ARE YOU MISSING THE BOAT?

THE EKRANOPLAN IN THE 21ST CENTURY

–

ITS POSSIBILITIES AND LIMITATIONS

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OVERVIEW:

Over the years much has been written about the concept of Wing in Ground Effect and the Ekranoplan. Some believe that it will bring about a new era in the future of high-speed marine transport. Others are more sceptical and think it is a blind alley that holds less promise than the hovercraft. Is it a technology that has already missed the boat, or has it yet to come of age?

This paper will explore and discuss a realistic assessment of:

- The business opportunity that may exist for potential Ekranoplan/WIG operators, including the business case, geo-demographic and economic factors, business / industry strategy
- What impact this technology could have on other players in the fast ferry industry

ABOUT THE AUTHOR:

Graham Taylor has a background in engineering, commercial management and business analysis, supported by an MBA from Thames Valley University, London in 1995. He has held a variety of positions within several industries, including the post of Technical Director of The Royal Institution of Naval Architects. He has maintained a close interest in the development of high-speed marine vehicles for 20 years, and has presented several papers on the commercialisation of WIG/Ekranoplan at international conferences.

ABOUT HYPERCRAFT ASSOCIATES:

Hypercraft Associates is currently engaged in working with leaders in WIG/Ekranoplan technology to assist the commercialisation of the concept.

INTRODUCTION: THE EKRANOPLAN AS A CONCEPT

Ekranoplan technology is capable of speeds in excess of 80 knots over water. That, together with other attributes, makes it appear to offer a transport solution that bridges the gap between aircraft and current high speed ferries, both in terms of speed and cost.

To what extent this technology can be exploited as a transport solution and what impact it would have on players already in the fast marine transport business is still open to debate. However, advocates of the Ekranoplan believe that the technology is now ready for the real world so that the impact could come sooner rather than later.

To explore the prospects for the Ekranoplan and adjacent technologies from the point of view of both operator and manufacturer this paper will look at the following:

- The Argument: Why go faster?
- The Technology: Convergence of Aero and Marine Worlds
- The Business Case: The Business Opportunity
- The Strategy Discussion: What Business are we in?

THE ARGUMENT: THE NEED FOR SPEED – WHY GO FASTER?

Why is the ferry business interested in going faster? The answer to this fundamental question has three components and, in practice, the truth lies somewhere in between:

- Speed as a means to save time
- Speed as a sales magnet
- Speed for its own sake

Firstly, as a means of saving time, speed brings sound commercial benefits with which to build a business case:

- Reducing journey times – better customer experience, serving more customers per day, working new markets, e.g. time sensitive, perishable goods.
- Reducing the cost of goods in transit (one of the arguments underpinning 'fast ship' projects [Ref. 1. 2])
- Saving operator capital cost, because one fast craft could do the work of several slow ones
- Extending routes – reaching new destinations within acceptable journey times

In essence it boils down to harder-working capital investment that gives more return than would be achievable by conventional craft. Speed turns the business machine faster.

Secondly, it may seem superficial, but one should not underestimate the sales appeal, or 'sex appeal', that is associated with speed. It brings with it rakish lines and a hint of brutal power that is exploitable in the product advertising. It also brings with it 'flagship' status. Indeed, the same accounts for BAs' and Air Frances' commitment to reintroduce Concord, albeit the appeal now tending towards 'vintage' rather than 'cutting-edge' technology.

Thirdly, speed can be a goal in itself because the quest for speed motivates many innovators and is therefore a technology driver.

Conventional craft - Pushing the Edge of the Envelope

Pushing the top speed in the performance envelope of marine craft means that the aerodynamic component becomes ever larger and so brings about the natural convergence of marine and aviation technologies.

