



WIND, WINGS,
CREATIVITY & THE
GOSSAMER CONDOR

*Peter Lissaman
Da Vinci Ventures*



THE GOSPEL
OF ST. JOHN

The Wind bloweth where it listeth, and
thou hearest the sound thereof, but canst
not tell whence it cometh, or whither it
goeth.

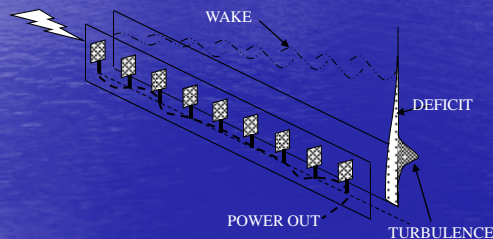
John. III, 8

THE EARLY DAYS

1973: Wilson & Lissaman	<u>Applied Aerodynamics of Wind Power Machines;</u>	NSF
1977: Lissaman & Bate	Energy effectiveness of arrays of WECS;	Swedish Energy Board
1980: Lissaman	Effect of drag on initial turbulence, a factor in array spacing;	AV Inc.
1981: Lissaman et al	Wind Loading definition for WECS structures;	AIAA, J. of Energy
1988: Lissaman et al	AVENU: A computer software system for wind farm design;	SBIR

The BIG Picture

Energy is always correct; except when it's wrong



CALIFORNIA DREAMING

The Gossamer Condor and the
Genesis of Human Powered
Flight

On Gossamer Wings



The Kremer Prize

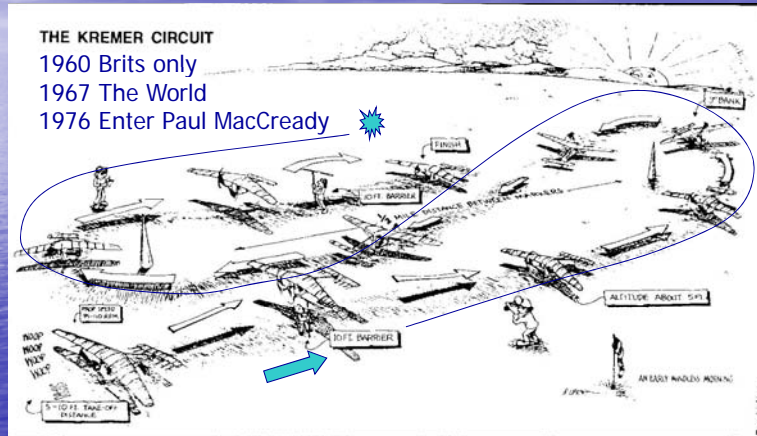


Figure 8, 1/2 Mile pylons, No wind

Whence came the Vision ?

In the beginning was the Word

And the Word was with Paul

And the Word was Paul

Flying: for the Birds, really!

Power/weight ratio

Horse:	0.33 ft/s
Human:	1.50 ft/s
Albatross:	2.25 ft/s
Pigeon:	30 ft/s
Humming Bird:	100 ft/s

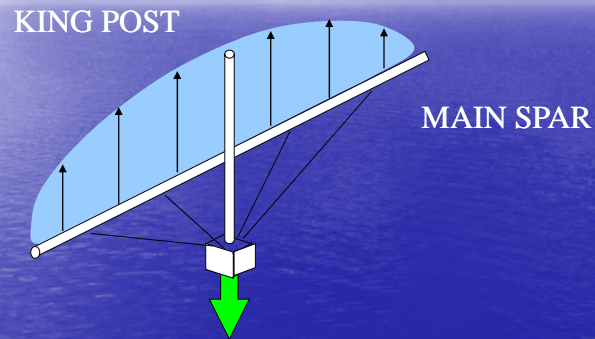
Words of the Masters I

Paint from the bones outwards. Leonardo da Vinci

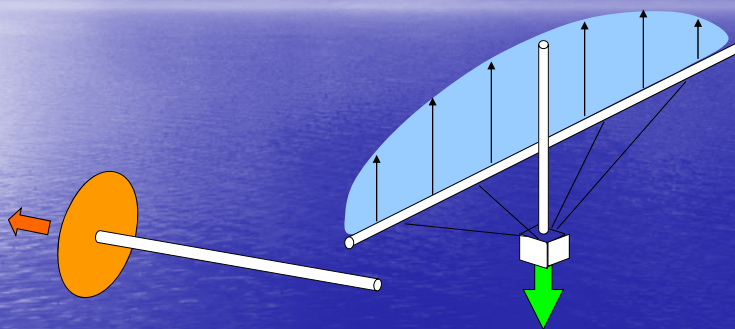
Simplicate and add lightness. Ed Heinemann

