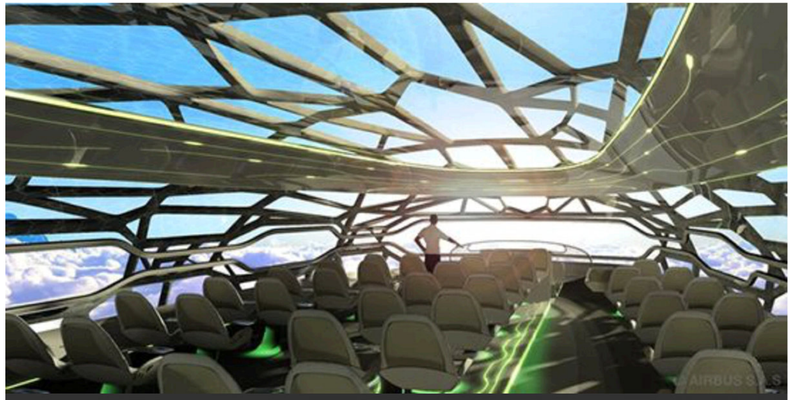
Bio-inspired Environmentally Friendly Aerial Vehicle (BEFAV)

PROF. JOANA ROCHA, MARCH 2023

Examples of Bio-inspired Designs

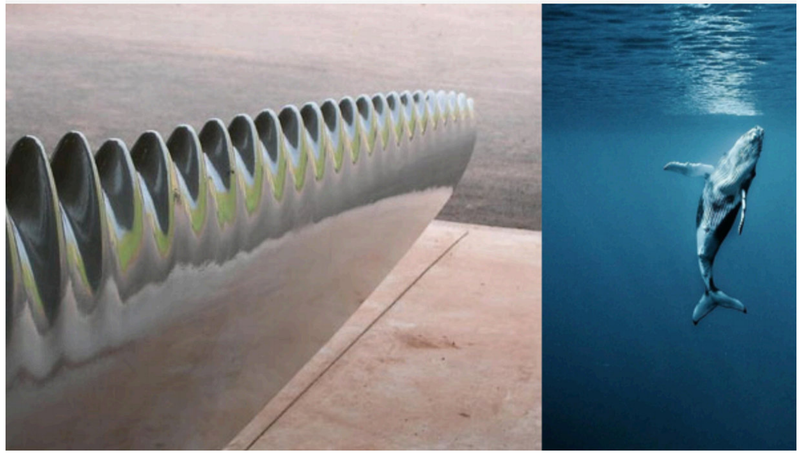
Owl's wing: unlike most birds, owls' feathers have a sharp, clean edge, with soft fringes that decrease the turbulence, and thus the noise, of air as it flows over wing (feathers serrated like a comb). They fly in almost complete silence. It is hoped that owl inspired wing design can decrease wing noise.

Birds bone-like structure: fuselage design, which instead of being wrapped in opaque steel, is composed of a web-like network of structural material that looks like a bird skeleton or bone structure (concept by Airbus).



(Airbus)

