VESTAS SAILROCKET

AND DEVELOPMENTS IN HIGH SPEED SAILING

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May 2011

THE CUSP OF A REVOLUTION?

- MULTIS AND MONOS REACHING END OF LINE
- CAVITATION A REAL BARRIER 50+K
- HYDROFOILS WIDELY ADOPTED BUT ON CRAFT WITH SEVERE LIMITATIONS

THE BASIS FOR THIS REVOLUTION IS EXPLAINED IN THE STORY BELOW. I COULD BE WRONG – SEE WHAT YOU THINK!

BLANK CANVAS - WHAT FORM?

WHY SPEED SAILING?

CUTTING EDGE DEVELOPMENT

WIDER APPLICATIONS ?

FUN IS A SERIOUS BUSINESS

MANY DIFFERENT SOLUTIONS [2000]

MOTH & HOBIE TRIFOILER CLASS HAS ESTABLISED

PRACTICALITY OF FOIL BORNE CRAFT

NOT TARGETING
RECORDS
BUT CAPABLE OF
28 KNOTS

LONGSHOT 43 KNOTS
HOBIE PRODUCTION VERSION 32 KNOTS

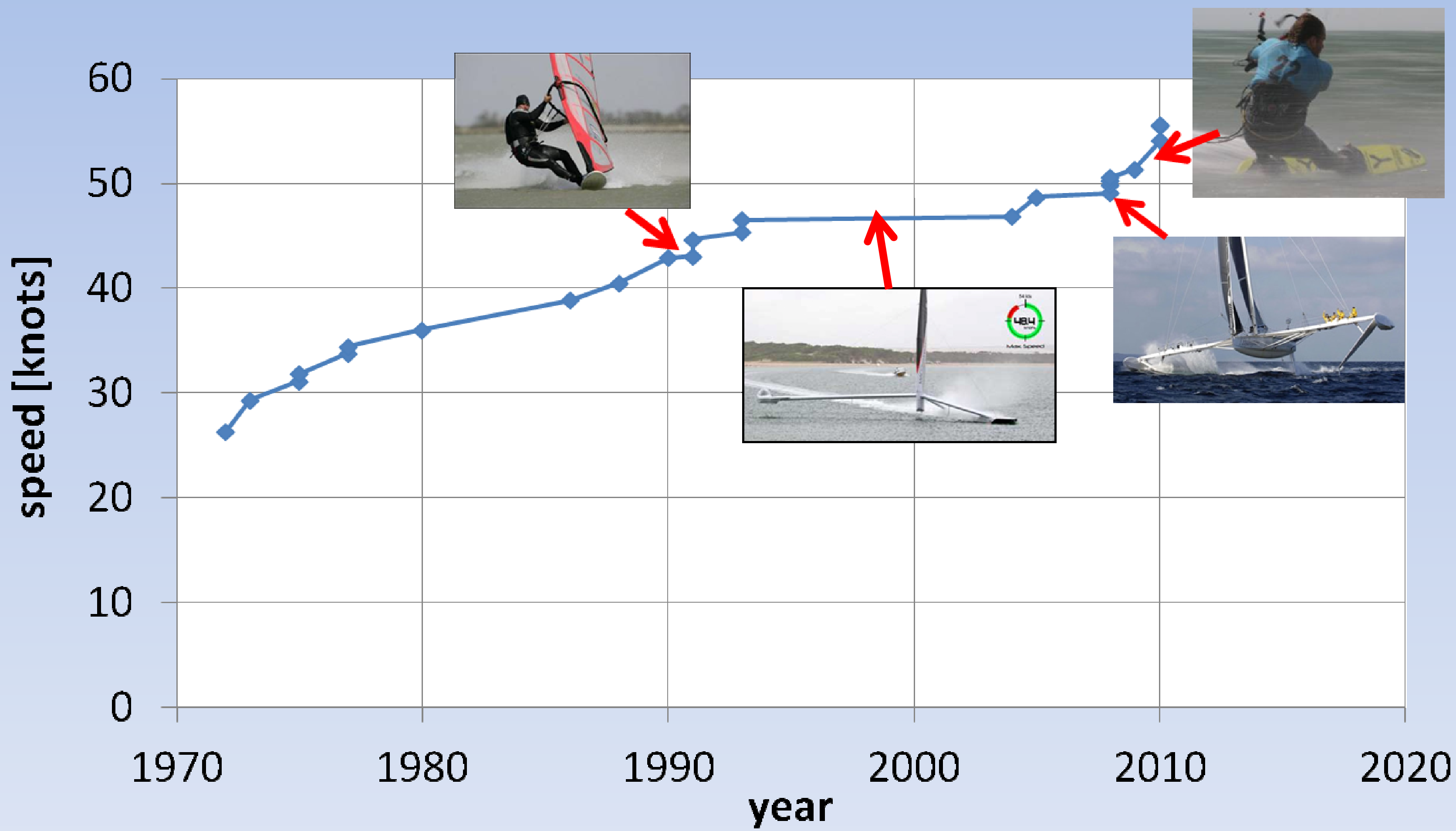
EARLY DAYS – NEWNHAM COMMON 1973

FIRST OFFICIAL WORLD SAILING SPEED RECORD ESTABLISHED

THE WSSRC RULES

- 500m one way course
- NO DESIGN RESTRICTIONS
- No restriction on wind strength or direction
- Unlimited run up
- No towing during run up
- No stored power ie batteries,compressed air; fuel
- Parts of the boat may be jettisoned during the run
- Must carry a minimum of 1 person

OUTRIGHT 500m RECORD 1973-2010
26.3-55.6 KNOTS



HIGH SAILFORCE/WEIGHT NEEDED FOR HIGH EFFICIENCY

HIGH SPEED (RELATIVE TO WIND) DEMANDS LOW APPARENT WIND ANGLE (EG 23 DEGREES FOR 50K IN 22K)

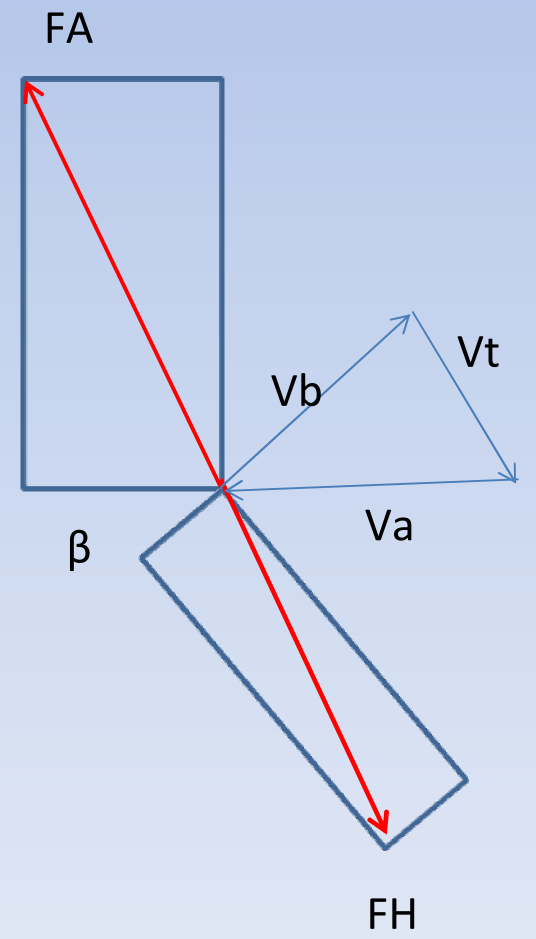
LOW APPARENT WIND ANGLE REQUIRES HIGH AERO AD HYDRO L/D RATIOS (MEASURED HORIZONTALLY)

HIGH L/D HYDRODYNAMICALLY REQUIRES THE L/D OF A GOOD HIGH AR FOIL

AS THE DRAG DUE TO PAYLOAD HAS TO BE ADDED THIS LOWERS THE L/D A LOT.

