Technology Developments for Wing in Ground Effect Craft

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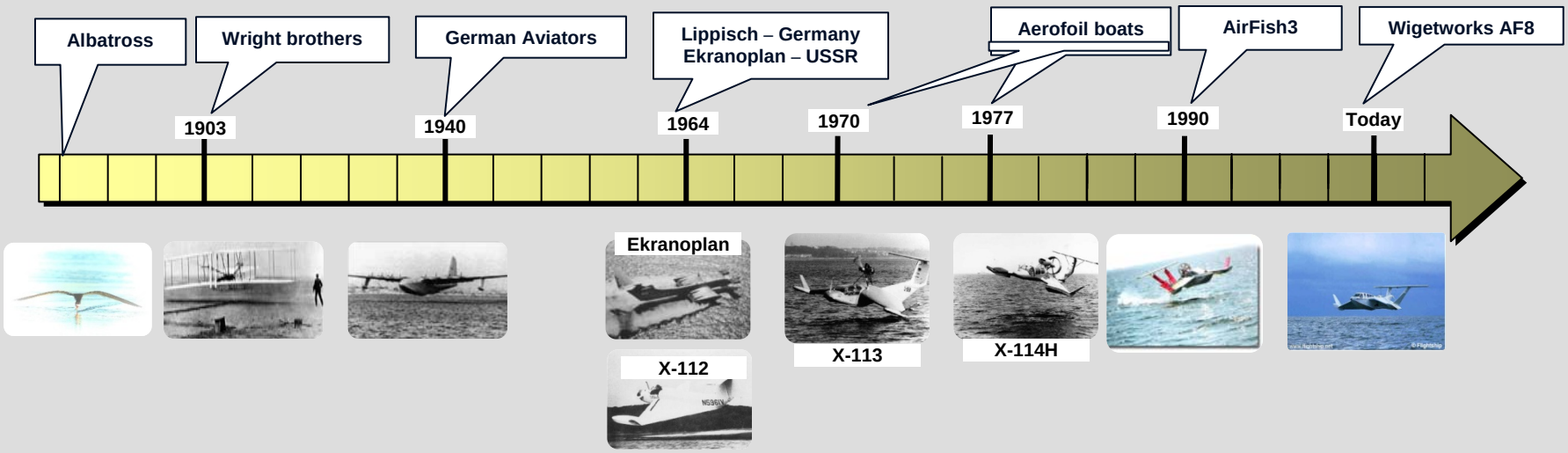
Acknowledgement

To demonstrate various technologies, some of the pictures presented herein are taken from the public domain. This is gratefully acknowledged.

Presentation Overview

- Origins of WIG effect craft
- Technology
  - ❖ Aerodynamics
  - ❖ Hydrodynamics
- IMO Requirements
- Rules & Classification
- Commercial Feasibility
- Conclusions

Origins and progress of WIG effect craft



Caspian Sea Monster Alexeev concept (USSR)

- Military Ekranoplan
- Square Platform vessel
- Critical Stability line along the length of ship
- Demand high pilot skill
- Suitable for sheltered waters and rivers

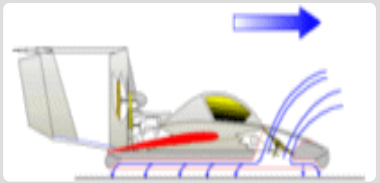
Lippisch concept (Germany)

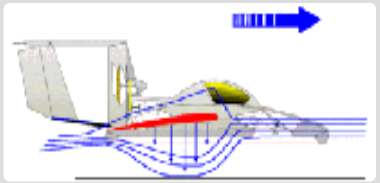
- Military and later commercial use
- Aerofoil Boat
- Reverse delta wing design
- Large T-shaped tail, longitudinal stability
- Demands lower pilot skill effects