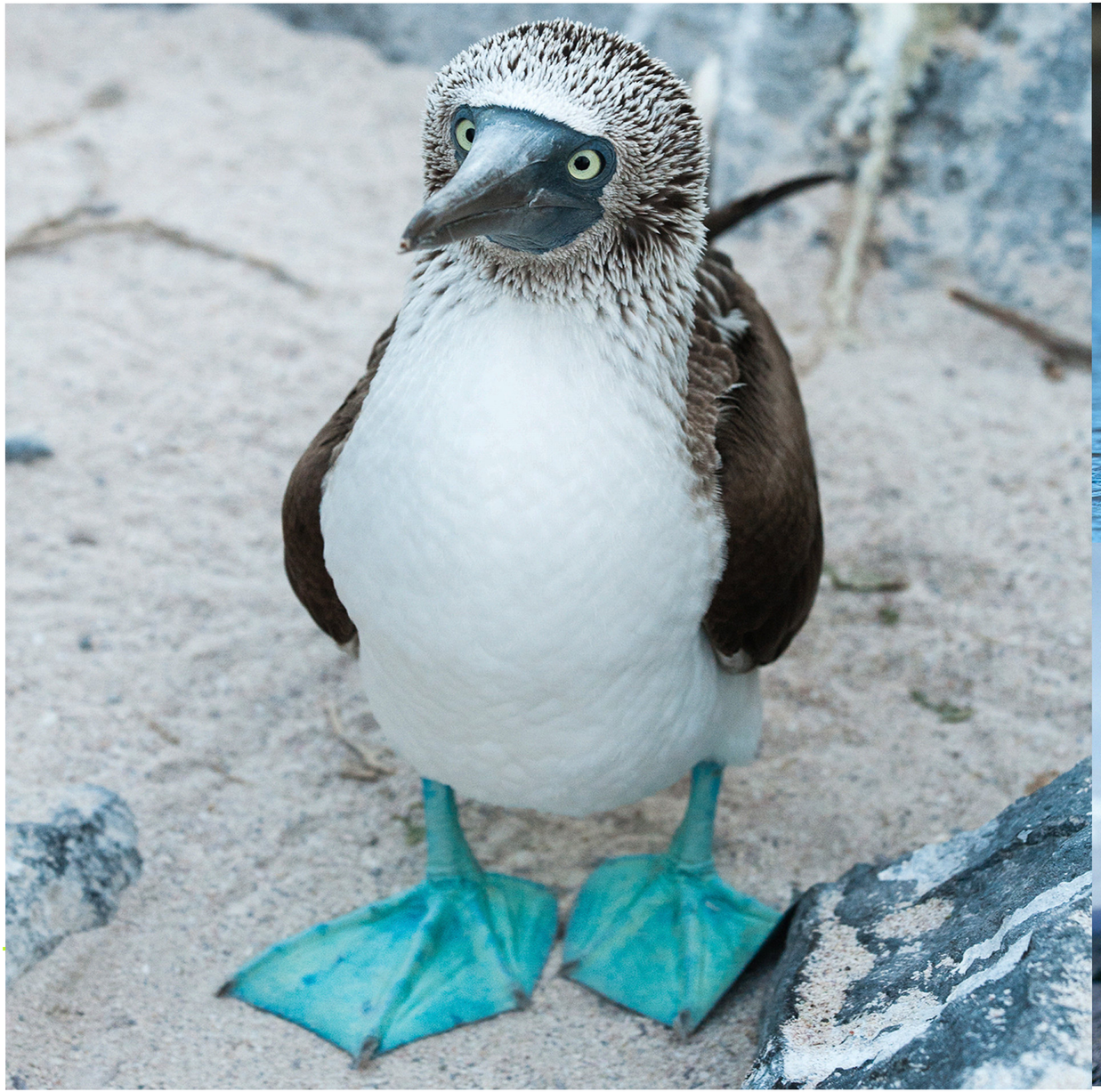
Examples of Bio-inspired Designs



Humpback whale flippers: the bumpy ridges on the leading edge of the whale flippers help them increase lift and reduce drag at the same time. When using the saw-like design in wind turbines, wind farms use 25% less energy to produce 20% more power (concept by WhalePower turbine).

Shark's fin: the "sharklets" introduced by Airbus — or vertical wing-tip extensions that resemble a shark's dorsal fin — are aerodynamic surfaces, which are mounted vertically at the wingtips, significantly reduce the size of the wingtip vortex, thus reducing induced drag.

Nature evolved for many years... and we can learn from it



Nature evolved for many years... and we can learn from it

- **What is biomimicry?**
  - Aims to imitate, study, and take inspiration from natural selection solutions adopted by nature and translate the principles to human engineering.
  - The biomimicry approach favours design choices tested by nature. Nature had millions of years to understand what works best and what doesn't.

- **Why are we applying bio-inspired concepts to aircraft?**
  - Looking at aircraft design by imitating nature's best-kept secrets could help solve a variety of transportation and aviation challenges. Aircraft designs following biometrics will allow human productions to be more efficient, resilient and sustainable.

- **Current challenge:**
  - A more sustainable aviation, how to make aircraft lighter, quieter, and more fuel efficient.

https://www.youtube.com/watch?v=exFla5j8pyo

Why it matters?

- More efficient aircraft.
- Quieter designs.
- Less CO_2 emissions.
- Environmentally friendly.

https://www.youtube.com/watch?v=FBUpnG1G4yQ&t=123s

Project Objective

The final goal of the project is the development of a medium-size sustainable aerial vehicle (AV), with **minimal drag/noise and GHG footprint**, which can travel between urban and rural or remote areas to deliver goods, while blending with nature, without disrupting the wellbeing of communities and local species.

