Introduction to Rotorcraft Aerodynamics
Lecture 1

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Rotorcraft Aerodynamics

- Notes are in Blackboard
- Example Sheet
- Online test
- Exam:
  - 2 small compulsory questions
  - 1 big optional question

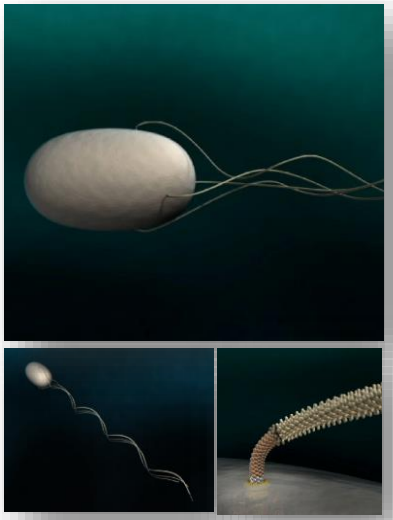
Content

- History of rotorcraft development.
- Aerodynamics of the rotor in axial flight.
  - Rotor operating states.
  - Rotor efficiency: Figure of Merit.
  - Performance Coefficients and Tip loss factors.
- Translational flight.
  - Flapping and feathering equivalence.
  - Rotor dynamics: Blade hinges and Rotor hub design.
  - Operating limitations.
- Rotor noise.

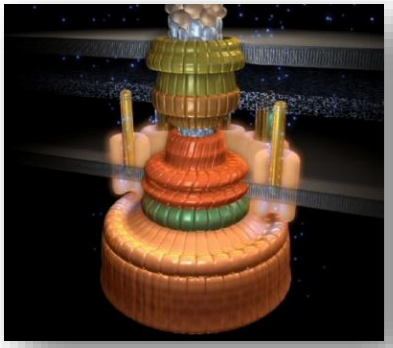
Rotary Systems in Nature!

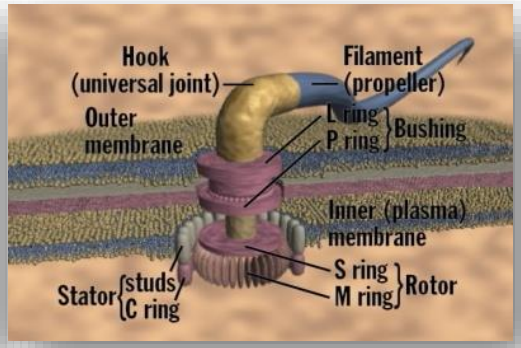
The sycamore seed.

It trades potential energy for rotational energy that provides a lifting force.

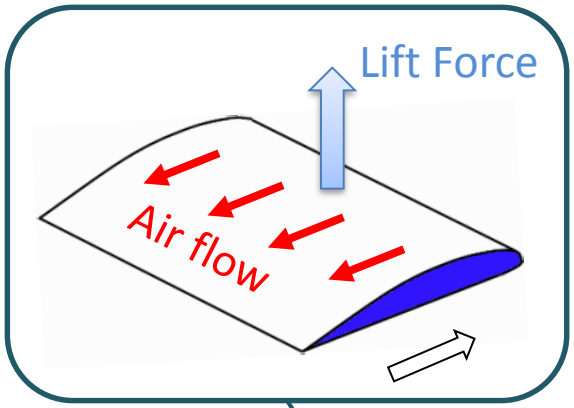


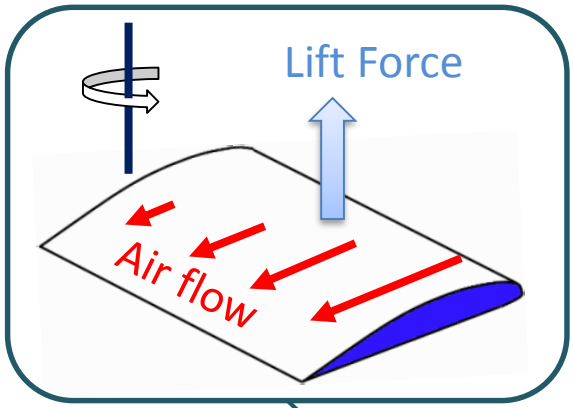
There is another form of rotary wing propulsion, employed on bacteria such as Eschericia (E.) Coli and Salmonella. The rotor system (known as the flagella) has a motor, a rotor and a paddle



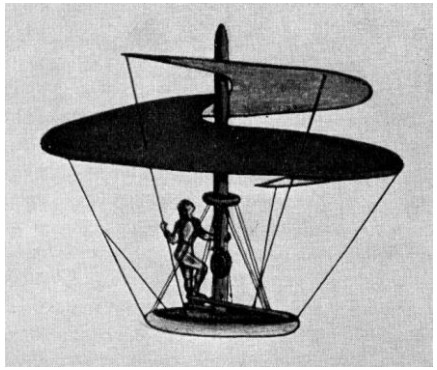


What is a Rotary Wing?

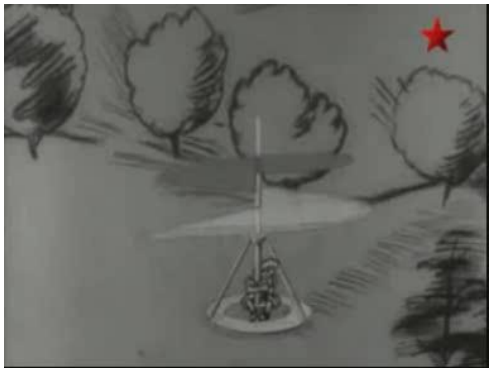


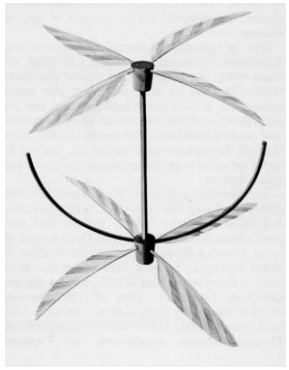


Some History of Rotating Wings



Leonardo da Vinci's design circa 1500





Chinese Top 1784

Rotating wings trade rotational energy for flow kinetic energy.

