NIBBIO

31th American Helicopter Society
Student Design Competition
Graduate Student Team Submission

POLITECNICO DI MILANO

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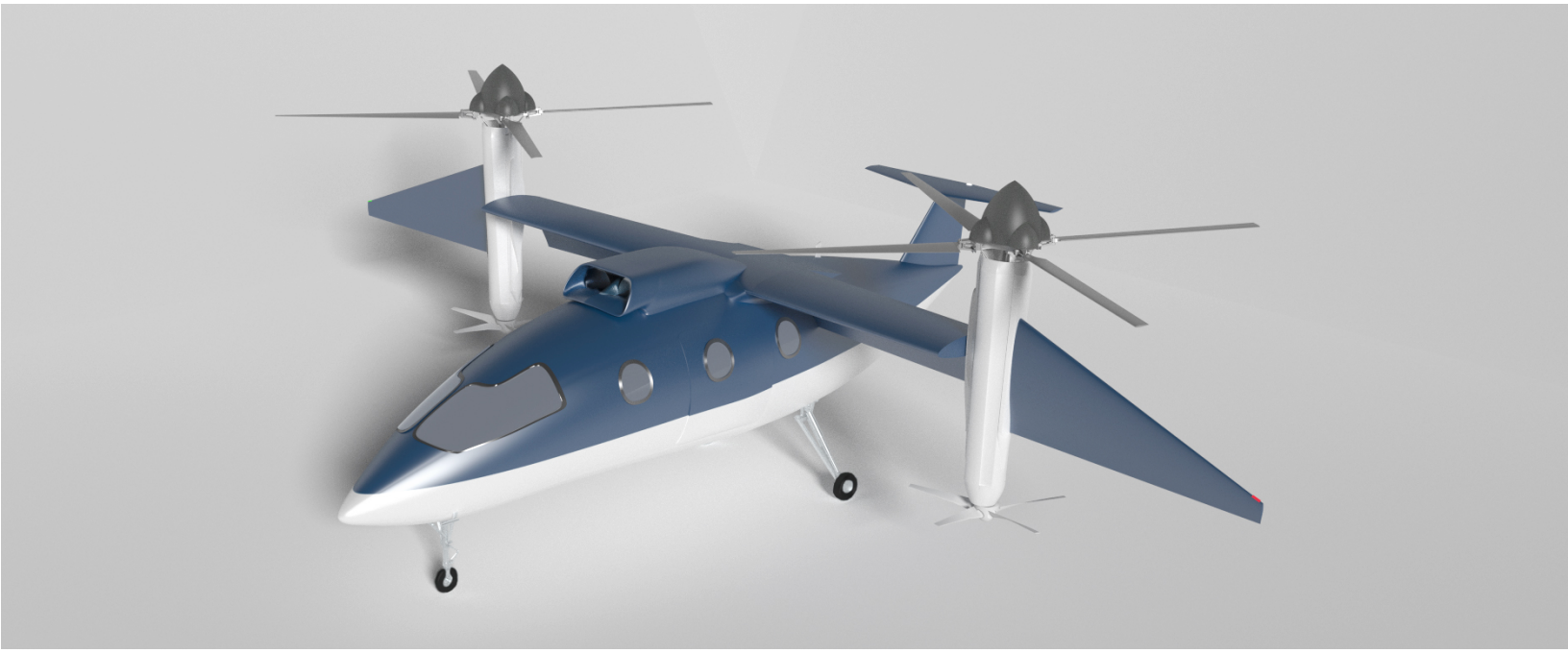
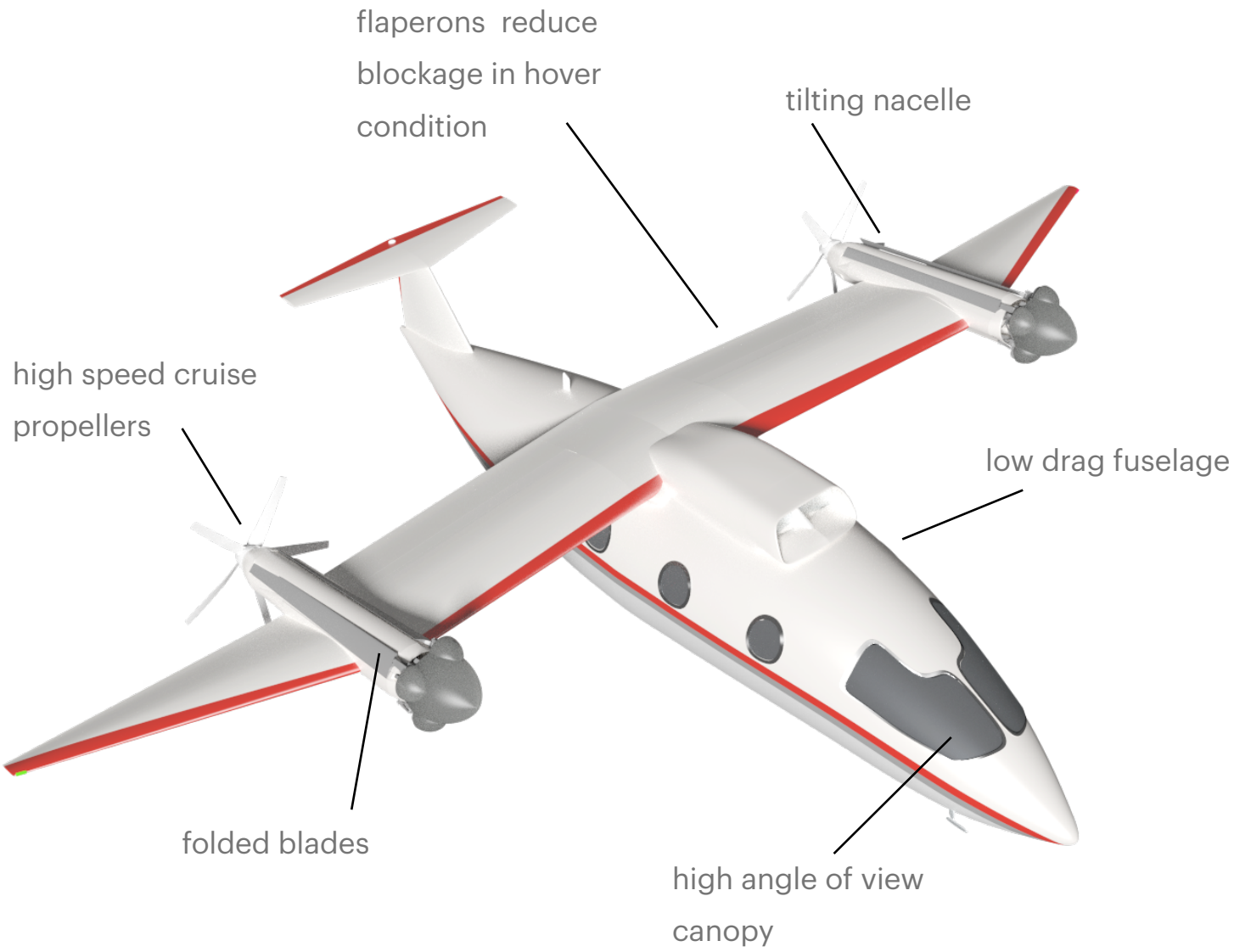
RFP Requirements	NIBBIO performance
TAS between 300 kt and 400 kt	399 kt TAS
Hover efficency within 25% of the ideal power loadign	figure of merit of 0.76
Cruise lift-to-drag ratio no less than 10	maximum lift to drag ratio of 19
Useful load fraction no less than 40% and Payload fraction no less than 12.5%	more than 12.5% of payload
Maximum gross weight between 10,000 lb and 12,000 lb	MTOW of 11,020 lb
Load factor structural capability at MGW at least -0.5G to +2G	Load factor between -1.0G and 2.5G