Over time, the project will involve the **design, manufacture and test** of a scaled-model of the BEFAV.

Project Milestones

Year 1 (2021-2022):

- Define technical specifications and initial design work.
- Analyze and determine performance, aerodynamic, structural, noise, and propulsion requirements of the initial design.
- Develop conceptual design for first BEFAV, based on bio-inspired concepts for improved design and proof-of-concept.

Year 2 (2022-2023):

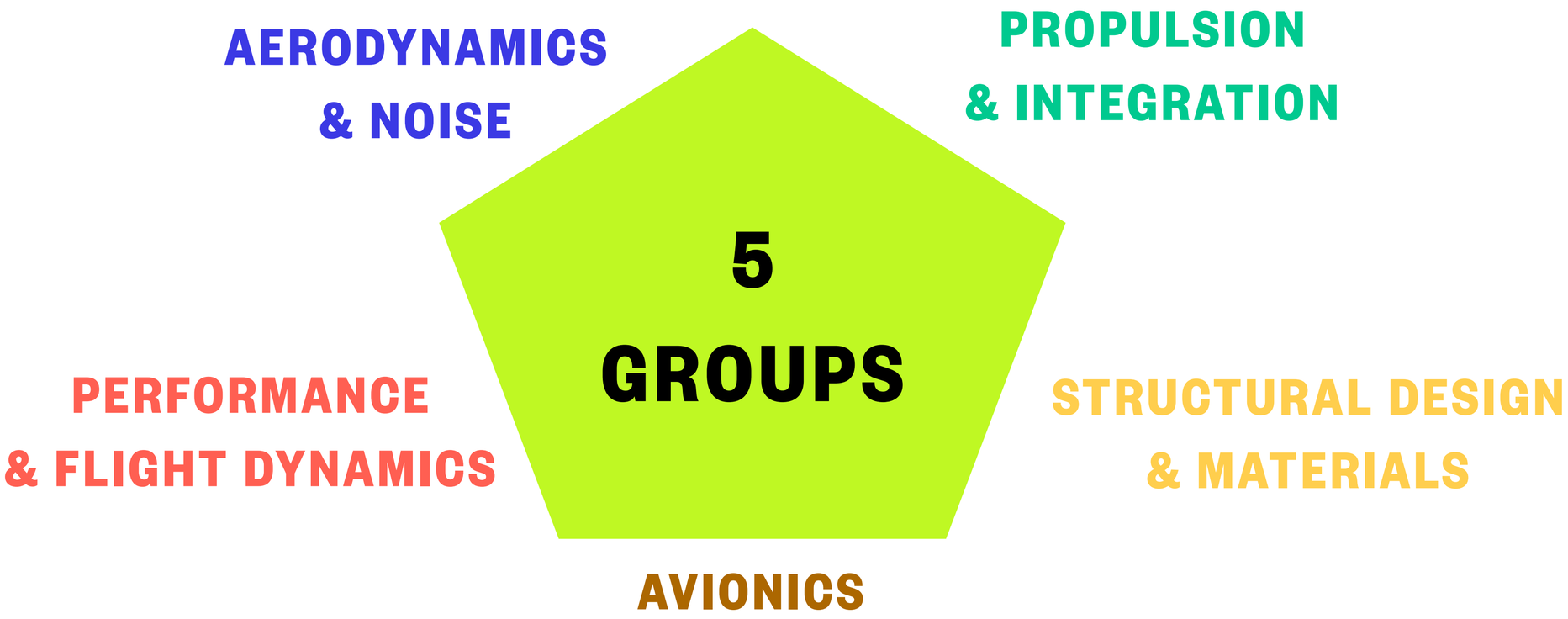
- Development of CAD models for the complete detailed design of BEFAV.
- Through detailed design, determine BEFAV aerodynamic, structural, and performance data through computation software (such as ANSYS mechanical, ANSYS CFX, etc).
- Compare computational results with previous years data, and make necessary changes to the BEFAV design.
- Optimize BEFAV and propose any required changes to the initial concept and mission analysis.
- Prepare the first steps for experimental testing, to be started in 2023-2024.

