gently up to cruise level setting.

Descend

The final approach is commenced when the aircraft is aligned with the runway centerline.

Perform the READY FOR LANDING checklist and slow down while still in level flight:

- Trim up 2 to 3 pitch.
- Landing speed is 40 kt, nothing below! Do not yet change the power setting!
- Gear down and locked.

The final descend should be performed with a 3° glide slope which is standard for most runways. This means, the height above touch down point at the Top of Descend (ToD) is about:

3000 ft in 10 NM distance
1000 ft in 3 NM distance
300 ft in 1 NM distance
100 ft in 2000 ft distance
50 ft in 1000 ft distance, above the runway threshold

Set descend power about 30% to 40%. The sink rate for a 3° glide slope, or Rate of Descend in fpm (RoD) is calculated by Ground Speed in kt (GS) times 5:

$$RoD = 5 \cdot GS$$

Sink Rate at 40 kt is 200 fpm, controlled by landing power.

Landing

A 3° glideslope is best maintained by power setting 50% and trim 2 pitch up. The airspeed is 47 kt and the sink rate is -200 fpm. Adjustments are done only by slight changes in the power setting.

For landing flare pull up and/or increase the power shortly.

Caution: Be aware of the ground effect! Avoid climbing during flare!

After touch down steer carefully and brake gently to low taxi speed. Enter the landing time into the flight log.

Taxi to parking position.

Parking

After parking perform the AFTER LANDING checklist:

- Set power to zero
- Transponder standby
- Record the landing time
- Trim neutral
- Parking brakes set
- COM/GPS off
- Lights off
- Engine 1 shutdown
- Engine 2 shutdown
- Switch battery off

Climb out of the cockpit and perform a thorough visual outside check to check for surface damage.

Pull the aircraft into the hangar or shelter. Set the blocks, strap the ropes and fasten the tarpaulins.

Emergency

In case of any emergency inflight perform the EMERGENCY checklist:

- Set POWER immediately to ZERO!
- Gear down and locked.
- Shutdown the engines.
- Deploy the aircraft parachute.
- Call MAYDAY on all reachable frequencies if possible.
- Switch off the battery.
- In case the aircraft cannot be rescued bail out and save yourself with your personal parachute.
- Brace for hard touch down/impact.

Maintenance

After every flight a thorough visual outside check should be performed to check for surface damage.

A knock sound check reveals broken inner struts if the sound is shattering. If this is the case the aircraft is to be grounded as long as the inner damage is not repaired.

After 50 hours a thorough outside and inside check of every fixed and moving structure shall be performed. The aircraft is not airworthy until this check is successfully finished.

Maintenance Log

A Maintenance Log has to be kept showing the date of the check, the kind of repair, and the person or workshop who performed the repair.

Checklists

FLYING WING ScV13e CHECKLIST

BEFORE TAKE OFF

VFR Flight Plan	calculated
Weight and Balance	calculated
Outside Check	completed
Controls	checked and free
Power	zero
Battery	on
Gear	down and locked
Ignition Engine1	on
Ignition Engine2	on
COM/GPS	on and tuned
ATIS and Taxi Clearance	received
Altimeter	set and checked
Transponder	Mode C or S
Rotating Beacon	on
Landing Light	on

TAKE OFF

Trim	neutral
Timer	set
Brakes	off
Takeoff Power	full 100%
Rotate	at 40 kt rotate

CAUTION! Strong pitch-up tendency!

AFTER TAKE OFF

Climb Rate	checked, positiv
Pitch	keep nose down!
Gear	up
Take Off Time	recorded
Cruise Power	set 60%
Trim	nose slightly down
Cruise with Full Power	trim down until level flight

TURNS

Turn	bank with aileron and coordinated rudder when turn starts hold both controls slightly and maintain bank, altitude watch air speed during turn!
Straight Flight	zero stick, keep wings level with very small control adjustments

E M E R G E N C Y

Power	**zero**
Gear	**down and locked**
Engines	**shutdown**
Chute	**deploy**
MAYDAY	**called**
Battery	**off**

READY FOR LANDING

Trim	up
Gear	down and locked
Landing Power	set
Landing Speed	40 kt, nothing below
Sink Rate	200 fpm, controlled by landing power
Landing	flare and brake

