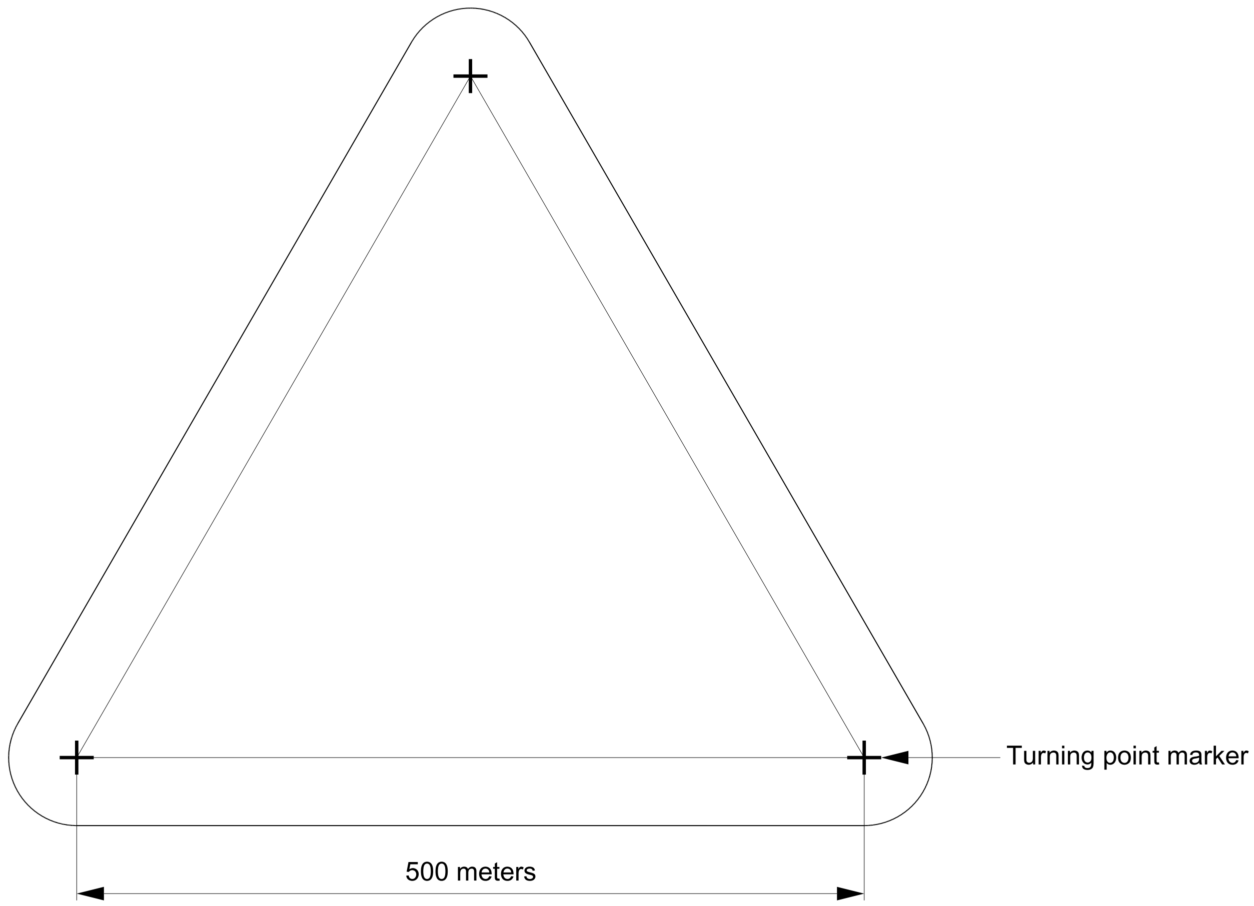
The Two Remaining Unchallenged Kremer Prizes