HIGH L/D CAN STILL BE ACHIEVED IF THE FOIL LIFT IS LARGE RELATIVE TO THE BUOYANT LIFT OR CRAFT WEIGHT

THEN THE EFFECT OF PAYLOAD DRAG IS DIMISHED

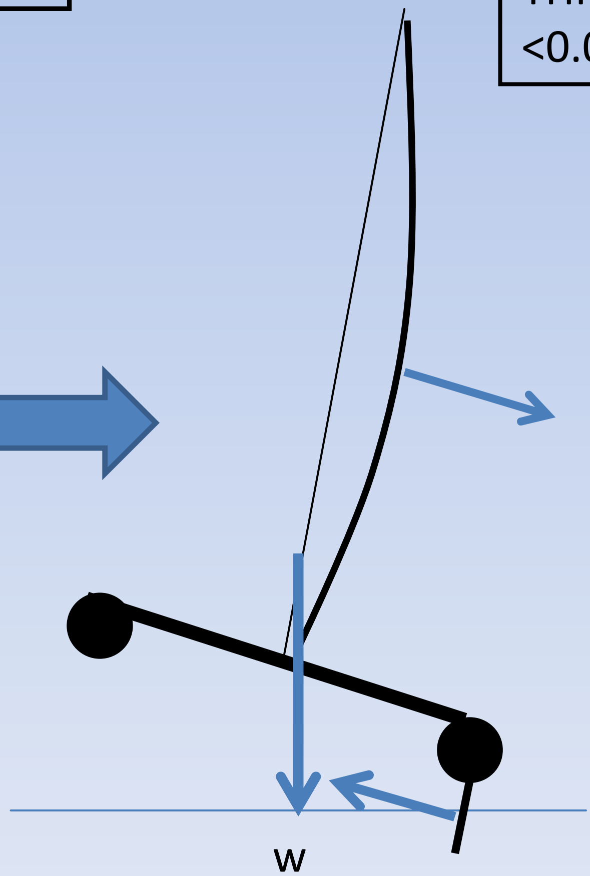


GRAVITY BASED STABILITY

MAX RIGHTING MOMENT
PROPORTIONAL TO MASS X BEAM

SAILFORCE/WEIGHT
< 0. 5
THRUST/WEIGHT
<0.05

HYDRODRAG
PROPORTIONAL TO
MASS



THRUST TO
DRAG RATIO
INHERENTLY
LIMITED

AERO DRAG PROPORTIONAL TO
BEAM

BEAM LIMITED
TO 0.8-1.0L

DISPLACEMENT MULTIHULLS

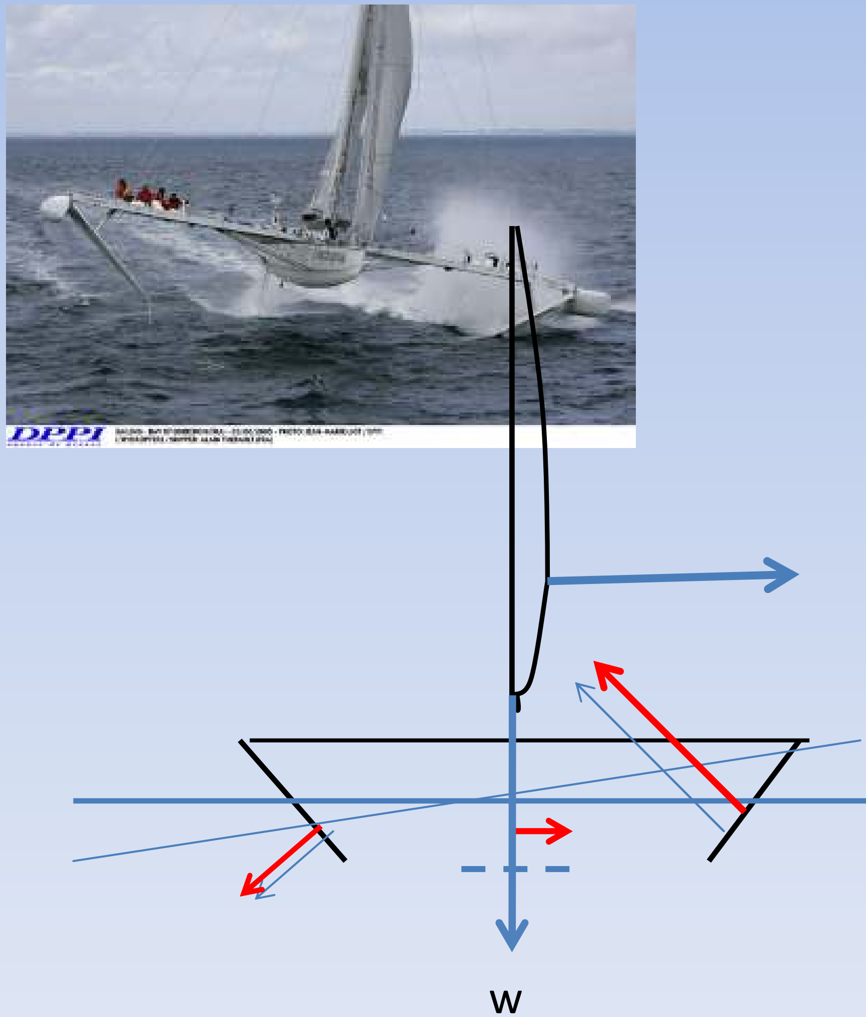
- Sail sized so stability limit reached at same Vt
- Weight proportional to L^3
- Wetted area proportional to L^2
- Max RM proportional to L^4
- Height of rig proportional to L

SPEED PROPORTIONAL TO SQUARE ROOT L

LENGTH [m]	SPEED [MAX knots]	[AV knots]	COST [million $]
10	26		0.1
20	37	+[28]	2.0
30	45		8.0
40	52	*[38]	20.0
50	58		30.0

+BANC POPULAIRE 60 F 24HR
*BANC POPULAIRE 40M 24HR

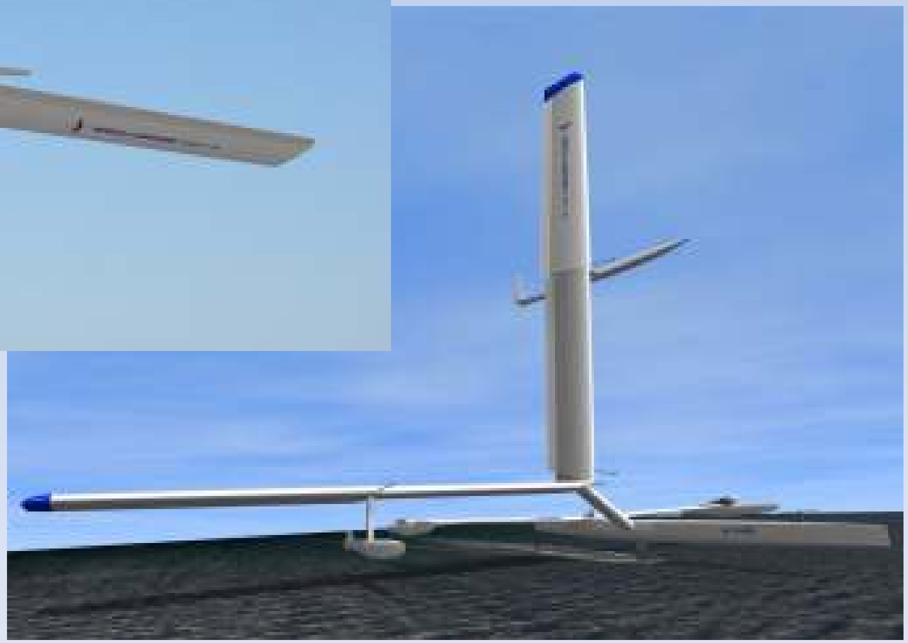
WIDELY USED SYMMETRIC SURFACE PIERCING FOIL CONFIGURATION



- VERY COMPLEX
- ROLL/HEAVE STABILITY NOT WELL DEFINED
- DIRECTION OF FORCE ON WW FOIL CHANGES
- IMMERSION OF BOTH FOILS CONTANTLY CHANGES
- REALLY NEEDS CONTROL OF INDIVIDUAL PITCH ANGLES
- VERY EFFICIENT WHEN WW FOIL IS JUST UNLOADED OR FLOWN CLEAR
- T FOIL SHARES SIDELOAD REACTION

