WAIP:
Winged Air Induction Pipe

WAIP:What is it?

2013

R&D Engineering Inc.

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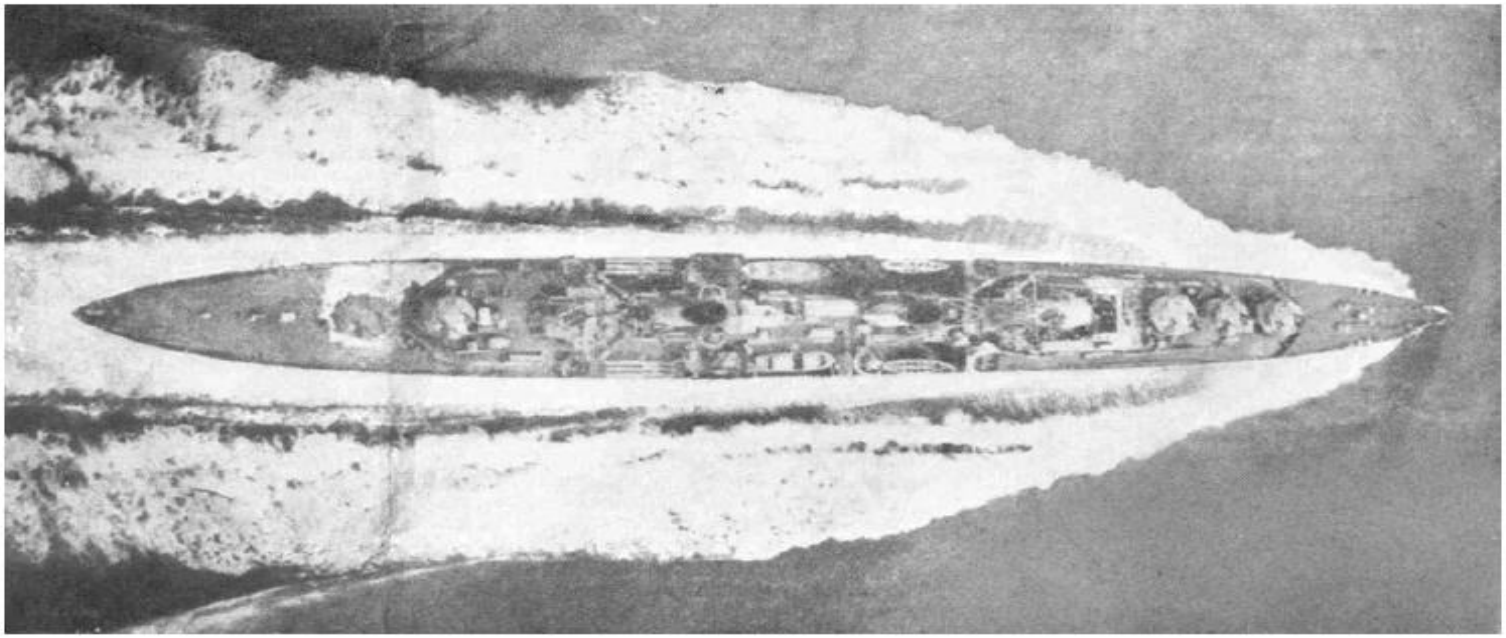
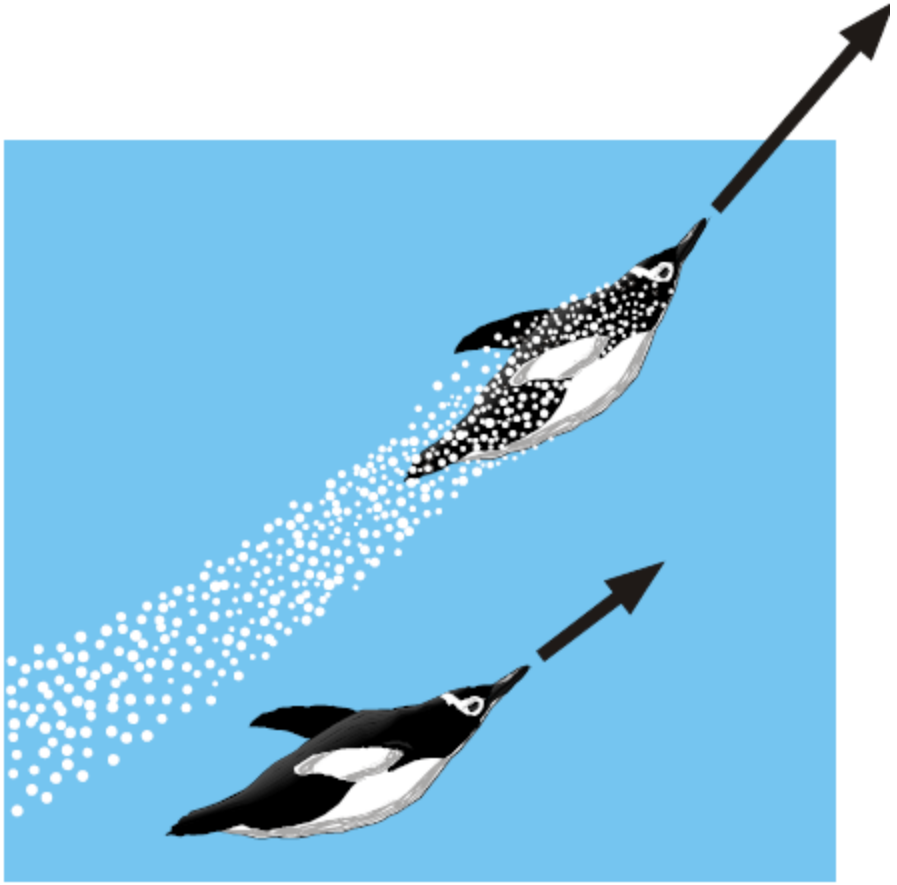
Frictional resistance