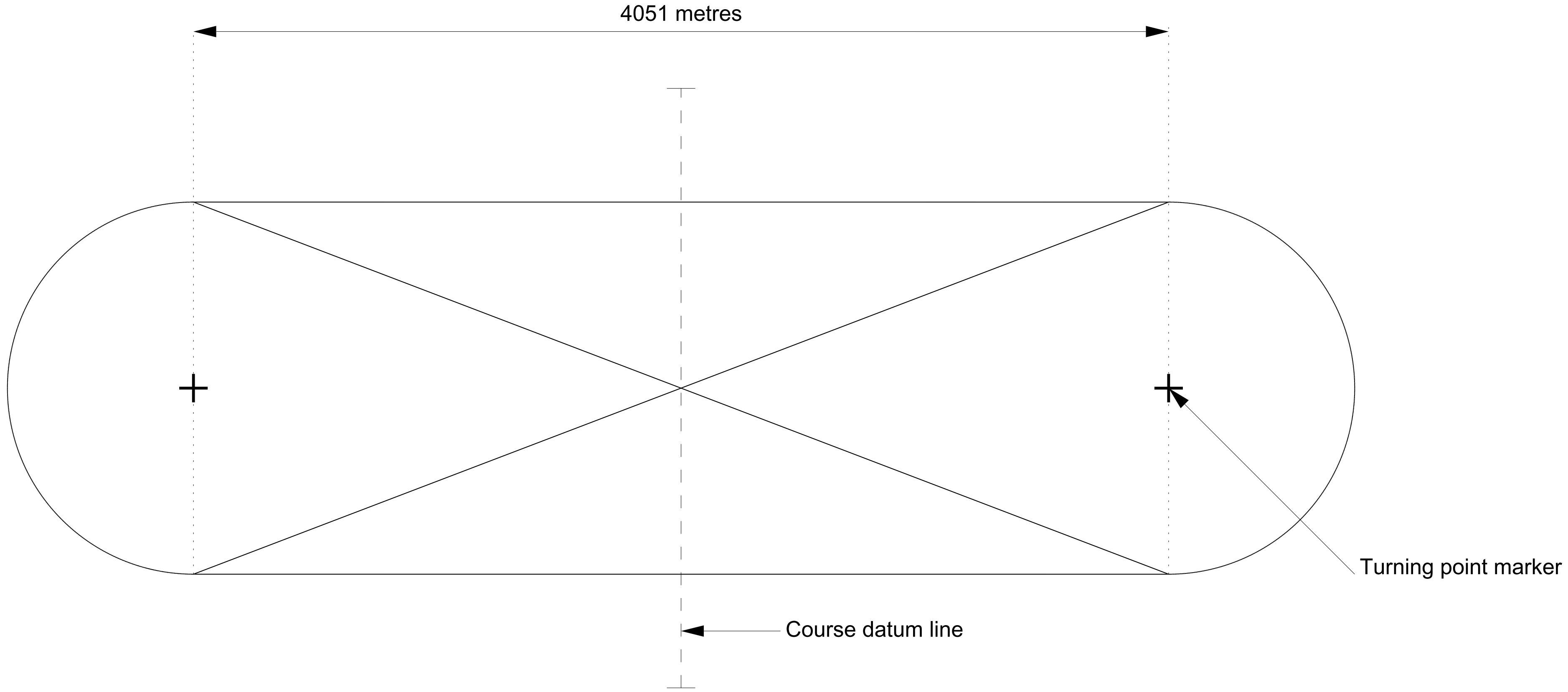
The State of the Art

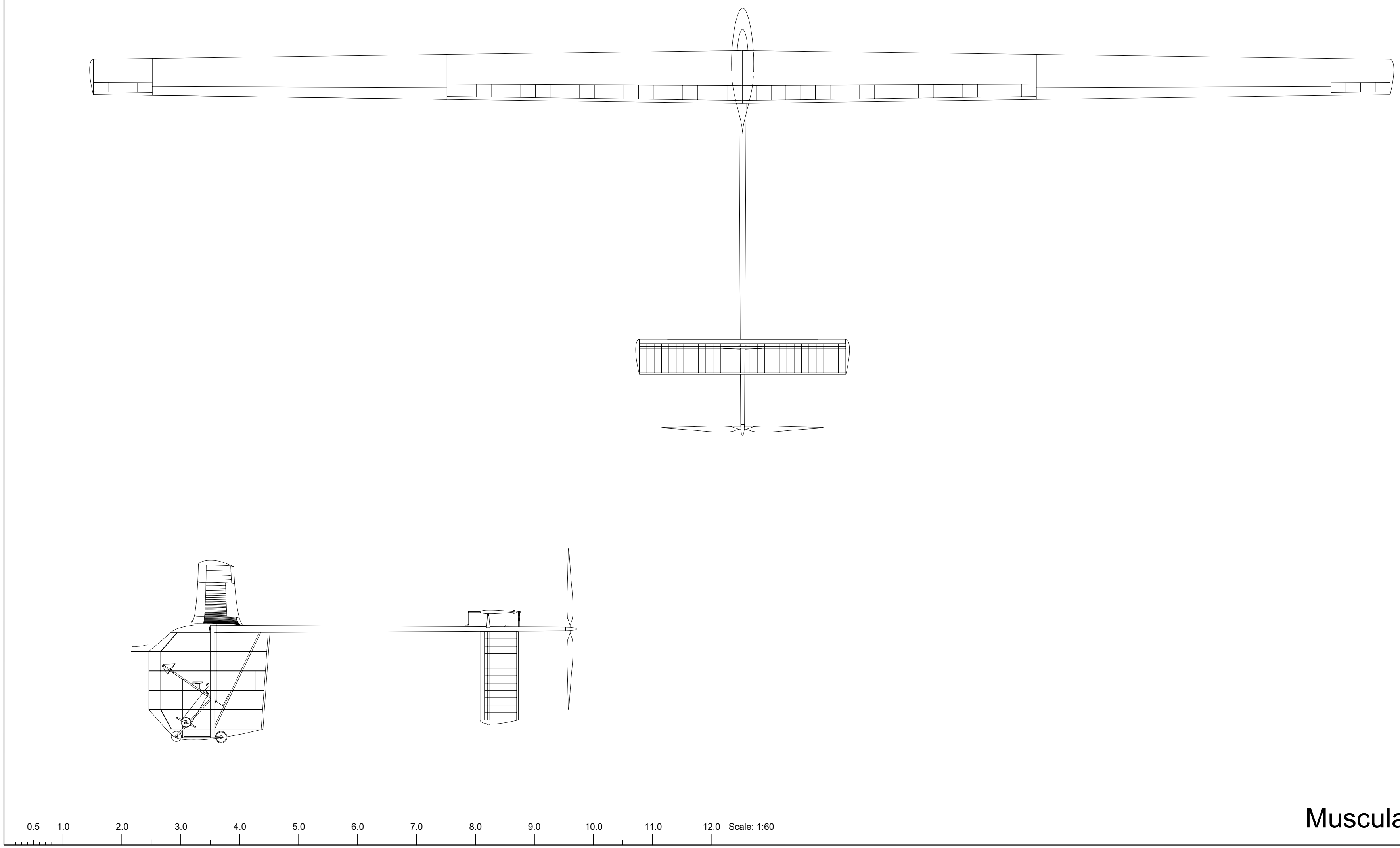
Musculair 1	Kremer figure of eight in 4 min 5 s Kremer speed competition 2 min 31.8 secs
Musculair 2	Kremer speed competition 2 min 2 secs at 44.26 kph
Marathon Eagle	298 W at 26.2 mph
Yunyi	12.5 m/s ? 260 W ? L/D = 42 ?