AFTER LANDING

Power	zero
Transponder	standby
Landing Time	recorded
Taxi	to parking position
Trim	neutral
Brakes	set
COM/GPS	off
Lights	off
Ignition Engine 1	off
Ignition Engine 2	off
Battery	off

by Kapt. Wolf Scheuermann

Appendix

Abschätzung der erforderlichen elektrischen Leistung

Daten ScV10, Kolbenmotor:

Fuel an Bord: 22.5858 kg = 143 lbs
Motorleistung: 40.3 kW ≈ 20% η_{Motor} bringt 118 lbs Schub maximal
Fuel liefert: 971.2 kWh Energie
Motorleistung holt 4.5 Flugstunden aus dem Treibstoff
Motor-Fuel-Leistung = Fuelenergie / Flugstunde = 971.2 kWh / 4.5 h = 215.8 kW
Wirkungsgrad: η_{Motor} = Motorleistung / Fuelleistung = 40.3 kW / 215.8 kW =
= 0.187 ≈ 19%

Daten ScV11e, Elektromotor:

Elektromotor: $\eta_e = 90\%$
Propeller: $\eta_{Prop} = 80\%$
Impeller: $\eta = 80\%$
→ elektrischer Impeller hat $\eta_{Gesamt} = 0.9 \cdot 0.8 \cdot 0.8 = 0.576 \approx 60\%$ (58%)
el.Energiefluß = el.Fuel-Leistung (pro Stunde) = $\eta_{Motor} / \eta_{Gesamt} \cdot 215.8$ kWh/h =
= 0.187 / 0.576 · 215.8 kWh/h = 70.1 kWh/h
D.h. ich brauche 70.1 kWh Batterie-Energie um 1 Std zu fliegen
und eine Gesamt-Elektromotorleistung von 40.3 kW · ηGesamt =40.3 kW · 0.576 = 23.2 kW
bzw. 23.2 kW / 2 = 11.6 kW pro Motor.

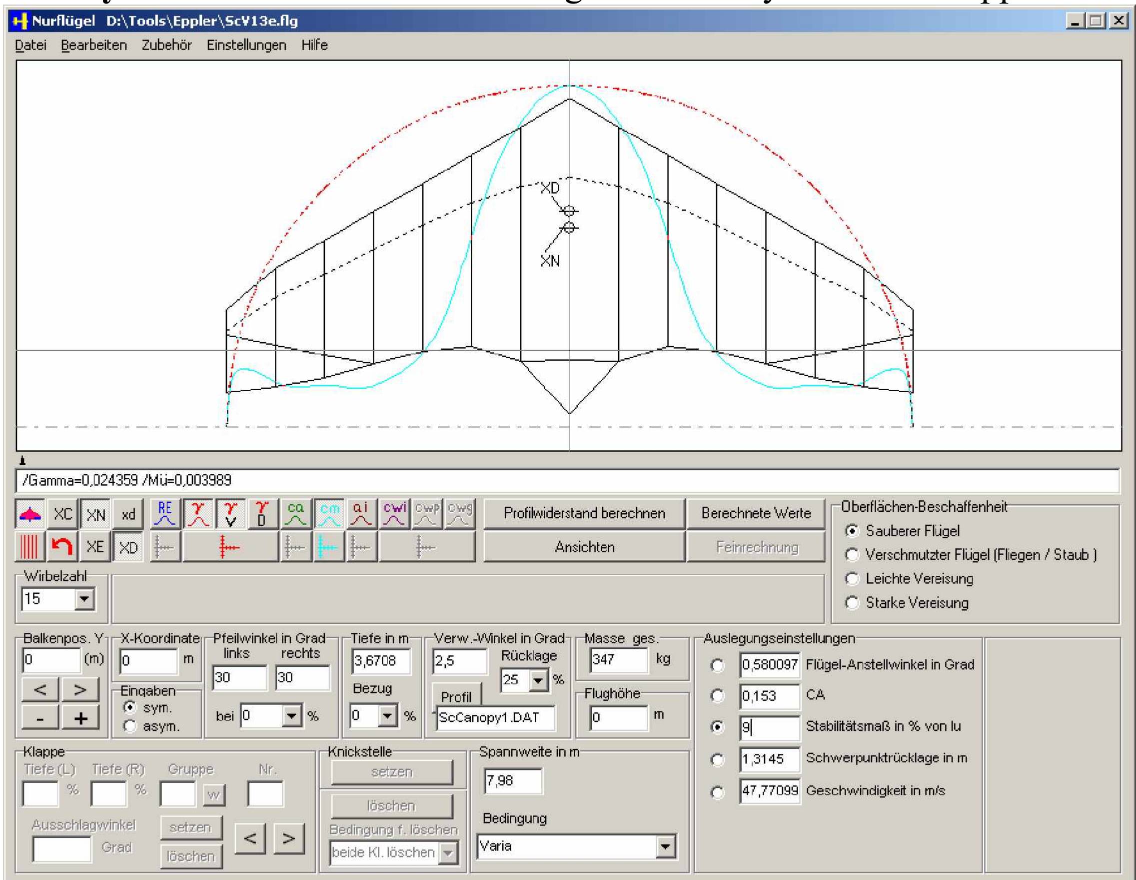
Akkumulatoren:

