WING IN GROUND EFFECT CRAFT
The Concept and the Market

By Graham Taylor

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In contrast to Darrol Stintons examination of large scale WIG vehicles in the preceding issues, this article argues the case for smaller WIGs, from both technical and market entry strategy viewpoints.

The key to WIG success must surely be its simplicity. This can be demonstrated by taking a card beer mat, bending it slightly in the centre of one edge so that air can get underneath and placing it on a smooth table. A flick on the opposite edge will send it skimming across the table on a dynamic cushion of air. Creation of a WIG market centres around a quest for a commercially viable vehicle, employing the exact same principles as the beer mat, on which a transport operation can be profitably based.

Numerous research projects around the world have shown that the WIG concept can be reduced to three constituent parts: a lifting structure, an automotive engine with propeller, and a rudder control mechanism. This makes it considerably more simple than almost all other forms of transport; even the agricultural Citroen 2CV car is a highly complex vehicle by comparison! Minimisation of the moving part count has direct positive impact on reliability, servicing and maintenance costs. Moreover, it provides a powerful leverage point when marketing to remote and developing parts of the world.

Model Experiments

Several years ago the absence of data on WIG motivated me to explore the subject through the use of a simple radio controlled model (reference 1), which I outline to demonstrate the accessibility of the WIG concept.

The model was built around a lightly loaded Lippisch reverse delta main wing. This form was believed to minimise the forward and aft transition of the aerodynamic centre when operating out-of-ground-effect (OGE) and in-ground-effect (IGE). The models' operation was constrained within ground effect by virtue of the low power output of its engine, whose propeller slipstream was partially ducted under the main wing to give a primitive static cushion in PAR fashion (Power Assisted Ram WIG).

The function of auxiliary surfaces necessary to control IGE/OGE pitch instability outlined earlier in this series depends on whether one aligns the longitudinal centre of gravity (LCG) with the in-ground-effect or out-of-ground effect aerodynamic centres. In the case of the model, the requirement for static hover necessitated that LCG be located at the centre of area or half-cord point. This in turn necessitated an additional dynamic lift area of positive incidence behind the main wing in the form of a large T-tail to counter OGE pitch-up and possible blow-over. As the craft accelerated lift became shared by the two wings, balancing again at the longitudinal centre of gravity.

The model performed surprisingly well and demonstrated how simple the WIG concept is. Running on a closely cropped playing field the static cushion gave a ground clearance of a few millimetres, which doubled as speed increased and the model made its transition to ground effect mode. Certain lessons were learned from its operation; IGE roll stability, afforded by the span-wise pressure differential exerted as a wing tip moves towards or away from the surface, could probably have been enhanced by a lateral divider. Stability was lost with increasing height and may have been improved by fitting dihedral wingtips. The model suffered from a tendency to turn into wind, which indicated a need for a revised superstructure profile.

It was also noted that T-tailed aircraft have a reputation for deep-stall where, at high angles of incidence, airflow leaving the main wing inhibits operation of the tail surface. This effect is described in a WIG context by Englar et al (reference 2) and appears a potential problem in many of today's WIG configurations. A similar, though not identical, effect was observed when operating the model. On occasion it would rise to a high angle of incidence and then side-slip. The problem was believed to be caused by the loss of airspeed over the control surfaces as a result of the crafts' drag induced deceleration. Because WIGs operate within a speed envelope in which the effectiveness of conventional aerodynamic control surfaces is rather marginal, directional and attitude control requires an element of thrust vectoring, often by use of blown control surfaces in the propeller slipstream. Such considerations would be built into any subsequent model.

Making the WIG Commercially Attractive.

This series has shown that the technical feasibility of WIG is beyond question, but are there any design philosophies that can ease their commercial introduction? For example, an American expression "If it walks like a duck and quacks like a duck, then it's a duck" has some relevance; for the more a WIG is configured like an aeroplane, the more it will be perceived as an aircraft. This sets a course for the same quagmire of aerospace technology and legislative problems that beset the hovercraft in its early days. Significantly, one of the design objectives of the Japanese Marine Slider project (reference 3) is to differentiate their craft from the aeroplane.

Although potentially superior, pursuit of the large, high-speed WIG, or wingship (to use Stephen Hooker's expression) may also be something of a poisoned chalice. With surface speeds of around 300 knots the time to an object on the horizon is about four minutes, necessitating the reaction and evasion capability of a computer game.