Normally 60-70% of total resistance



Friction is reduced in nature by micro bubbles



Source: Ingo Rechenberg

Two(2) main parts of ship resistance

- Wave making resistance

  Every ship now can reduce this resistance by designing Bulbous Bow.

- Frictional resistance

  (called Drag Reduction by specialists)

  Every engineer/scientist is looking for any practical reduction ways so far,but not succeeded except this WAIP.

Two(2) regions of Drag Reduction in Air Lubrication ways

- Turbulence Modulation Method:

  WAIP is a typical example.

  RDE only has made R&D for over 20 years.

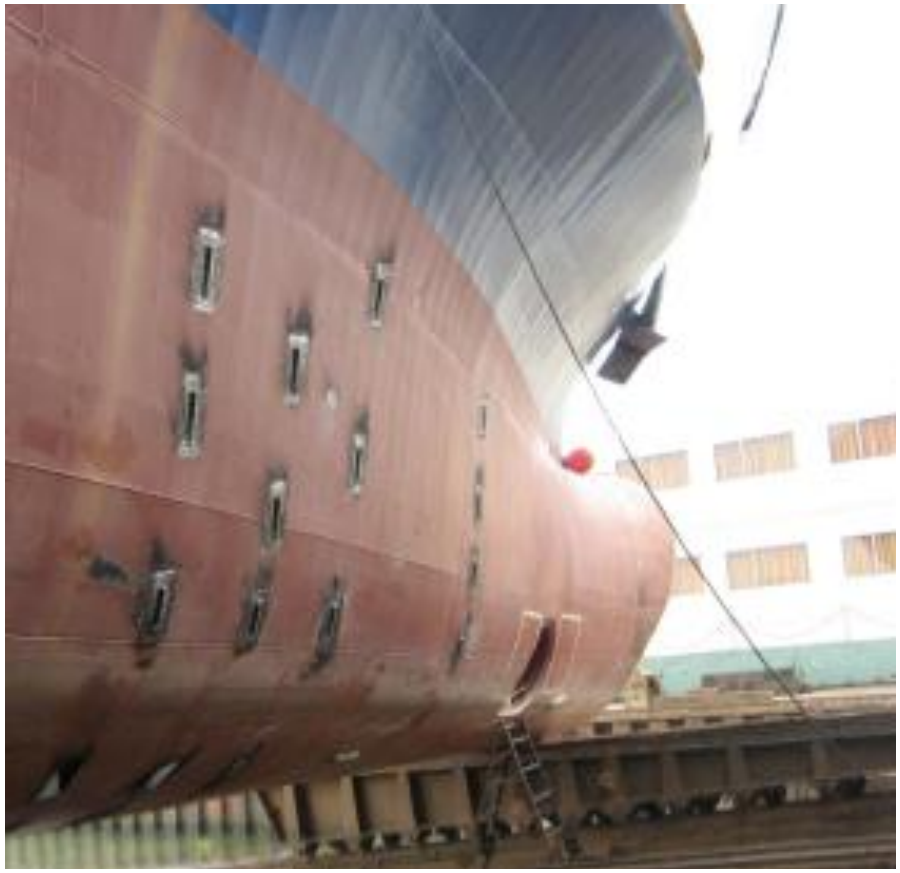
- Air Film Method:

  Examples：ACS by DK shipping,others

  Many other researchers are aiming at application of this method to vertical hull Drag Reduction.

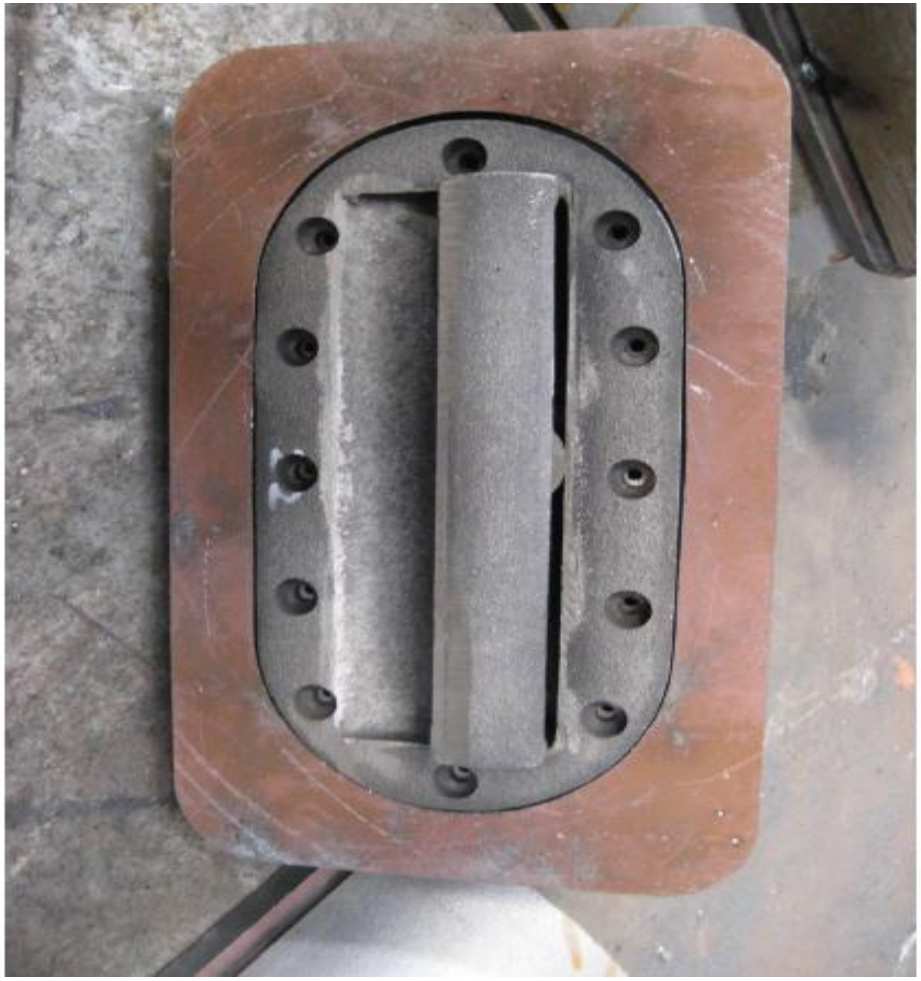
Vertical WAIP microbubble generation photo taken at MARIN

