Wise up to a WIG

An incredible photo of a WIG in action, a SKY2 experimental two men cambered ram wing craft skims the waves in a banked turn. Photo courtesy of Syozo Kubo, Tottori University, Japan.

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What is a WIG?

Both W.I.G and W.I.S.E are abbreviations for the phenomena called “Wing In Ground” effect (or “Wing In Surface Effect”, as is becoming the fashionable term). The WIG effect provides extra lift to a wing when it flies close to a surface, i.e. the sea. Racing catamarans and hydroplanes often incorporate wing shapes which produce lift to help reduce hull resistance. WIG takes this concept a stage further and is the next step on the evolutionary path of the high speed boat.

A number of institutions around the world are working on WIG projects right now. For example, the latest Budweiser Unlimited hydroplane is very much a WIG. Rhein-Flugzeugbau GmbH of West Germany market a two seater “runabout” (or should that be ‘flyabout’?) capable of 90 mph powered by only a 80 hp engine. Russia, on the other hand, has developed a 350 ton 300 mph ‘Caspian Sea Monster’ WIG transport craft.

And now, as they say, for something completely different. Graham Taylor presents an entirely new class of marine vehicle to spur your imagination.

Radio controlled cambered ram wing model ready for launch. Photo courtesy Syozo Kubo, Tottori University, Japan.

Marine slider “uSKY2” skims past. Photo courtesy Syozo Kubo, Tottori University, Japan.
"What is an article on funny looking aeroplanes doing in my boat magazine?" you may well demand! Ok, keep your hair on, they're not aeroplanes, they're WIGs! This article is about a whole new form of marine craft.

**WIG, the dynamic hovercraft.**

A wing flying close to a surface is much more efficient than one in free flight because it benefits from a reduction in 'image drag', as tip vortices are cancelled by the presence of the surface. It also benefits from additional lift created by ramming air between the underside of the wing and the surface. In effect the wing itself becomes a sort of dynamically supported hovercraft. The WIG effect is not a new phenomenon. Pilots have known about it for years. Aircraft and large birds experience WIG effect on take-off and landing. Seaplane pilots used it to conserve fuel on long missions.

**The WIG effect explained.**

The extent of the WIG effect is dependent on the proximity of the wing to the surface, since the lift and drag benefit is reduced as the wing rises off from the surface, and increases again as the surface is approached. Roughly speaking, the WIG effect is very strong when the distance between the surface and the wing is less than the wing chord, and falls off as this distance approaches the wing span. The beauty of this is that for a given speed a WIG craft can be made to self-stabilise at a constant skimming height. Alternatively, the weight supported by the wing can be considerably increased to about 4 times that of a conventional craft, for the same engine power, before it touches the surface. In addition, this height stabilising effect means that a WIG does not need the complex aileron controls of an aircraft, since any tendency to roll one way or another would be very quickly countered when the wing drops towards the surface. The WIG effect can be easily demonstrated by taking a piece of card, say a beer mat, and bending it slightly up in the centre of one edge so that air can get underneath. If you then place it on a table top and give it a flick on the opposite edge you will see it skim across the table on a dynamic cushion of air. So a WIG is a winged vehicle designed, not for free flight like an aeroplane, but to skim just above the surface like a hovercraft.

**Pitch Stability.**

The greatest problem of the WIG concept is pitch stability; preventing the craft flipping over - what hydroplane racers call 'blow-over'. This is because the centre of lift moves forwards as the wing rises from the surface (see Fig. 1). For a conventional wing section in normal flight, the centre of lift is around 1/4 to 1/3rd of the wing chord back from the leading edge, and the centre of gravity would normally be located in this region. As the wing approaches a surface the centre of lift moves backwards, due to the WIG effect, causing the wing to nose-dive. In static hover, with an air cushion underneath, the centre of lift will be at the centre of area, i.e. 1/2 of the chord, so the centre of gravity needs to be in the middle. Now as the wing transforms from its 'hover' mode to forward flight and rises off the surface its centre of lift will move forward, causing the 'blow-over' effect.
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Very exciting performance over dry land from my simple experimental WIG model, which uses an inverted reverse delta main wing and a stabilising tail wing. Model now dismantled to fit floats.

Front view of my model showing the air duct below the engine which creates an air cushion for take off.

To overcome this problem four different self-stabilising layouts have evolved (see Fig 2):

1. Lippish Reverse delta: Dr Lippish (the designer of the Delta wing) found that an inverted 'reverse delta' wing could be designed so that the position of the centre of lift does not vary considerably through WIG transition.