To put this in context, below are examples of current technologies:

- Sea-cat typical: circa 37 knots
- Jetfoil: circa 43 knots
- Hovercraft, typical: circa 45 knots
- Hovercraft BH4: circa 60 knots
- Fastest catamaran ferry - Luciano Federico (Buquebus): circa 57 knots
- Fastest SES: BELL SES-100B (1977): circa 90 knots

There comes a point where aerodynamics begin to dominate, and the craft will want to get airborne. How close this point is to the present marine performance envelope becomes clear if we consider that a 35 tonne Boeing 737 can lift off the runway at 99 knots. This highlights the increasing need to view ferries as aerodynamic vehicles if speed is to be pushed much further. Several initiatives exist that aim to utilise aerodynamic lift in ferry type vehicles; Incats' The Wing project is one example.

THE TECHNOLOGY: THE EKRANOPLAN, A CONVERGENCE OF AERO AND MARINE WORLDS

Accepting that there is a natural convergence between 'aero' and marine vehicles, let us examine a vehicle that already sits between these worlds. The Ekranoplan or wing in ground effect (WIG) as it is often known, is best thought of as a sea skimming 'dynamic hovercraft'. Unlike the conventional hovercraft which drags its static cushion with it, the Ekranoplan generates a 'dynamic cushion' by its own forward passage. It is in essence a very simple vehicle, being no more complicated than a conventional boat [Figure 1].

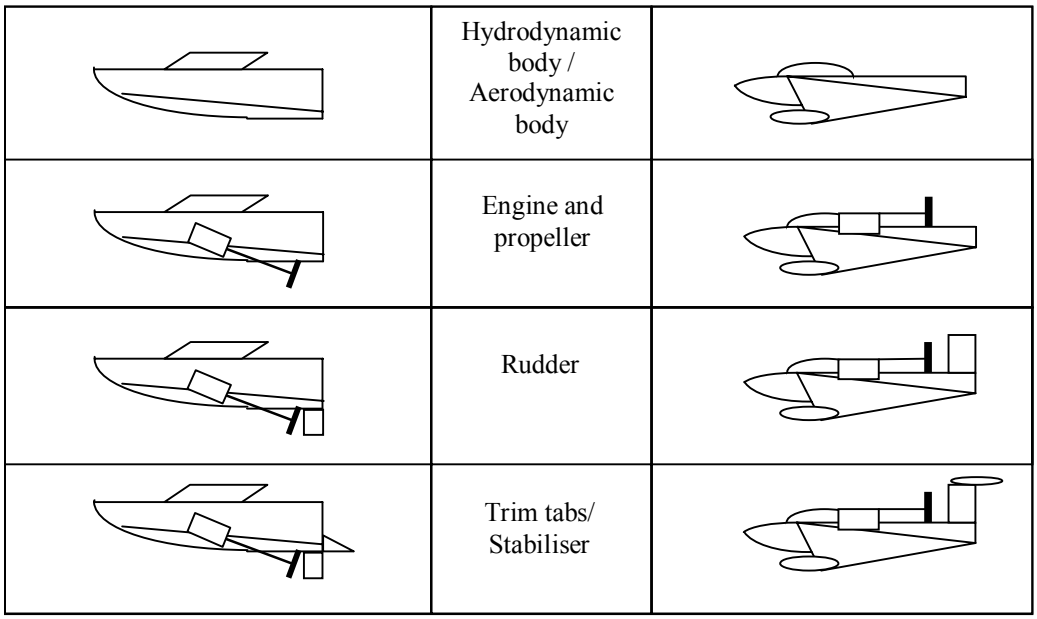

Figure 1: Four Main Components of Boats and Ekranoplans

'Ground effect' can be simply demonstrated by laying a piece of card on a table; given a flick it can be sent skimming on a 'dynamic' cushion of air. The 'wings' of an Ekranoplan in close proximity to a surface benefit from 'ground effect', giving it higher lift and lower drag than a wing in conventional flight, so making the vehicle energy efficient and stable in height from the surface. The author prefers the Russian term 'Ekranoplan' to 'Wing-in-ground-effect' or WIG. 'Ekranoplan' is a unique term for this type of unique vehicle, while 'Wing-in-ground-effect' carries the inference that the wing will inevitably end up in the ground, and WIG has too strong an association with hair loss!