Types of Rotary Wings Systems?

Helicopters

Propellers

Fans

Autogyros

Wind Turbines

Types of Rotary Wings Systems?

Lift

Helicopters

Autogyros

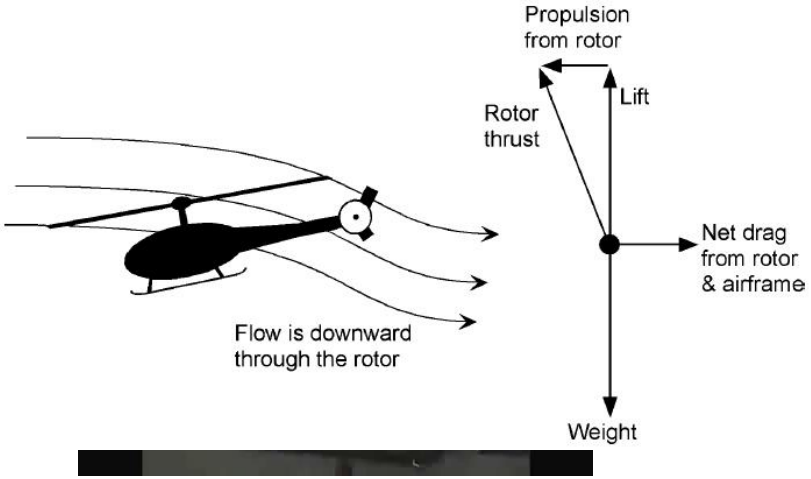
Propellers

Fans

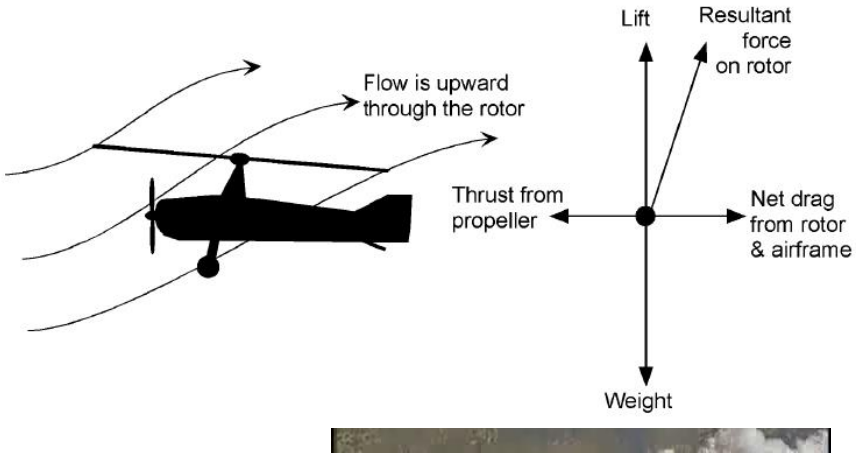
Wind Turbines

Powered vs. Autorotating Rotors

Helicopters



Autogyros



Powered vs. Autorotating Rotors

Helicopters

1930s - present

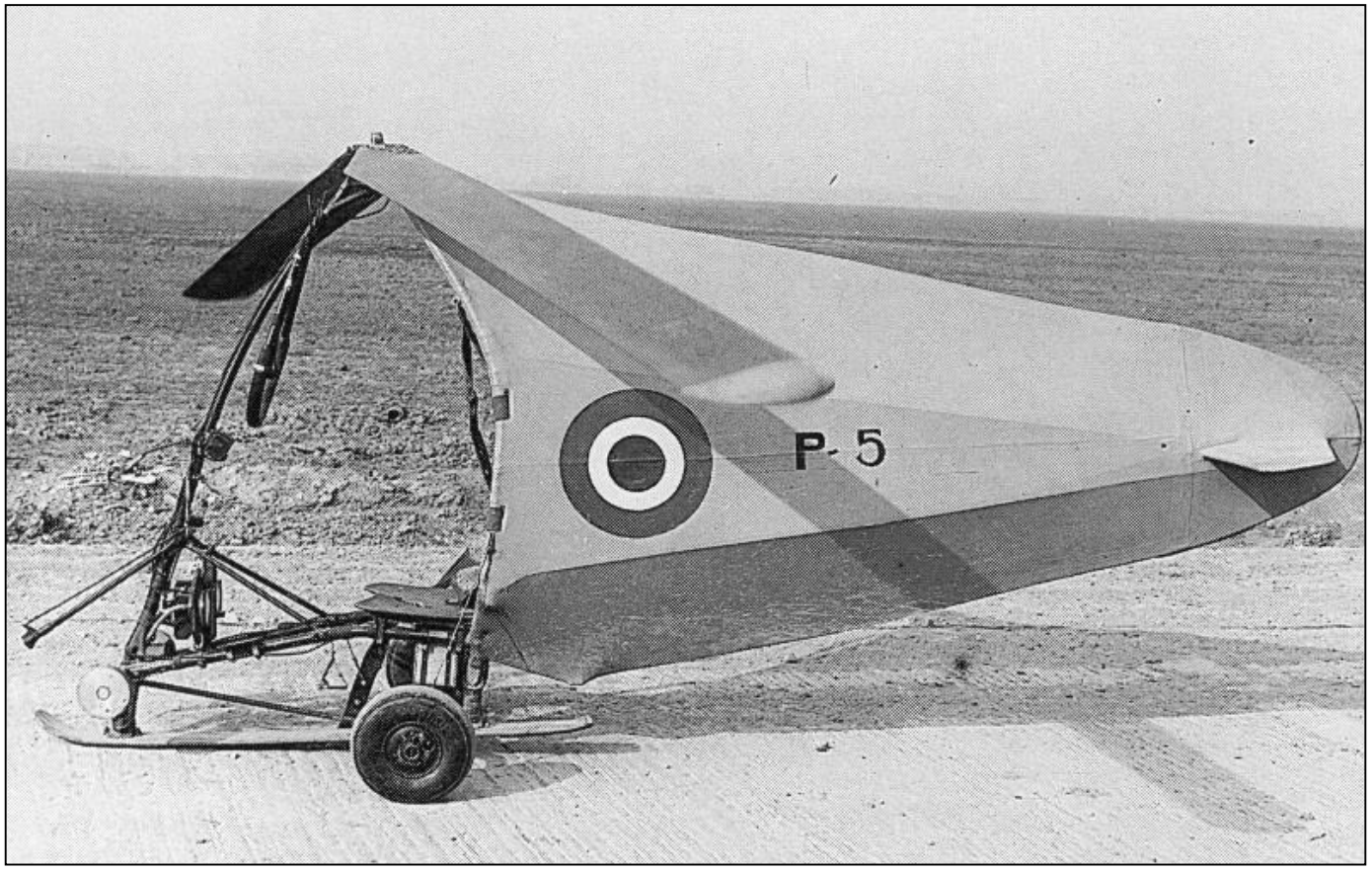
Autogyros

1920s - present

Compound Helicopters

Lecture 1 - The Applications *(and a bit of history)*

| simple fan | aircraft propeller **| autogyro rotor |** helicopter rotor | wind turbine |