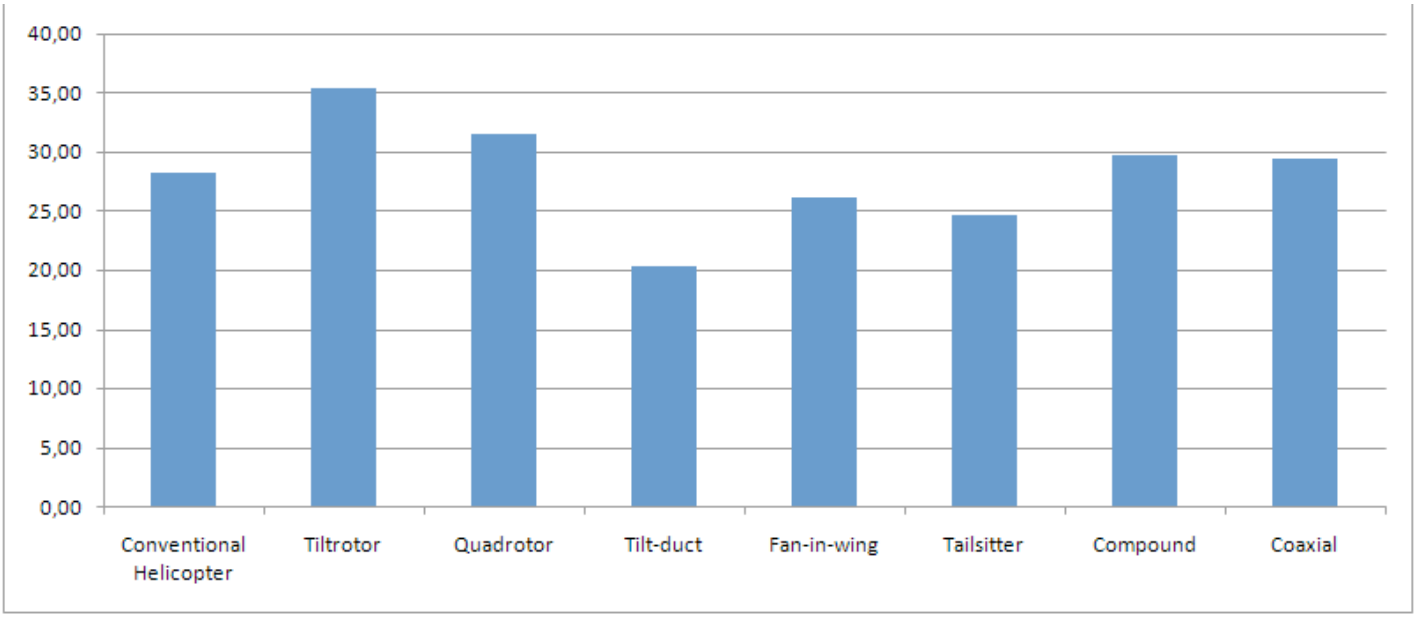
TEAM CAURUS



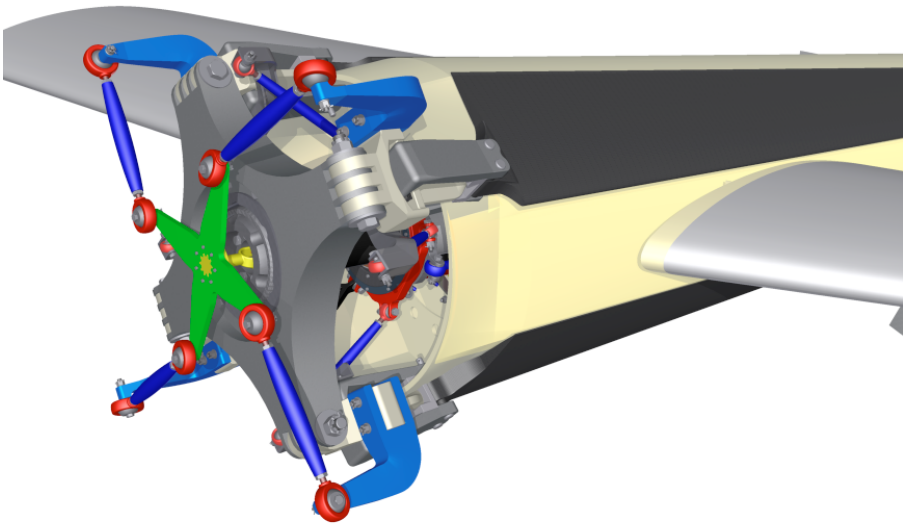
"Nibbio" is the Politecnico di Milano graduate team "Caurus" response to the RFP for the 31st AHS International Students Design Competition, cosponsored by AgustaWestland. Nibbio is a foldable blade tiltrotor with pusher propellers for cruising flight.
Nibbio has unprecedented capabilities considering the existing tiltrotors in terms of high hover efficiency, forward speed and lift-to-drag ratio.
The designed folding blade system (FBS) allows the usage of hover optimized rotorcraft blades in order to increase hover efficiency; in addition blades are folded after the transition through the FBS and two pusher propellers aid in the achievement of cruising speed between 300 kt and 400 kt. The outboard wing increase the aspect ratio and aid to reach high lift-to-drag ratio.



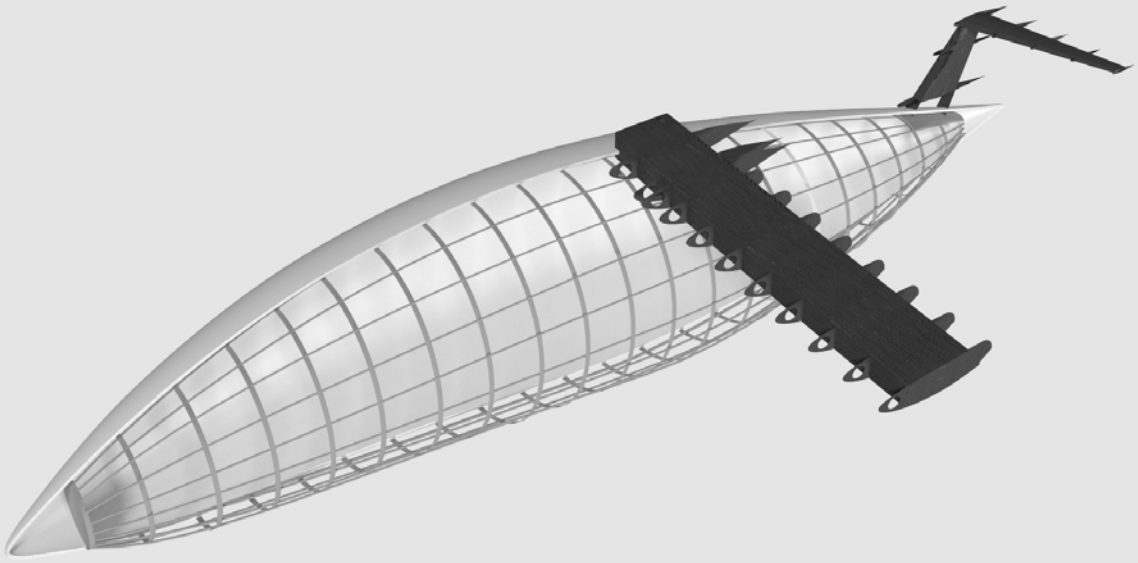
To maximize performance “NIbbio“ has been designed so that every component can adapt to the configuration, granting the best performance possible.