Project Milestones

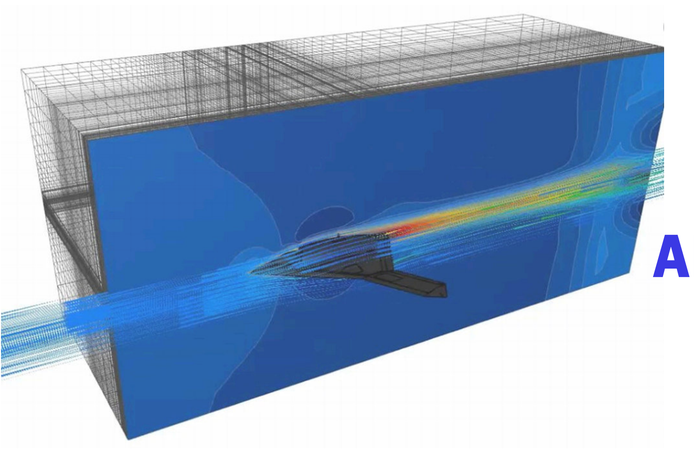
Year 3 (2023-2024):

- Fabricate BEFAV scaled-model structural components (such as wing, fuselage, landing gear, etc).
- Design and build a test platform to test the BEFAV model wind tunnel, in order to obtain aerodynamic and performance data. Compare experimental data with computational results.
- Design and build an experiment to access BEFAV model stress and strain behaviour.
- Redefine BEFAV component and perform new computational analyses as required.
- Compare experimental data with computational results.

Typical Project Team Structure



Project Team Structure

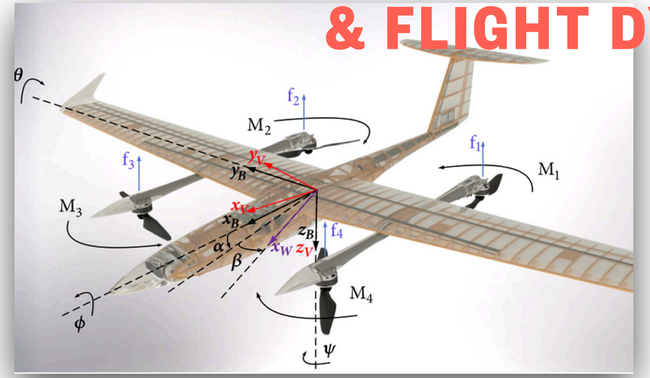


AERODYNAMICS & NOISE

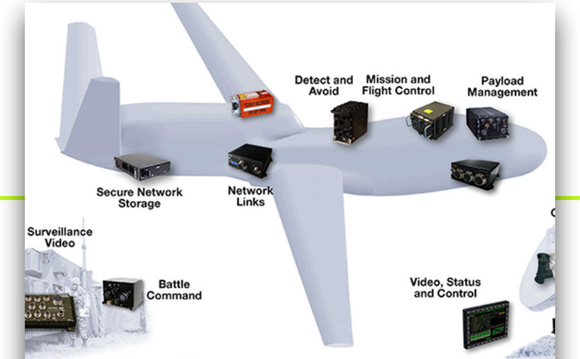
PROPULSION & INTEGRATION

5 GROUPS

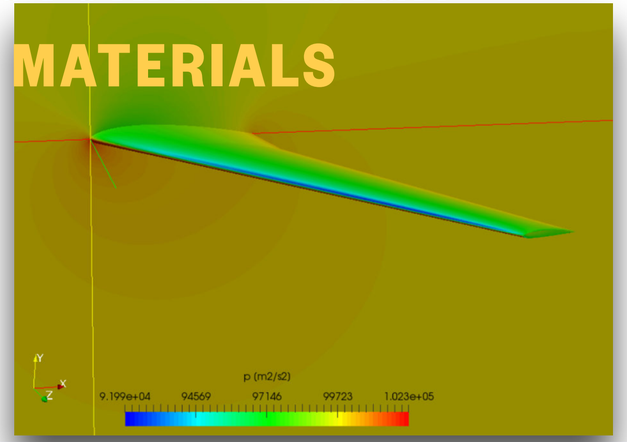
PERFORMANCE & FLIGHT DYNAMICS



AVIONICS



STRUCTURAL DESIGN & MATERIALS



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THANK YOU FOR YOUR INTEREST IN BEFAV

FOR MORE INFORMATION, CONTACT: JOANA.ROCHA@CARLETON.CA