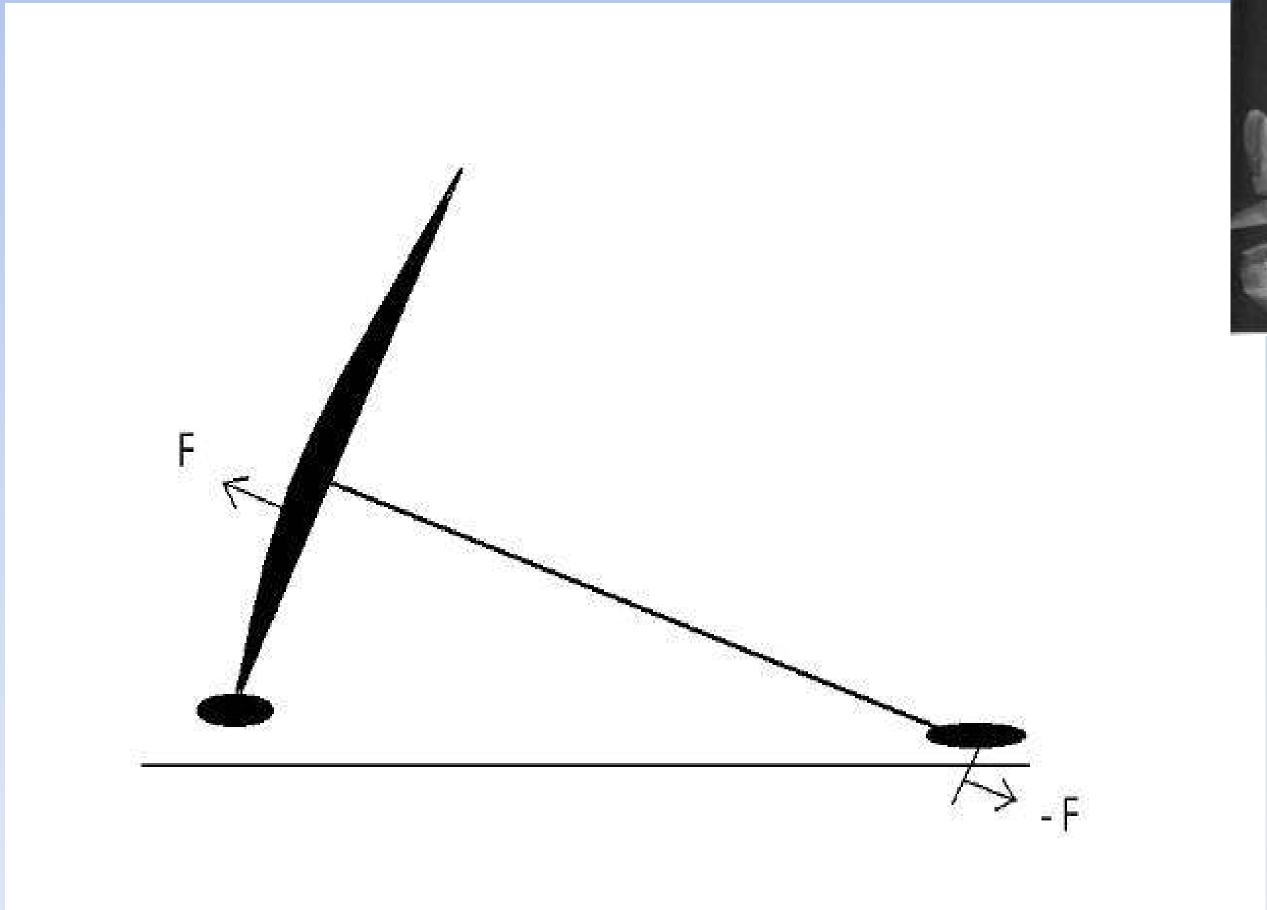
V39 ALBATROSS

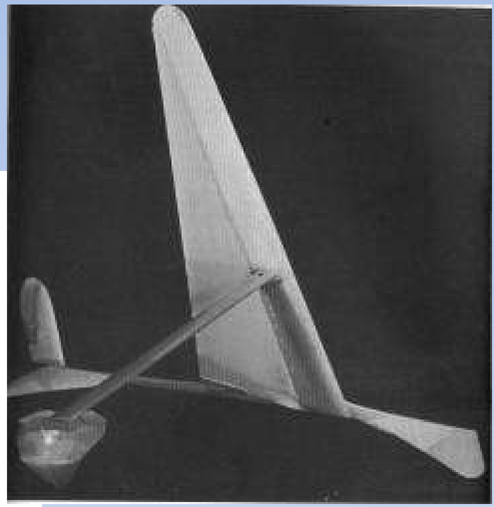
WING IN GROUND EFFECT STABILISED
ROCK OVER FOR TACKING



SMITH ELEGANT BUT NEGLECTED SOLUTION

- Transverse forces balance each other exactly
- Fore/aft moments very nearly balance





2 CONCEPTS WITH NO CLEARLY DEFINED SAIL LOAD LIMITS

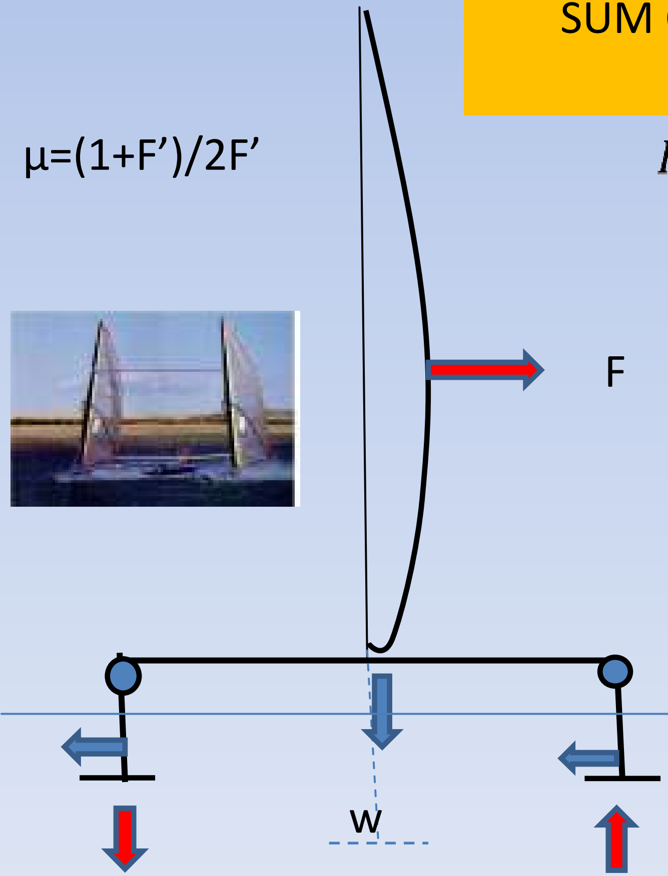
'INDUCED DRAG EFFICIENCY'

$$\mu = \frac{\text{PAYLOAD+SAILFORCE}}{\text{SUM OF ALL LIFT FORCES}}$$

$$F' = F/W$$

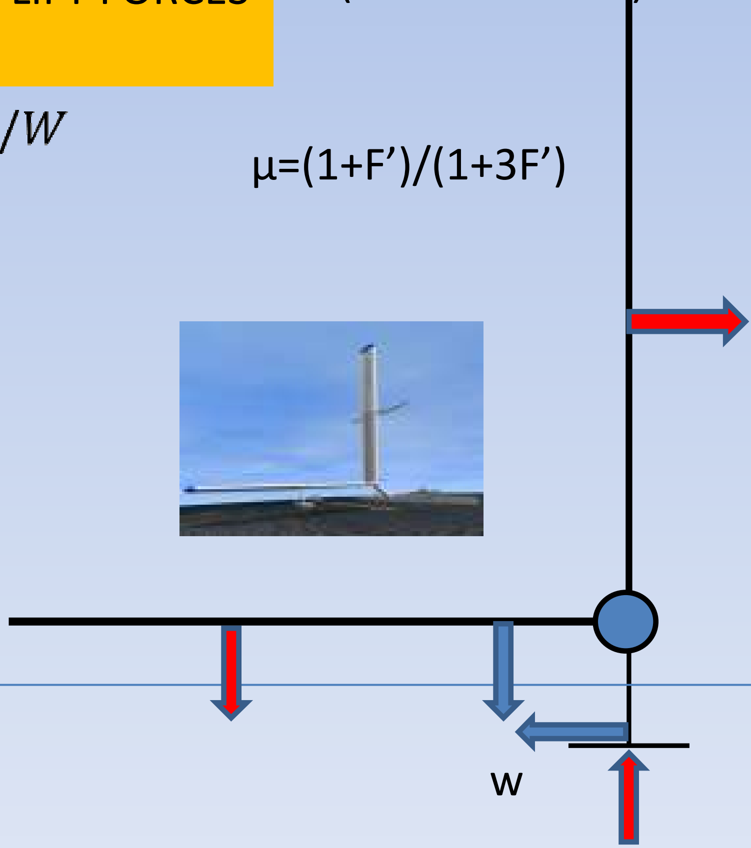
SYM FOILER

μ=(1+F')/2F'



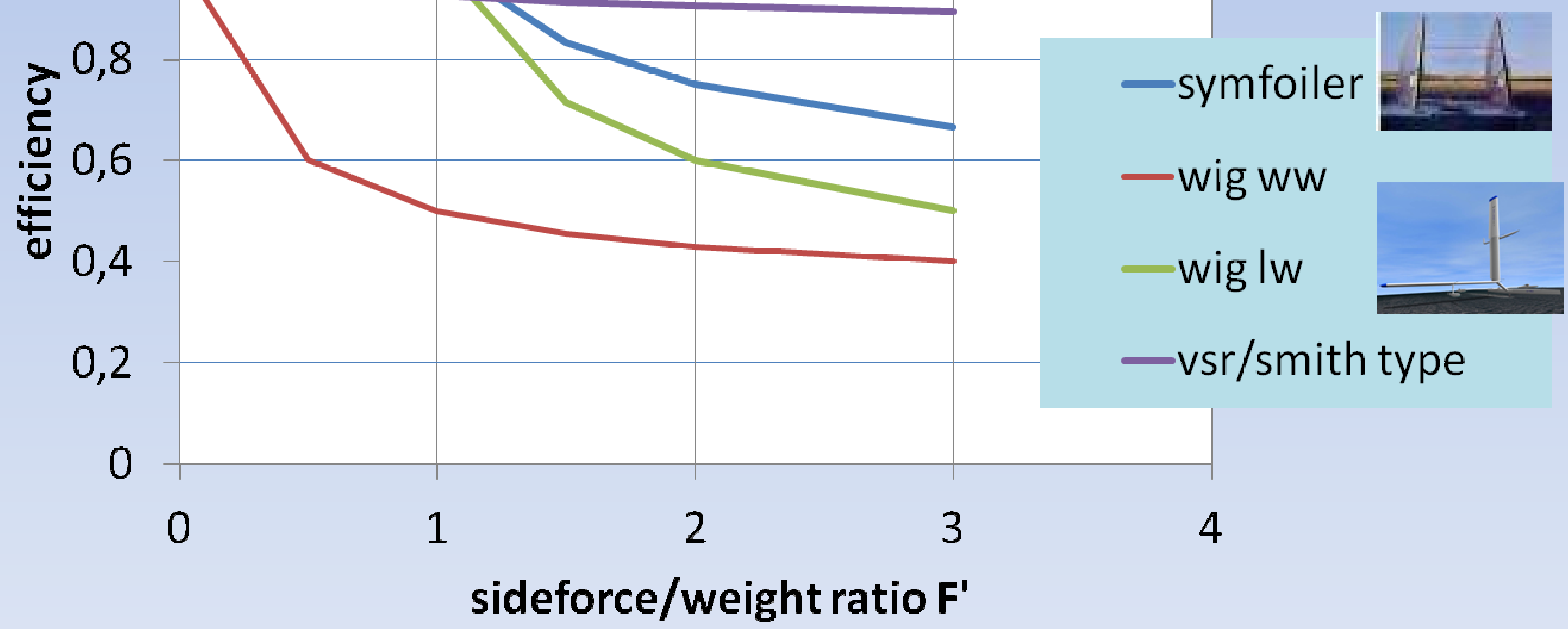
AERO STABILISED WIG
(WING TO WW)