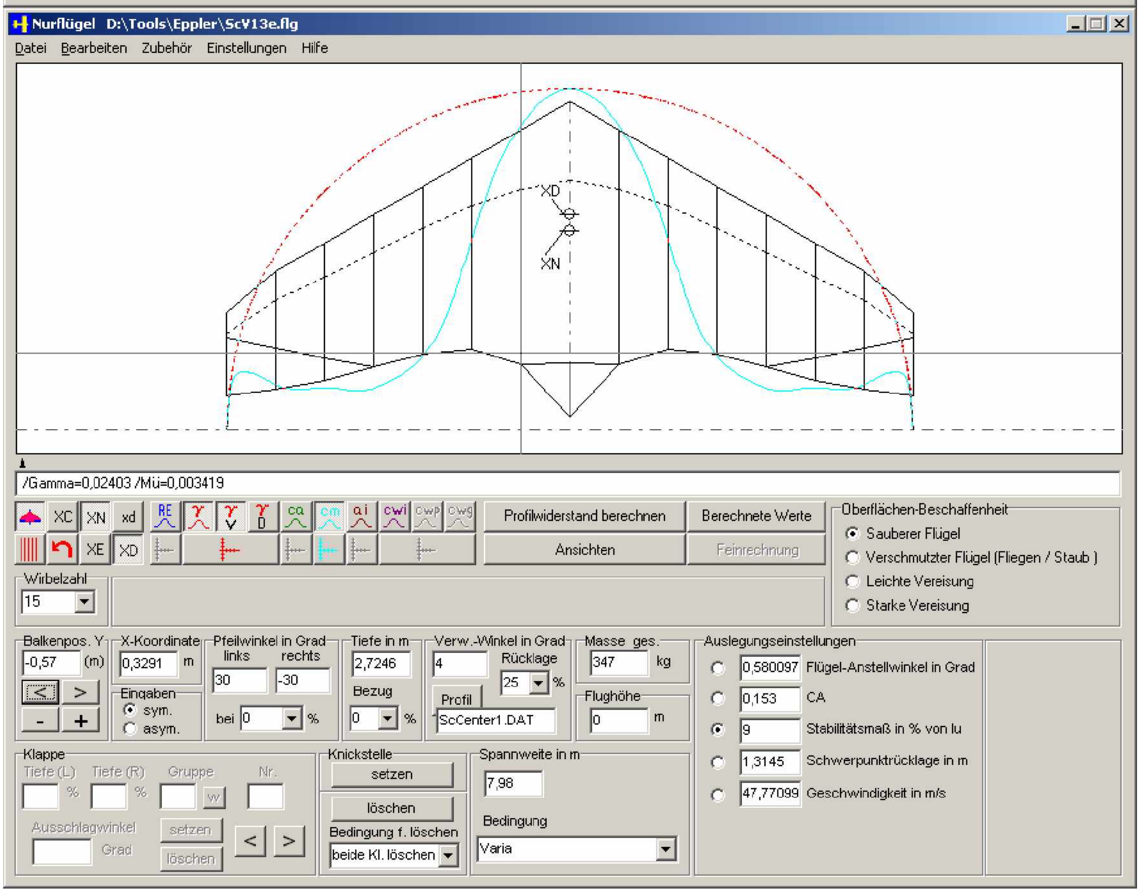
NiMH-Akku:	0.42 MJ/kg = kWh/kg	zum Vergleich:
Kerosin:	43 MJ/kg	Faktor 100 !
Lithium-Polymer-Akku:	0.54 MJ/kg	