Filia Ariea **has** succeeded in vertical hull drag reduction in July 2008.
85m coaster 10% saving at 12knots



WAIP: Winged Air Induction Pipe

WAIP fitted to Mixing chamber



Mixing chamber under fabrication at Holland shipyard in July 2008

Main features of WAIP

1.Fine Microbubble (peak dia.1.0mm) is generated by Kelvin-Helmholtz Instability.

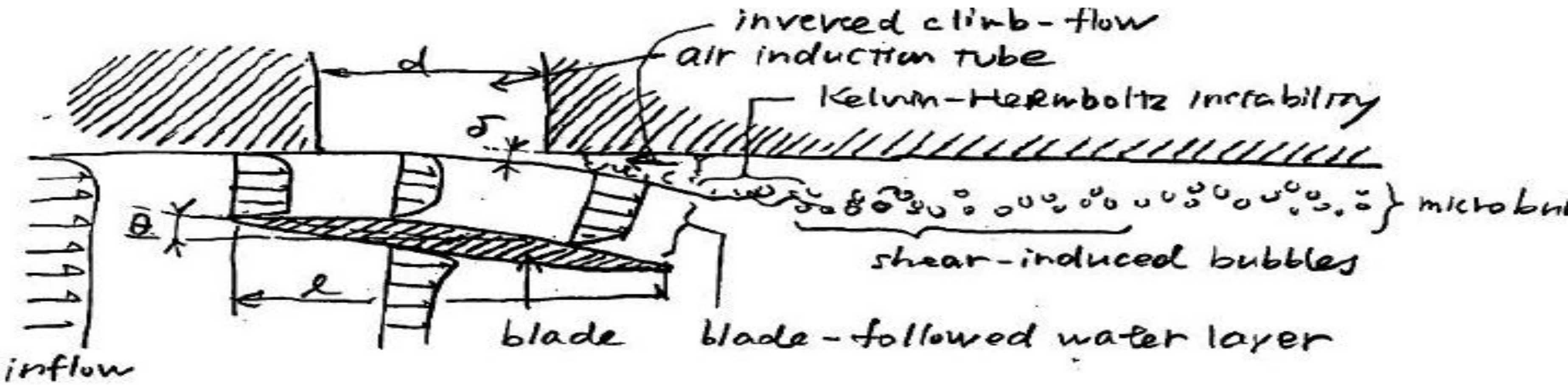
2.Microbubble is released as soon as generated. The Microbubble stays in water pretty long time as cloud with hull-tightening force on it.

3.Any ship goes through the cloud with hull drag being reduced by hull-tightening Microbubble. When the WAIP is above water level,it stops generating Microbubble.

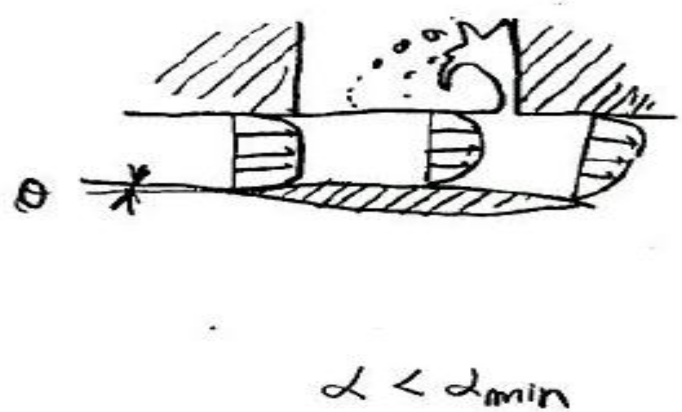
KHI needs air phase and water phase at the same time on wing of WAIP

