Hydrofret Concept

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ABSTRACT

Yves Goupil and Georges Gazuit are currently studying a new concept they baptized Hydrofret, to move the freight transport bases from the classic airports to the harbours, in order to minimize the number of airplanes flying over inhabited regions, as well as limit the saturation problem we are currently witnessing.

Their seaplane is not restricted to the classic limitations of air-based aircrafts and could provide a global solution to a high number of potential problems that will occur in the next 20 years.

At least, it is worth have a thought about it.

ABOUT THE AUTHORS

Georges Gazuit

Born in 1926 in Montluçon
Ingénieur des Arts et Métiers - Cluny 1943
Ingénieur mécanicien honoraire (LV) d'Aéronavale
Industrial career : Radial Tyres machines builder. International leader between 1965 and 1985.

Aviation fan :

- Design and construction of a 5m-span biplane (40 HP) in 1948
- Design and construction of a metal made 4-seater (150 HP)shown at Le Bourget in 1969 and 1970. Plane certified and sold to a Canadian company
- participates with the Amiral Goupil to the study of a new concept : Hydrofret using ground effect for take-off and a new tandem wing configuration also regarded as a potential solution for marine UAV

Owner of more than 30 patents in different domains

Yves Goupil

Born in Normandy (1931)
The Amiral Goupil made his whole career in the French Marine (1951-1991). He studied at the Ecole Navale and was formed as a fighter pilot (carriers) in the US-Navy. All-weather pilot.
He worked at the CEV Bretigny and was also Chief-Pilot of the CEV-Cazaux, mainly on the weaponry trials and landing and catapult-launching trials on carriers : Etendard, Crusader and Marine Jaguar prototype . . .
Chef du Cabinet Militaire du Ministre de la Défense, Major Géneral de la MARINE.
Associated with Georges Gazuit within the Hydrofret project.

FIRST PART - YVES GOUPIL

Why The Sea Plane ?

The air transport is somewhat victim of its success. At the actual growth rate, the traffic will increase 100 % within 10 years. This will induce large problems of congestion of Airports and associated airspaces, as we see it already today. Technical solutions are studied to increase the efficiency of the Air Traffic Control ; but the most acute problem exist on airports. To cope with that, two major actions are proposed :

1. Airports extension or constructions of new ones .
2. Larger capacity aircrafts (super-jumbos)

- Action 1 is hampered by
  - the reduction of land spaces available at reasonable distance from the main cities, and corresponding high costs
  - the growing environmental constraints linked to noise effect on populations.
- Action 2 has some drawbacks : passengers are reluctant to the reduction of the number of scheduled flights offered per day.
- The existing airport infrastructures will need extensive update to accept super-jumbos : runways, taxiways, parkings, passenger access gangways.

Of course, Actions 1 and 2 are essential, but insufficient to achieve a 100 % growth of the traffic within 10 years. Air transports professionals estimate a maximum improvement of 40 % with implementation of these actions. So it appears absolutely necessary to look for additional and new solutions to prevent unacceptable congestion of the air traffic in a near future. One solution would be to divert part of the traffic out of airports prone to saturation. The only traffic which can be so diverted (without effect on passengers) is the air freight, less dependant on the proximity of main cities. This solution is already used on some closed military airfields, but that remains marginal. If we want to be completely independent from congested airports, the only abundant receptacles are the water surfaces : lakes, large rivers, sea bays leading to the main maritime ports. That implies to come back to the SEAPLANE : so is the HYDROFRET project.

The Seaplane presents some specific advantages :

- reduced operating infrastructure : no runways, taxiways, parkings. The loading-unloading equipments of commercial maritime ports can be used.
- much less weight limited than aircrafts(impaired by landing gear complexity, overall size inside the OACI square of $80m \times 80m$).Furthermore, the bigger the seaplane is, the more seaworthy it is.
- under 250 tons max weight, amphibious capacity is possible, giving the highest versatility in air transport.
- lower environmental impact (flight over water during take-off and landing)

The seaplane presents also some specific challenges of which the most serious are : sea water corrosion and interaction between hull an water surface at high speed (150 knots).

- corrosion problems are well known : good solutions exist but request specific surveillance.
- very limited experience is available concerning the behaviour of a hull at 150 knots on the water. We are very conscious of this problem.