The Kremer Sport Competition Course



The Kremer Marathon Competition Course

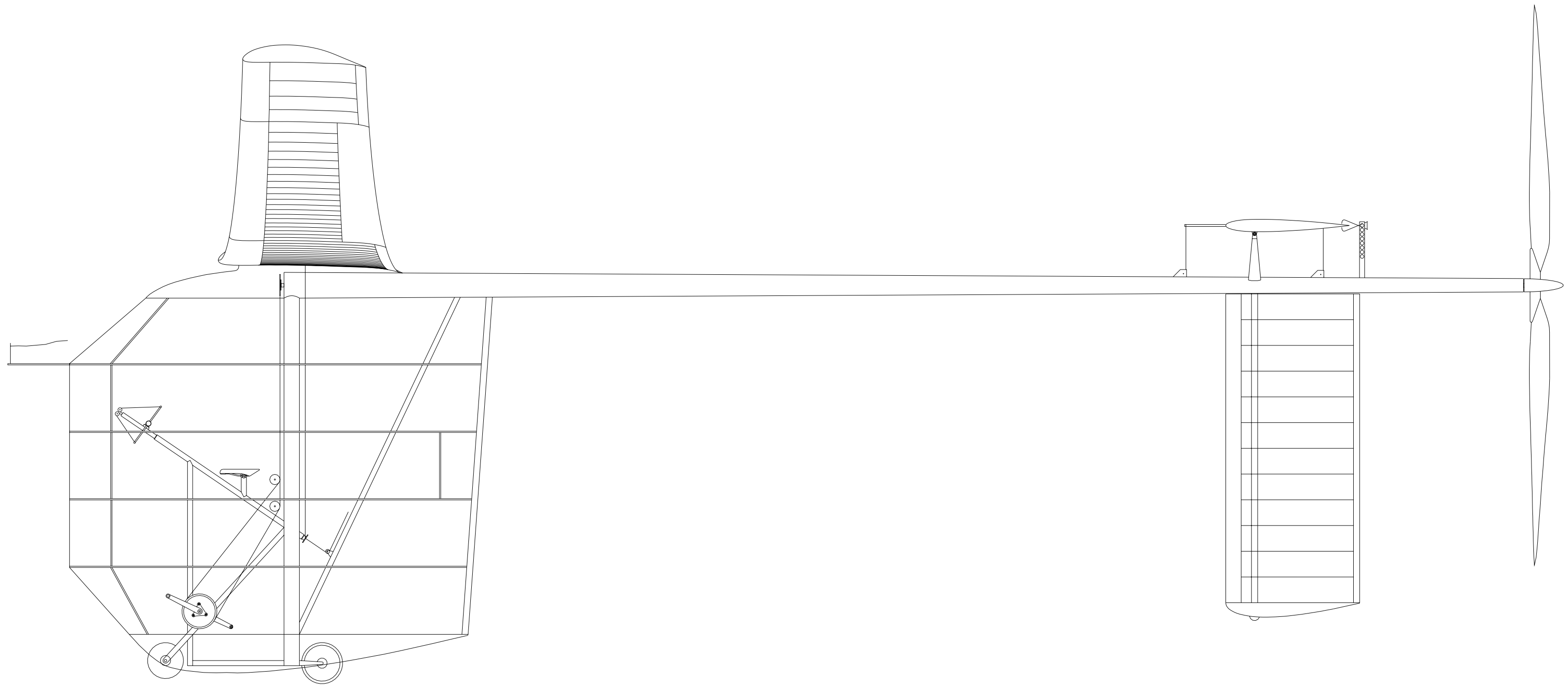




Musculair 1

MUSCULAIR 1

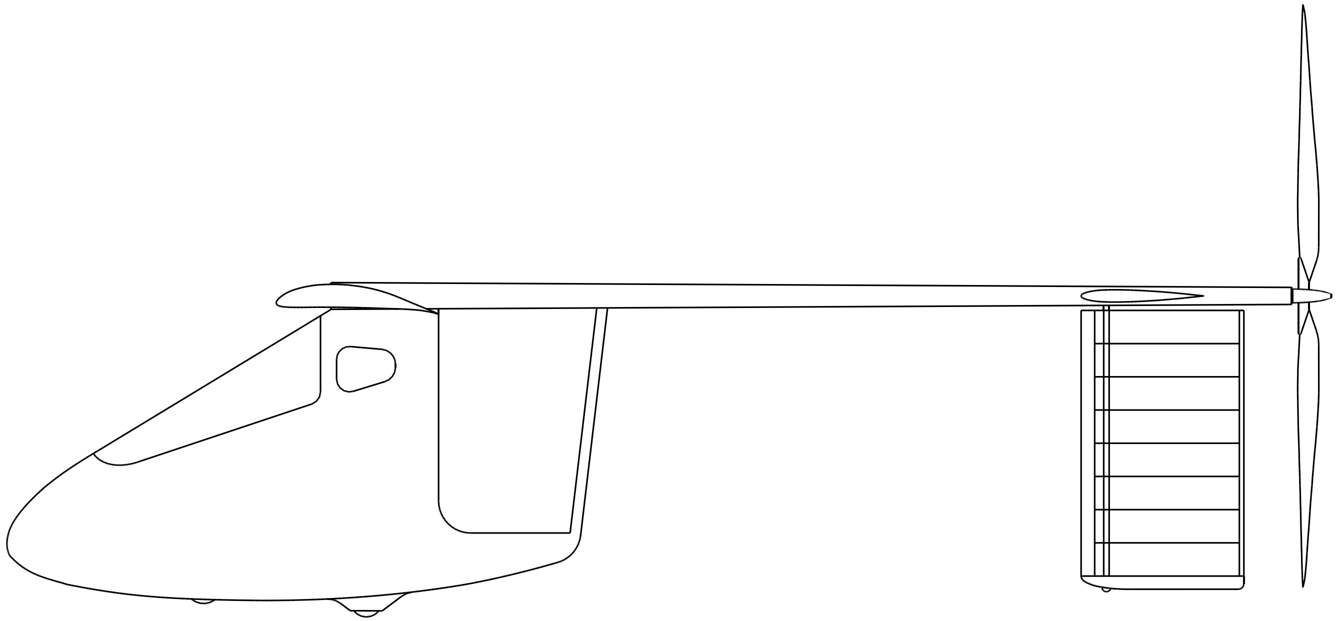
Span: 22 m
Wing area: 16.5 m2
Empty weight: 28 kg
Flight power: 225 W at 8.5 m/s 265 W at 11 m/s
Best glide ratio: 1:38
Minimum sinking speed: 0.22 m/s
Wing airfoil: FX76MP 160 at root - FX76MP 140 at tip
Stabiliser airfoil: FX76 100
Rudder airfoil: FX76 100
Prop diameter: 2.72 m



