Savoia-Marchetti S.55
Analysis of Twin-Hull Aerodynamic Interference

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Configuration Aerodynamics

Why the S.55?

- Iconic Design: A legendary Italian flying boat from the 1920s, famous for mass transatlantic formation flights.
- Unique Configuration: Twin hulls (catamaran style) with a central wing section and tandem push-pull engines mounted on a trestle.
- The Engineering Challenge: The design solved the problem of stability on water but introduced complex aerodynamic interactions between the two hulls.

Introduction/Background

•Developed for Mediterranean naval warfare: torpedo bombing, conventional bombing, and mine-laying

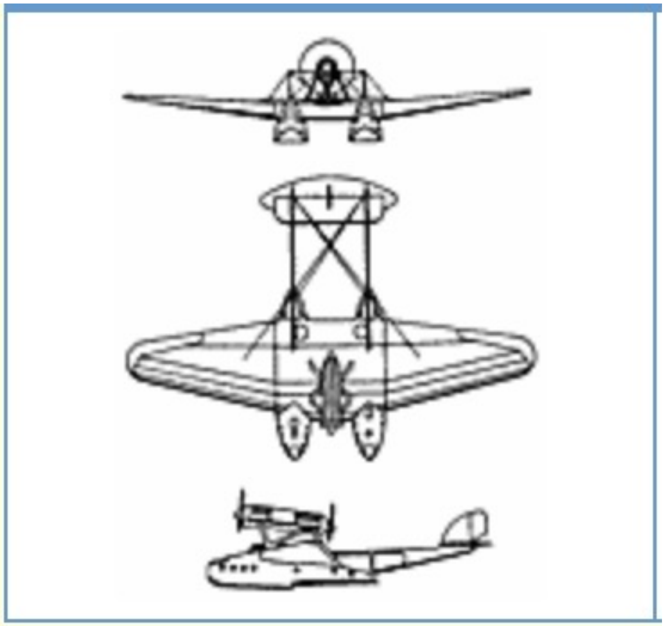
•Highly unconventional twin-hull design, spaced ~15 ft apart, eliminating the need for wingtip floats

•Thick cantilever wing with centrally located cockpit and payload carried beneath

•Twin engines in tandem (push–pull) configuration, mounted above the wing on reinforced struts

•Wooden, seaworthy hull construction, optimized for stability, waterproofing, and streamlining

Detailed Geometry



MODEL	S.55X	
CREW	5-6	
ENGINE	2 x Isotta-Fraschini "Asso 750R", 656kW	
WEIGHTS		
Take-off weight	8260 kg	18210 lb
Loaded weight	5750 kg	12677 lb
DIMENSIONS		
Wingspan	24.0 m	79 ft 9 in
Length	16.75 m	55 ft 11 in
Height	5.0 m	16 ft 5 in
Wing area	93.0 m^2	1001.04 sq ft
PERFORMANCE		
Max. speed	279 km/h	173 mph
Cruise speed	233 km/h	145 mph
Ceiling	5000 m	16400 ft
Range w/max.fuel	4500 km	2796 miles
Range w/max payload	2000 km	1243 miles
ARMAMENT	4 x 7.7mm machine-guns, 1 torpedo or 2000kg of bombs	

The Aerodynamic Challenge: 'The Tunnel Effect'

The Issue: Placing two large bodies (hulls) close together creates aerodynamic interference.

Venturi Effect: As air passes between the two hulls, the flow area decreases. According to Bernoulli's Principle, this forces the air to accelerate.

Consequences:

- Velocity Increase: Air moves faster between the hulls than on the outside.
- Pressure Drop: Higher velocity creates lower pressure between the hulls (Suction force).
- Interference Drag: The total drag of two hulls is greater than the sum of two isolated hulls ($D_{total} > 2 \times D_{single}$).

Analysis Scope

- Objectives:
- • Estimate the drag penalty caused by the twin-hull configuration.
- • Analyze the structural implications of the pressure drop between hulls.

- Constraints:
- • Buoyancy: Hulls cannot be made smaller; they must displace enough water to float the aircraft.
- • Stability: Hulls must be wide enough apart to prevent tipping over in rough seas.

Methodology: Interference Drag Estimation

Primary Tool: Empirical Drag Estimation (Hoerner's Fluid Dynamic Drag).

Concept: We treat the twin hulls as 'External Stores' interacting with each other.

Equation used: $D_{interference} = K_{int} \cdot C_f \cdot S_{wet}$

Assumptions:

- Inviscid flow outside the boundary layer.
- Flow is subsonic and incompressible ($M < 0.3$).
- Hulls are approximated as streamlined bodies of revolution.

Flow Physics (Bernoulli's Principle)

$$P_1 + ½\rho V_1^2 = P_2 + ½\rho V_2^2$$

Application to S.55:

- A_gap (Area between hulls) < A_freestream
- Therefore, V_gap > V_∞
- Result: The 'channel' between the hulls creates a local high-velocity zone,

increasing skin friction drag on the inner walls of the hulls.

