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Flying Ships: Future of Electric Unmanned WIG Vehicles

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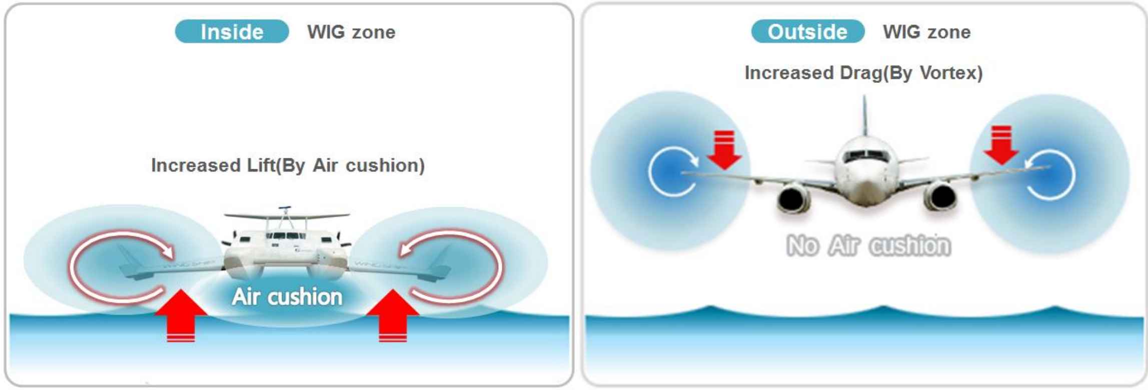
Outline

- What are WIG Vehicles?
- Why do we want to use them?
- History
- Current research & Challenges
- AIRSHIP & SEAWINGS European projects
- Conclusions

- Definition of Ground Effect:
  - The lift force experienced by an aircraft close to a surface.
  - Influences aerodynamic behavior during take-off and landing.

- WIG Vehicles (ekranoplans, flying ships):
  - Exploit ground effect for energy-efficient flight.

- Importance and Applications
  - Faster than marine vessels, more efficient than airplanes.
  - Potential uses in transportation, military, and emergency response.



Main Advantages

- **Speed**
  - Can travel at almost 200km/h (hydrofoil ferry at 75km/h).
- **Efficiency**
  - Spends 75% less than a hydrofoil ferry and 35% less than a conventional plane, carrying 50% more of payload.
- **Payload**
  - 1.500 Tons at 400 km/h with an autonomy of 20.000 km.
- **Effectiveness**
  - Faster than sea transport and less carbon-intensive as air cargo transports.
- **Electric**
  - Small Cessna airplane needs ~75 kW of instantaneous power during landing and take-off, a small WIG needs around 5 kW - 7 kW.

Early History

•Early Concepts: By the **1920s**, the ground effect was a known phenomenon by **Wright brothers**

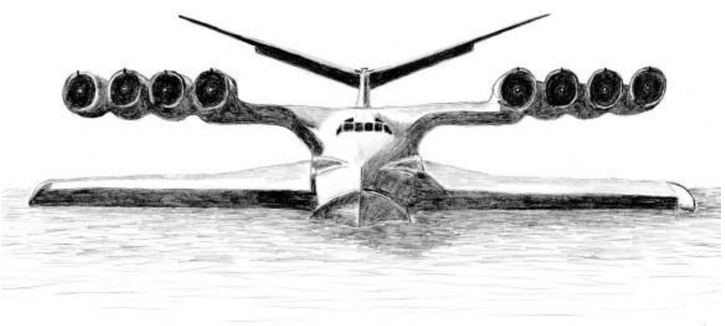
•Early **1930s Toivo Kaario** designed a ground-effect vehicle

•Early **1960s Rostislav Alexeiev** advanced the study of ground effect backed by significant military funding.

•His most iconic creation was the "**Caspian Sea Monster**".

•Technical contributions of Alexeiev’s program: Advances in modelling and control of these ships.

General characteristics



•**Crew:** 5
•**Capacity:** 50 people
•**Length:** 92.00 m
•**Wingspan:** 37.60 m
•**Height:** 21.80 m
•**Empty weight:** 240,000 kg
•**Max takeoff weight:** 544,000 kg
•**Powerplant:** 10 × Dobrynin VD-7 turbojets (two tail-mounted, eight canard-mounted), 127.53 kN (28,670 lbf) thrust each

Performance

•**Maximum speed:** 500 km/h
•**Cruise speed:** 430 km/h
•**Range:** 1,500 km
•**Ground effect altitude:** 4–14 m
•**Maximum sea state:** 1.2 m (≈ sea state 3)

Nowadays

- The Soviet Union and afterwards Russia discontinued the development program due to the technical and operational difficulties.