Scale: 1:30 0.5 1.0 2.0 3.0 4.0 5.0 6.0 m

MUSCULAIR 2

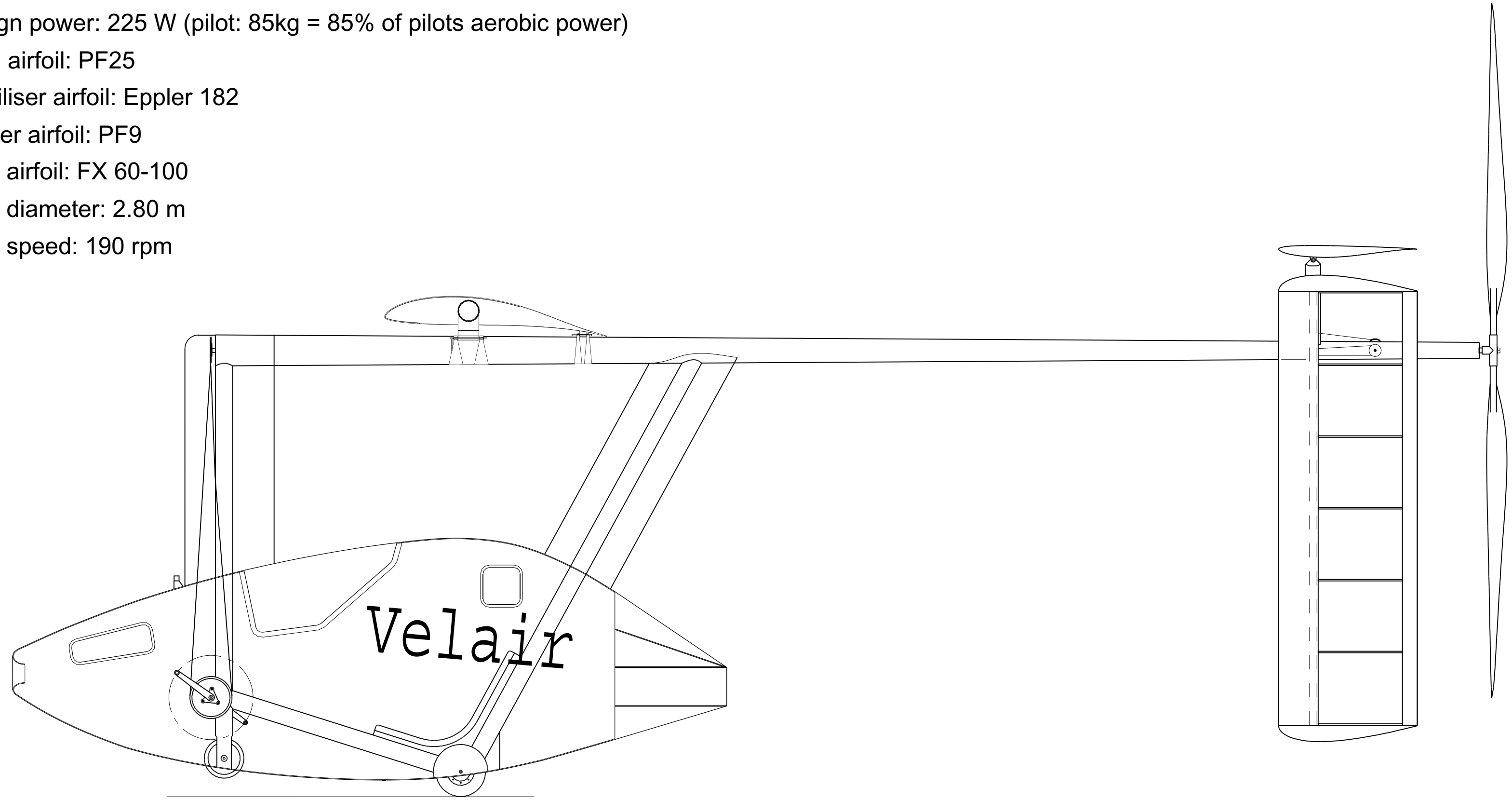
Span: 19.5 m
Wing area: 11.7 m2
Empty weight: 25 kg
Flight power: 250 W at 10 m/s 315 W at 12 m/s
Best glide ratio: 1:37
Minimum sinking speed: 0.27 m/s
Wing airfoil: FX76MP modified by Dieter Althaus
Stabiliser airfoil: FX76 100
Rudder airfoil: FX76 100
Prop diameter: 2.68 m



Scale: 1:30 0.5 1.0 2.0 3.0 4.0 5.0 6.0 m

span: 23.2 m
wing area: 16.9 m2
aspect ratio: 32
empty weight: 30.5 kg
design speed: 8.6 m/s
design power: 225 W (pilot: 85kg = 85% of pilots aerobic power)
wing airfoil: PF25
stabiliser airfoil: Eppler 182
rudder airfoil: PF9
prop airfoil: FX 60-100
prop diameter: 2.80 m
prop speed: 190 rpm

VELAIR 89
Human Powered Aircraft
Designed by Peer Frank



Scale: 1:25 0.5 1.0 2.0 3.0 4.0 5.0 6.0 m

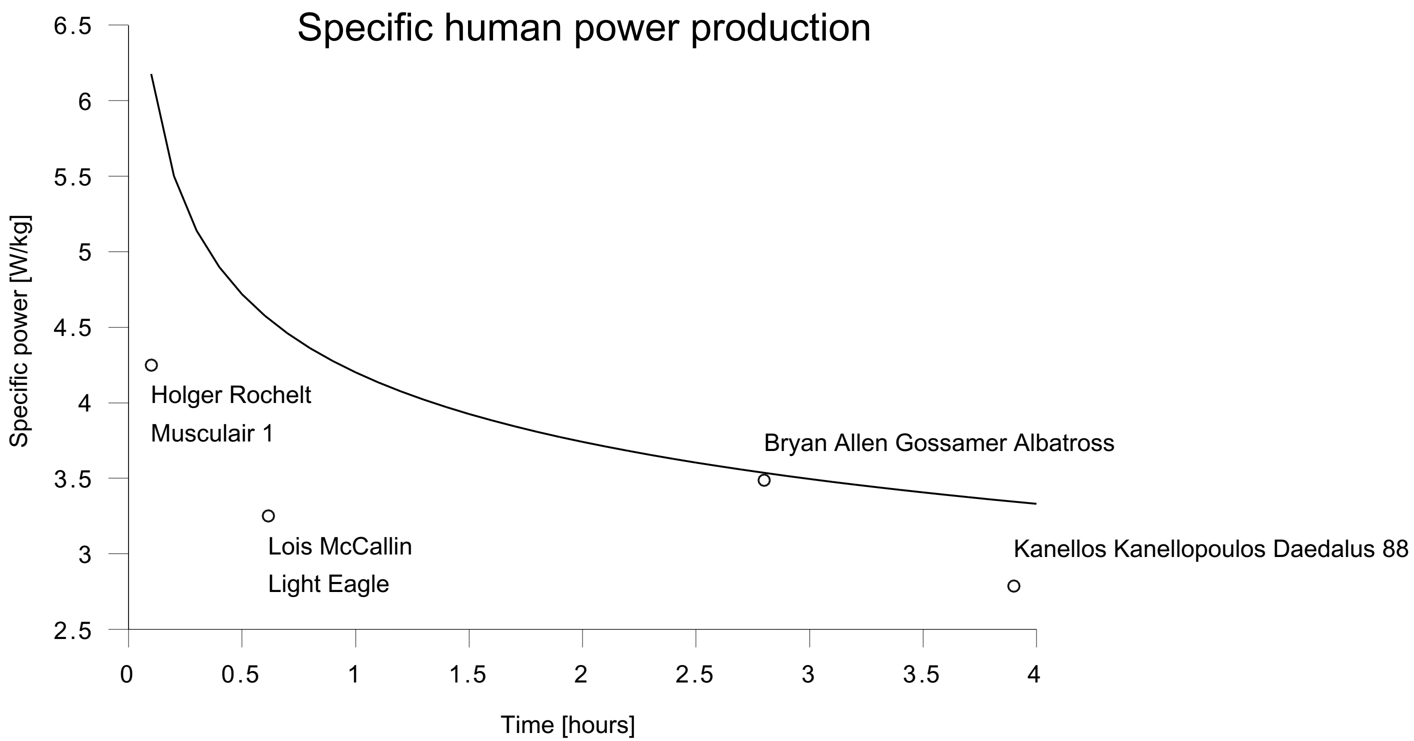
The competitions are close to the ragged edge of what is possible, they were deliberately set up to be so.