The Ekranoplan was one of the technologies, like the hovercraft and hydrofoil, whose bulk of development took place in the late 1950's - 60's. Behind the Iron Curtain, the USSR's Central

Hydrofoil Design Bureau put the ideas of Rostislav Alexeyev through a development process, culminating in the awesome KM 'Caspian Sea Monster' and several other large military vehicles [Figure 2]. The KM, weighing 550 tonnes, and travelling at 160 knots, was one of the largest machines ever to get airborne (and some 100 tonnes heavier than a current Incat 86m vessel) [Ref. 3]. It is worth noting that the 'maiden voyage' of the KM was in 1966, preceding by two years the 165 tonne 60 knot SR.N4 cross-channel hovercraft (Feb. 1968) that seemed so revolutionary in the West at the time.

Figure 2: The KM 'Caspian Sea Monster' – Russian 550 tonne Ekranoplan of 1966.

The other leading school of thought on Ekranoplan/WIG design was founded by Dr. Alexander Lippisch (the 'father' of delta wing), first in USA (circa 1963) under Collins Radio/Lippisch Research Corp and then in Germany under Rhein-Flugzeugbau GmbH (1967 onward). The work is continued by Fischer Flugmechanik and is characterised by the 'Lippisch reverse delta' wing configuration.

Looking back we see that development of 'conventional' vessels (wave piercing, catamarans) which were unimaginable in the 1960's - 70's, have overtaken both hovercraft and hydrofoil concepts. The hydrofoil concept has been reduced from the 320 tonne Plainview (maiden voyage 1968) to little more than a ride control appendage in todays' world, while the hovercraft is relegated mostly to amphibious niches.

The Ekranoplan in todays world - Did it miss the boat? Or is its time yet to come?

What of the Ekranoplan? Where does it fit in? Has it also had its day? Certainly, the service speed it offers is not yet beaten. However, one of the problems that befell Ekranoplan development was the way that it appeared to be more attractive with larger size. This has led to a dominance of exotic proposals for ocean crossing craft or 'Wingships' (Reeves, Hooker and Stinton, Lockheed Georgia [Refs. 4, 5, 6, 7]). In truth, such craft may be as unattainable as the 3,000 tonne SES concepts once put out by players in an adjacent technology (Vosper Thornycroft, Rohr Industries [Ref. 8]). Although the Caspian Sea Monster showed that it was technically possible to fly such a large craft, it has been something of a false start. Technically, bigger is better, but like most new ventures it is best to start small.

Development of small craft continues in many places in the world (it is becoming a fashionable topic for university research – our next generation is getting switched on to this). However, despite some 45 players listed on The WIG Page web site [Ref. 9] at the time of writing, very few are truly active, and the author believes there is less than a handful of 'design houses' that are capable of producing a commercially viable WIG. Some examples are shown in Figure 3. The key centres for development are:

Country	Organisation
Germany	Fischer Flugmechanik
Russia	Amphistar/Aquaglide Centre of Ekranoplan Technologies ALSIN
China	Marine Design and Research Institute of China (MARIC)
China	China Academy of Sciences and Technological Development (CASTD)
China	China Ship Scientific Research Centre (CSSRC)
USA	Flarecraft
Australia	Flightship Ground Effect

The AF8/SF8 built by Fischer Flugmechanik and AFD (Germany) for Flightship Ground Effect (Australia) 2001.

The Hoverwing HW2VT scale prototype of 80 seat ferry by Fischer Flugmechanik

The TY-1 by China Academy of Science and Technology (China)

Amphistar/Aquaglide by Centre of Ekranoplan Technologies ALSIN (Russia)

Figure 3: Examples of current technology

THE BUSINESS CASE: THE BUSINESS OPPORTUNITY

This section of the report will show that, even after defining the limitations of the Ekranoplan concept, there is still a viable business opportunity. Let us first consider the attributes of the Ekranoplan concept:

Attributes of Ekranoplan - The Unique Sales Proposition:

- High load – relative to aircraft (both weight and volume)
- High speed – circa 90 knots
- Low complexity
- Low operational/maintenance cost
- Low capital cost – relative to aircraft
- Low power requirement
- Low fuel consumption
- No wake
- Immune to sea currents
- No sea sickness

Against this, it is recognised that the development of Ekranoplans must encompass safety, seaworthiness, certification/regulation, cost (identified by Van Opstal 2000 [Ref.10]).