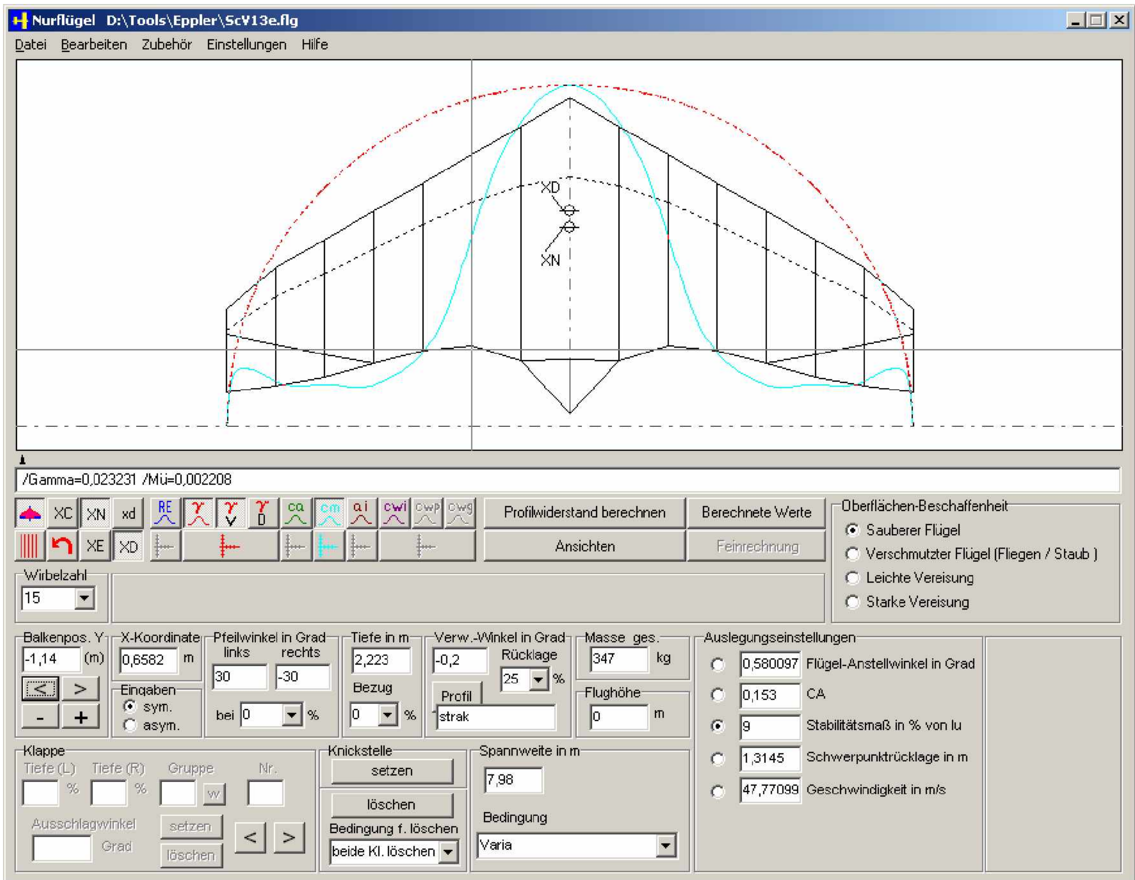
Fuel-Masse = 22 kg = 0.42 · 22 kWh Energie in NiMH-Akkus = 9.29 kWh
Beim el.Energiefluß von 70.1 kWh/h ergibt sich somit eine Flugzeit von
ca. 10 kWh / 70.1 kWh/h = 0.143 h = 9 min allerdings mit Volllast!
Da ca. 70% des maximalen Schubes reichen um Level zu fliegen, lässt sich die Zeit strecken, vielleicht auf ca. ½ Std.