μ=(1+F')/(1+3F')

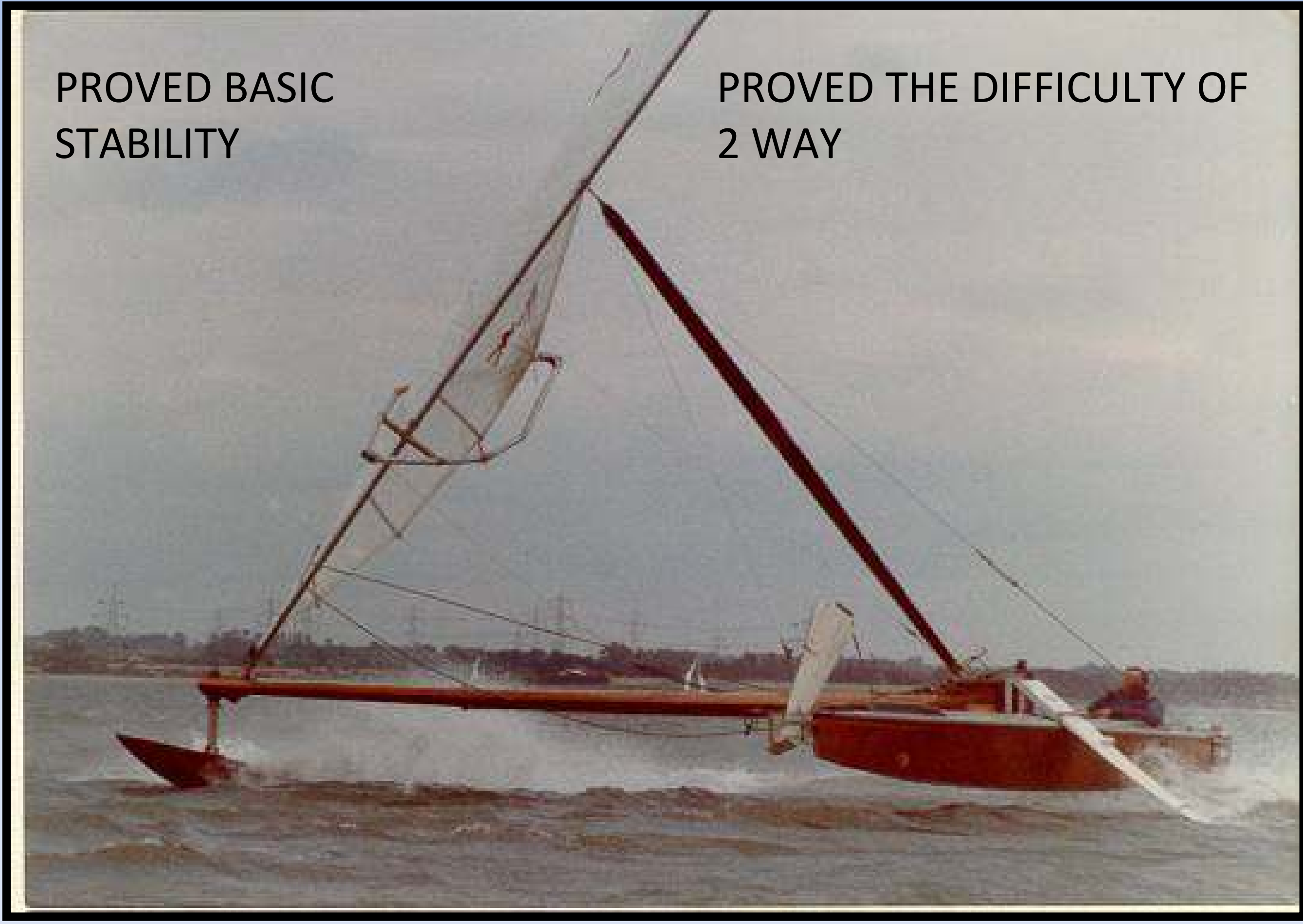


EFFICIENCY ON THE BASIS OF INDUCED DRAG

μ= PAYLOAD+SAILFORCE / SUM OF ALL LIFT FORCES



EARLY SMITH CONFIGURATION 1988



EXPERIMENTS IN TEXAS 1989

1999 DESIGNED PLATFORM AND HULL FORM

- PRACTICAL PLATFORM
- VERY ADJUSTABLE GEOMETRY
- LOTS OF RESISTANCE TO PITCHPOLE

LAUNCH SAILROCKET1 – APRIL 2004

PROBLEM 1 – SOFT SAIL

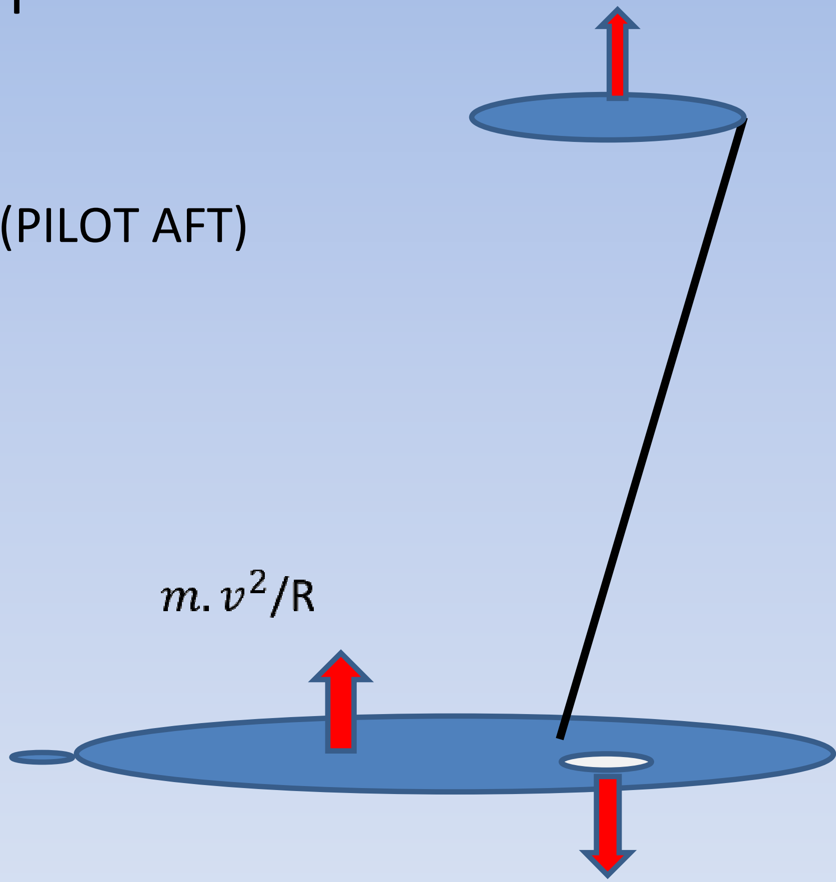
WALVIS BAY SPEED STRIP

PROBLEM 2 -UNCONTROLLABLE ROUND UPS

STATICALLY BALANCED BUT NOT DYNAMICALLY

CAUSES

CENTRE OF MASS TOO FAR AFT (PILOT AFT)
NON FEATHERING WING
POOR RUDDER ACTUATION



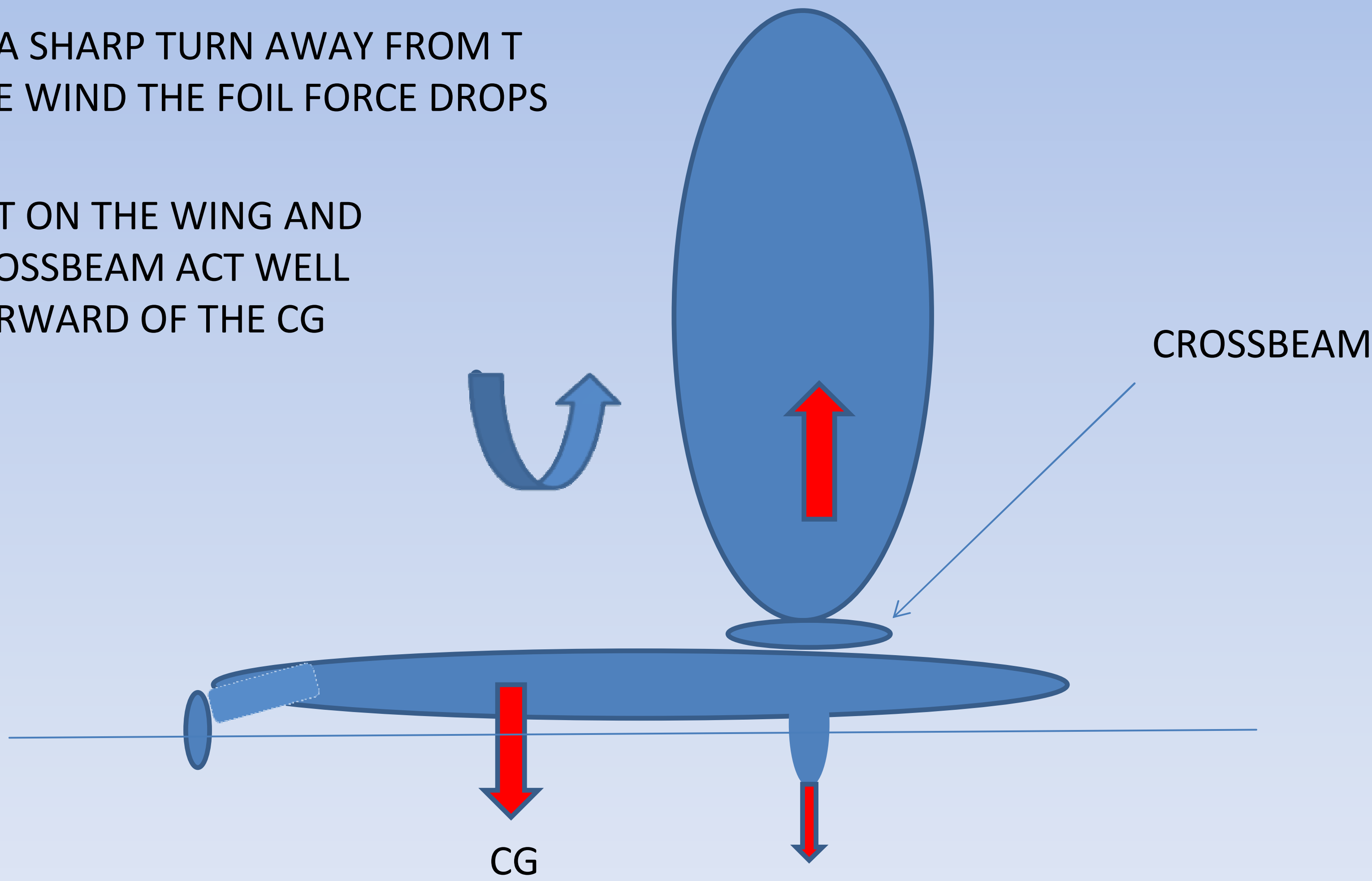
40 KNOTS IN 17 KNOTS TRUE – LEEWARD POD STILL CONTACTING

PROBLEM 3 – TAKE OFF

PROBLEM 3

IN A SHARP TURN AWAY FROM T
THE WIND THE FOIL FORCE DROPS

LIFT ON THE WING AND
CROSSBEAM ACT WELL
FORWARD OF THE CG



SAILROCKET 1

DESIGNED	2000
DESIGN SPEED	50 KNOTS
LAUNCHED	2004
BEST RUN	49.3 KNOTS 2009

FASTEST RUN 49.3KNOTS (52 KNOTS PEAK)

LIMITATIONS OF VSR1

- DIRECTIONALLY UNSTABLE OUTSIDE LIMITED RANGE