The easy things (easy is used in a rather careless way here)

Structural and mechanical design.
Outline aerodynamic design.

The difficult things.

Detail optimisation of the aerodynamic design.
Acheiving good control authority and maintaining it in turbulance.

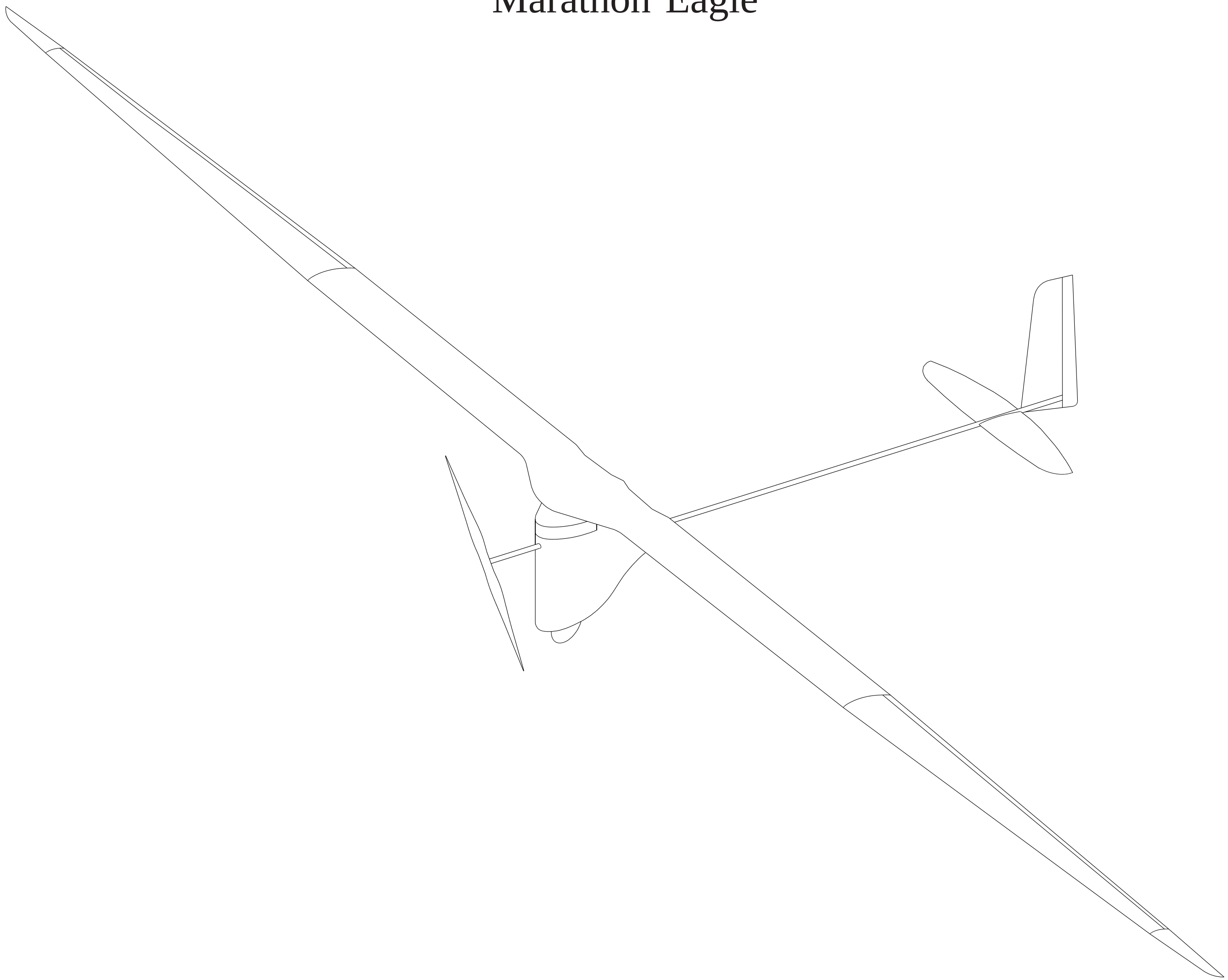


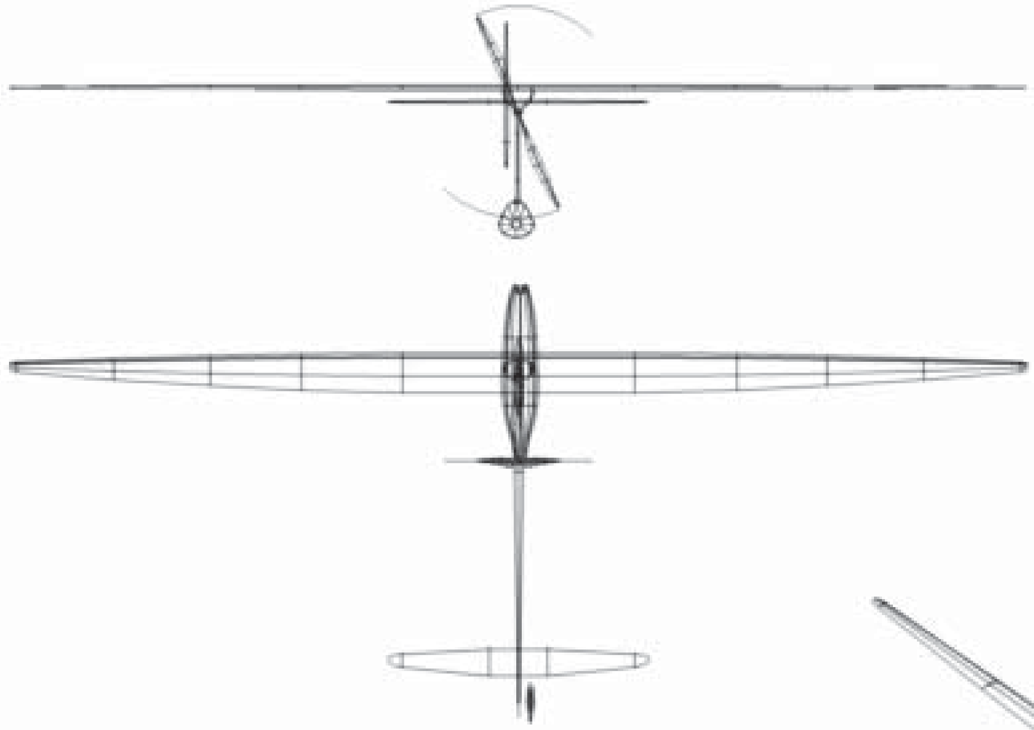
Langford gives the following relationship for power available as a function of time.