2. Three wing 'PAR-WIG' Power Assisted Ram having one main wing with front and back stabilising wings (Nagoya University - Japan)

3. Jorg Tandem Airfoil Boat

Uses two wings in a canard type layout

4. Cambered Ram Wing using a highly cambered main wing. (Tottori University - Japan's Marine Slider project). Designed to look clearly different from an aeroplane.

Experimental Model Concept.

The reasoning behind my experiments went like this: Consider the hovercraft, able to travel over flattish terrain but limited to a top speed of about 60 knots, since at this speed the air pressure on the front of its cushion skirt becomes greater than the air pressure within, causing the skirt to collapse. To increase hovercraft speed to, say, 120 knots would require enormous power input to pressurise the static cushion against the outside 'drag' pressure on the skirt. Also the hovercraft spends very little of its time in static hover, yet usually has two sets of engines: one for propulsion and one for lift. If a machine were to be capable of carrying hovercraft type loads at double hovercraft speeds it makes sense to do away with the skirt and support the craft on a dynamic cushion. Also, static hover/take-off could be achieved by deflecting thrust from the main engines into a more primitive and leaky cushion, without a significant effect on overall fuel efficiency, since so little time is spent operating in this mode. So cut out the flexible skirt and the lift engines and we have a very simple craft indeed. So much for the theory - now to the prototype.

The practice.

I agree it doesn't look much, but it does demonstrate the concept. For the sake of simplicity my pro-

Right: Concept sketch of the author's WIG Mk2 project. Developed from the same general ideas as Mk1, but designed to look more like a hovercraft. A ducted fan under the front cowel would provide thrust via outlets either side of the cockpit, and would be retracted under the hull for takeoff.

totype was not intended for water borne operation. The main body of the craft takes the form of a reverse delta wing with inverted dihedral, giving an angle of attack of 5 degrees. This provides not just the dynamic lift, but also functions as a simple plenum chamber for the static cushion (see Fig 3). Air is rammed under the craft by its forward motion and also ducted from the airscrew. The airscrew creates sufficient pressure under the wing for it to hover just clear of the ground.

Having rambled on about the benefits of the reverse delta wing I concede that my model is a bit of a 'cop-out' since its wing has a flat section, which was constructed of balsa veneered foam (dare I admit it?) polystyrene ceiling tiles, then film covered. The balancing of lift movement during hover-to-WIG transition was ensured by fitting a large tail plane with a positive angle of attack, which compensated by adding lift at the rear (see Fig 4). The superstructure, tail and rear were balsa sheet, and the removable engine plate/duct cover from 1/8" ply. Small wire skids were fitted beneath the tail and wing tips as the prototype was intended for land operation only.
**MODEL SPECIFICATION**

<table>
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<tr>
<th>WEIGHT:</th>
<th>2 lb. 2 oz. all up</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>SPAN:</td>
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</tr>
<tr>
<td>TAIL HEIGHT:</td>
<td>6.5 ins</td>
</tr>
<tr>
<td>ENGINE:</td>
<td>(Mk1) Cox 0.049 in</td>
</tr>
<tr>
<td></td>
<td>(Mk2) Cox 0.051 twin</td>
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**Operation**

As a prototype the model was a complete success. It demonstrated the concept of the static and dynamic cushions. The static cushion height of about 1/8th inch was sufficient to enable the craft to float with minimum friction on smooth surfaces such as the local cricket pitch or car park, whilst the craft rose to 1/4" - 1/2" at full speed. I found one or two faults which could be corrected in the design of MKII.

Cornering stability could be improved by the addition of small dihedral wingtip ailerons as fitted to full size experimental craft; correcting the crafts tendency to 'weather cock' into a crosswind would require a revision of the superstructure profile.

The model achieved its most successful runs powered by a Cox .049in engine, including leaping a six foot Norfolk ditch and chasing two rather startled joggers. The speed of the model was somewhat faster than I could run after it - which I thought was not bad for such a small engine. This was changed to a .051in twin cylinder engine which developed substantially more power but its weight altered the centre of gravity beyond correction, so offered no real improvement. The prototype has now been pulled apart for fitting a redesigned superstructure which will enable the C of G to be corrected, as well fitting wing tip floats.

**A final thought!**

In this article I've explained my experience of Wing In Ground effect craft. It is clear that they hold a lot of potential and it would be exciting to see more development. Sadly you can't expect everyone to appreciate the potential of this type of craft. As one ten year old spectator asked me, after spending some fifteen minutes watching my model skimming across the local playing field: "What's wrong with your aeroplane, mister? Won't it take off?" "One day..." I thought, "one day..."