- PITCH UNSTABLE OUTSIDE A LIMITED RANGE
- C OF G TOO FAR AFT
- EFFECTS MADE WORSE BY NON FEATHERING WING
- SUBCAVITATING HYDROFOILS

SUCCESSES OF VSR1

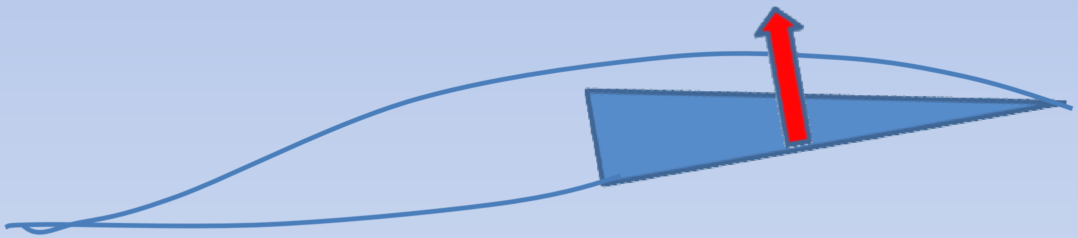
- ACHIEVED PREDICTED SPEEDS
- EXCEEDED ORIGINAL TARGET SPEED
- DEMONSTRATED ABILITY TO HARNESS HIGH POWER/WEIGHT
- DEMONSTRATED DIRECTIONAL STABILITY (SAILED ITSELF ON THE COURSE)

BARRIERS TO THE 60'S

1. CAVITATION
   - steep rise in drag and very rapid deterioration of foil surface
   - Impossible to avoid at >55knots irrespective of Cl (loading)
2. SUPERCAVITATING FOIL DRAG
   - Lower L/D than fully wetted foils – needs greater power/weight
3. LIMITED THRUST/STATIC STABILITY – particularly in relation to wetted area
4. ADDED DRAG DUE TO WAVES – particularly planing and displacement hulls

CAVITATION & VENTILATION

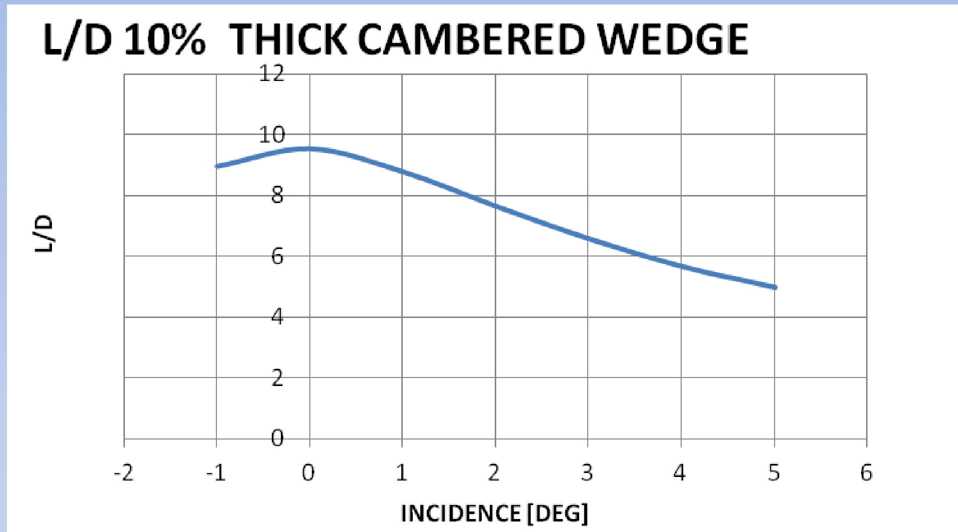
- CAVIAATION CAN NOT BE AVOIDED ABOVE 55 KNOTS EXCEPT BY PREVENTILATING THE LOW PRESSURE SURFACE



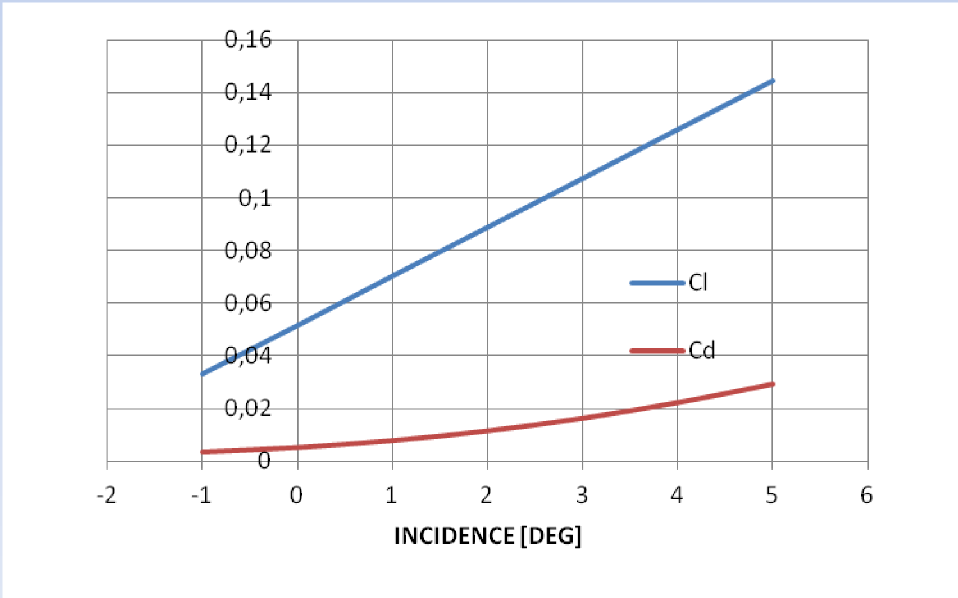
- THIS MEANS USING A SUPERVENTILATING FOIL OR INCLINED PLANING SURFACE (KITE BOARDS)