HYDROFRET has been specially designed to have the lowest take-off and water landing speeds as possible. That is a must. This is achieved (we hope so!!!) by a specific aerodynamic formula :

- Catamaran hull
- Tandem wings
- Large surface lifting fuselage
- Use of Ram wing, air cushion and surface effect lifts.

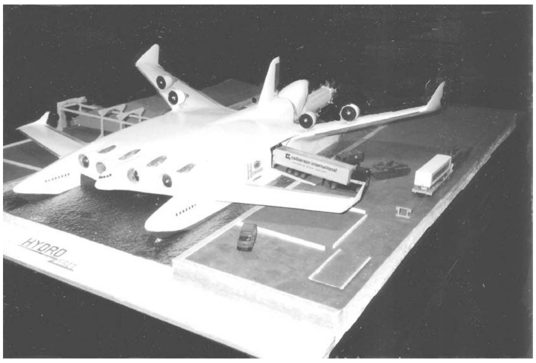

Figure 1 : Hydrofret in harbor

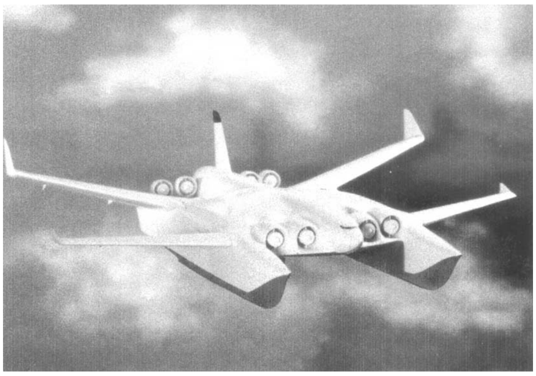

Figure 2 : Hydrofret

APPENDIX
AIR FREIGHT TRANSPORT EXPANSION

Air freight today

The air freight has increased from 80 billions tons per km in 1990 to 150 billions tons per km in 2000 (i.e. 6.5 % annual rate).This rate is about two percentage points higher than the rate for passenger traffic for the same period. Air freight today represent 40 % in value of all the goods moving worldwide but only less than 2 % in tonnage. The actual worlds fleet of freighters (rough figures), consists of 1600 units of which two thirds are narrow-body aircrafts. Freight capacity ranging from 10 tons payload (BAe 146 F), to 110 tons (B 747-400). About 25 % of these aircrafts were directly built as freighter and 75 % initially used as passenger aircrafts for an average 15-20 years period and then converted to freighters. 60 % of the air freight is still travelling in the cargo-luggage bay of the passenger aircrafts but this percentage is rapidly decreasing in favor of pure freighters.

Air Freight in the future

The growth rate in air cargo traffic for the next 20 years is estimated at 6 % per year (minimum) compared to 4.5 % for passengers. Tonnage would approach 500 billions tons per km by 2020. Freighter productivity will increase and the corresponding fleet will double while the traffic levels more than triple.
This evolution has many reasons :

- multiplication of worldwide exchanges.
- increased consumption of off season products
- e-commerce which justifies rapid transport and delivery.
- high value of manufactured products in ever increased quantity, requiring the shortest duration transport.

The 2020 freighter fleet will consist of 3750 aircrafts with 3100 new ones to be delivered over the period. 60 % will be wide-body aircrafts (average payload : 50-60 tons, max payload : 200-250 tons).

Among the improvements to be considered for the new freighters which could affect their design are :

- ease of loading-unloading operations (roll-on roll-off possibility, large cargo doors)
- large volume of the cargo bay : the average density of air freight is around 1.5 which means that very often, the limit volume of the cargo is reached well before all the tonnage capacity of the freighter is used.
- possibility to use common intermodal containers.

CONCLUSION

A lot of interesting work ahead for young designers!!!! (the figures given here are taken from Aviation Week)

SECOND PART - GEORGES GAZUIT

Hydrofret

Innovation generally presents two different aspects :

- Fundamental innovation which is not directly linked to a specific need.
- Cyclic innovation which rehabilitate an old concept to a new requirement.

The seaplane HYDROFRET, belongs to this second aspect, as well as the tram or the electric car.

The seaplane used water but did not like it. There are many reasons to that :

- Corrosion
- High hydrodynamic drag (water density=800 times air density)
- Suction effect on the hull during take-off, which requires the use off a step
- High level off vibrations in relation with speed on the water
- Possible impacts with floating or submerged foreign objects.