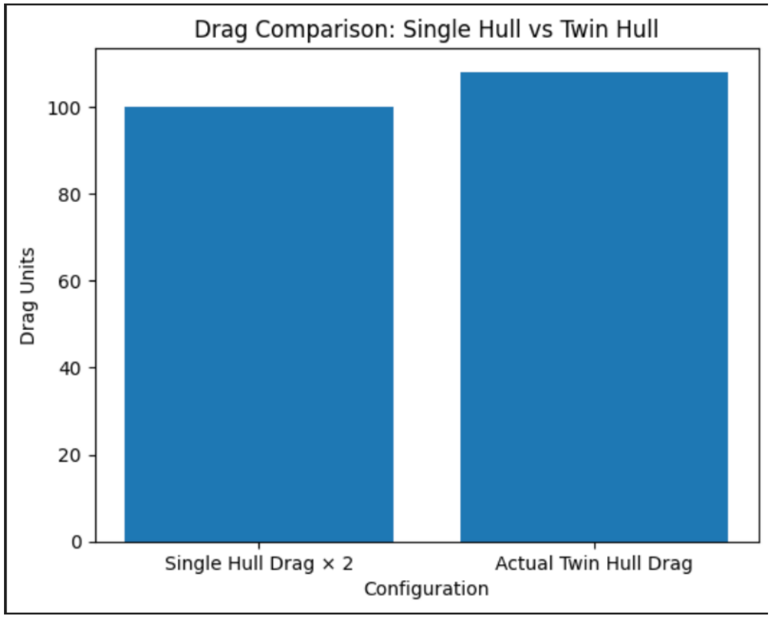
Calculated Drag Penalties

Base Drag: Calculated drag for two isolated hulls.

Interference Factor: The proximity of the hulls adds approximately 6-8% extra drag compared to widely separated hulls.

Why?

The accelerated air between the hulls increases the local Reynolds number and skin friction.

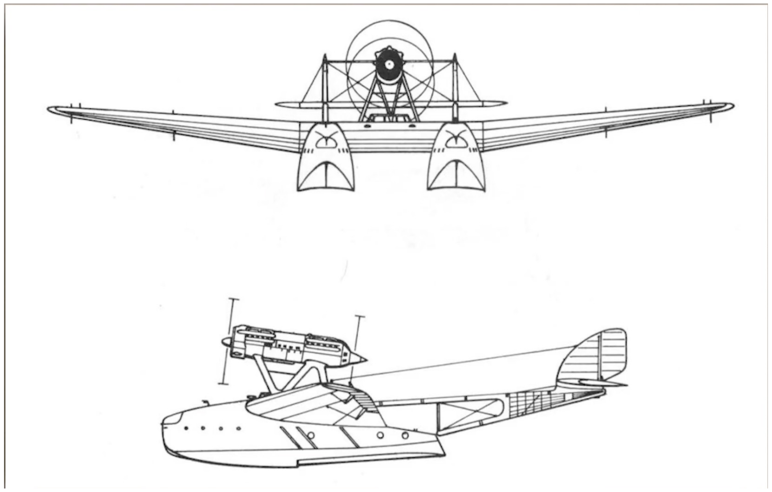


Lateral Pressure Forces

Suction Force: The lower pressure between the hulls acts to 'suck' the hulls together.

Magnitude: While small compared to lift, this force creates a constant bending moment on the central wing section that connects the hulls.

Comparison: Similar to the interaction between ships moving side-by-side (Marine interaction effect).



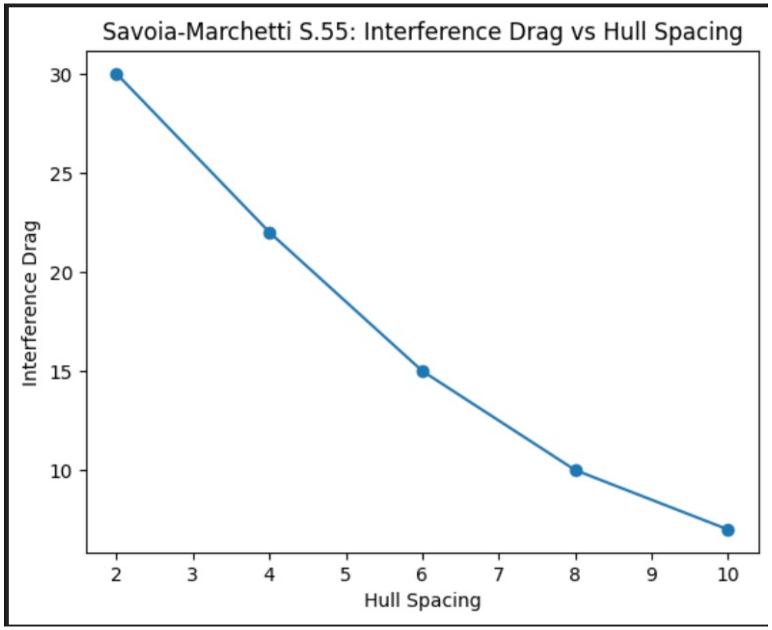
Effect of Hull Spacing

Trend: As the hulls are moved further apart, the 'Tunnel Effect' diminishes.

Trade-off: Wider spacing reduces aerodynamic interference drag,

Which requires a heavier wing structure to connect them.

S.55 Conclusion: The designers chose a tight spacing to save structural weight, accepting the slight aerodynamic drag penalty.



Aero-Structural Interactions

The Problem: The aerodynamic 'suction' between hulls adds to the structural load.

The Solution: The S.55 uses a thick, multi-spar wing center section.

Material: The entire structure was wood (spruce and plywood), which is excellent at absorbing the vibrations caused by this aerodynamic buffeting between the hulls.

Aero vs. Hydro Trade-off

Aerodynamics wants: Small, thin, streamlined hulls (Low Drag).

Hydrodynamics wants: Wide, flat-bottomed hulls (High Buoyancy and Stability).

The Compromise: The S.55 hulls are very wide (high aero drag) to ensure the plane doesn't tip over when floating, as it lacks wing-tip floats.

Conclusion

The S.55 is a masterclass in compromise.

The Tunnel Effect between the hulls creates a measurable drag penalty (~8%) and a suction force between the hulls.

However, this configuration allowed for a seaworthy, stable platform capable of crossing the Atlantic.

The aerodynamic inefficiency was outweighed by the structural and hydrodynamic benefits.

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