$$power = 4.1979\, time^{-0.16729}$$

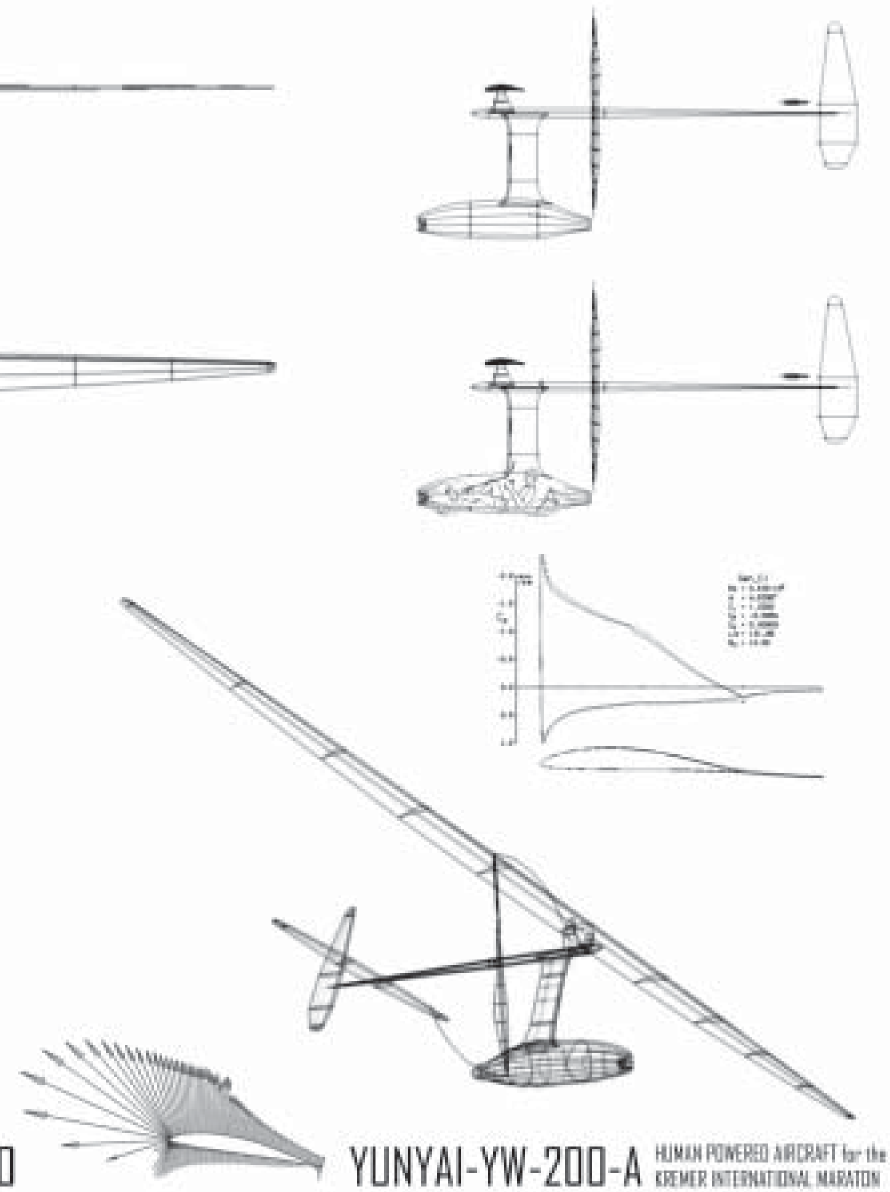
From: Langford, J. Aurora Flight Sciences Corporation: The Daedalus Project: A Summary of Lessons Learned. AIAA-89-2048, Presented at the AIAA Aircraft Design, Systems and Operations Conference. Seattle August 1989.

Marathon Eagle





b (span) (fesztáv)	16.8 m
S (wing surface) (szárnyfelület)	9.4 m^2
AR	30.0
m (empty weight) (saját tömeg)	26.8 kg
v stall (átesési sebesség)	10.2 m/s
v c (cruising speed) (utazósebesség)	12.5 m/s
v min.sink (minimális süllyedés seb.)	12.5 m/s
n (load factor) (terhelési többes)	+2.2-1.2 g
Cl wing	1.0
Cd0 wing	0.0893
S drag	0.66 m^2
Cd0 drag surf	0.058
P min (legkisebb szükséges telj.)	280.3 W
L/D cruising (siklószám)	42.3