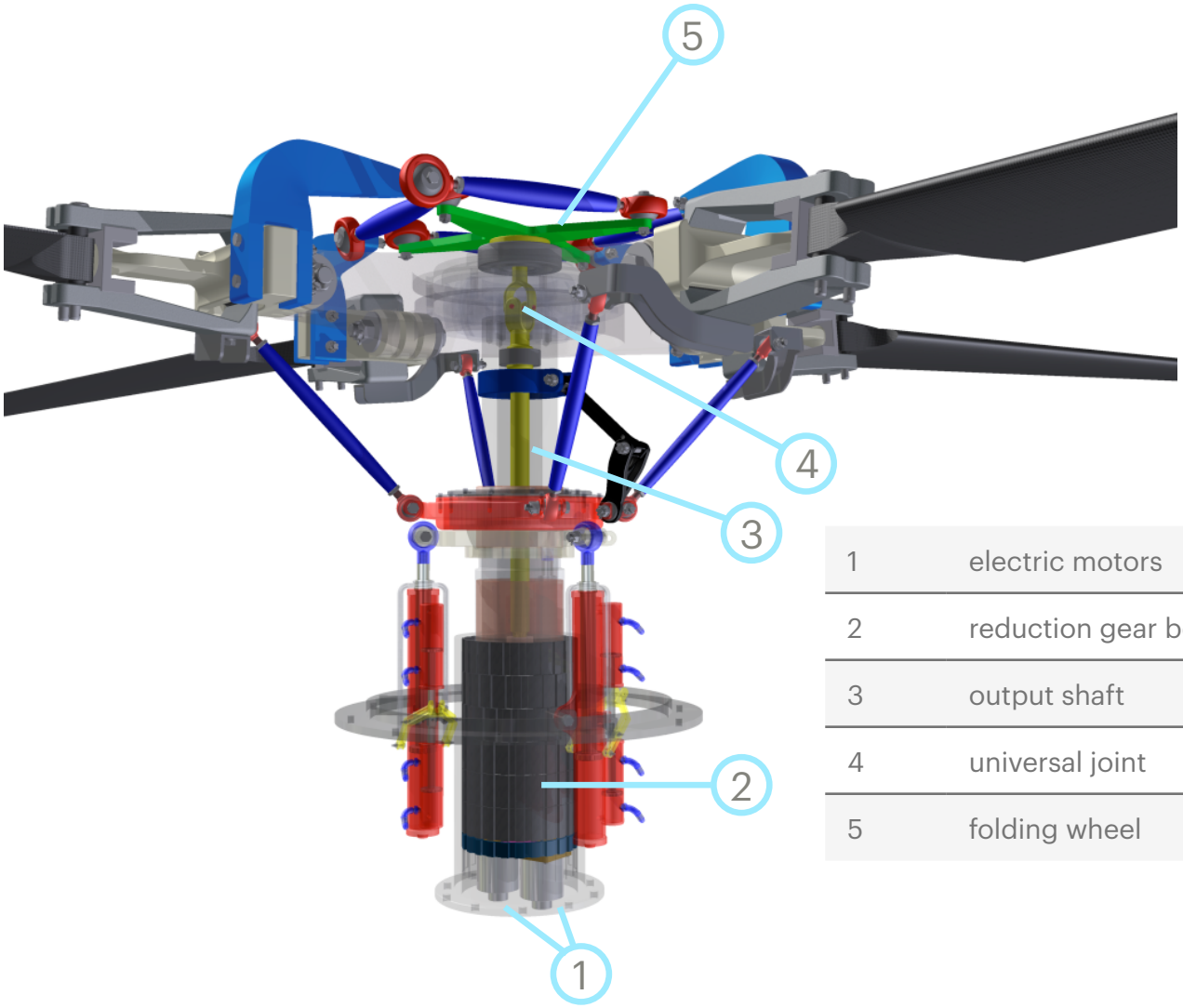
The first important issue to face in a vertical take off and landing aircraft design is configuration. In order to make the most proper choice possible the possibilities have been carefully analyzed. Score obtained by different architecture through an analytical hierarchical process (AHP) were compared. Results show that tiltrotor provides better high speed, range, payload fractions and altitude capabilities respect to the other configurations. These characteristics made titlrotor the best initial configuration candidate.