Definition

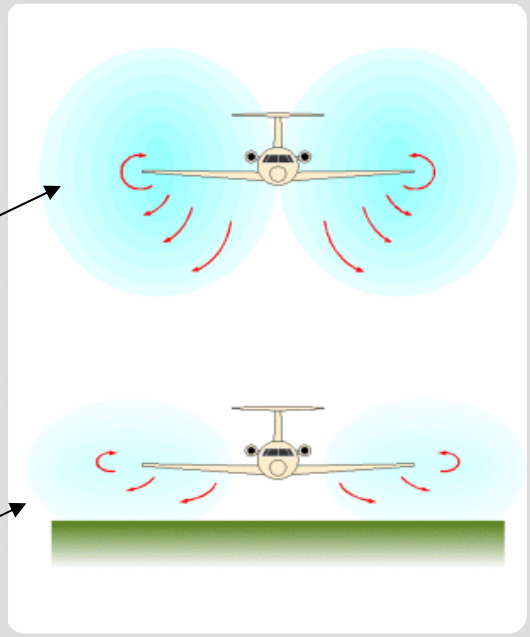
- **A boat or a plane?**
  - Neither! It is a craft in its own right!!
    - High speed craft
    - Hovercraft
    - Aircraft
    - Spacecraft

- **Types**
  - **Type A:** No out of ground effect capabilities
  - **Type B:** Limited flight capabilities (up to 150m)
  - **Type C:** Full flight capabilities (aircraft)



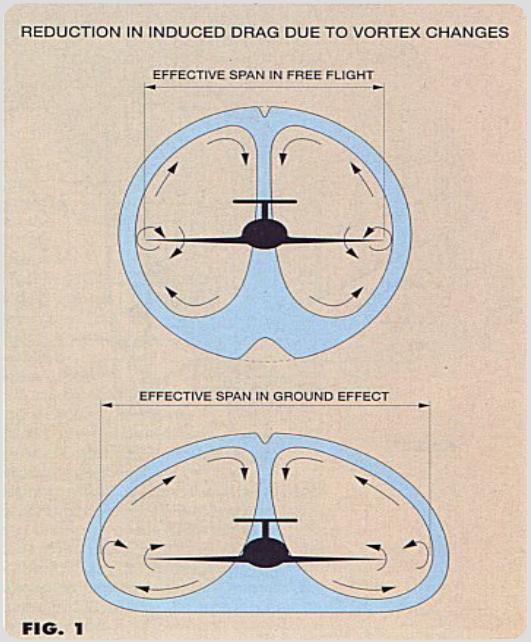


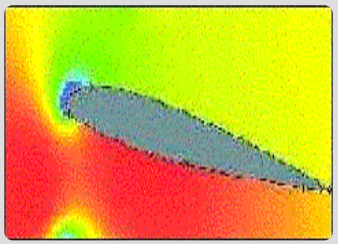
Technology fundamentals – Aerodynamics

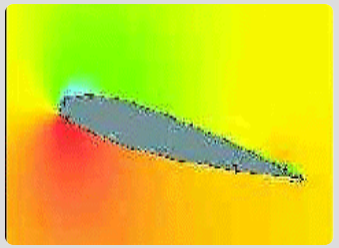


Energy loss due to Wing tip vortices

Water surface interfering with lateral airflow (reduced drag increased WIG efficiency)