Hafner “Rotachute”

Lecture 1 - The Applications *(and a bit of history)*

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Hafner “Rotabuggy”

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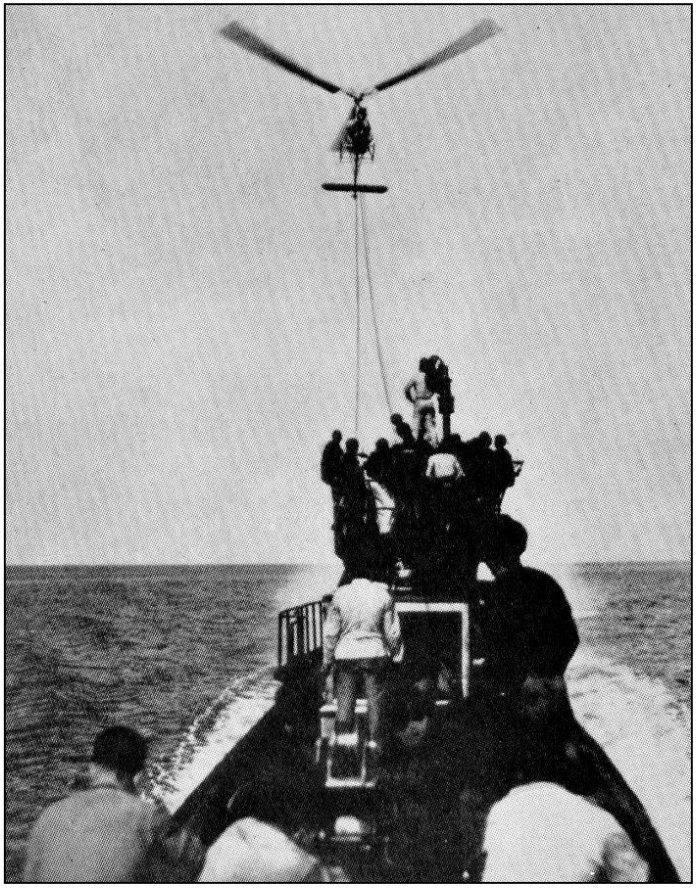
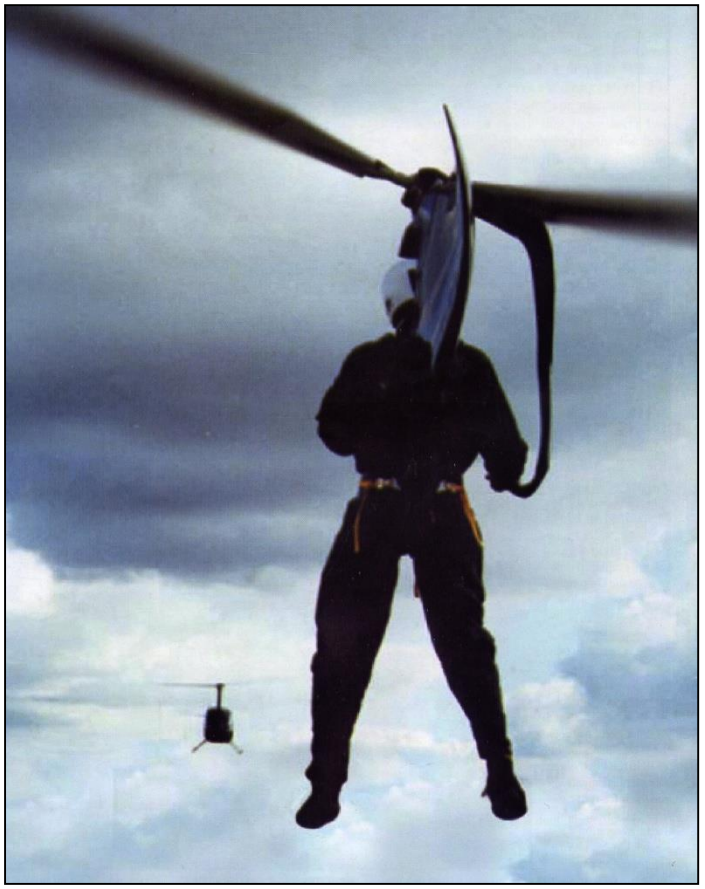


Focke-Achgelis Fa 330



“Modern equivalent”

Lecture 1 - The Applications *(and a bit of history)*

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Cierva C6

Lecture 1 - The Applications

| simple fan **| aircraft propeller | autogyro rotor |** helicopter rotor | wind turbine |