Today, when the ideas of profitability, efficiency and safety are essential, the seaplane is still considered penalized unless you reduce these drawbacks in raising the seaplane out of water at the lowest possible speed.

Out of water speed

There is one way to reduce this speed when the aerodynamic lift is still insufficient : create an additional vertical thrust. Several systems may be envisaged :

1. Direct lift engines.
2. Vectored thrust engines(Harrier)
3. Conversion of kinetic energy into vertical thrust such as :
   - Air-cushion(Hovercraft) : air pressure generated by a power source is sent inside a volume closed by a flexible skirt
   - Ram wing effect : a simplified air -cushion with two lateral surfaces and a mobile flap to close the volume at the rear.
   - Ground effect (Ekranoplan)

1 and 2 are impaired by a poor efficiency leading to high fuel consumption while 3 has given way to different solutions with pro and con results.

The air-cushion has a very good efficiency, but is unstable in pitch and roll, and requests a distinct power source and a cumbersome skirt.

The Ram wing no longer needs a skirt but usually remains unstable and has a weaker effect than air-cushion. Furthermore, the air escaping by the open front face acts as an additional drag.

Ground effect is given free, providing you have a sufficient speed.

In the case of Hydrofret, this speed would be above the speed at which we expect to raise the seaplane out of the water.

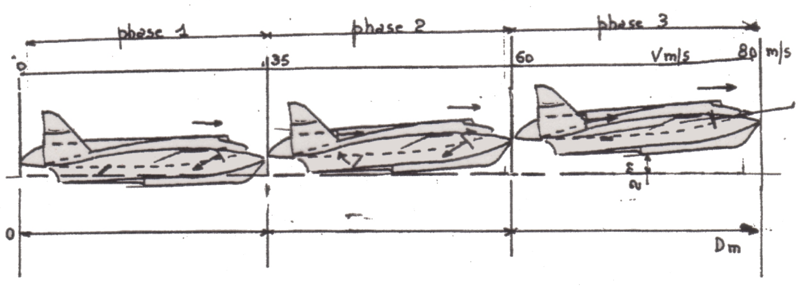

Figure 3 : The 3 phases of take-off

Hydrofret options

Ram Wing

We have opted for a Ram wing during the initial phase of take-off (0 to 70-80 knots), then for ground effect.

Reasons for that are :

- simplicity of Ram wing operation
- Possibility to have the two lateral surfaces as floats of a catamaran design.
- Advantages of the catamaran :
  - large internal volume (150 % of a conventional hull) lifting effect of the fuselage (10-15 % of total lift)
  - reduced cross-stress
- Use of forward engines as power source for Ram wing effect (see the graphs of take-off).

In the first phase, the Ram wing effect is prevailing; in the second, the ground effect is taking over and the mobile rear flap is gradually retracted.

However, theoretically, the catamaran presents a larger wetted surface and corresponding drag than the classical design. But this negative effect is reduced by the noticeable lift of the fuselage (15 %) which allows an equivalent reduction of the wing surface. So the Lift to Drag ratio of the design is better than we had at first anticipated. This has been confirmed by wind tunnel tests on a 1/66 model.

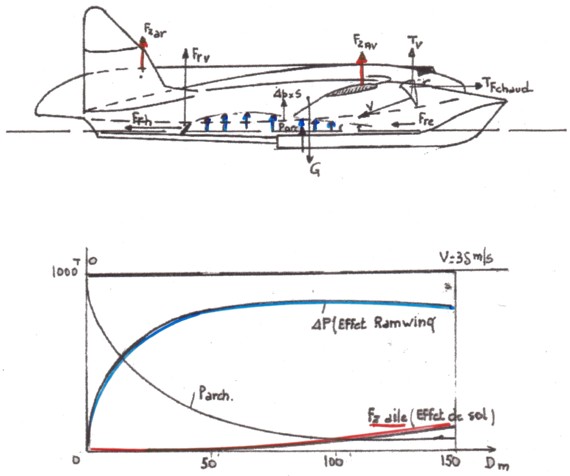

Figure 4 : Phase 1

Tandem wing

This is the second option of Hydrofret. Above 500 tons max weight, the span of a mono-wing aircraft exceeds the 80 meters required by ICAO (International Civil Aviation Organisation). Our concept would be even larger with a Flying Wing design.
The only two solutions are :

– folding outer wing panels

– Tandem wing.