Kapt. Wolf Scheuermann

Aerodynamic Calculations according to the theory of Richard Eppler



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Verschmutzter Flügel (Fliegen / Staub)
Leichte Vereisung
Starke Vereisung
Wirbelzahl
15
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30 -30
Tiefe in m
2,223
Bezug
Verw.-Winkel in Grad
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Rücklage
25 %
Profil
strak
Masse ges.
347 kg
Flughöhe
0 m
Eingaben
sym.
asym.
bei 0 %
0 %
Auslegungseinstellungen
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0,153 CA
9 Stabilitätsmaß in % von lu
1,3145 Schwerpunktrücklage in m
47,77099 Geschwindigkeit in m/s
Klappe
Tiefe (L) Tiefe (R) Gruppe Nr.
Ausschlagwinkel
Grad
setzen
löschen
Knickstelle
setzen
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Bedingung f. löschen
beide Kl. löschen
Spannweite in m
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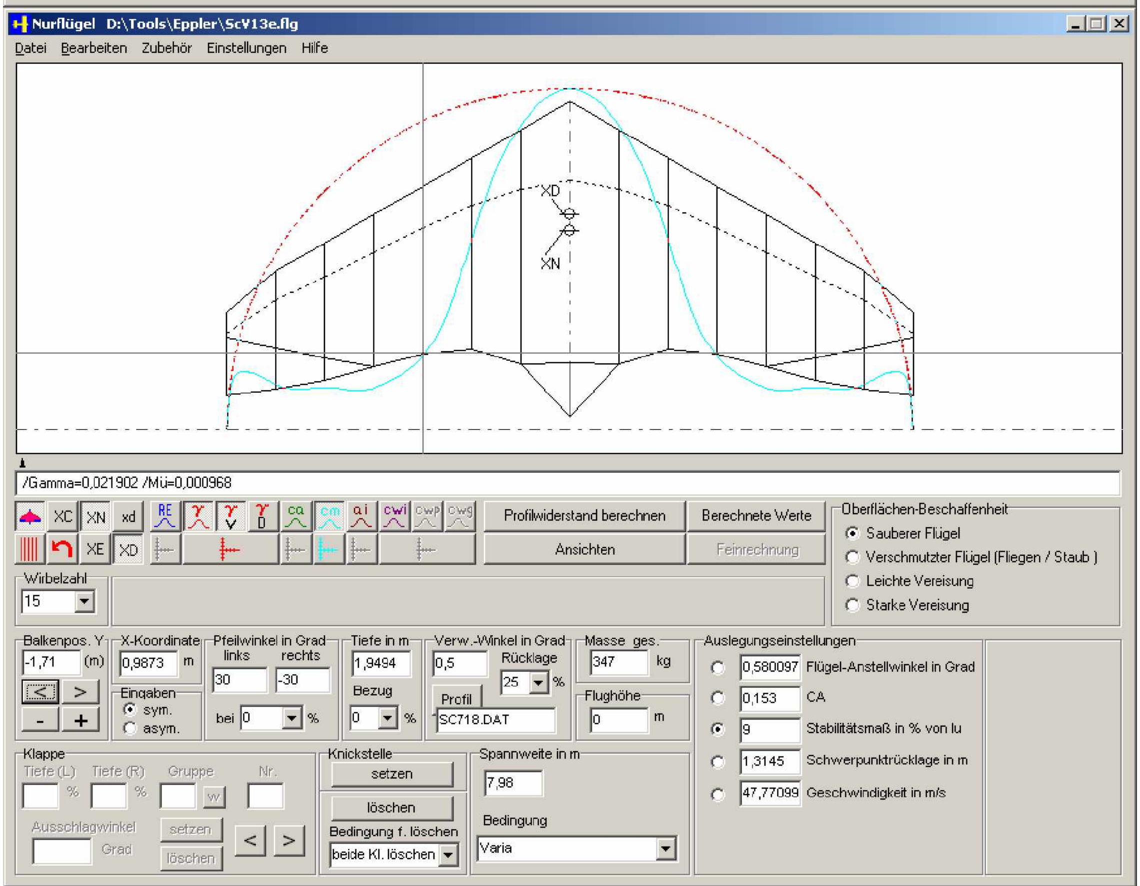
Bedingung
Varia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Starke Vereisung
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347 kg
Flughöhe
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Eingaben
sym.
asym.
bei 0 %
0 %
Auslegungseinstellungen