Safety inherent in the vehicle is a design matter, linked with certification. The development of safety codes and regulation can only go hand in hand with the development of the craft. Indeed Germanischer Lloyd is pioneering this area. The 'safety case' for Ekranoplans will be built on track record of demonstrable safe operation. Safe operation will have to take into consideration other traffic in the area, and this will serve to define the manoeuvrability requirements of the vehicle and the global market opportunity. Both can be expected to change in time given operational development of the craft. Questions exist as to whether Ekranoplans could operate on existing passenger routes and, therefore, in 'congested waters'. However, it should be remembered that the BH4 cross-channel hovercraft operated in very congested waters for 30 years.

It is not possible to be precise about capital costs at this time because these will depend on production, which is not yet in place. However, costs of 30% or less of equivalent aircraft are a design target.

Capabilities and Limitations

The Ekranoplan concept is not globally applicable because it does have limitations. This may be why many have been turned off by it in the past. It cannot serve the world. It is a solution for a niche market; but we will see that the niche that results is still sufficiently attractive to be of great interest. Over the long term, and with evolution, this niche will broaden. Initially the Ekranoplan must be seen as a coastal, inland waterway or inter-island vessel. Operation limited by:

- Low sea states <1.5m wave height
- Low wind
- Coastal/inland/estuary/delta
- Obstacles
- Daylight operations (probably)
- Low traffic density areas/controlled traffic lanes due to high speed (perhaps)
- Seasonal use (probably)

Where Are the Customers?

The global search for customers depends on matching the capabilities of the craft against geography and population. Studies by the author [Refs. 11, 12] in which WIG costs were set against those of ferries and aircraft have shown that, contrary to the concept of ocean crossing wingships, Ekranoplans can have competitive advantage over relatively short ranges of up to around 160 km. The bottom limit is determined by the time lost in quayside turn-around, while a point beyond which aircraft would be more economic determines the top. This also ties in with some obvious logic concerning the attributes of aircraft versus Ekranoplans over short distances. Over a short distance an Ekranoplan is able to turn in a similar service ('block') speed because it does not lose time in climb and descent, as would an aircraft.

Market Regions and Economic Demand

Who will be the paying customer? A match of sea states, route length, geography, population and economy done by the author in 1997 [Ref. 13] identified three initial/main market regions: East Asia, Caribbean, Europe [Figure 4]. This analysis was supported by Van Opstal [Ref. 14] in 2001. The population within the three areas totals 300m (600m including coastal China).