SUPERVENTILATING PERFORMANCE

- LIFT SLOPE < π/2



- TULIN MAPPING FULLY WETTED TO FULLY VENTILATED
- L/D UP TO 10 3D AR3
- 10% THICK
- CAMBER OF PRESSURE FACE CRITICAL



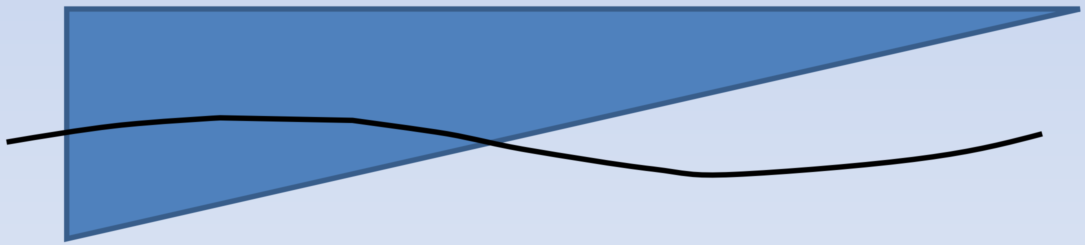
PLANING ADDED DRAG IN WAVES

The following assumptions are used

1.The vertical motion of the craft is neglected
2.The apparent wave length is large compared to the wetted length
3.Savitski lift forces apply instantaneously
4.Prismatic single chine hull
5.No added spray drag component

$$z = z_0 . \sin \omega t$$

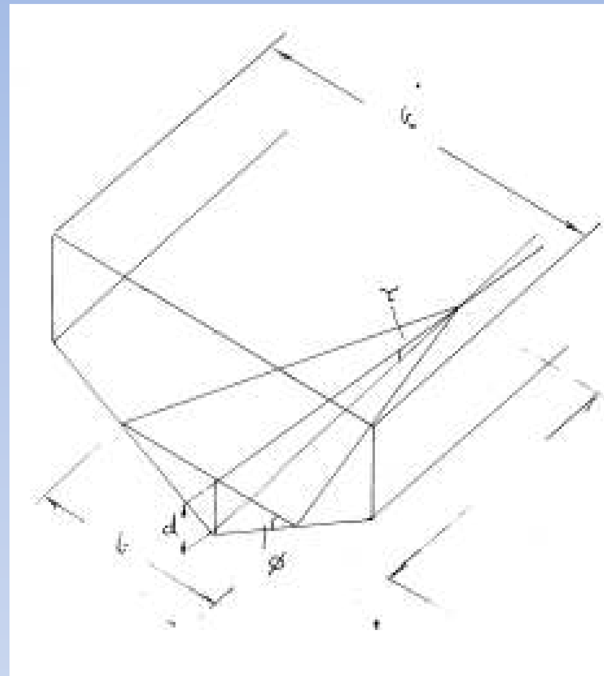
$$\delta\alpha = \dot{z} / V_b$$



θ θ

λ λ

PLANING ADDED DRAG IN WAVES



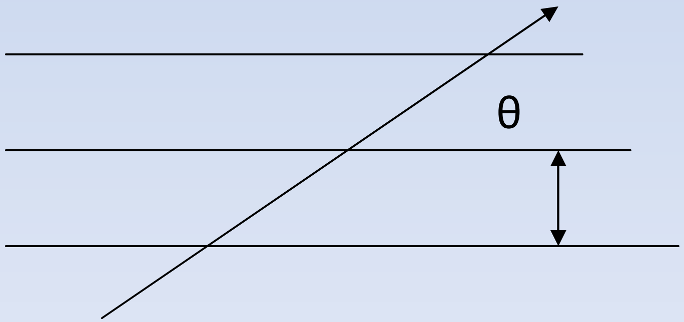
$$E = \int_0^T F \cdot dz = \int_0^T F \cdot \dot{z} \cdot dt$$

$$E = 0.5 \cdot \rho \cdot V_b \cdot b^2 \cdot \frac{\partial C_l}{\partial \alpha} \cdot \int_0^T \omega^2 \cdot z_0{}^2 \cdot \cos^2 \omega.t \cdot dt$$

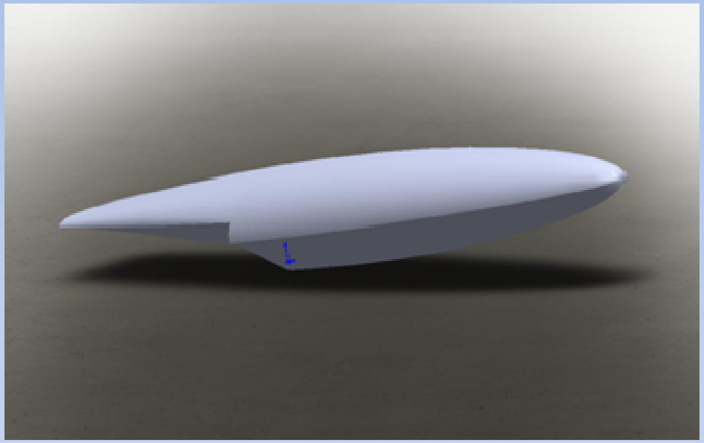
$$\overline{P} = E / T = 0.5 \cdot \rho \cdot b^2 \cdot z_0{}^2 \cdot \frac{\partial C_l}{\partial \alpha} \cdot V_b \cdot \omega^2 = V_b \cdot D_w$$

$$D_w = \frac{\rho \cdot b^2 \cdot z_0{}^2 \cdot \omega^2 \cdot}{4} \left[\frac{\partial C_l}{\partial \alpha} \right]$$

$$= \rho \left[\frac{\pi \cdot b \cdot z_0 \cdot V_b \cdot \sin \theta}{\lambda} \right]^2 \left[\frac{\partial C_l}{\partial \alpha} \right]$$

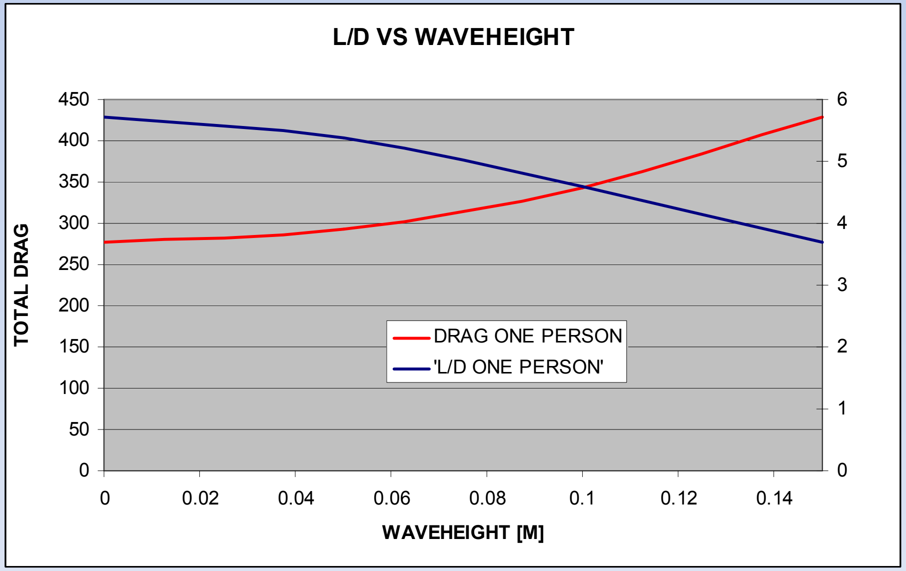


RESULTS APPLIED TO VSR2 FLOATS



Dimension		
LOA	2.1	m
Beam	0.89	m
Deadrise	19.8	Deg
Total displacement	320	Kg
Design trim	6	Degrees
Step to transom	0.8	M
Normal static payload	127	kg

1. 60% INCREASE IN DRAG IN 150MM WAVES
2. L/D REDUCES FROM 5.8 TO 3.7



VSR2

- DESIGN OUT THE FAULTS WITH VSR1
- HIGHER TARGET SPEED 60K
- SUPERVENTILATING FOIL
- RAISED AERODYNAMIC FUSELAGE
- CARRY SECOND PERSON
- FEATHERING WING