0,580097 Flügel-Anstellwinkel in Grad
0,153 CA
9 Stabilitätsmaß in % von lu
1,3145 Schwerpunktrücklage in m
47,77099 Geschwindigkeit in m/s
Klappe
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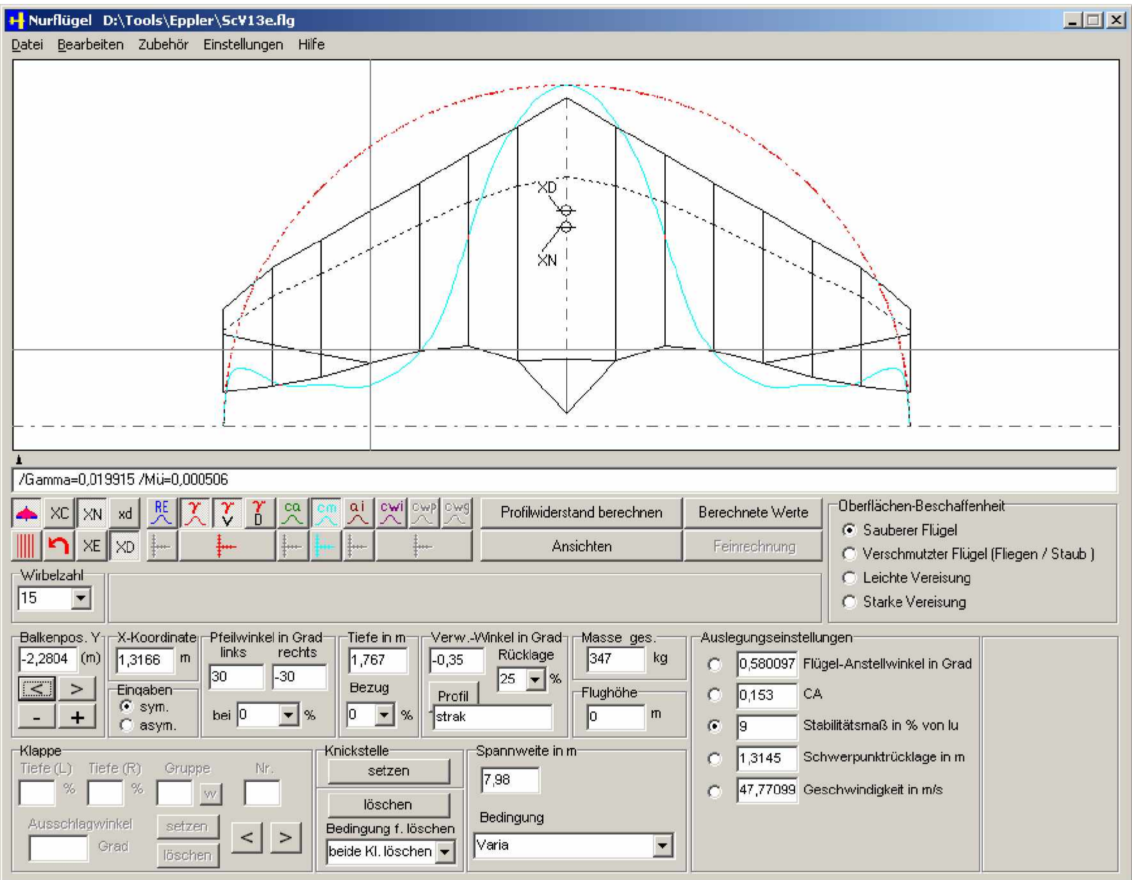
Ausschlagwinkel
Grad
setzen
löschen
Knickstelle
setzen
löschen
Bedingung f. löschen
beide Kl. löschen
Spannweite in m
7,98
Bedingung
Varia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Verw.-Winkel in Grad
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Rücklage
25 %
Profil
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Flughöhe