“Modern equivalent”

Lecture 1 - The Applications (the future)

| simple fan | **aircraft propeller | autogyro rotor |** helicopter rotor | wind turbine |

Gyrojet / RWIL* “Supergyro”

Rotary Wing INNOVATIONS LIMITED

* *Rotary Wing Innovations Ltd is a University of Bristol Spin-out company*

Lecture 1 - The Applications

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Lecture 1 - The Applications *(and a bit of history)*

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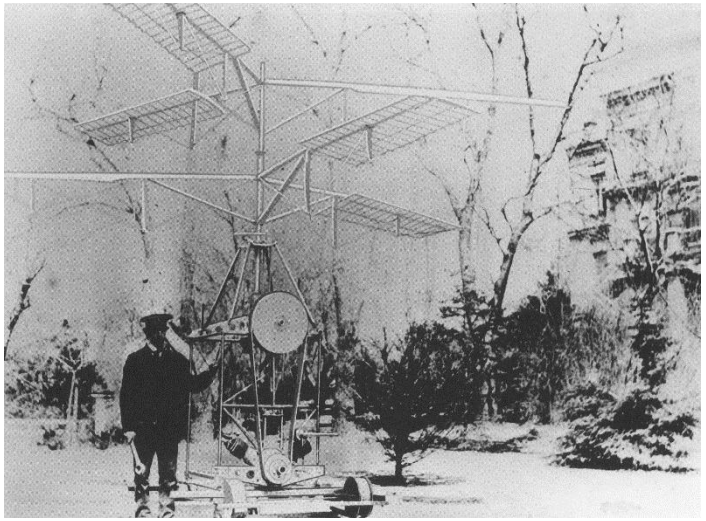

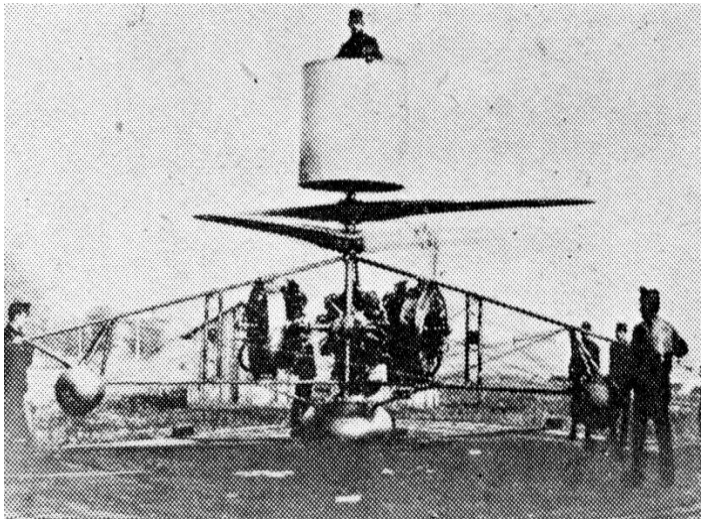

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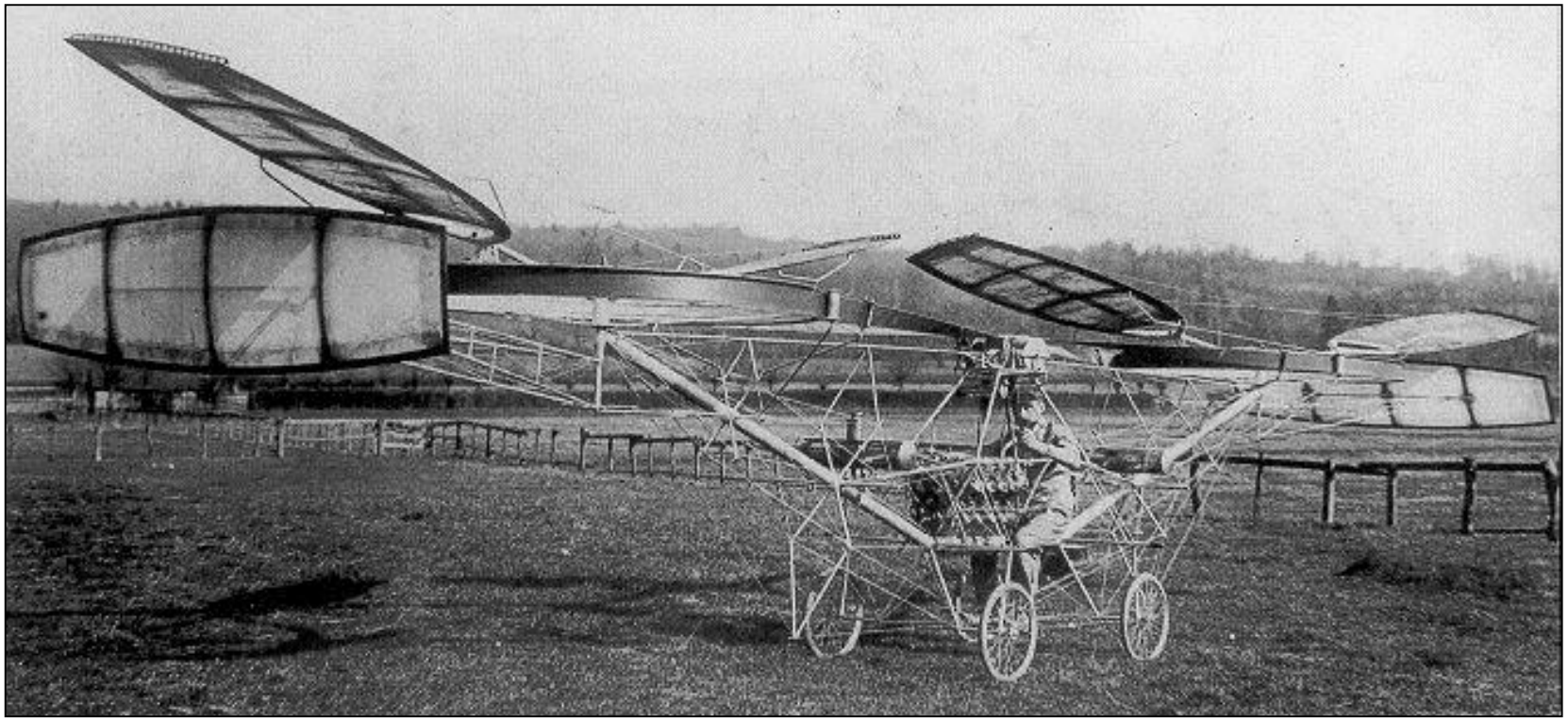