To achieve the requirements presented in the RFP team Caurus developed a folding blades system, which allows to have high performances both in hover and horizontal flight. This kind of solution allows to use a hover optimized rotor and a propeller designed for high speed, without substancially increasing drag.



Composite materials have been emplyoed for the wing and the tail to reduce weight. Fuselage have been designed to be in alluminum alloy to grant safety and integrity to the structure, but at the same time a glare paneling has been chosen to enhance the weight reduction.



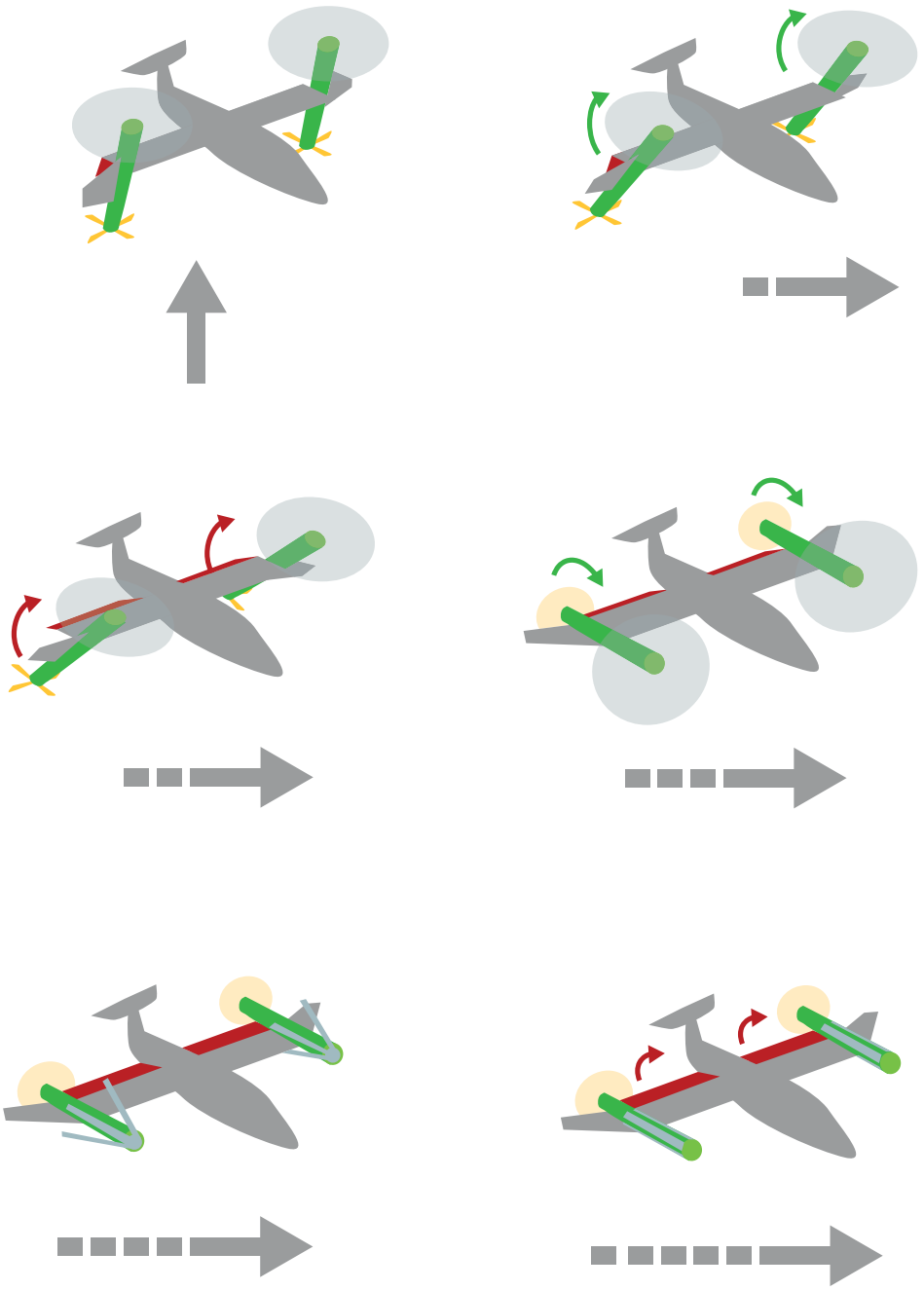
1	electric motors
2	reduction gear box
3	output shaft
4	universal joint
5	folding wheel