The most reliable component is the one that's not there. Eb Rechtin

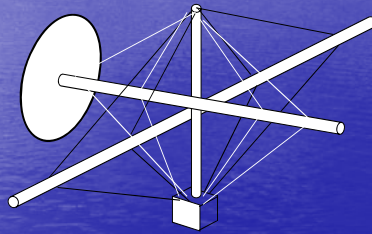
A Cartesian Simplicity



Plus a Thrust

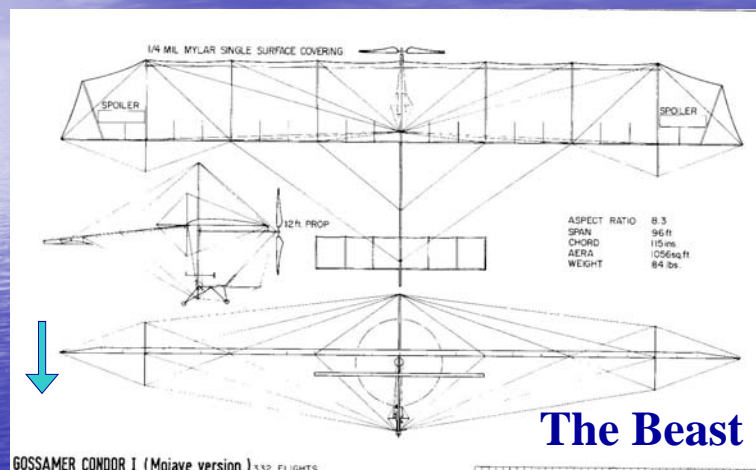


A Tangled Web



800 feet of rigging (~ 8 spans)
About $\frac{1}{2} C_{D0}$

Gossamer Condor I



The Joys of Optimization

Wings: 12ft stock Al. Al. tubes – 9 too many (mebbe), so 96' span.

Prop: Big as possible (subject to C_{do}) – 6' ground clearance, so less than 12' diam!

Engine: Twice airframe weight, for human P/W musculature– an upper bound on airframe

Structure: Al. tubing – easy to obtain and work.

Skin: Mylar – easy and strong. Diaphanous!