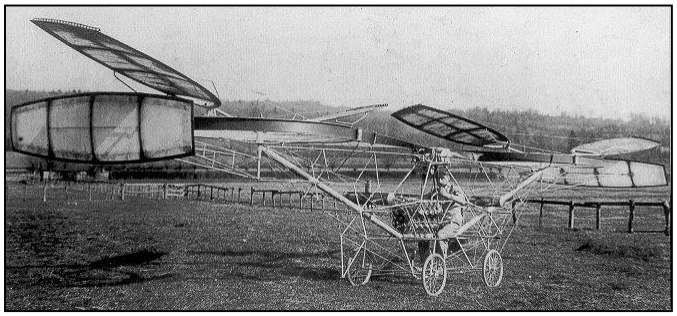
Paul Cornu (1907)

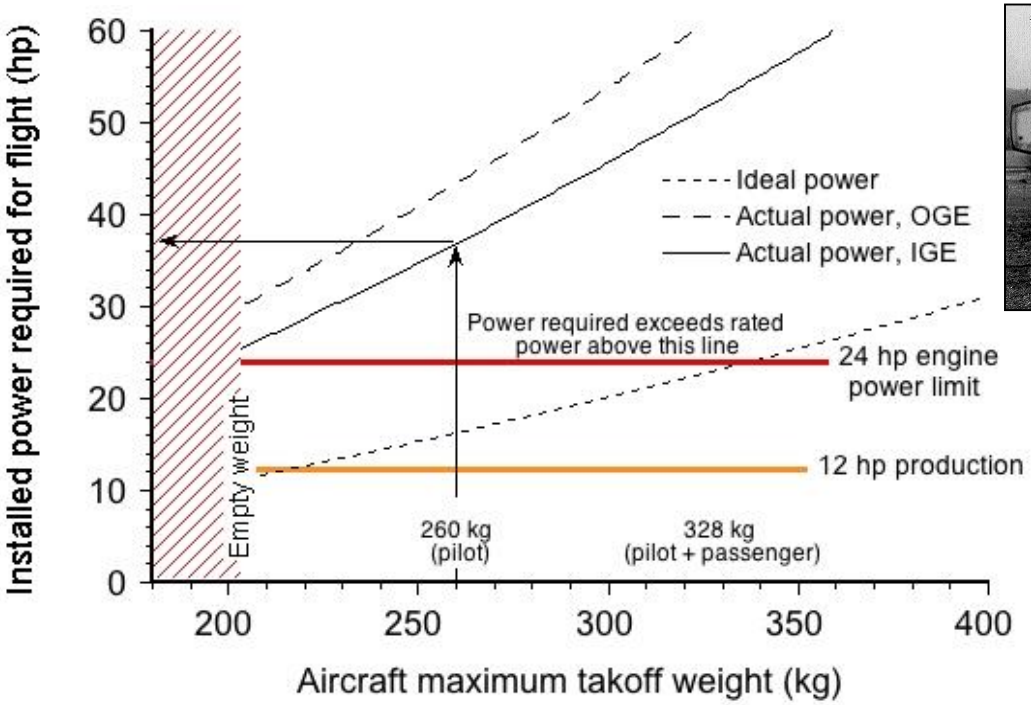
Lecture 1 - The Applications *(and a bit of history)*

| simple fan | aircraft propeller | autogyro rotor **| helicopter rotor |** wind turbine |

Could It Fly?

The following chart was developed by Dr. Gordon Leishman, a leading helicopter aerodynamicist, to analyze the lifting capability of the Cornu helicopter as described by Cornu himself with the actual power available from his engine.





Predictions of power requirements for flight for Cornu's piloted machine, showing that with a 12 to 24 hp Antoinette engine, a free flight, even in ground effect, was a highly improbable event.

Lecture 1 - The Applications *(and a bit of history)*

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Breguet-Dorand Gyroplane Laboratoire **(1935)**

Focke's Fw 61 **(1936)**

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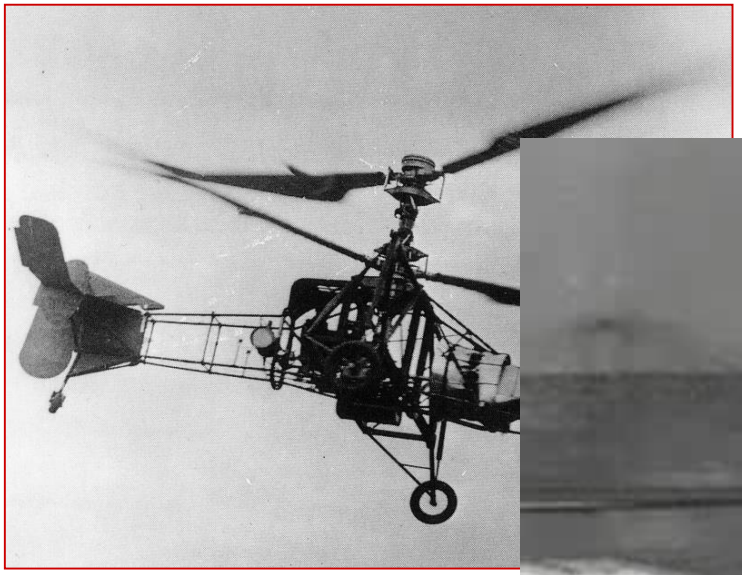