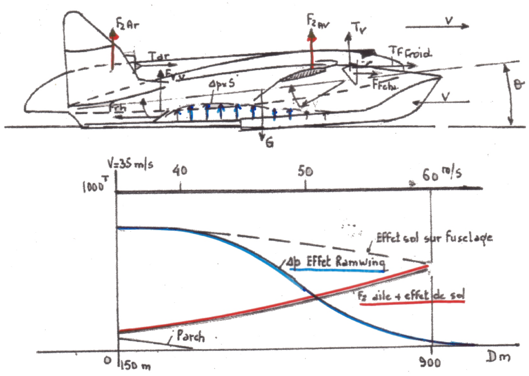

Figure 5 : Phase 2

But the Tandem Wing has a bad reputation !!

The past experiences (Pou du ciel, Delanne, Nenadovitch) were so disappointing that the concept was considered aerodynamically unacceptable. The culprit was the interaction between the wings.

The possible solution was obvious : find a relative position of the rear wing where there is no longer significant interaction from the front wing. This position can be defined by the values of D/

L and H / L, where D=longitudinal distance between the leading edges of the wings, H=vertical distance, L=mean chord length of profile.

We have studied the problem under different aspects :

- *Theoretical*
  - Mr LAPORTE from the Ecole Polytechnique, has written a thesis on deflexion of an air flow behind a profile and interaction on a second profile downstream.
  - NACA and French Publications (SUPAERO), on the subject.
- *Practical*
  - Wind tunnel test on the 1 / 66 model at MALAVARD facility (ORLEANS), by Mr DEVINANT (Ecole Supérieure de l'Energie et des Matériaux).
  - Flights of a small radio-controlled model.

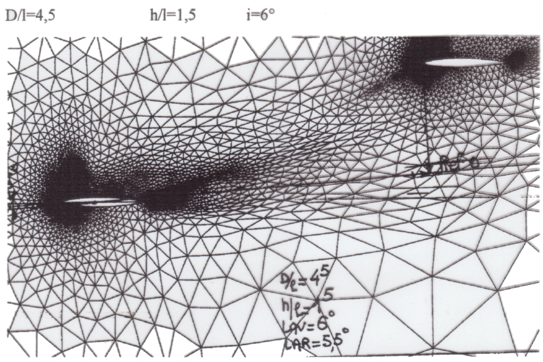

Figure 6 : Theoretical study

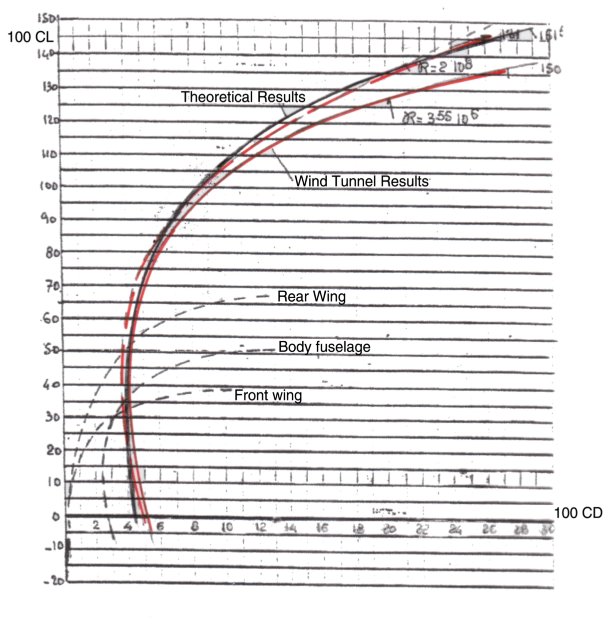

Figure 7 : Wind Tunnel Results

The corresponding results appear on the graphs : with $D/L \geq 4$ and $H/L \geq 1$, the aerodynamic efficiency of the rear wing is 98-99 % at low incidence, and 95-96 % at high incidence (the corresponding deflexions being 0.5° and 2° on the rear wing). Moreover, the lift vs. drag curve is becoming flat at max incidence : there is no definite stall but a purpoising effect between two incidences.

To sum up the tandem wings concept should allow :

– 30 % reduction of span
– 3.6 % reduction off wing structural weight(thanks to a decrease in flexion stress), i.e. 2 % on the total structure.
– better application of Whitcomb law
– deletion of the stabilizer (pitch control by differential flap action on both wings)
– better lift on take-off (no more negative lift induced by a stabilizer).