Computerised fly-by-wire aircraft technology could be used to compensate for IGE/OGE instability. However, the pilot of an airliner experiencing a control malfunction has the benefit of time, afforded to him by the several thousand feet of travel before impact, in which to avert disaster. A high speed WIG at an altitude of 50 feet provides no such margin. Is it perhaps better that WIG design contains a degree of inherent IGE and OGE stability even if OGE capability is not intended? High speed WIGs carry a perceived risk against which the safety concerns over the channel tunnel pale into insignificance.

A discussion I had with a leading UK based operator revealed that to minimise commercial and passenger risk operators prefer: evolutionary rather than revolutionary solutions, production line rather than one-off products, and suppliers with evidence of previous experience. These views come as no surprise and are mirrored in the airline industry where Boeing has successfully fended off high-tech newcomers.

If leading management guru Michael Porter (reference 5) is to be believed, the source of global competitive advantage lies in a strong home market base. We can use this hypothesis to glance around the world and make certain predictions about where WIG development might proliferate. For example, North America (with the possible exception of the great lakes and northernmost Canada) appears to have no immediate market for wingships since the infrastructure is satisfied by other transport means. Applying Porters hypothesis effectively rules out US players like Lockheed and General Dynamics from a significant roles as WIG manufacturer despite their numerous design studies.

Elsewhere in the globe, where there is still potential for major investment in transport infrastructure, the scope may exist for larger craft. Russia and China already have WIG programs, while serious investment in WIG research by Japan or Korea could be expected if one looks beyond the Technosuperliner. Sadly this analysis puts the UK on the list of non-runners. With operators preferences in mind the global wingship market could be dominated by just one or two players. It may well mature before we get a look in.

The future for smaller, slower craft of up to, say, 150 seats is far brighter, and it is here that I see immediate commercial potential. Despite their sub-optimal technical qualities they can provide a viable solution on which a commercial transport operation could be based. The geographic opportunities are far wider, embracing river, estuary, coastal and inter-island service. Potential locations include Mediterranean islands, Pacific rim countries and Third World flood plains, providing passenger, freight, emergency and patrol services. Their simplicity enables them to be constructed in boatyards throughout the world, requiring few specialist skills or materials. Operators and passengers need only be persuaded that such craft are the logical, evolutionary extension/replacement of their SES or hydrofoil craft. The economic argument for their adoption is exactly the same as used to replace displacement craft by high speed ferries: harder working reduced overall expenditure, offering the opportunity to cut journey times or fleet size and to develop new routes. In time unit experience will bring cost down, resolve legislative and safety issues, and provide a more sound base to tackle wingship projects.

In summary, the WIG principle is easily demonstrated and explored yet the world-wide pool of knowledge on the subject is surprisingly small. There is vast potential for further research into the concept. Indeed; investigation of WIG phenomena lies well within the capabilities of many university laboratories. There is also a need for re-interpretation of aerodynamic terminology within the context of ground effect.

Undoubtedly there is scope for large 'wingship' vehicles but in this authors view there is also a danger of 'Gerry Anderson' thinking associated with pursuit of complex high-tech craft that threatens to bring it closer to technical ideals than commercial ones. Smaller, lower speed WIGs offer an easier market entry strategy, global opportunity and a base from which companies may expand the market. The beauty of WIG is its simplicity - we must use it to our advantage.

References and Further Reading

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2. R J Englar, D M Schuster, D A Ford. *Evaluation of the Aerodynamics and Control of Unlimited Racing Hydroplanes Operating In and Out of Ground Effect* 29 Aerospace Science Meeting. Jan 7-10 1991 Reno, Nevada. AIAA 91-0553
3. S Kubo T Matsuoka T Kawamura. *Development of a Wing-in-Ground Effect Craft Marine Slider; μSKI-1 as a high Speed Boat*, Proc. 4th Pacific Cong. Marine Sci & Tech. Vol1.I, 1990 pp 220-227
4. S Hooker. *A review of current technical knowledge necessary to develop large scale wing-in-surface effect craft.* Proceedings of Intersociety Advanced Marine Conference 1989. Arlington VA pp 367-429
5. M E Porter (1990) *The Competitive Advantage of Nations* The Macmillan Press Ltd