aboratoire **(1935)**

Focke's Fw 61 **(1936**

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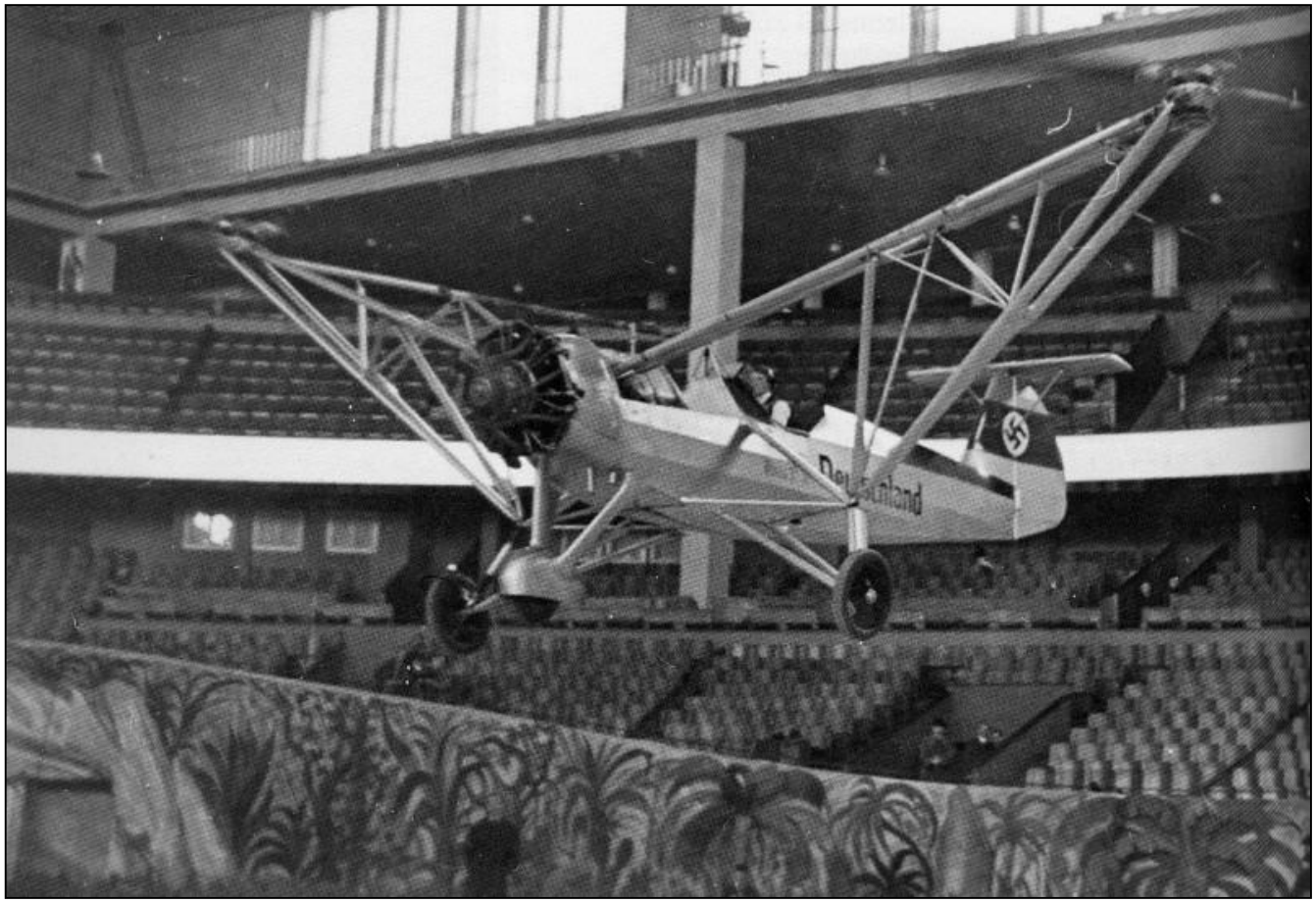

Hanna Reitsch pilots Fw 61 in Deutschlandhalle , Berlin **(1938)**

Lecture 1 - The Applications *(and a bit of history)*

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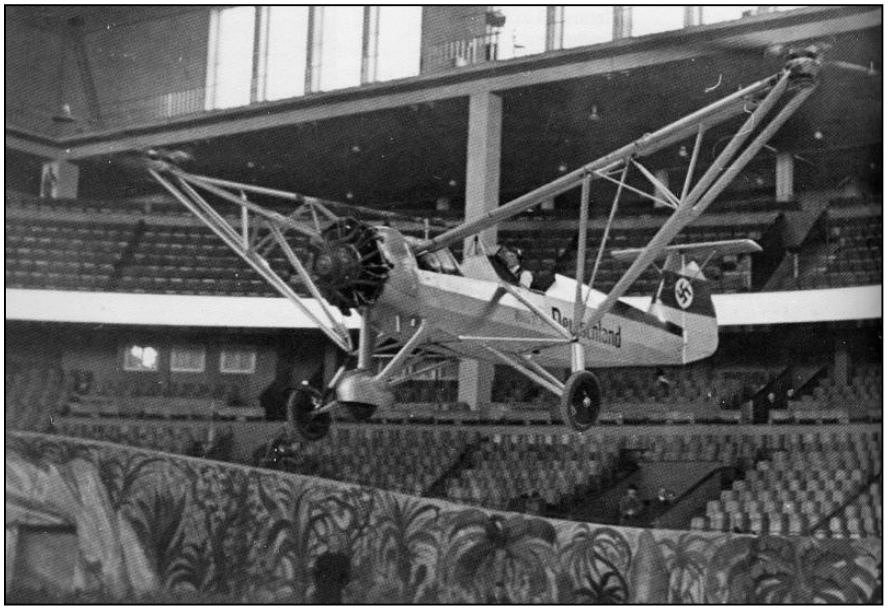