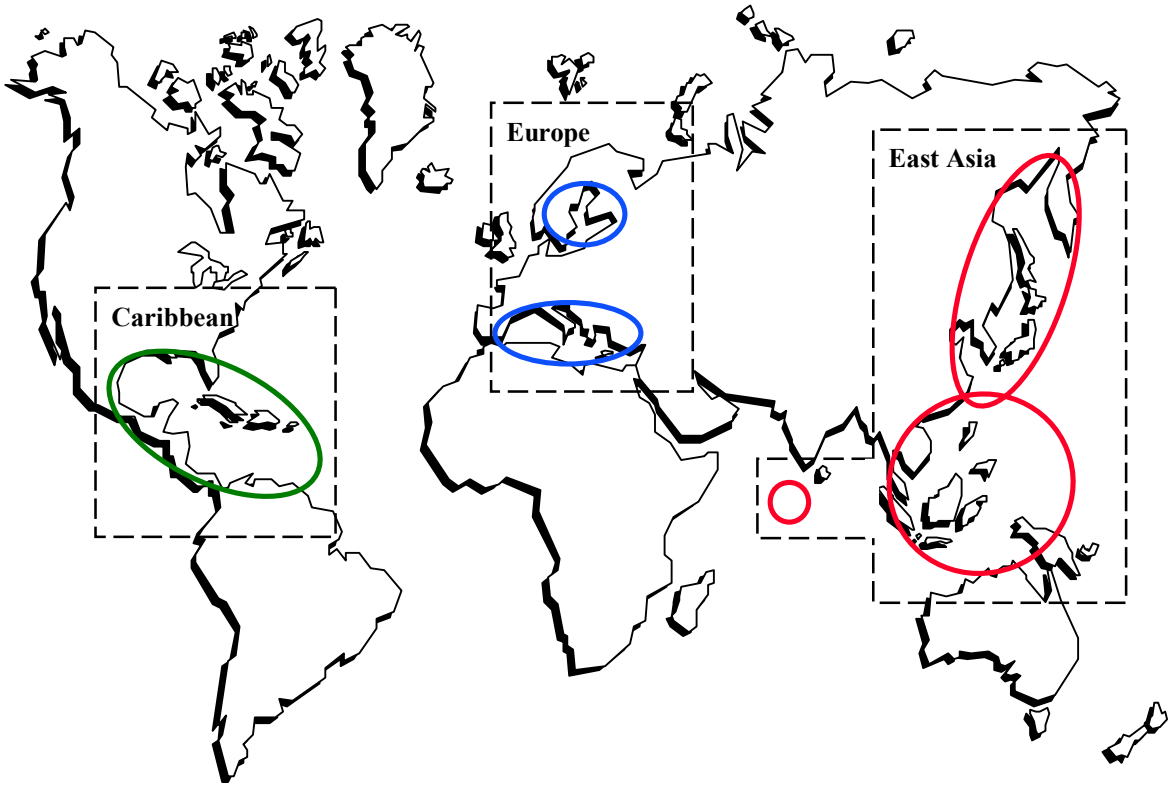

Figure 4: Initial/Main Markets

The development time span for fully evolved commercial Ekranoplans could be circa ten years, so one needs a projection of what the world will look like then (note: this is the same question that an operator of conventional craft should ask). The economic outlook for the market regions is very difficult to project at the time of writing. The world is still reeling from the repercussions of September 11th 2001, on top of the depression/recession in US and European economies. GDP (Gross domestic product) is used below to form a view of the economy of the regions.

East Asia: Most economies have recovered to about the levels of GDP they reached just before the 1997 Asian financial crisis, with the notable exception that Indonesia is still about 60% down [Ref.15]. GDP growth for the region ranges from 4.5% in Singapore to 1.1% in Taiwan. There is still instability due to the stalling in telecoms and PC component sectors that underpin the economies [Ref. 16]. In addition, Chinas' strengthening economic growth (GDP growth 8%) looms over the region, juxtaposed by Japans' growth of zero/negative which looks set in for a few years [Ref. 17]. In addition, demographic and social changes are forecast, which will increase the need for transport [Ref. 18].

Caribbean: Comprised of small population and small economies with steady economic growth. More important is tourism industry which underpins many of the economies, for example tourism is responsible for 70% of Antiguas' GDP. Tourism is moderate to fast growing, for example in year 2000 visitors to Cuba (population 11m) exceeded 1.6m and are projected to reach 7m in 2010. These tourists bring with them First World wealth.

Europe: presently low GDP growth typically around 2% but very hard to project past the 'first world' recession/depression and the War on Terrorism in Afghanistan.

The analysis shows that, although projections of the economic positions of the target market is not as clear as we would like, we can still draw conclusions:

- East Asia is attractive from the point of view of growth over the long term, but marketing will require country specific local knowledge
- The Caribbean is attractive so long as the tourist industry remains in good shape
- Europe can be expected to be more cautious

THE STRATEGY DISCUSSION: WHAT BUSINESS ARE WE IN?

Ekranoplans and the transport industry

At the time of writing the state of travel and transport industries are in a state of flux, mostly as a result of the crisis in air travel. In the marine business, some sectors that are fed by aviation will be impacted greatly, while others that serve indigenous demand may not.