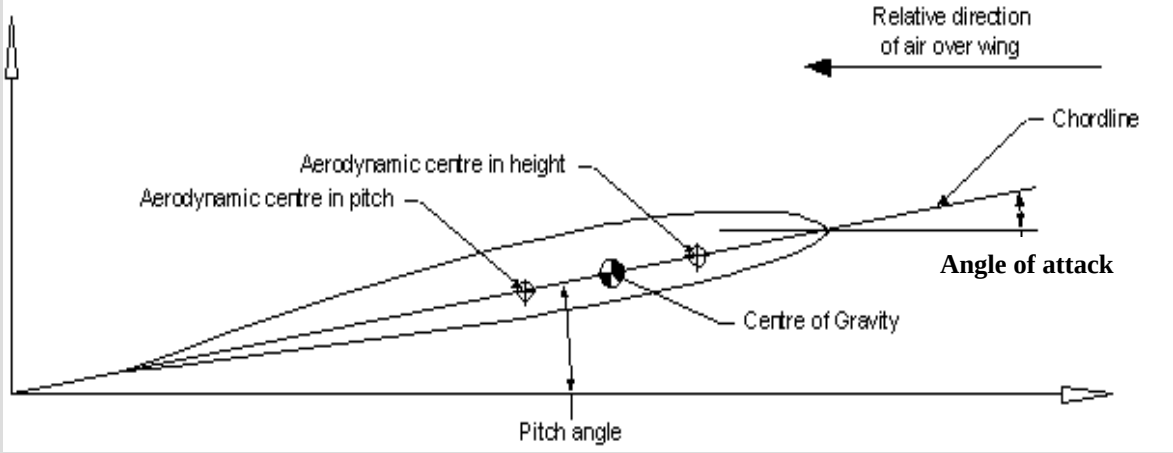




- Span Dominated Ground Effect (SDGE)
  - reduced drag
  - increased effective span
- Chord Dominated Ground Effect (CDGE)
  - Increase lift
  - Ram Effect

Technology fundamentals – Aerodynamics (cont.)

- The higher the **L/D ratio** the higher is the efficiency and lower is the fuel consumption
- Need to engineer an adequate margin of safety into the design
- Aerodynamic centres (of pitch and height), must be designed to achieve static stability
- **<u>For longitudinal stability :</u>**
  - ❖ the aerodynamic centre in height must be correctly located in the wing
  - ❖ the aerodynamic centre in pitch must be located correctly on the chord line



Technology fundamentals – hydrodynamic design aspects

- **Seaworthiness** – Design for hydrostructural strength (loads) on maximum landing H_s
- **Power mismatch** – design for minimum take off drag
  - ❖ Design for low take off hump drag and determine the installed power from this drag.
  - ❖ Size engines for higher take off power and lower power run in cruise
  - ❖ Design the vessel for low take off speed
- **Hull design** – increased hydrodynamic Lift / Drag ratio
  - ❖ Steps – used to decrease wetted area (avoid hull sticking on water)
  - ❖ Chines (suppress spray drag)
  - ❖ Ventilation (i.e. air lubrication) – by reducing friction drag

Technology fundamentals – hydrodynamic design options

Hydroski

- High hydrodynamic lift
- Poor L/D ratio
- Good for landing

Hydrofoils

- Good L/D
- Low heave motion RAO at take off
- Limited application
- X114-h accident

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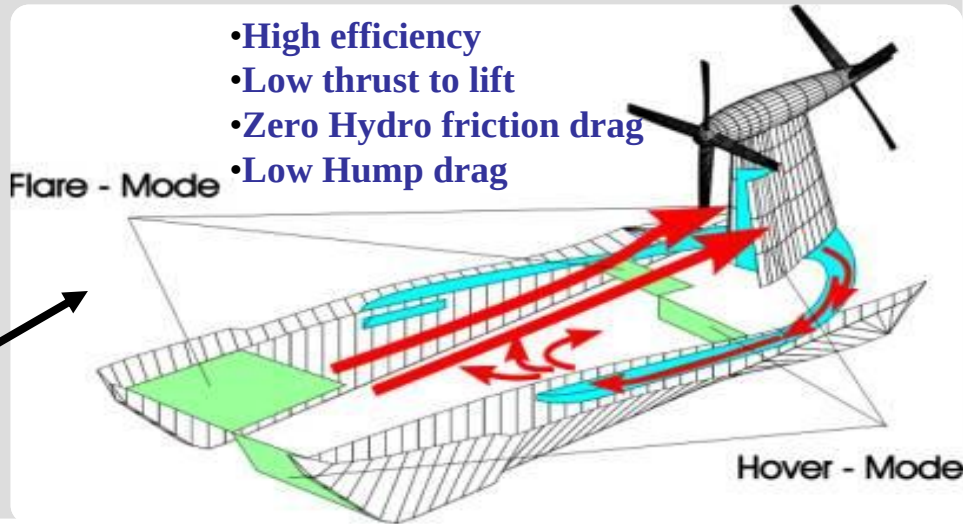
- Low efficiency
- High thrust to Lift
- Jet leakage
- Pressure loss in jets