The Unforgiving Three

Induced Drag

$$D = \{1/\pi\} \{L^2 / b^2\} / q$$

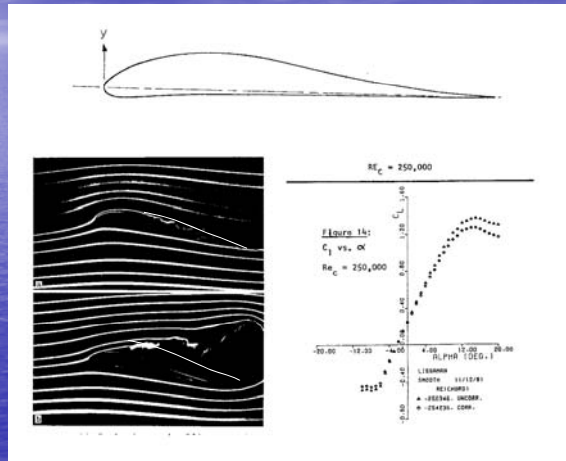
Static Propulsive Power

$$P = \{1/\pi^{1/2}\} T^{3/2} / d \{8/\rho\}^{1/2}$$

Structural Stability

$$S = \{\pi^2\} E / (k/1)^2$$

A Form to Cleave the Flow



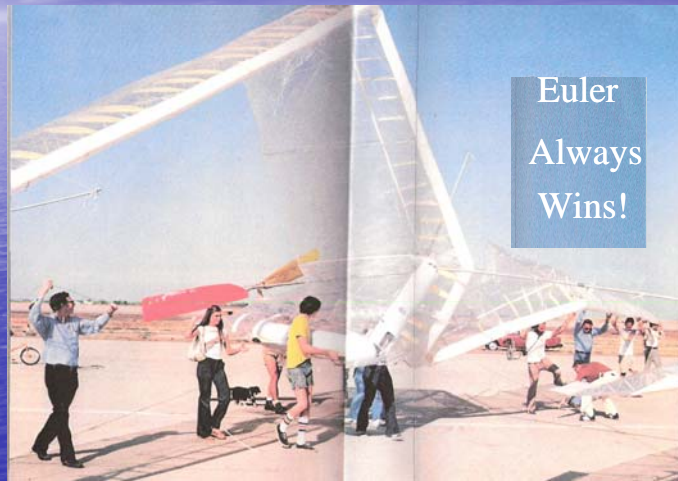
Lissaman7769 Airfoil Tests: Mueller, 1983

Blade Element Theory



- * Constant Chord
- * Beta Control: Hose Clamp
- * Blade Mass Balance: Bad Vibes/Radius Adjustment
- * Blade Pitch Balance: Eyeball Thrust/Blade Twist

Elastic Instability a la Mode



Turn, Turn, Toil and Trouble

Huge Apparent Mass Moments
in roll

Coefficients about the same as
those of the dragonfly

Forget C_{L_a} – have to use C_{L_r}
Invent Gossamer aerodynamics

Words of the Masters II

Computers are useless. They only
give you answers. Pablo Picasso

Brains First – then Hard Work.

Winnie-the-Pooh

Imagination is more important than
knowledge. Albert Einstein

Gossamer Management

(according to the Wall Street Journal!)

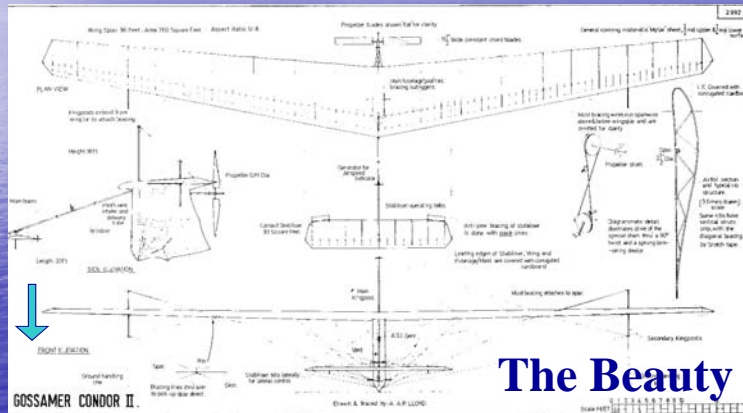
All meetings held standing up

Anyone absent to be ignored

Action taken after each meeting

{ Plus a lotta California Dreamin' }

Kremer Configuration



The Kremer Aircraft

Specifications

Wing span	96.0 ft
Wing area	760.0 ft ²
Prop diam.	12.0 ft
Airframe Wt.	70.0 lbs
AUW	210.0 lbs
Cruise speed	16.1 ft/s
L/D	18

Construction started: March 1977

Flew Kremer Course: August 1977

Installed in Smithsonian ASM: Sept 1978

Man becomes a Flying Animal



August 23, 1977, Shafter, CA
Bryan Allen: Pilot and engine

Oh, what a piece of work is a man!
In form, in moving, how
express and admirable!
In action how like an angel!
In apprehension how like a god!
Hamlet || ii

Aftermath of a Winged Victory

Recognition and Five Minutes of Fame all round
Honors bestowed liberally upon the worthy and
the unworthy

Press produced a pretty potent, precise picture
Precursor of a generation of ultra-low power
vehicles –GM Impact, AV Pointer, Solar
Challenger

No-one made any money

But, a Good Time was had by all

The Kremer Prize



A Splendiforous Event!

HRH sets the Tone

1979: The Gossamer Squadron receives the Kremer Prize in London.

It is presented by Prince Charles (then a bachelor).

HRH states that the Condor Team behaved like “Englishmen, or eccentrics”, apparently a compliment!

Lessons Learnt

Configure with an Olympian
Perspective!

Believe the Fundamentals

Test, re-test and test the test

*The Lyfe so short, the Crafte so long to Lerne
Geoffrey Chaucer*

St Exupery's Take

It seems that perfection is attained
Not when there is no more to be added,
But when there is nothing left to take away.
At the end of its evolution
The machine effaces itself.

Antoine de Saint-Exupery French Poet/aviator, from Wind, Sand and Stars.