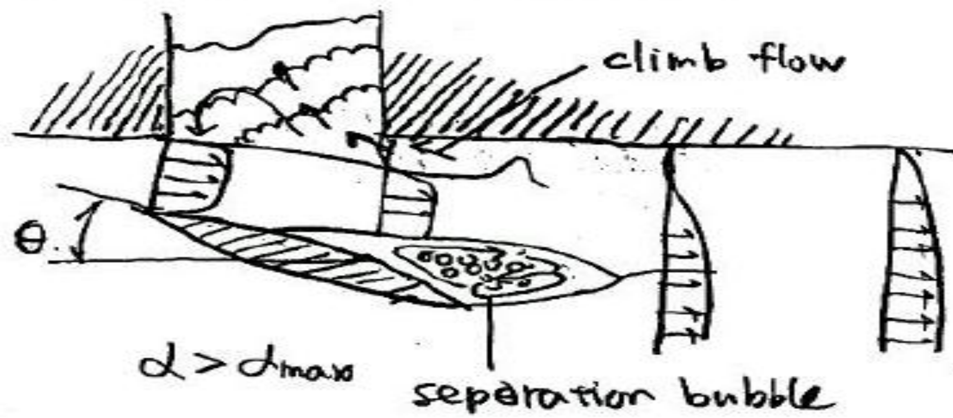
- KHI is natural physical phenomenon and needs not any additional power for generation of microbubble at WAIP except water head corresponding pressurization by compressors.
- When WAIP underwater,it generates microbubble at any time.

KHI condition to generate Microbubble



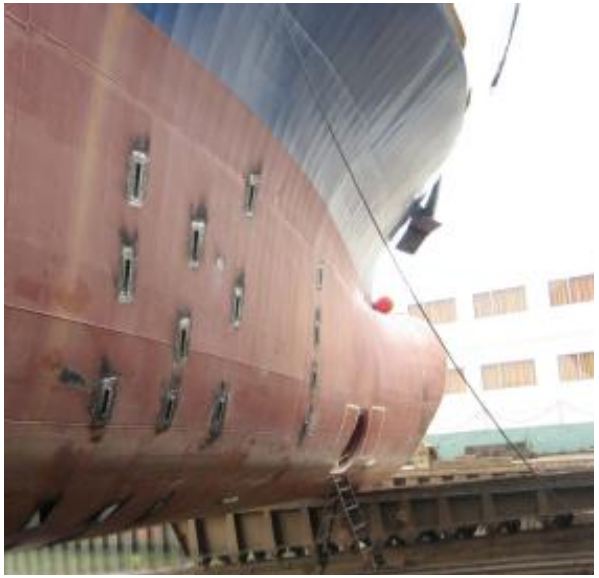
θが小さすぎ… δがとれない airが入らない
θが大きすぎ… 逆上流がtubeに入る. or bladeのstall





Microbubble stays in water pretty long time with hull tightening force on it.