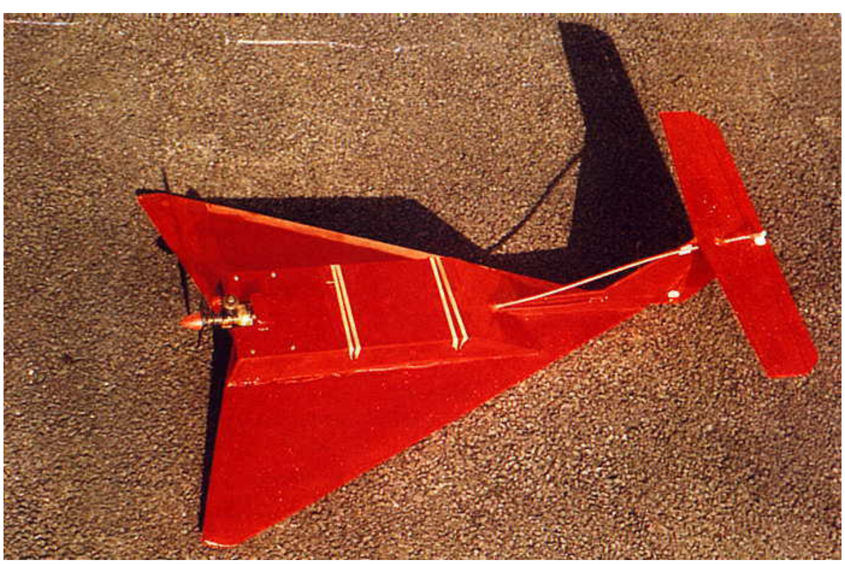
About the Author

Graham Taylor MBA is a business analyst and Companion of RINA who has maintained a close interest in development in WIG technology over the past 15 years.

Illustrations

Photos 1 & 2

A simple radio controlled model using PAR Lippisch layout, by the author



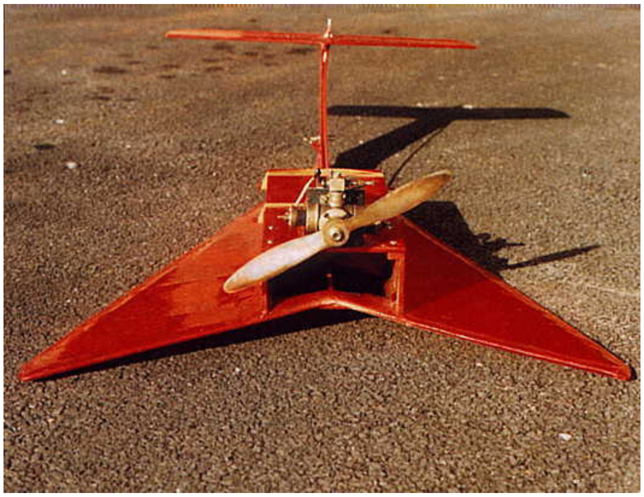
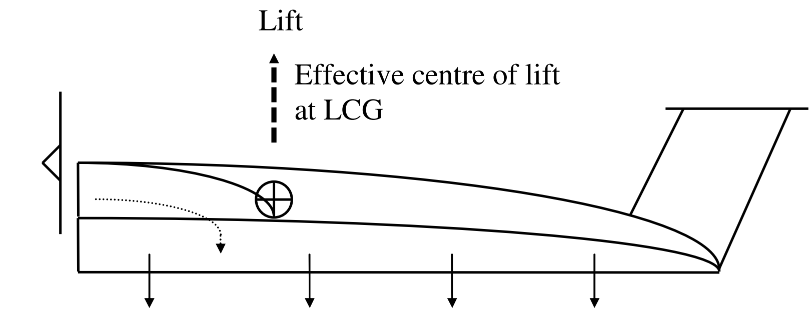


Photo 3
The Flarecraft L-325 five seat 'water taxi' of Lippisch configuration is one of the first commercially manufactured ground effect craft. Its Subaru 230 HP air prop system gives a cruising speed of 75 mph.

Model Configuration

Static Hover Mode:
Centre of lift = Centre of area = Longitudinal Centre of Gravity



Wing in Ground Effect Mode:
Centre of lift = combined lift of main wing + tail wing
= Longitudinal Centre of Gravity