LAUNCH MARCH 8 2011

LENGTH	12m
BEAM	10m
MASS	280kg
WING AREA	22m^2

VSR2

40 KNOTS 3RD RUN (24/5/2011)

1. NO WING EXTENSION
2. LOW SPEED FOIL
3. TIP NOT SHEETED IN.

50knots is easy - October 2011

Foil matters

MINIMUM IMMERSED SPAN 800MM FOR HOOKED IN SECURITY IN WAVES

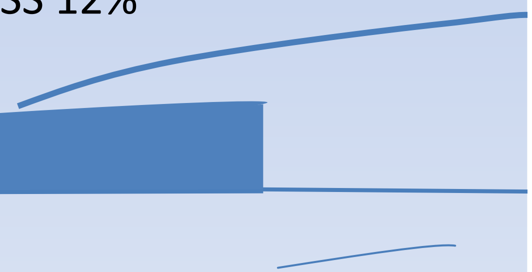
BENDING AT CORNER

= 1TONNE X 400MM

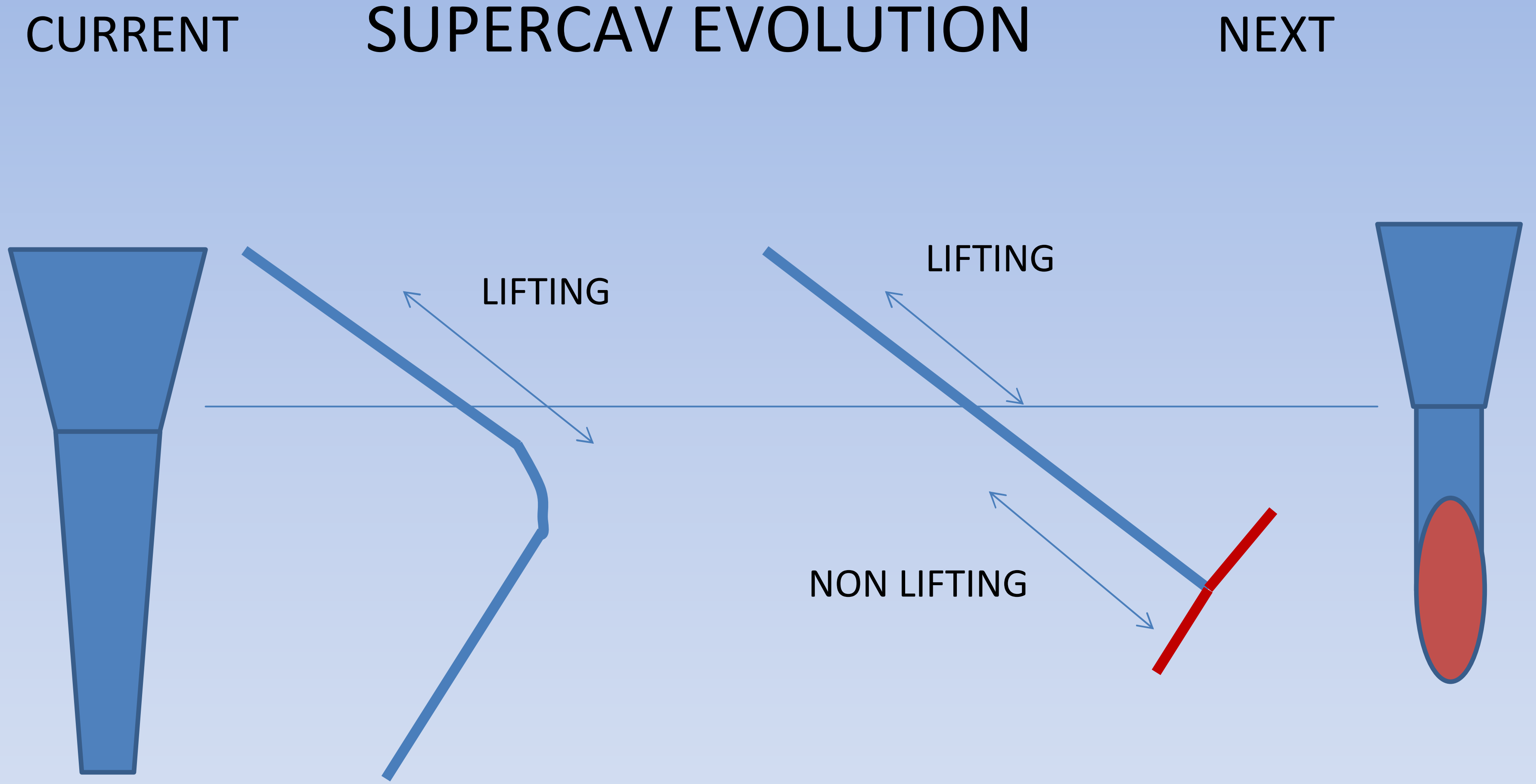
CHORD AT CORNER
= 320MM THICKNESS 12%

AREA = 0.16m^2
CL@50KNOTS = 0.1
TYPICAL INCIDENCE 2 Deg

PARTIAL CAVITY
HIGH DRAG FROM BAD SHAPE
VIBRATION FROM INSTABILITY OF CAVITY
HIGHER WETTED FRICTION



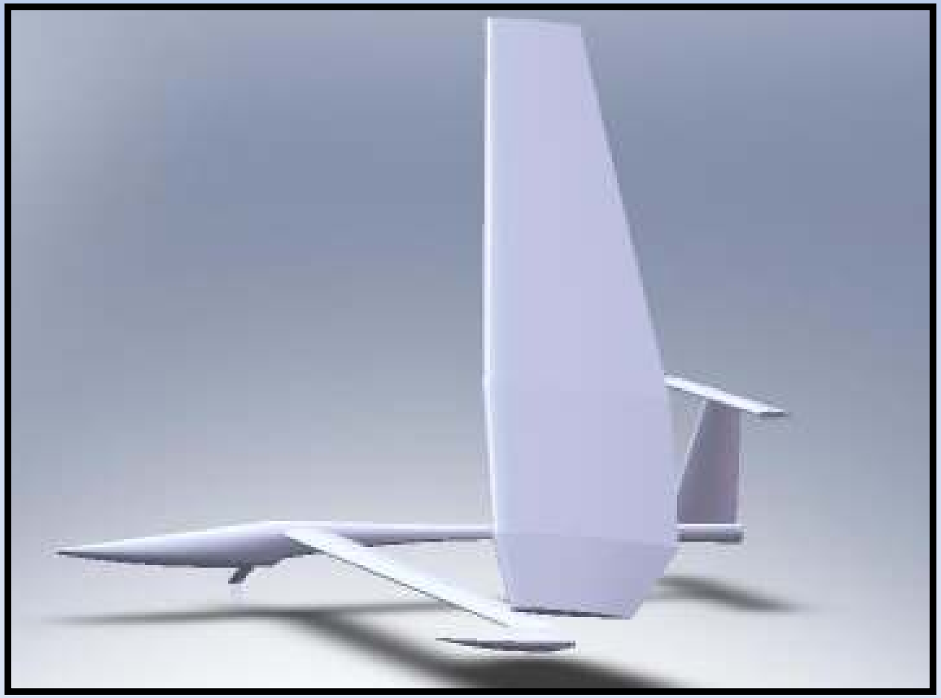
SUPERCAV EVOLUTION



IDEAL FOIL DEVELOPMENT VEHICLE

THE FUTURE

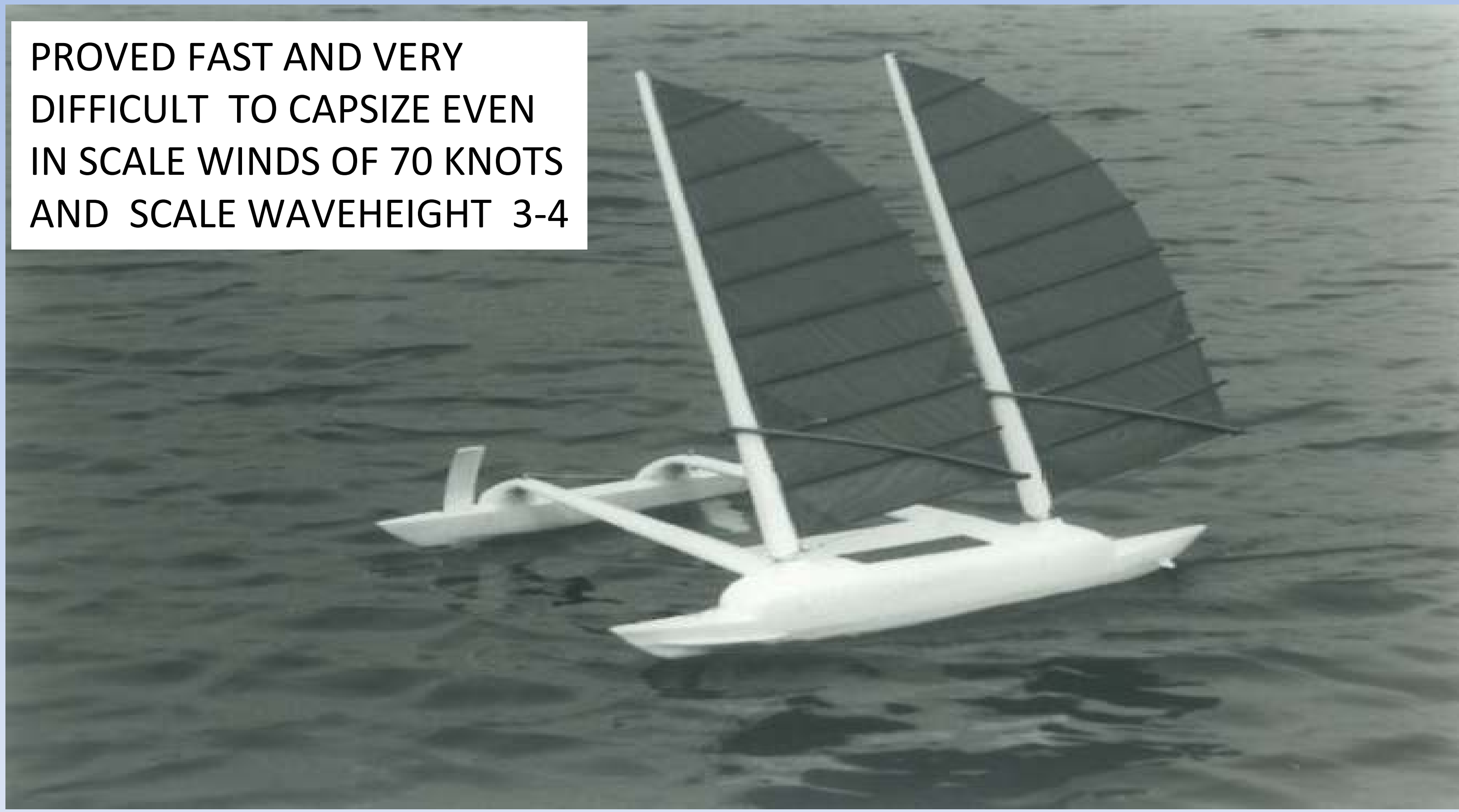
WHAT WILL THE FASTEST SAILING BOATS LOOK LIKE IN 15 YEARS?