The main rotors are designed with a hingeless architecture

A flexbeam acts as flapping/lag hinge granting a flapping frequency of 1.2

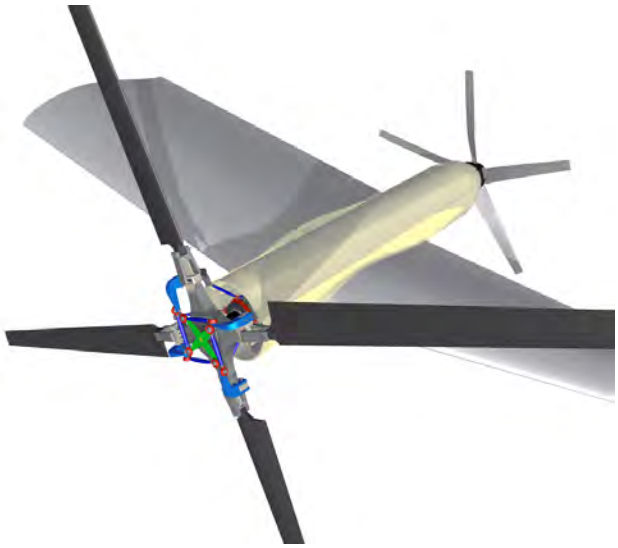
Pitch links allow changes in the pitch attitude of the blade

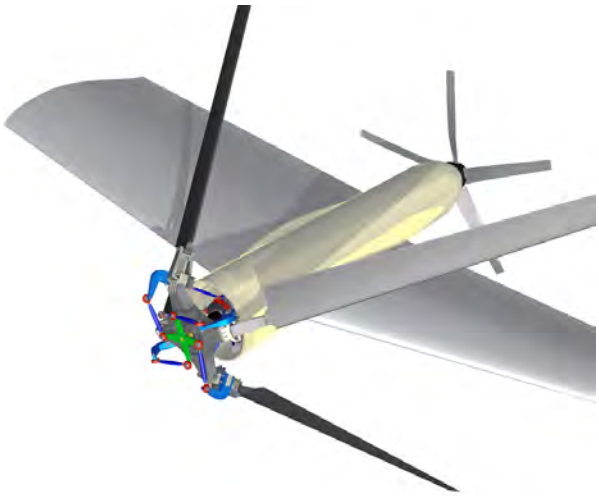
A gimbal joint permits roll and pitch rotations

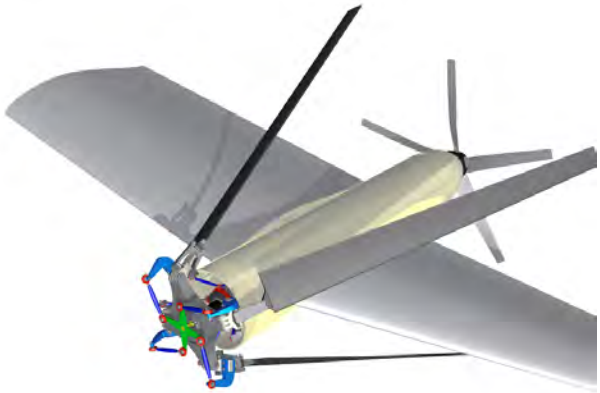


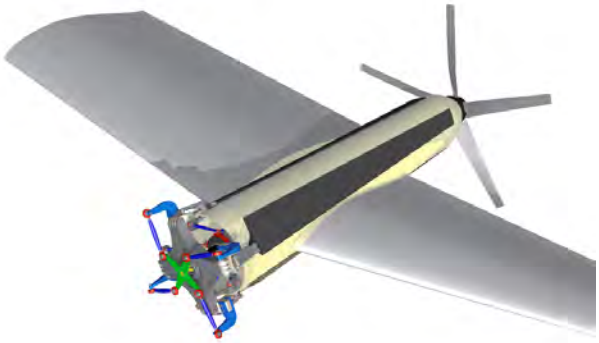
both vertical and traditional take off and landing are possible
dual propulsion system :

- rotor blades for hover operation and vtol
- rear propellers for high speed cruise
- nacelles and outboard wings are tilted to change configuration
- front rotors can be stopped and folded