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Sikorsky XR-4a **(1942)**

Lecture 1 - The Applications *(and a bit of history)*

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Bristol Type 171 Sycamore

Lecture 1 - The Applications *(and a bit of history)*

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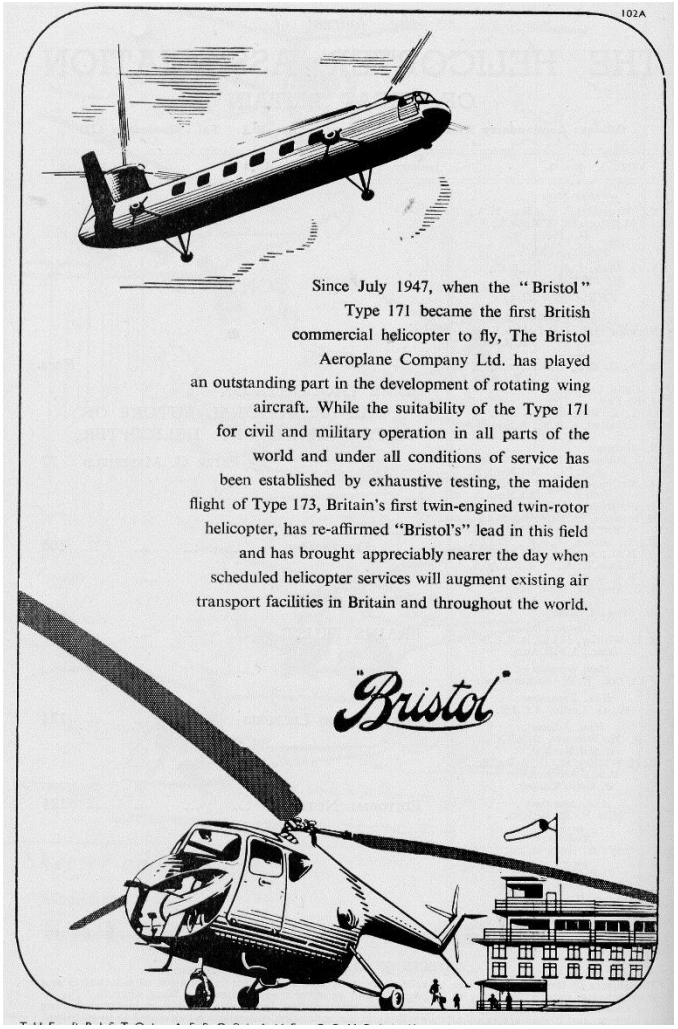

Lecture 1 - The Applications *(present and future)*

| simple fan | aircraft propeller | autogyro rotor **| helicopter rotor |** wind turbine |

Now the technologically advanced rotor system as fitted to the Leonardo Helicopters AW101 or Airbus Helicopter X3

Lecture 1 - The Applications *(and a bit of history)*

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Fairey Gyrodyne **(1948)**

Lecture 1 - The Applications *(and a bit of history)*

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Fairey Rotodyne **(1958)**

Lecture 1 - The Applications *(and a bit of history)*

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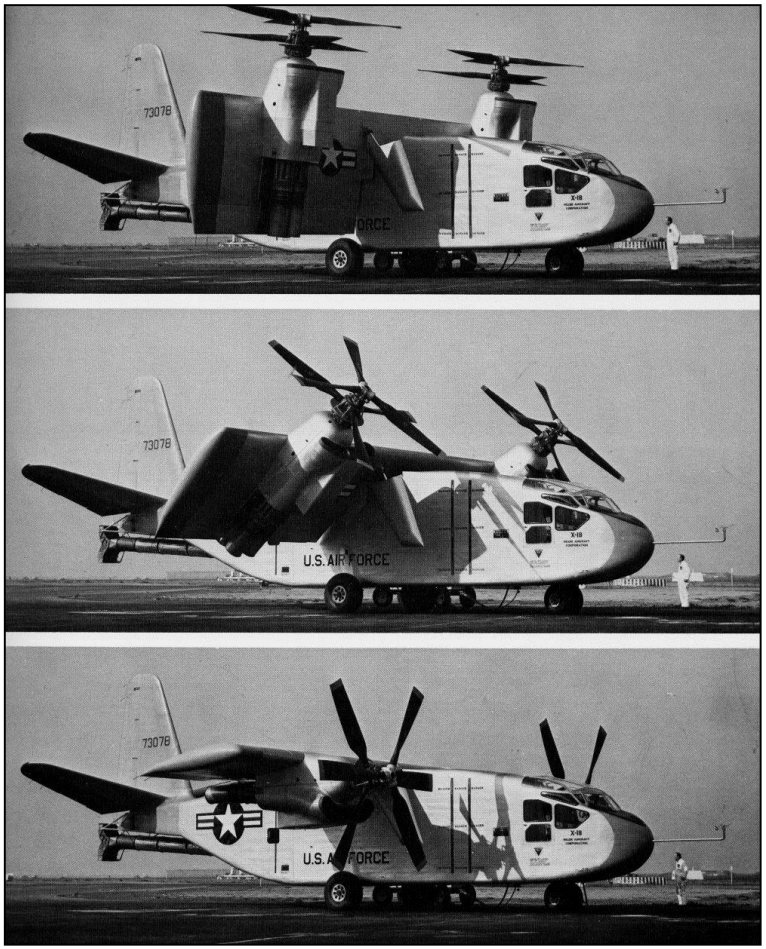
For the Bell XV-3, the thrust generator is both propeller and lifting rotor in this “Tilt-Rotor” configuration.