We have seen that Ekranoplans offer similar utility to that of an aircraft, without the large capital and maintenance costs associated with aircraft. This is only half the picture. Aviation carries with it very high unseen fixed costs, e.g. airports and services, air traffic control, support staff. The whole aviation business model only works when there is high and reliable revenue, because the costs have to be met irrespective of traffic levels. The extent of these hidden fixed costs is only now becoming clear as the fall out from the terrorism of September 11th puts the aviation industry through the biggest shake-up in its history. With loss of traffic there rapidly becomes insufficient revenue to service the huge fixed cost burden, and it is proving too much for many operations. In truth, airlines were in dire trouble before the terrorist action. Many reported losses in May 2001, when the demand for air travel in USA and Europe fell by 2% after a decade of steady growth [Refs. 19, 20].

In addition, one should not overlook the enormous cost, commitment and political will that a country as a whole must make towards such infrastructure. For example the first phase of Osaka's new 'offshore' airport is $4 billion over budget and still sinking into the bay [Ref. 21]. Not every country can make such a commitment to infrastructure investment while the shadow of uncertainty looms over air travel.

Ekranoplans, on the other hand, offer a comparable speed of service off the quayside. The concept de-couples fast transport from high infrastructure spend.

Adoption of Ekranoplan technology

If Ekranoplans offer a viable transport solution why hasn't the Ekranoplan been adopted already? The reasons are both technological and business based.

A concept can only emerge from R&D if the technology exists to support it. For example the evolution of advanced materials and construction methods has enabled the re-introduction of the stepped hull concept which fell from favour in the 1940's. In the same way, the Ekranoplan lends itself to the materials of the 2000's rather than the 1960's.

So far the marine industry has failed to take Ekranoplans seriously. Perhaps this is because industry players do not recognise Ekranoplans as a marine vehicle (they do, after all, look a bit like aircraft), and also make the mistake of defining their business by their existing products/services range. Should the answer to the question "What business are we in?" be (a) "We sell/operate boats", or (b) the wider definition "We are in the business of supplying/operating surface transport in a marine environment"? Clearly Ekranoplans fit in the wider definition.

At the same time, many players in the high-speed marine business are considering fast vessels that retain water contact but incorporate large elements of aerodynamic lift. Yet, in the authors view, they 'sit on the fence' when it comes to Ekranoplan/WIG. Unsure of whether the technology will materialise or not, they hope to step in once the commercial case has been proven. Whilst it can be shown that late entrants to an industry can do better than the pioneers over the long term [Ref. 22], this may not apply to the Ekranoplan industry. Safety and economics demand a track record, and the first player to establish one will be in the strongest strategic position. The world market is unlikely to support more than a handful of manufacturers, and the number of operators may be limited too. In

addition, the barriers to entry for late starters will be high; the pool of experienced people is small and will quickly be drained, and the R&D costs are large.

Players in the fast marine transport sectors are also completely absorbed in exploiting and extending their current technologies. For example, wave-piercing catamarans have now moved from 'rising stars' to 'cash cow' status. Understandably few would want to upset their stable businesses by adding a 'risky' new technology. However, it can be a trap to watch only the short and medium term while ignoring the longer-term wider picture. Christensen [Ref. 23] calls this the 'Innovators Dilemma' in which even the very best companies become so wedded to sustaining their existing technologies and markets that they disregard a 'disruptive innovation' coming from 'left field'. The Ekranoplan concept appears to conform very closely to Christensens' definition of a disruptive innovation, in that initially it may appear to be 1) inferior to existing products in many respects (e.g. sea-keeping) and 2) offer different values and serve different markets to the existing products. If Christensens' theory has any merit then three conclusions can be drawn:

1) That the market leaders in Ekranoplan transport may not be from the existing pool of fast ferry players
2) Once established, Ekranoplans could take market from the existing players
3) Existing players will be unable to catch up

Certainly Christensens' theories echo the authors experience when talking to established marine players.