- Until recently, there were no meaningful efforts to bring their use back, just isolated initiatives.
    - Singapore-based company WigetWorks: AirFish-8

- European Projects AIRSHIP & SEAWINGS
    - Unmanned WIG Vehicles

SEAWINGS

AIRSHIP

- Overcoming operational difficulties by utilising advanced GNC techniques.

- Work started 5 years ago.

- **Albatros prototype**

Wingspan: 2 m
Length: 2.1 m
Weight: 12 kg
Payload: ~5kg

Batteries: LiPo Batteries 4S-14.8V-5000 mAh - 60 C (x2)
Brushless motors: SPITZ C-5505-06 760 KV, 1660W (x2)
Servos: FUTABA 3001-3 Kg (x4)

Our Research

Challenges

- Extremely difficult to be driven by human pilots
- Highly nonlinear system
    - Requires advanced control algorithms
- Perception complexities due to high speeds and dynamic sea surfaces
    - Low-latency and long-range detection needed
- Difficult to simulate changes from aerodynamic to hydrodynamic operation (take-off and landing)

AIRSHIP

Autonomous Flying Ships for Inter-Island and Inland Waters Transport

*AIRSHIP envisions an innovative use of a known transportation means: **flying ships**.*

*Such vehicles (also known as ekranoplans or WIG vehicles) inherit all the advantages of conventional airborne transportation, while being **more energy efficient** and **environmentally friendly**, both from the carbon footprint and the acoustic noise pollution point of view.*

*AIRSHIP aims to lay the foundations of a new class of fully electrical unmanned aircraft system, the UWV (Unmanned WIG Vehicle) that **brings together speed, flexibility and energy efficiency.***

Funded by the European Union

AIRSHIP's Research Goals

1. Zero-Emissions Propulsion: Develop electrical networks, power management, and interface electronics, integrating solar and hydrogen sources with energy storage to fully electrify the WIG.
2. Fully autonomous vehicle: Utilize advanced GNC and Perception techniques
3. AI-Driven Intelligence: Utilize cutting-edge AI for on-board cognitive intelligence, enhancing adaptivity, resilience, and situational awareness.
4. Feasibility & Impact Analysis: Conduct studies on environmental impact, legal and ethical considerations, business scenarios, and technology roadmapping, while engaging with stakeholders.
5. Proof of Concept: Demonstrate these technologies in a fully autonomous, electrically-powered WIG vehicle.

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Zero-Emissions Power System

- Objective: To develop a fully electric, zero-emission UWV
- Power Architecture:
  - DC Microgrid-based architecture for stability and safety.
  - Inclusion of solar panels and super capacitors for additional energy and storage.
- Digital Twin:
  - Real-time simulation and modeling for optimization and predictive maintenance.
- Energy Sources:
  - Conventional batteries, hydrogen fuel cells, and solar cells.
  - Quick energy bursts from super capacitors for load changes.

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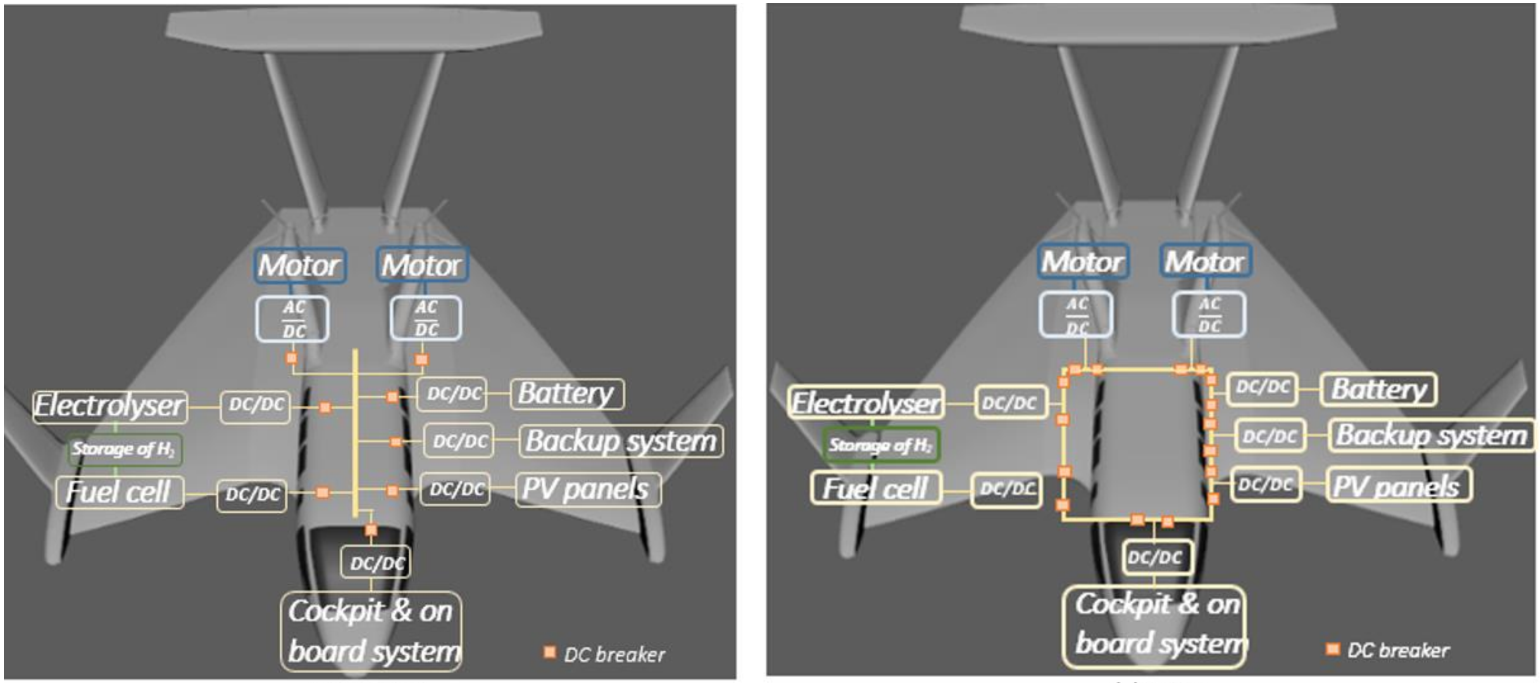
Zero-Emissions Power System