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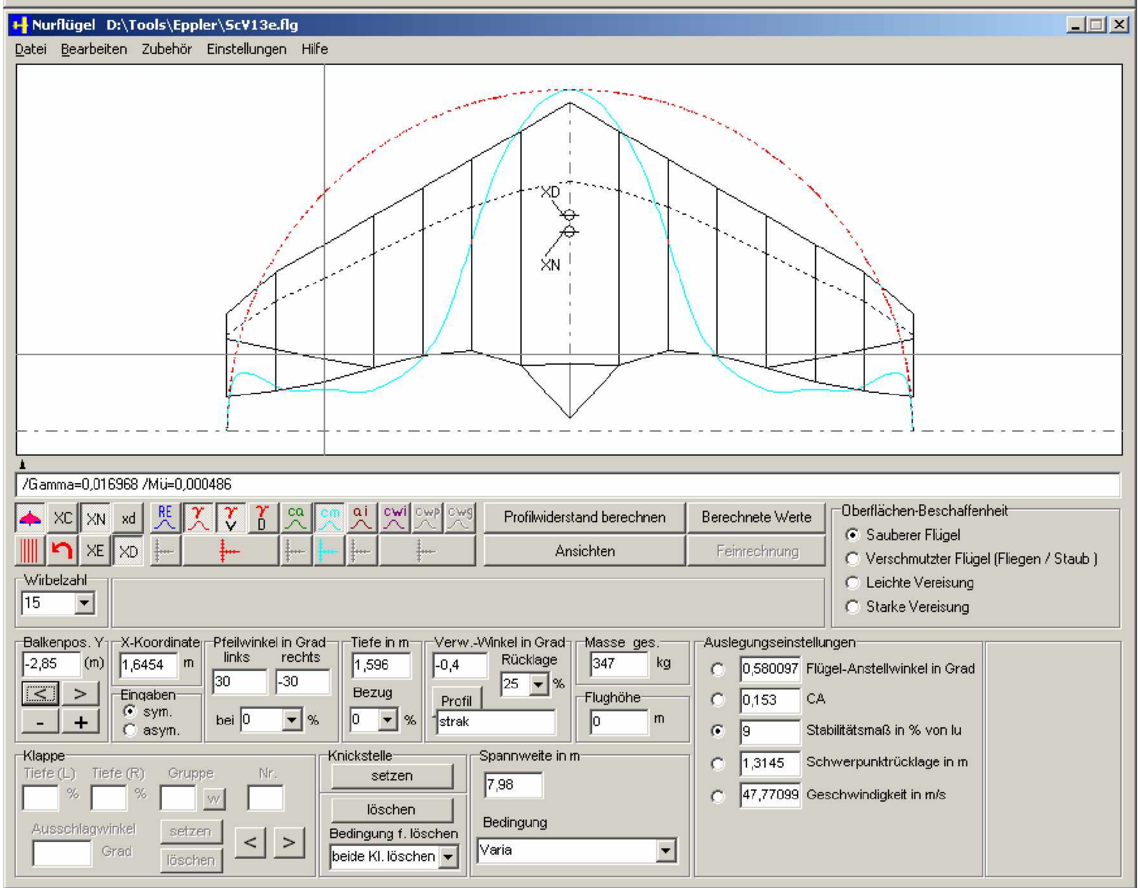
Bedingung
Varia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Flughöhe
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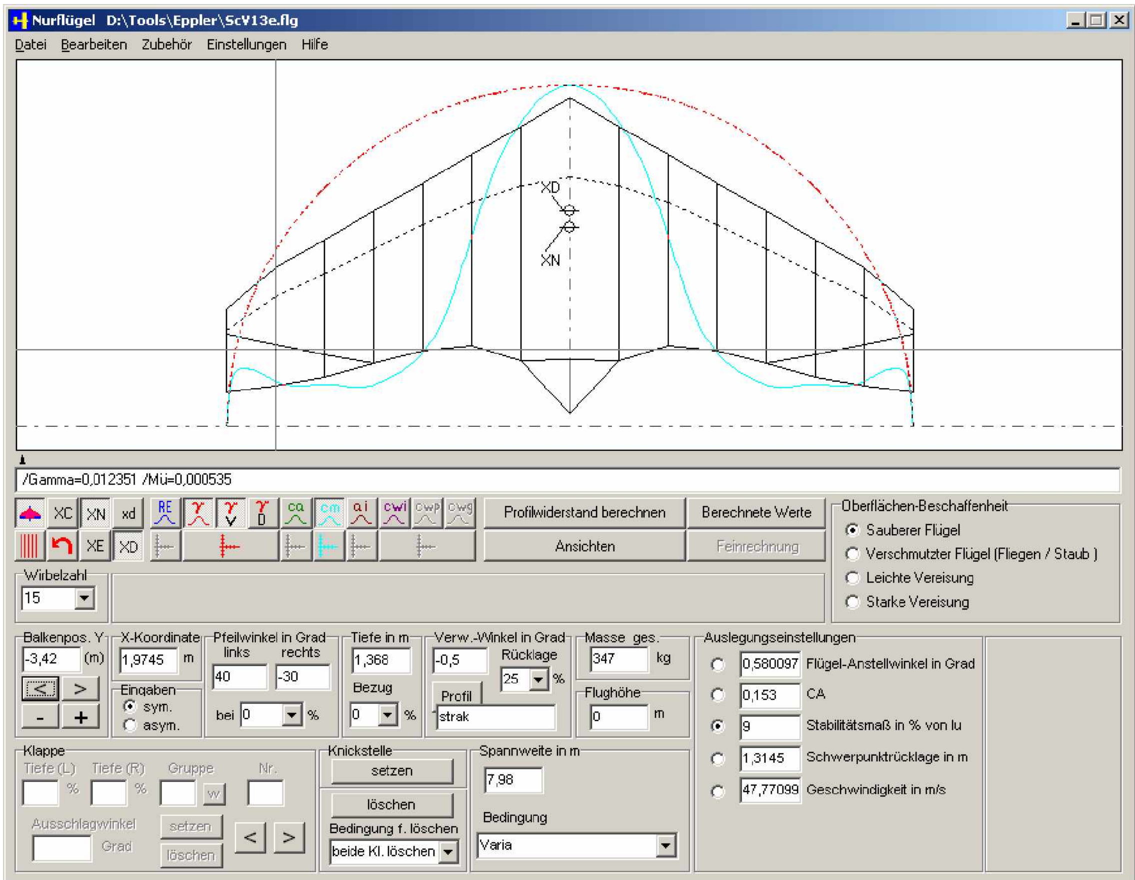
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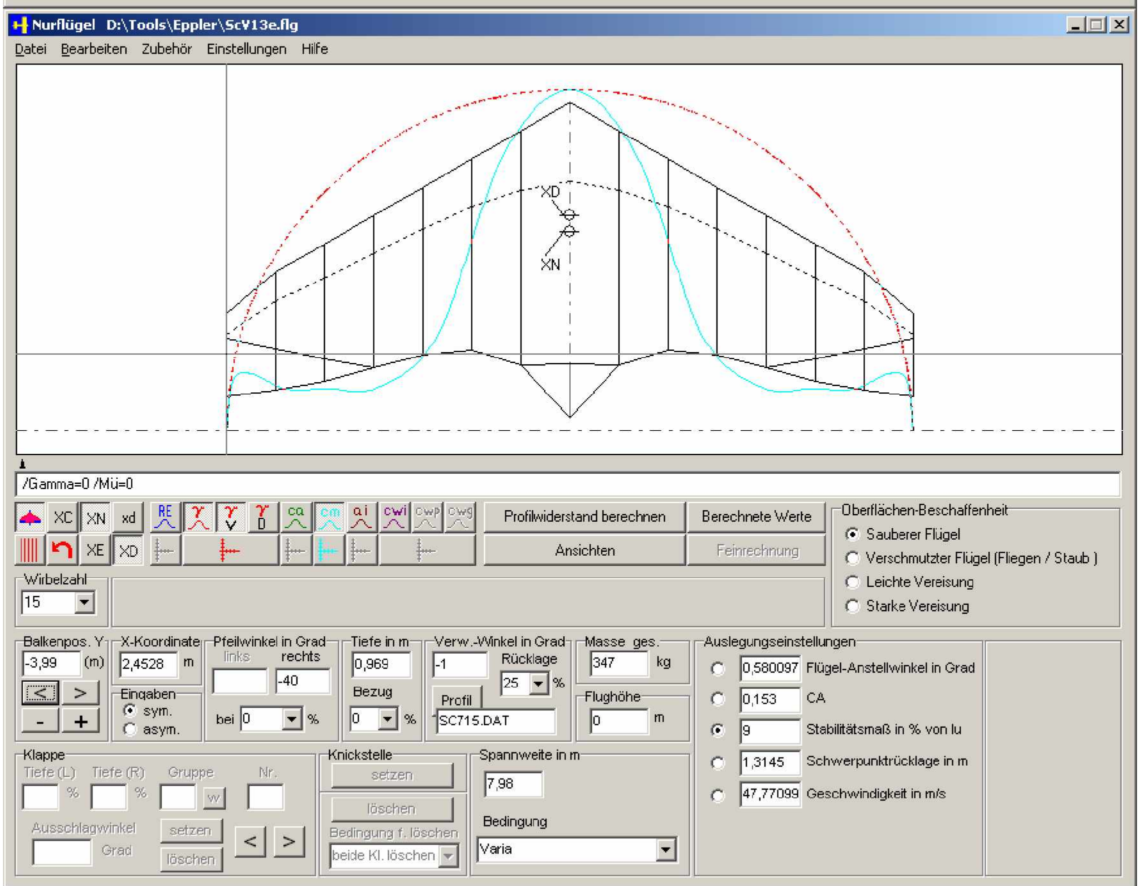
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Ausschlagwinkel
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setzen
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Aeroelasticity

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