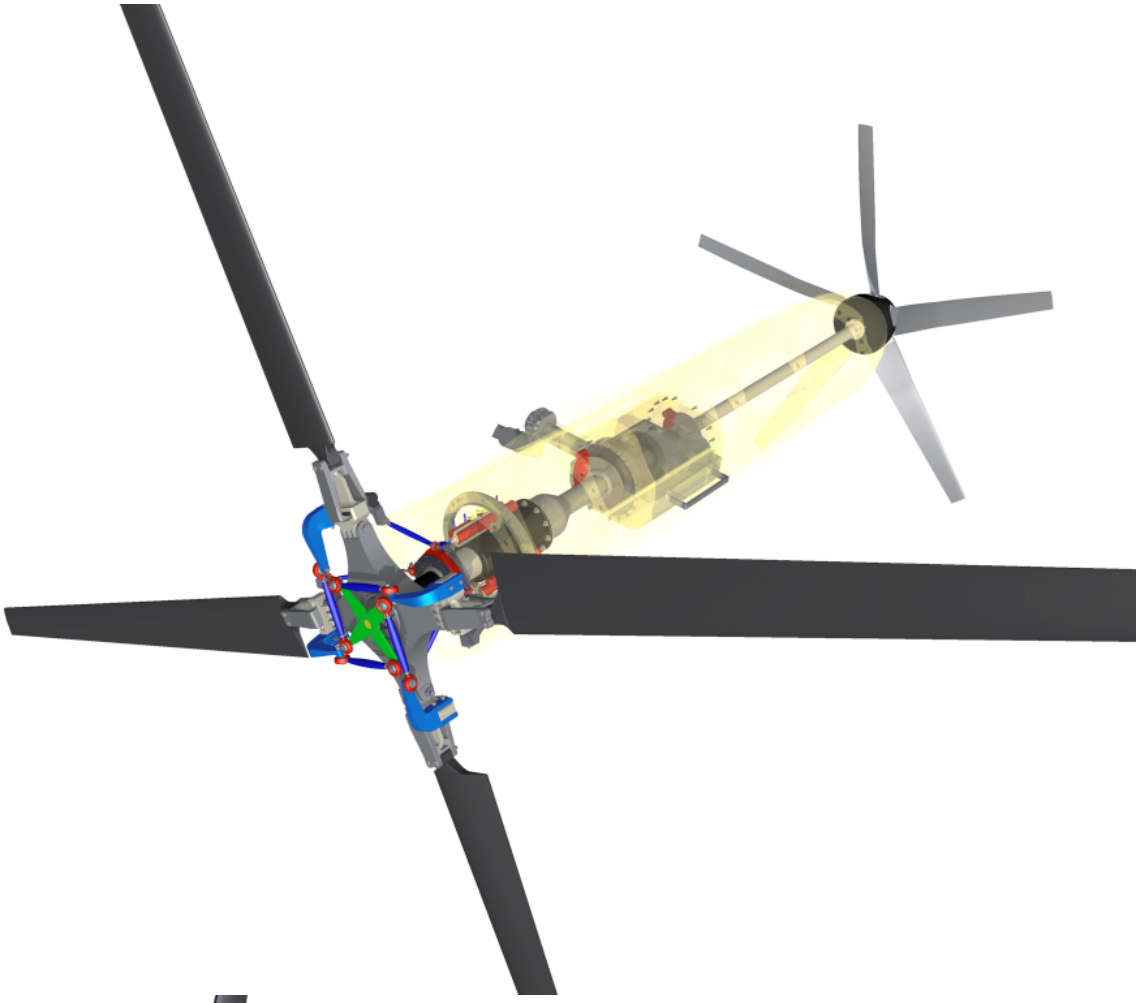


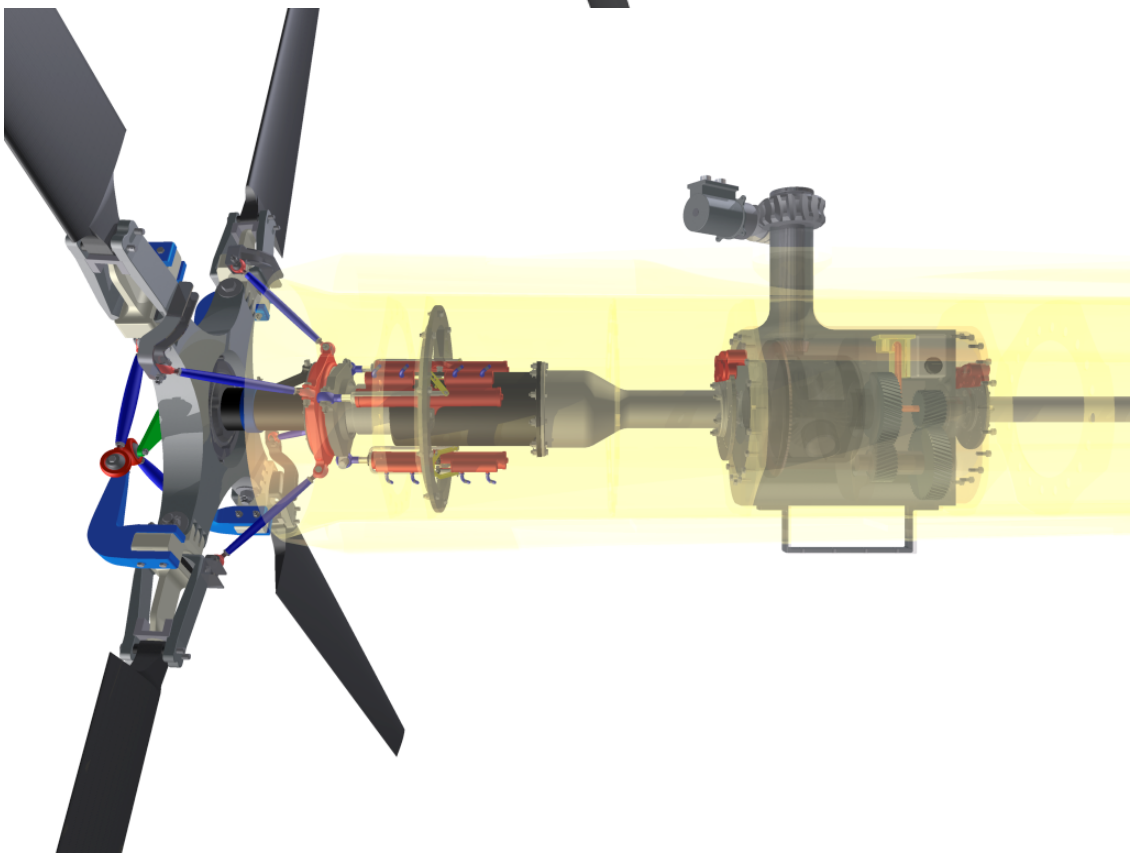


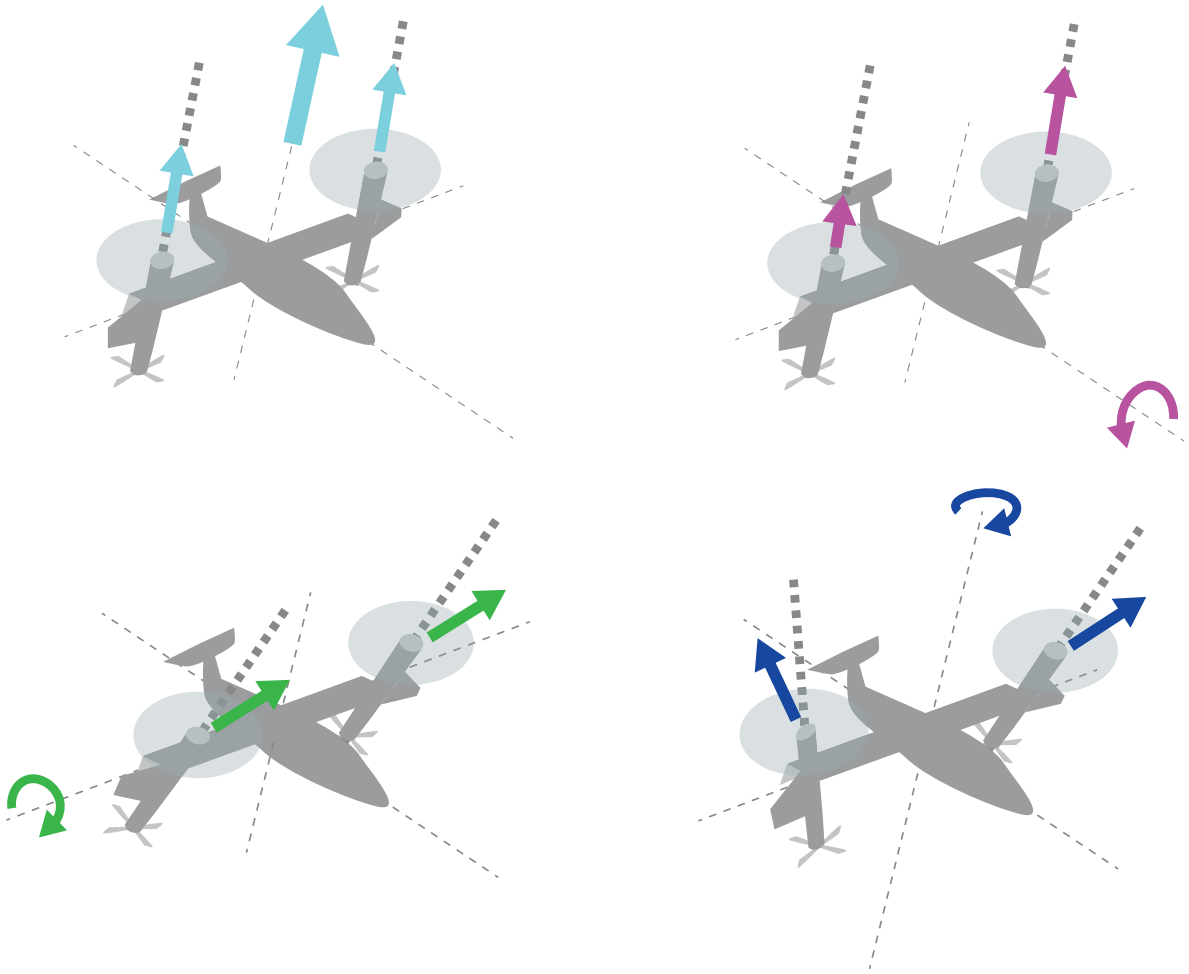


When rear propellers are acceleretad, front rotors are slowed and stopped.

The rotor blades can be folded around a mechanical hinge and accomodated along the nacelles to reduce drag.