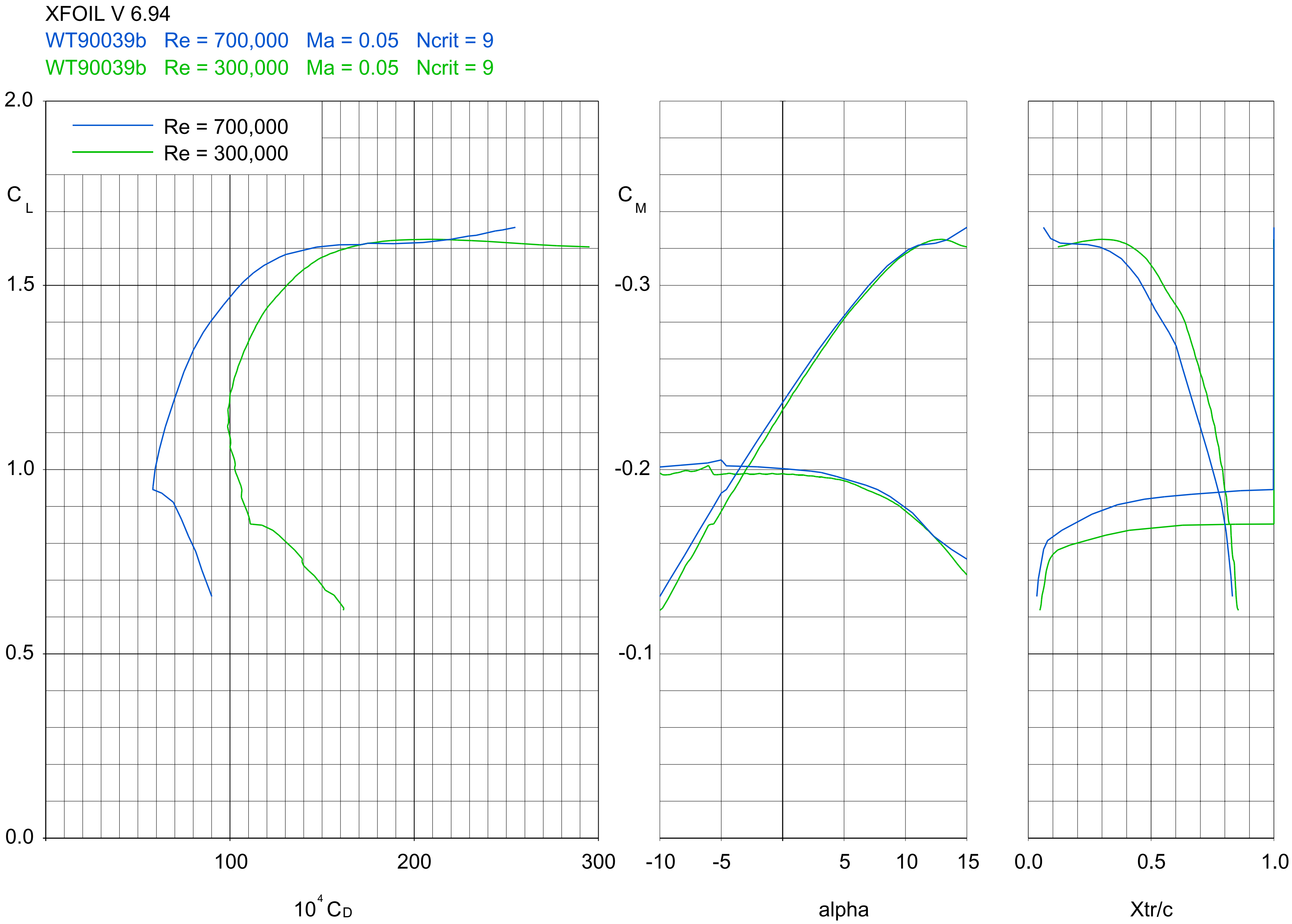


0 1 2 3 4 5 10m

M 1:100

YUNYAI-YW-200-A

HUMAN POWERED AIRCRAFT for the
KREMER INTERNATIONAL MARATON



XFOIL V 6.94
WT90039b Re = 700,000 Ma = 0.05 Ncrit = 9
WT90039b Re = 300,000 Ma = 0.05 Ncrit = 9
Re = 700,000
Re = 300,000
C L
2.0
1.5
1.0
0.5
0.0
100
200
300
10^4 CD
C M
-0.3
-0.2
-0.1
-10
-5
5
10
15
alpha
0.0
0.5
1.0
Xtr/c

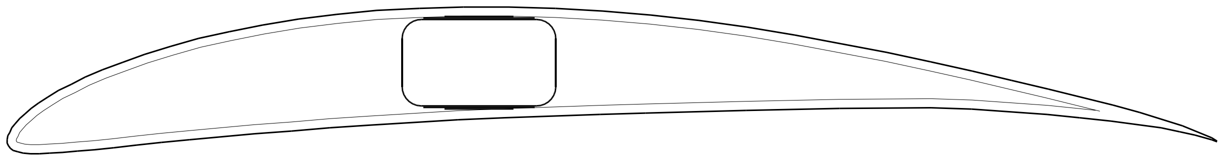
Some suggestions:

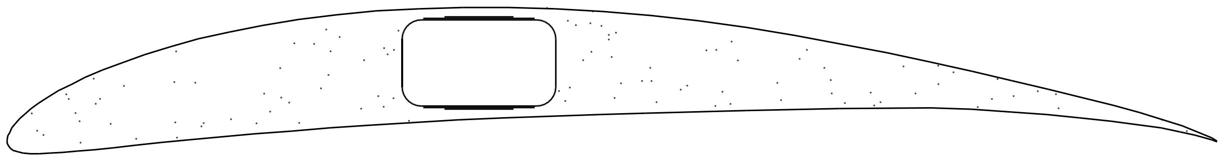
Use filament wound tubes and pultrusion to make the spars?

The wing of a ‘Marathon’ aircraft is small enough to make from hot wire cut foam.

The pusher configuration used by Musculair and Velair has several advantages:
1. The aircraft is stabilised in pitch and yaw.
2. Control in improved.
3. The propeller can be used as a dive brake and ‘brake / damper’ to improve safety.