Hoverwing (static air cushion)

- **High efficiency**
- **Low thrust to lift**
- **Zero Hydro friction drag**
- **Low Hump drag**



In hover mode the green skirts go down and
the blue door behind the propeller opens up,
so that air is pushed through
the blue channels into the cavity under the body

Overall Commercial feasibility of WIG effect craft

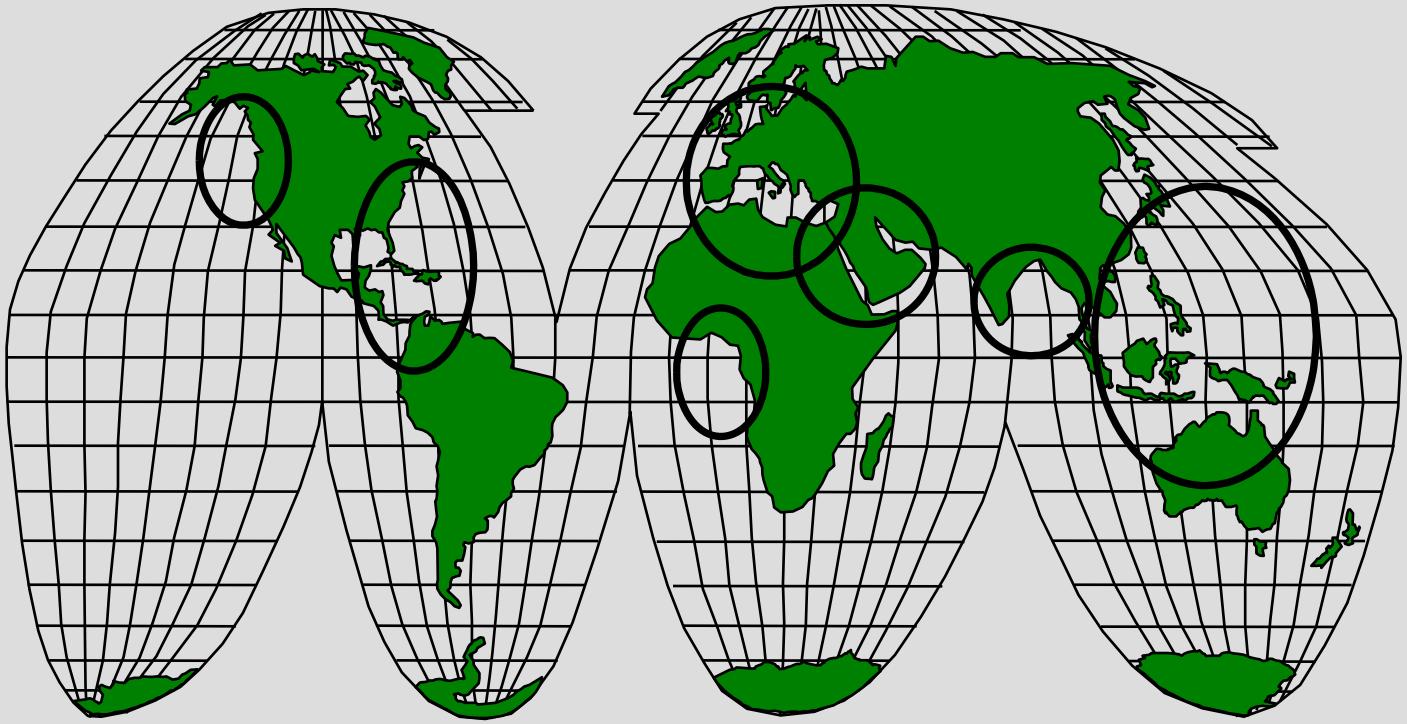
Advantages

- Increased speed for marine transport
- High efficiency when compared to other HSC
- Low operating costs as compared to aircraft
- Low infrastructural requirements (any existing port is sufficient !!)
- High comfort level in cruise compared to other HSC
- Safer than equivalent size aircraft (flies in proximity to water, more quiet than aeroplane, constant and small pitch angle, no risk of stalling)

Limitations

- Sensitive to weather conditions such as wave height and wind speed as much as HSC
- Technology is not mature yet (application for specific application and route, safety)
- Legislation must be clear

Viable or Flight of Fancy?



IMO Considerations

- MSC/Circ.1054 – Interim guidelines for WIG Craft – **2002**
  - ❖ Levels of Safety consistent with SOLAS and LL conventions
  - ❖ Definitions
  - ❖ Flight modes
  - ❖ Surveys
  - ❖ Interim recommendations for structures, machinery, operations
  - ❖ Safety assessment and management
- MSC/Circ.1162 – General Principles and recommendations for knowledge, skills and training for officers of WIG craft operating in both displacement and ground effect modes – **2005**
- the International Civil Aviation Organisation (ICAO) and IMO agreed that WIG craft should come under the jurisdiction of the IMO. However, any WIG craft that is capable of sustained operation will still be classified as an aircraft and comes under the jurisdiction of ICAO.

Provisions of Classification – WIG effect craft

- Structural strength, buoyancy, controllability and arrangements on board for safe and effective operation of the craft
- Watertight and weathertight integrity of the craft
- Dependability and functioning of engineering systems installed for manoeuvring and operation of the craft