These improvements are favorable for the design of a very large aircraft.

DISCUSSION

Jean Margail (JM), Airbus
Your project is very interesting in terms of innovation, but you speak about the market and I would like to know your estimate of the selling price of such a craft ? My point of view is that your competitors will be older crafts, for example the companies that are more likely to be interested, like UPS or FedEx, by your craft usually buy Boeings 747 for 15 millions of US Dollars and spend 10 millions for the modifications.

Yves Goupil (YG), Hydrofret
I agree with you that the fly away price would be much in the advantage of Airbus or Boeing products. But I will give you an example. The artificial Island of Osaka costed, with only one runway, costed 12 billions of US Dollars ! So what ? To land on the water with a ground based aircraft on a artificial area costed 12 billions Dollars ? So if you speak about economy, just looking at the airplane price, then you are completely right. The problem is that if you look at air transport as a full system, and you add the price of the new airports, for infrastructures, for environmental regulations and the price you will pay for the delays . . ., you will have a cheaper aircraft but taking into account all the rest, I am not sure wether it will be in the advantage of the seaplane or not. Everybody is paying is paying in the air transport system, all the actors : the builders, the airports, the customers and the companies but nobody is able to evaluate the global cost of this system. Some parts are cheaper with a ground based aircraft, some are cheaper with our design, I would say that our design would be better in terms of operating cost for example.

JM
Classical aircrafts are compelled to follow several regulations, I am certain that your craft will suffer such regulations, too. There will also be an extra cost for maintenance.

YG
My experience of cargo based freighter is that sea water corrosion is well treated. But then the craft has to be designed to be well and easily maintained. You don't need taxiways, you don't

need runways, you can load and unload the craft using classical marine containers and classical maritime devices.

JM

I agree, your design is very good. Well, what I am talking about is the reality of the market. Companies like UPS and FedEx are really fighting for cutting down the purchase price.

YG

Do you know the total cost generated by delays for US companies last year ? 5 billions US Dollars ! You can do a lot with such an amount of money !

JM

What was the main reason for these delays ?

YG

Congestion ! Congestion and weather. During the summer, there are lots of thunderstorms. In Europe, the average delay is now well over 15 minutes, with 35% delayed by more than 15 minutes. This must be counted ! In the USA, lots of aircrafts are waiting for 30 minutes for landing. This is also an operating cost.

More, I am thinking about a place that will sure play a big role in commercial aviation : South-East Asia. The geographical characteristic is archipelagos of mountain islands. The runways are really expensive there. The people are already living on the sea-side. I think that for these people, the best solution is to buy seaplanes. Think about the cost of a landing fee on the artificial airport in Osaka. It is 40% than elsewhere. . .

JM

But I am sure that authorities will invent some taxes to fly over water. It's business !

YG

But the artificial runway already has to be reinforced ! Otherwise, in 40 years it will be completely sunk ! Imagine that 3 companies already left Kensai ! They were thinking about building a second runway, but it is not sure they'll do it.

Hanno Fischer (HF), Fischer Flugmechanik

This is a very interesting project and I would like to know the L/D during take-off.

YG

We expect it to be between 7 and 8, and about 16 in flight.

HF

Because this determines the necessary power you install on the craft.

YG

We have on the biggest Hydrofret that weighs 1000 tonnes 8 engines and the total thrust is about 280 tonnes.

HF

What is interesting with your concept compared to a pure ground effect craft is that you can use the extra power used for take-off to increase the cruise speed of your craft, and this we cannot do for the moment on our ground effect crafts. So I think the combination has a good chance !

YG

I insist on the fact that it is not a ground effect machine. It is a normal seaplane that has an aerodynamic configuration allowing the lowest take-off and landing speed.

But our experience of ground effect is that if the waves are more than $20m$, which can happen, then, where is the ground effect ?

HF

This is question of dimension and speed. If you are big enough and fast enough, you don't feel it. With a bad road, if you drive fast enough, you don't feel all the holes !

Mario Mihalina (MM), Euroavia Zagreb

Why didn't you start with a smaller project ? All the other projects started with smaller crafts ...

YG

But it is not a project, it is a concept ! The reason why we made such a big design is to show that such a big seaplane is easier to design than a comparable airplane in terms of payload or weight.