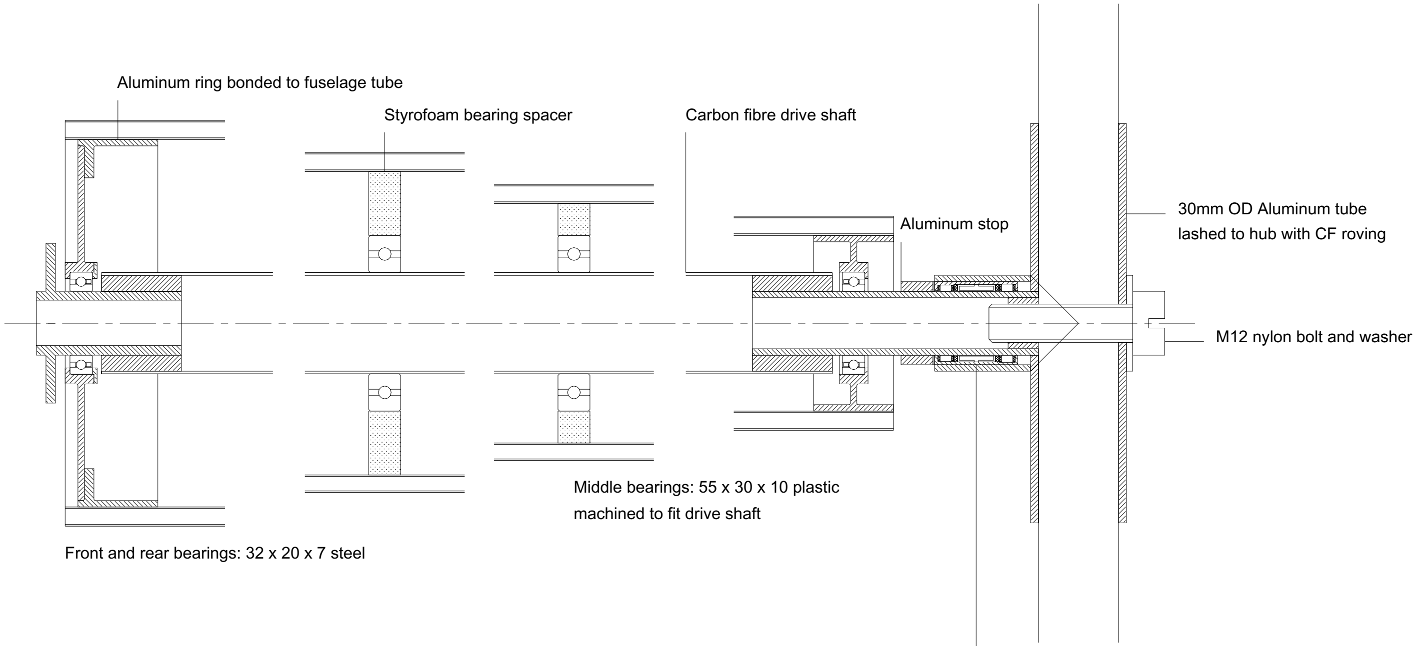
Marathon Eagle Wing and Simple Foam Wing Structure for High Speed Aircraft



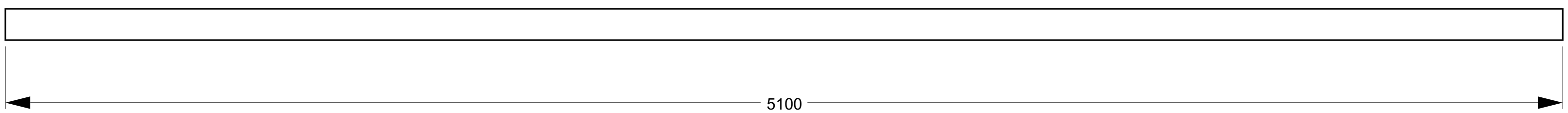


VELAIR DRIVE SHAFT

scale 1:2



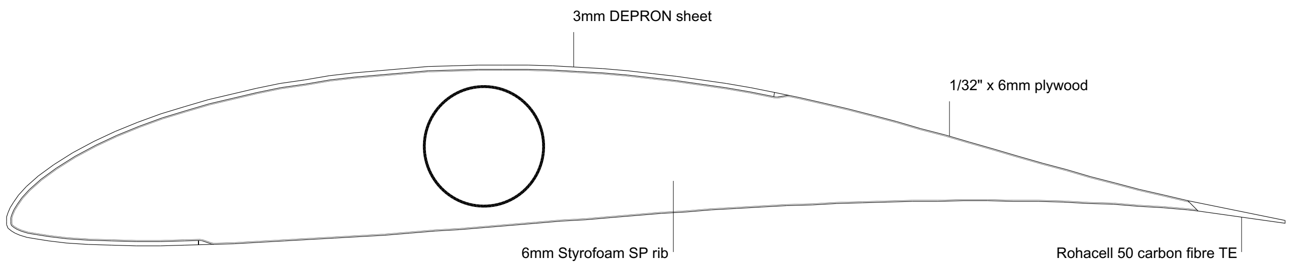
Laminate construction of drive shaft
6 layers of 0.14mm CPT pre preg at ± 45°
30mm internal diameter



VELAIR WING RIB

Airfoil: PF25

Scale: 1:4



Although the two unclaimed Kremer competitions remain as grand challenges it is important to remember that we already know how to make a 'practical aircraft'

Hot Air Balloon flying (need light winds)
Skiing (need snow)
Wind surfing (need enough wind)
Aero modelling (wind limited)

Are all considered practical and worth while despite being as weather dependant as the current state of the art of human powered flight.

Many Olympic sports run over courses of a few hundred to a few thousand m while flights of 30 km and speeds of 45 kph are already easily within the state of the art in human powered flight.

References

"Human Powered Aircraft The Way Ahead." Proceedings of the Human-powered Aircraft Group Half Day Conference at the Royal Aeronautical Society, London, 24th January 1989

Lilley, G.M., Human Powered Aircraft, The State of The Art including the near Kremer Competitions

Bliesner, Wayne. The Design and Construction Details of the Marathon Eagle. "Technology for Human Powered Aircraft." Proceedings of the Human-powered Aircraft Group Half Day Conference. The Royal Aeronautical Society, London, 30 January 1991.

"Progress in Human Powered Aircraft Research and Achievement." Proceedings of the Human-powered Aircraft Group Half Day Conference at the Royal Aeronautical Society, London, Thursday 21 January 1993

Lilley, G.M., The Human Powered Seaplane
Wimpenny, J., McIntyre, J., Sporting Aeroplanes

"Human Powered Aircraft for Sport." Proceedings of the Human-powered Aircraft Group Half day conference at the Royal Aeronautical Society, London, Thursday 25 January 1996

Bliesner, W.B., Pushing the Limits: Marathon Eagle from Conception to Flight Test
Frank, P., Human Powered Aircraft for Sport - Present and Future
Wimpenny, J., Airworthiness of Human Powered Aircraft for Sport in Near Ground Turbulence

Prof G M Lilley, and Dr A E Holdo, 'Human Powered Flight off Water'. The Royal Aeronautical Society, January 18th, 1994

Bussolari, S.R., Langford, J.S., and Youngren, H.H. Flight research with the MIT Daedalus prototype, SAE Paper #871350, June 1987.

Bussolari, Steven R., and Nadal, Ethan R. The Physiological Limits of Long Duration Human power Production, Human Power, in press, 1989.

Sullivan, R.B., and Zerweckh, S.H., Flight Test Results for the Daedalus and Light Eagle Human-powered Aircraft, NASA Grant Report, October 1988.

Schorberl, E. The Muculair 1 & 2 Human-powered Aircraft and their Optimisation. The Technical Journal of the IHPVA. Vol.5. No.2 (1986)

Zoltan Prohaszka, "Yunyi Preparing for the Kremer Marathon.", HPAG lecture at the Royal Aeronautical Society, London, Thursday 20 January 2005