Impact on other players

If the Ekranoplan becomes a commercially viable vehicle it could have serious knock-on consequences for existing marine industry players because, over a period of time, it can be expected to:

a) Develop away from the initial niche markets into more mainstream markets, taking market share from existing players.
b) Evolve as a product. Current vehicles are essentially prototypes. Through the process of product evolution, commercial vehicles of 10-15 years time may look quite different to the vehicles we see today. The process of product development in a marine concept is exemplified by Incats' wave piercing concept which has transformed from a 1.1 tonne prototype into the 400+ tonne craft we see today [Ref. 24]. One of the most significant changes forecast is the move from the 'stick-with-wings' aircraft-like configuration to the 'blended' lifting-body configuration similar to the Fischer Flugmechanik 'Hoverwing' concept [Figure 5]. This brings with it a massive increase in payload volume, giving greater passenger comfort and enabling such craft to carry loads that would not fit in an aircraft.
c) Provide the builder and user a new level of technology (e.g. lightweight structures, aerodynamic lift, high speed operations etc.) that could be transferable to high-end conventional fast craft. This could be considered as a strategic advantage over non-Ekranoplan players, insofar as it is 'a resource denied to the competition' and so may lock out existing players from the high-end sector in the future.

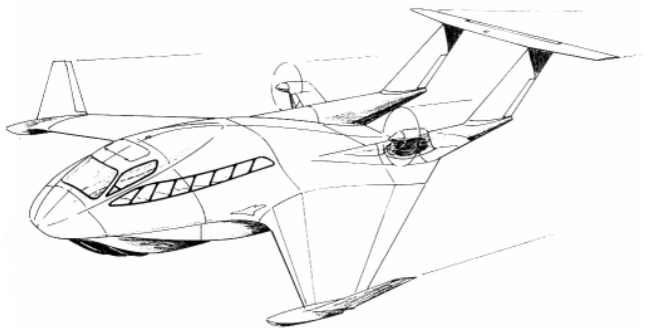

Figure 5: Example of the future shape of Ekranoplans - The blended form of Fischer Flugmechanik 'Hoverwing' 20 seat ferry proposal.

CONCLUSIONS: THE 21ST CENTURY, ACT NOW – OR MISS THE BOAT

We have seen the irrepressible quest for speed, fuelled by its ability to better serve markets and turn the business machine faster. Conventional craft are pushing into the aerodynamic envelope, while Ekranoplans are already there. The technology of ground effect is more ready than ever to make the R&D dream a reality.

In terms of possibilities; in the right market Ekranoplan technology offers a similar utility to air transport, but without many of the costs. The possibilities will increase as the craft evolve.

In terms of limitations; the concept has its limitations, and these define the market niche. But many of these limitations may disappear with evolution, operational experience and scale.

Given the current crisis in air travel, the right market appears to be in East Asia, to serve the indigenous population and to mesh with future economic and societal change. This gives players in the region a global advantage.

Who will be the market leader in this new field is hard to guess. Because of the degree to which existing players are wedded to their current technology, the development of Ekranoplans may well be led by new players. These new players could gain a strategic advantage over the others in the long term.

To invest in Ekranoplan technology is undoubtedly to take the long view. Those that do will take a leap of faith. They say in show business '*It takes ten years to become an overnight success'*. For Ekranoplans to succeed in the future, the time to start is now. Another imperative is that those people with the most experience gained their knowledge during the 1960s-1970s and are getting 'long in the tooth'. Without wishing to appear morbid, the clock is ticking.

The author believes that for the Ekranoplan to be commercially successful it must first start small, as has been demonstrated by the evolution of similar, adjacent technologies.

So far Ekranoplans have not been taken seriously by the marine industry. There are echoes of the story of Turbinia, the pioneering steam turbine craft whose technology was only recognised for its worth by the British Admiralty after it publicly ran rings around the British fleet in the 1897 Spithead Naval Review. Builders and operators should ask themselves this: "If you woke up in ten years time to find Ekranoplans taking some of your market, would you really be surprised?" Those who want to be the leaders in this field best start now. Those who don't will miss the boat.

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