a) Radial b) Ring

Simplified schematics of the proposed WIG Power Architecture based on a DC Microgrid

- **Primary** source of electrical energy during cruising: fuel cells, supplied with green H2, in combination with PV cells on its surface.
- **Additional** energy during taking-off and landing: Li-ion batteries.
- Rapid additional energy in the case of **sudden** electrical load changes: a set of super capacitors.

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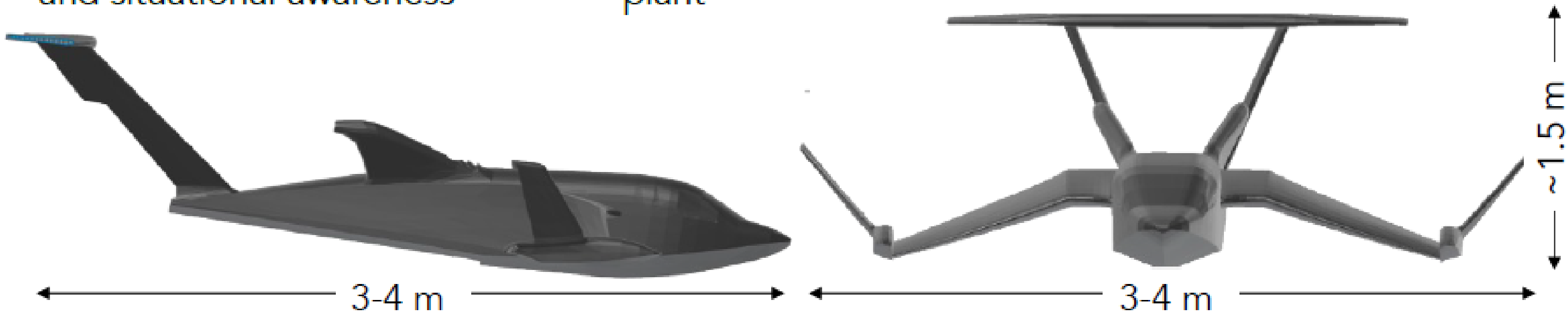
- Main features of the AIRSHIP-1 Autonomous WIG drone model to be built for the testing:

A1

- Payload: ~10 Kg
- Cruise Speed: 15-20 m/s
- Advanced, AI-based self and situational awareness
- Wingspan: 3-4 meters
- Autonomy: 1-2 hours
- Zero-emission power plant



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SEAWINGS

Sea/Air Interphasic Wing-In-Ground Effect Autonomous Drones

SEAWINGS addresses the call's request for innovative defence technologies focusing on a niche, but important topic that could bring a completely new class of versatile drones into service within the EU military/defence ecosystem.

*"…we expect that the **cheap**, **high-speed**, fully **autonomous WIGs** will eventually play an important role in the **defence** of **remote European outposts** during the early stages of a military conflict, as **reconnaissance** craft, or as first-response units in case of a **natural/humanitarian disaster**."*

Funded by the European Union

Conclusions

•WIG vehicles combine speed, flexibility, and energy efficiency, offering a sustainable alternative to traditional transport.

•Increasing interest in WIG technology for various applications.

•New technologies can overcome some of the past drawbacks.

•European projects paving the way for practical implementations UWV.
  •Addressing current research challenges including zero-emission power systems.

AIRSHIP
UNMANNED WIG VEHICLE TRANSPORTATION

SEAWINGS

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THANK YOU!

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