Lecture 1 - The Applications *(and a bit of history)*

| simple fan | **aircraft propeller** | autogyro rotor | ***helicopter rotor*** | wind turbine |



HELICOPTERS – A brief History

Lecture 1 - The Applications *(and a bit of history)*

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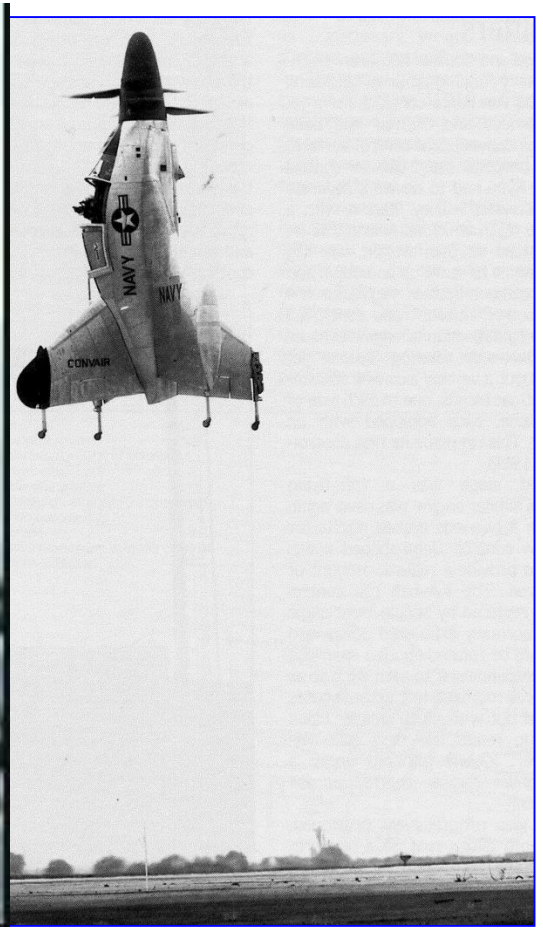

Lecture 1 - The Applications *(and a bit of history)*

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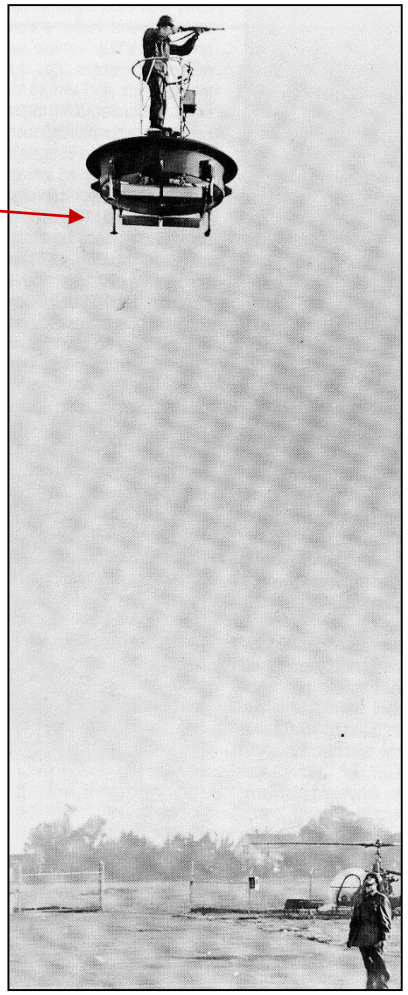
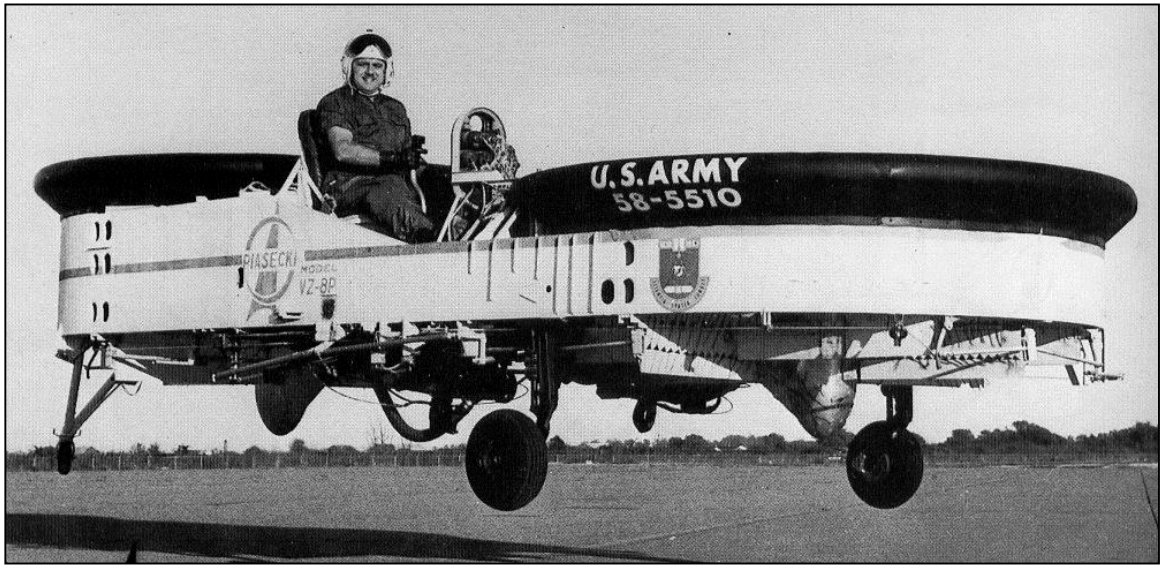
The Hiller VZ-1 (Pawnee) manned observation platform had an 8ft diameter ducted propeller system with control by vanes within the propeller wake.



The same system is employed on this Piasecki VZ-8P



Lecture 1 - The Applications *(and a bit of history)*

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Multi-rotor

Recommended Text Books

Basic Helicopter Aerodynamics, 3rd Edition
John M. Seddon, Simon Newman

The Foundations of Helicopter Flight
Simon Newman

Principles of Helicopter Aerodynamics,
Gordon Leishman