

## Cruising by air and sea: brief history, status and outlook for a submersible aircraft

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**Keywords:** Submersible Aircraft, Innovative Design, Transitional Configuration

**Abstract.** Even in a post-modern era, some possible new configurations for aircrafts and spacecrafts remain to be explored. Normally, the main attention was given detaching from ground and by looking at the sky, but the sea should not be forgotten and thus the possibility to go from/to the sky to/from the sea should have to be considered. This paper is just centered around the historical first developments for the submersible aircraft and the possible future developments. Market segments for manned aircraft seems to be largely unexplored.

### Introduction and Historical References

In the field of aeronautics, there exists an aircraft configuration that remains unrealized, only existing as a concept in works of fiction such as books and movies. This refers to the idea of a craft capable of cruising through both air and sea. As far back as 1904, Jules Verne, a visionary who shaped the modern era through his fictional writings, had already imagined a machine called *l'Épouvante*, which could transform and adapt for terrestrial, aerial, or marine motion [1].

Not surprisingly, there is a long-standing tradition of attempting to tackle this challenge. The emergence of unmanned vehicles has reinvigorated the research in this fascinating area [2-12]. It is worth noting that in 2008, DARPA made a statement regarding the potential design of a manned version, as shown in Figure 1, [13].

Looking at the historical context, the initial concepts for these configurations emerged in the military sectors of both the United States and Russia, which is a common trend in the history of aeronautics and aerospace [14-16].

Crouse [17] delves into the conceptual design of a submersible airplane, and notably, Longobardi's patent [18] is explicitly mentioned for proposing the incorporation of foldable wings in such a configuration. This patent, dating back to 1918, also envisioned the vehicle functioning as a car.

### Manned configurations and a Possible New Market

Living in Napoli, the idea was to have a mission profile really related to the land, sky and sea in order to give a full range of opportunities for tourists. Let's imagine a small aircraft which can

- (i) take-off and land over a small field;
- (ii) take-off and land over a sea area and
- (iii) submerge and cruise underwater the fantastic natural and archeological scenarios in Baia or the blue sea around Capri.

The task at hand is highly demanding due to the evident conflict between the requirements for air and sea domains. However, recent indications suggest that the design issues may have been

overlooked or insufficiently addressed, along with the associated opportunities for funding in the market.

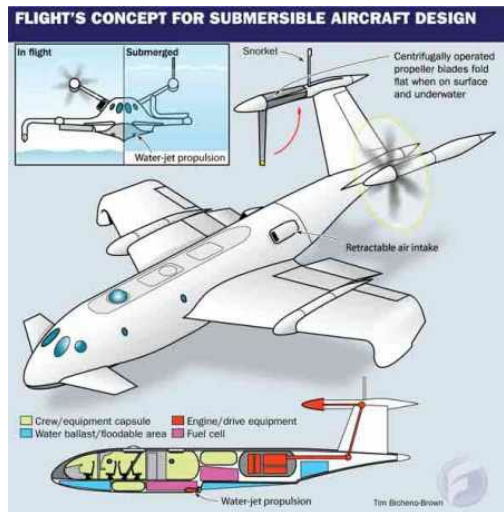


Fig. 1. DARPA Concept (<https://www.flightglobal.com/picture-darpa-seeks-submersible-aircraft-concepts/83329.article>)

Effectively managing the path of this novel submersible aircraft will necessitate a wholly innovative approach. This entails establishing designated areas for landing and submergence over the sea, implementing signals to indicate the presence of the submerged aircraft, and addressing other related considerations.

Nonetheless, the primary challenge lies in devising and determining the feasibility of potential new configurations for the aircraft.

### The Seagull

A suitable starting point for analysis could be the Seagull aircraft, recently developed by Novotech (Italy). This aircraft features a main hull, two auxiliary side floats (sponsons), and a V-tail, as depicted in Figure 2.

The Seagull is a hybrid-electric, two-seater (side by side) amphibian aircraft with a pusher propeller. It stands out for its automated folding wing system and incorporates extensive use of composite structures manufactured through eco-compatible production processes.

The Seagull program commenced in January 2018, and the production of the first prototype was completed by December 2020. As shown in Figure 2, the Seagull aircraft underwent initial water tests in the early part of 2021 to evaluate maneuverability and floating capabilities. Currently, the aircraft is in the process of obtaining flight permits from the Italian Civil Aviation Authority, while the second prototype is nearing completion.

Designed to facilitate communication between individuals and overcome existing barriers in public and private transport, the Seagull can autonomously moor at common seaports thanks to its folding wing system. The high-wing configuration enables panoramic views both in the air and over the sea, while the sponsons can be adapted and transformed into water tanks for loading and unloading. Indeed, thanks to the folding wing system, it can be moored in a common seaport.

The high-wing configuration allows the possibility to look around in both air and over sea, while the sponsons can be adapted and transformed in two tanks able to load and unload water for diving and emerging from water. Now, this vehicle in air

- can accommodate 1 passenger and 1 pilot;
- has foldable wings for increasing maneuverability in the water taxiing;
- can fly 220 km at 4000 ft altitude;

- has an estimated cruise speed of 185 km/hr;
- can accommodate up to 700 kg;
- can be equipped with hybrid electric or I.C. engine with a power up to 100 HP @5800 RPM.

It should be modified so to allow a transit under surface for about 45 minutes at a cruise speed of 4 knots (about 7 km/hr). This goal will be achieved if these design problems will be faced and solved:

- immersion and emersion phases
- additional engine/propeller for underwater cruise
- estimation of the increased weight and installed power
- management of the breathable air for the pilot and the passenger
- sealing of the interiors and the air systems (engine, electrical wiring, etc.)



*Fig. 2. Seagull: (top) sketch and (bottom) picture of the prototype in marine configuration*

Managing these challenges is undoubtedly complex, but it is seeming emerging from the literature that utilizing foldable wings represents the most promising starting point for exploring the possibilities.

It is also important to keep in mind that the market segment associated with this submersible aircraft is highly specific, well-defined, and somewhat limited in scope.

### **Concluding Remarks**

As humankind sets its sights on returning to the moon and embarking on the first manned mission to Mars, along with the advent of super- and hypersonic transportation, it seems that the time is ripe for exploring underwater cruising as well, despite the design challenges that remain largely theoretical at this point.

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