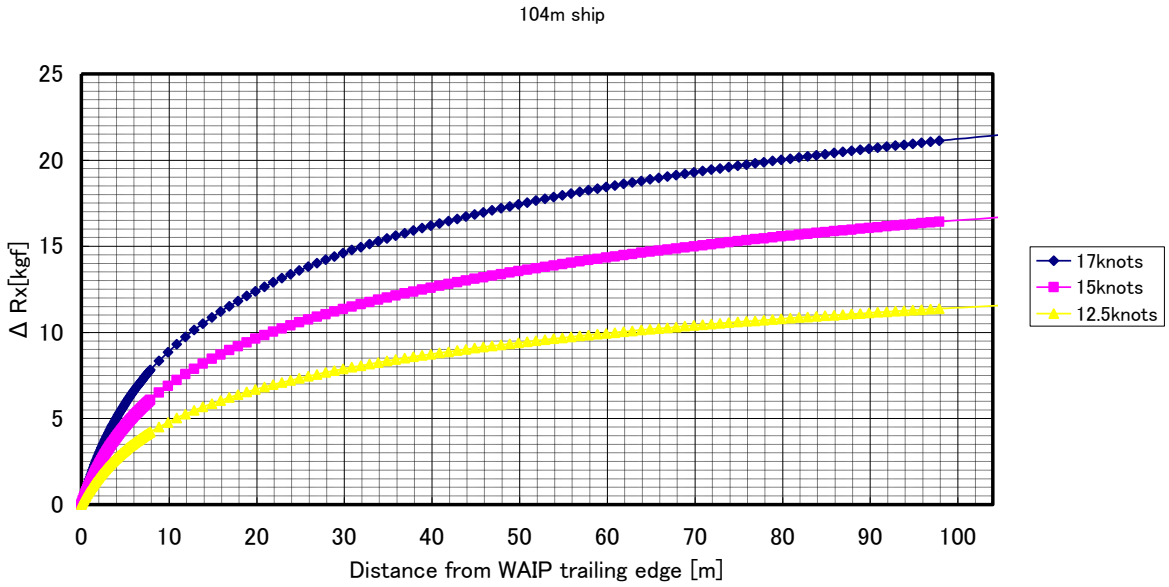
Then no restriction to drag reduction of vertical hull form of whichever ship type it may be.



RDE can calculate how much fuel saving a ship can attain by how many WAIPs on board.

Δ R: Accumulated drag reduced in kgf

L: Distance from trailing edge of wing



Actual application examples:

/M/V Santander Ferry 1

/M/V New Ferry Misaki

/M/V Filia Ariea

LppxBmdxDmd=28.8x5.45x1.55m,350psx2

14.3%saving was shown by 10WAIPattached.

/New Ferry Misaki

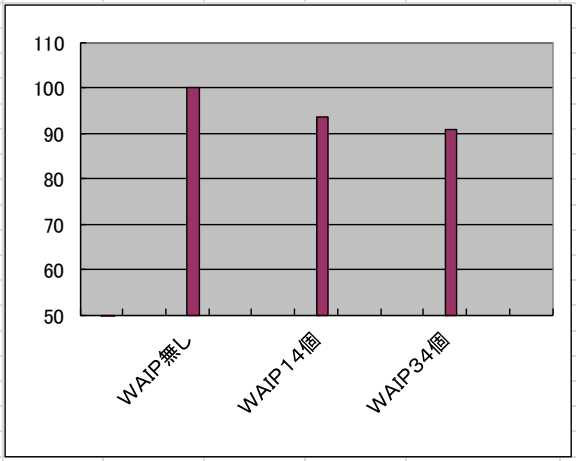
34 WAIP installed to New Ferry Misaki
:14August, 2005 and another 20 August,2007