- Effectiveness of other defined features and systems that have been built into the craft in order to establish basic conditions on board
- Classification respects working standards related with aeronautical rules

Rule Framework

- **Volumes 1,2,3** – classification requirements assessment and appraisal **(the process of classification)**
- **Volumes 4,5,6,7** – requirements for craft design, physical arrangements, structures, engineering systems and trials/testing – **(The WIG craft as a product)**
- **Volumes 8 and 9** – requirements for materials and components **(supporting information and requirements to deliver the product)**
- **Typical Notation : ✠100A1 WIG MCH, Type A Passenger, WTL0.5/WEL2.0, WSC10**
  - MCH is mandatory
  - Craft without anchoring or mooring can use E instead of 1

Surveys

- Similar to marine practice but allowance for operating hrs
- Annual survey – (engine run time requirements depend on manufacturer)
- Special survey – every 2 years (engine run time requirements depend on manufacturer)
- Safety for Life at operation items
- Upkeep by exchange
- List of documentation available for surveyors
- Transfer of Class procedures
- Qualified personnel survey system (no chief engineers for WIG effect craft)

Recent proven Technology - Wigetworks

- FRP epoxy composite construction
- Wing span – 15.6m
- Cruising speed – 70 ~ 90 Knots
- Operating height - 2 ~ 5m above sea level
- A single 500HP - V8 car engine
- Capacity – 8 seater (extendable to 10)
- Inherently stable
- Simple hydrodynamic design allows for ease and simplicity of operation

Worlds First WIG Effect Craft fully surveyed to IMO Rules.
Manufactured in Germany, Refurbished in Singapore
(Source: http://www.wigetworks.com)

Conclusions

- WIG effect craft technology is present and promising (Wigetworks full scale production by 2011)
- Increasing globalisation - sea and air ports strained
- Need for innovative, versatile, safe and affordable transport solutions
- Further work is required from safety regulators to change perception in developed world.
- Further certification of manufacturing technology
- The role of Class is important

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