THE NEW AGE OF PROAS

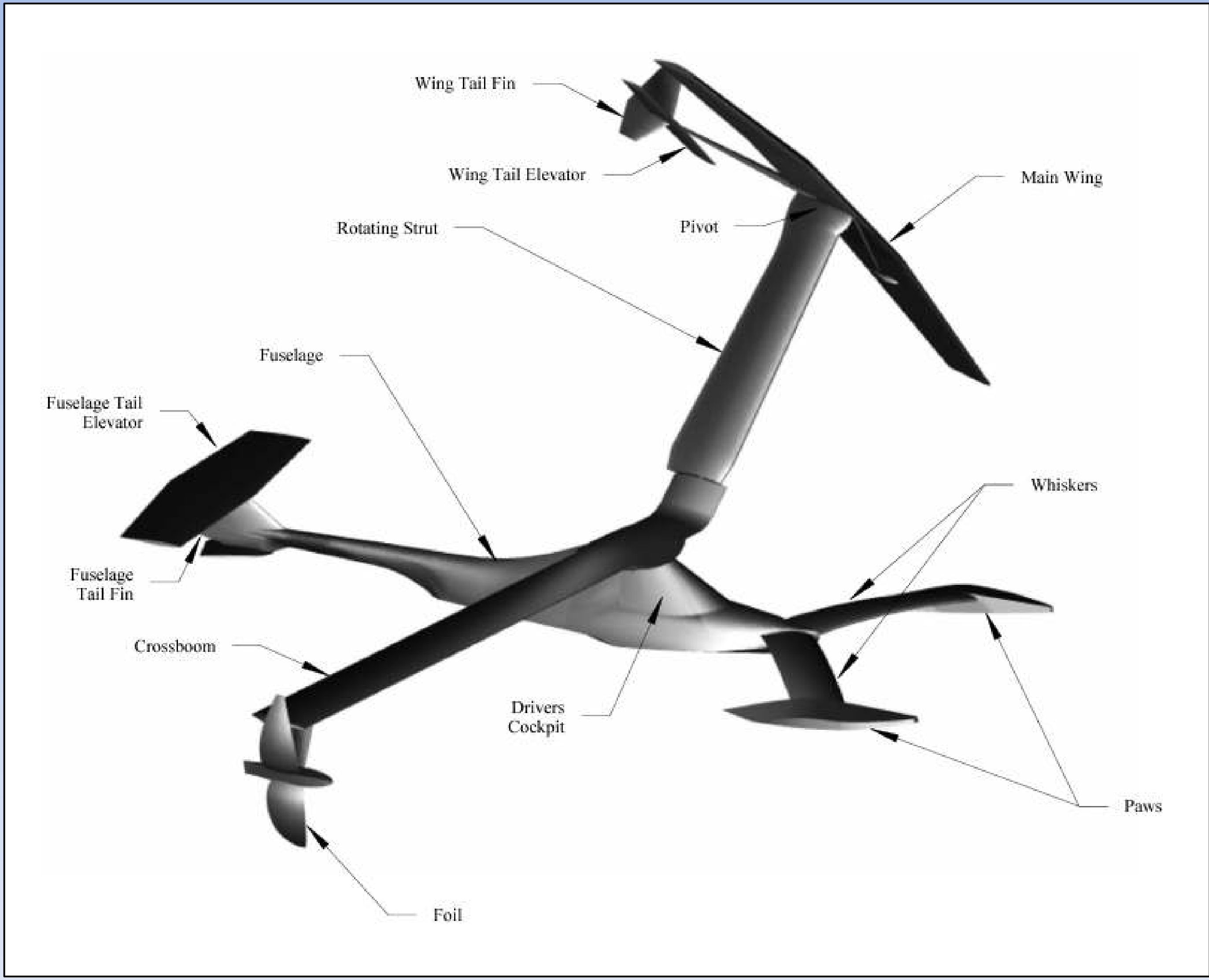
- SAILING IS AN ASYMMETRIC PROCESS
- THE MOST EFFICIENT DEVICES REFLECT THIS
- SYMMETRIC MULTIHULLS HAVE HIGH REDUNDANCY ON EACH TACK AND HIGH WINDAGE
- THE STRUCTURAL TECHNOLOGY IS NO LONGER AN ISSUE
- ‘SMITH’ STABILITY IS EASIER TO INTRODUCE
- TACKING TIME IS NOT CRITICAL OFFSHORE

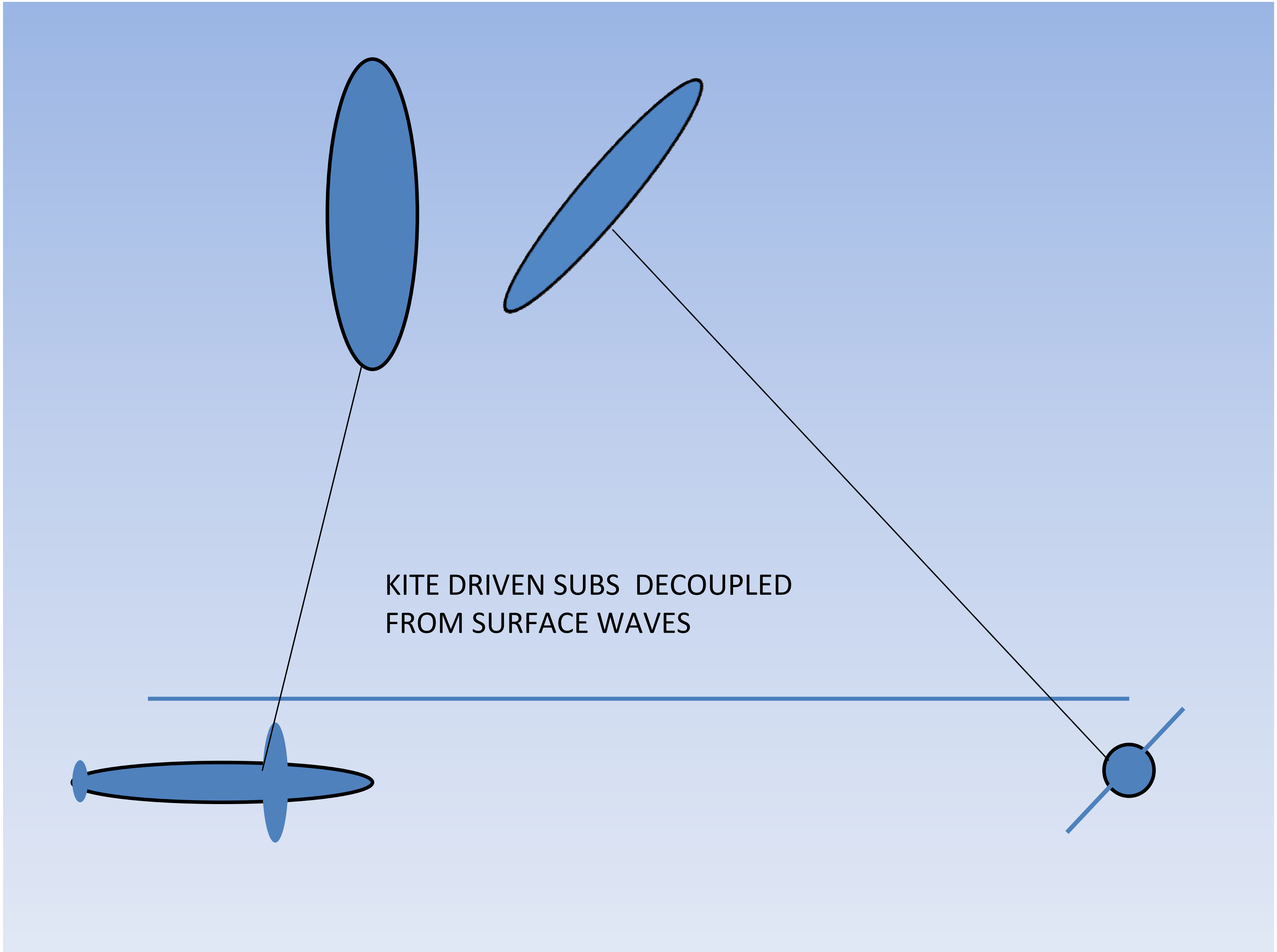
EXPERIMENTAL SMITH TYPE PROA



PROVED FAST AND VERY DIFFICULT TO CAPSIZE EVEN IN SCALE WINDS OF 70 KNOTS AND SCALE WAVEHEIGHT 3-4

MONOFOIL - THE FLYING BOAT




KITE DRIVEN SUBS DECOUPLED
FROM SURFACE WAVES

15 YEAR FORECAST

1. KITE POWER WILL BECOME PROMINANT IN MANY VARIED APPLICATIONS , INCLUDING FUEL SAVING ON COMMERCIAL CARGO VESSELS.
2. PROAS WILL GRADUALLY OUTPERFORM TRIMARANS AND CATAMARANS AND BECOME DOMINANT IN RACING ACROSS OCEANS
3. PROAS WILL ADOPT THE ‘SMITH’ BALANCING CONCEPT TO VARYING DEGREES
4. VARIABLE GEOMETRY WILL BECOME THE NORM
5. THERE WILL BE A RETURN TO LOWER TECH STRUCTURAL SOLUTIONS (EVEN FOR RACING CRAFT)
6. THE WORLD SPEED RECORD WILL REACH 75 KNOTS
7. 24 HOUR AVERAGE OF 50 KNOTS (1200NM)
8. KITE BOARDS WILL REACH THE LOW 60’S KNOTS

THE FINAL WORD

The sailboat offends neither fish, fowl nor man. To make it go faster is to make it even more a thing of freedom and beauty'

Bernard Smith . The Forty Knot Sailboat 1963