Lpp*Bmd*Dmd*d=68.0*12.3*8.95*3.2m　4,076ps

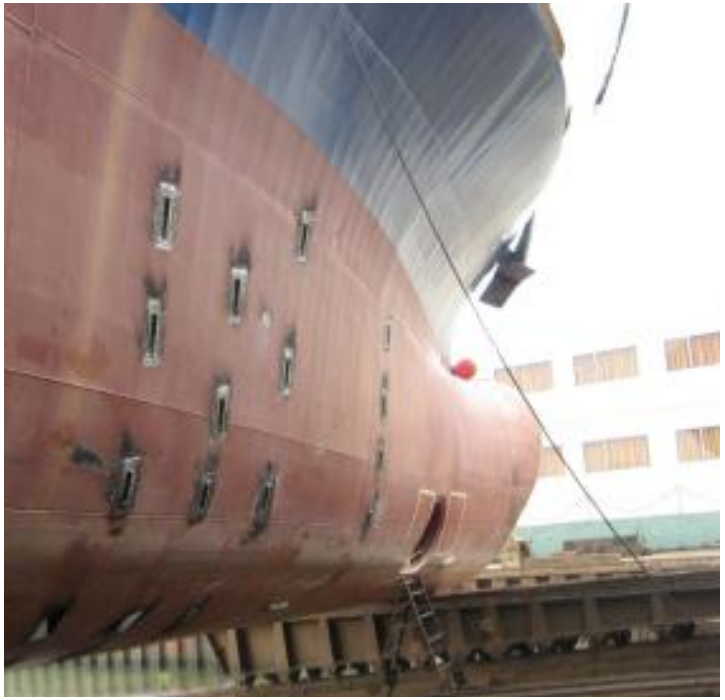
グラフ

RDE:070428

	指数	Main Engineの燃費
WAIP無し	100	4，105．9 Litre／Day（111．9）
WAIP14個	93.5	3，842．5 Litre／Day（104．7）
WAIP34個	90.9	3，733Liter／Day（100．0）

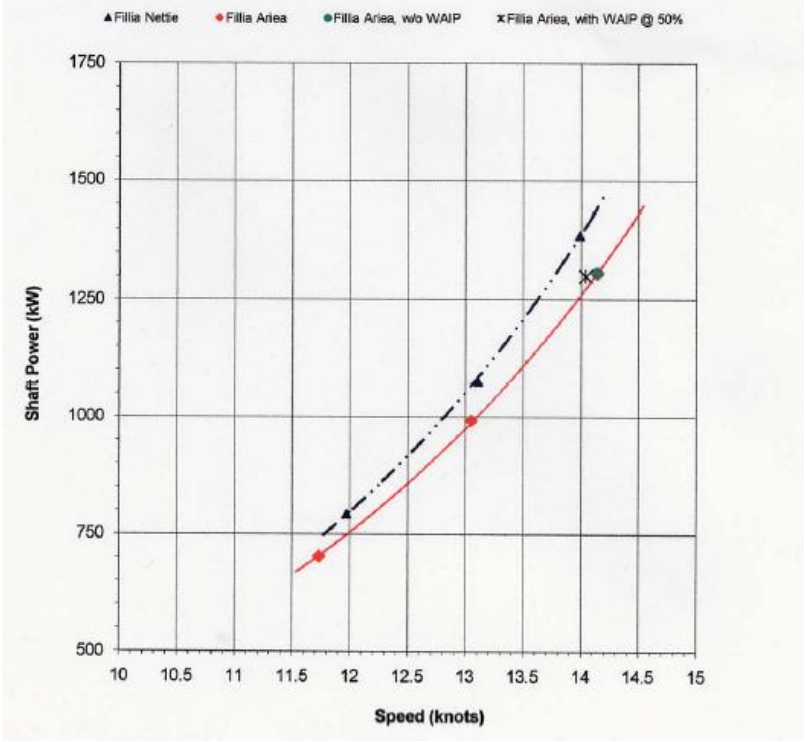


/Filia Ariea: Lpp=85m coaster June,2008; about 10% saving realized by 52WAIPs at 12knots



Speed - power graphic

Ship's name	:	Filia Ariea	Draught fore	: 1.88 m
Report nr.	:	973-A / 08	aft	: 3.12 m
Date	:	June 12th, 2008	mean	: 2.50 m
Displacement	:	2150 t	Trial condition	: Ballast
Corrected for shallow water and wind				



Necessary data for calculation

Lpp*Bmld*Dmld*d(least draft for operations)

Normal output/Normal speed:

For designing WAIP allocation and F.O.saving amount

Actual output/Actual speed:

Actual expected F.O.saving amount