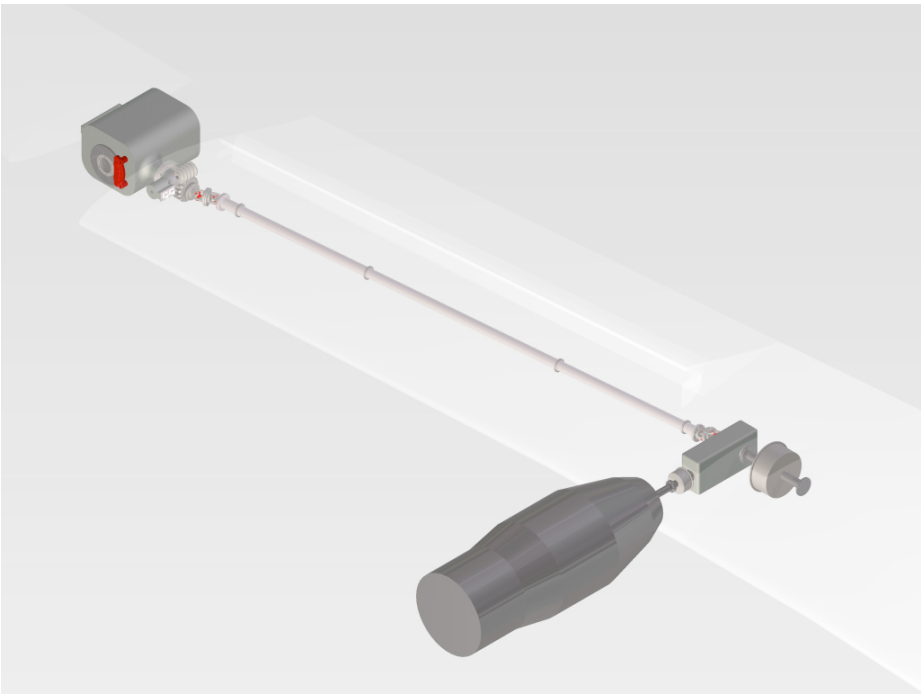


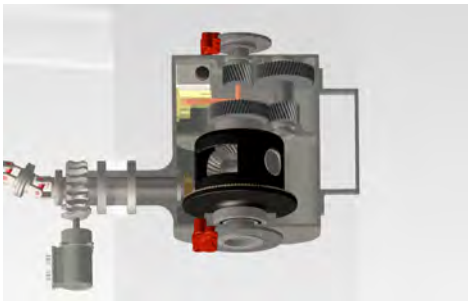
helicopter mode:

- classical helicopter controls: lateral, longitudinal cyclic and collective pitch
- synchronous and differential tilting of the nacelles grant additional control capabilities

airplane mode:

- traditional control surfaces are employed: ailerons, rudder, elevators



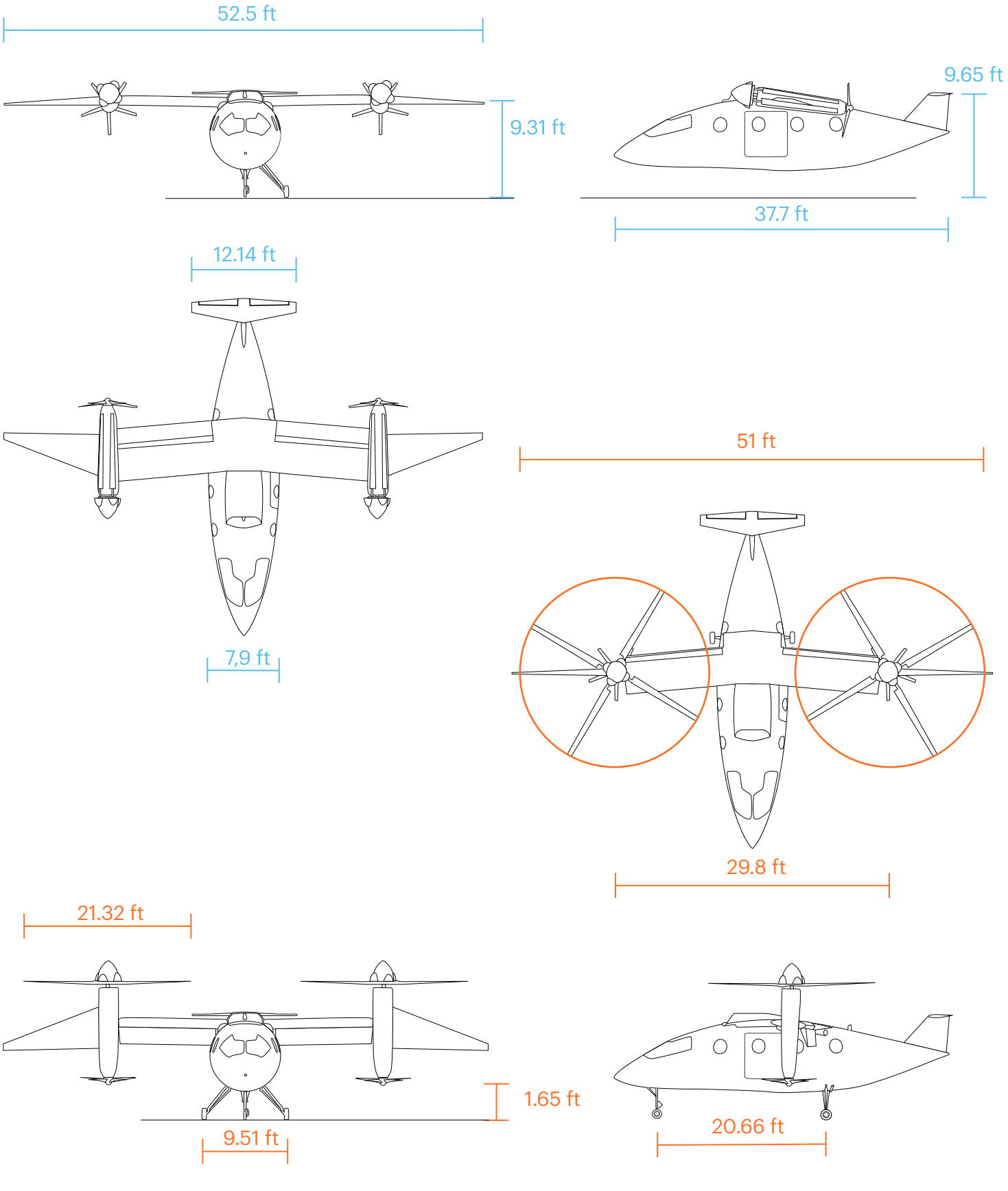


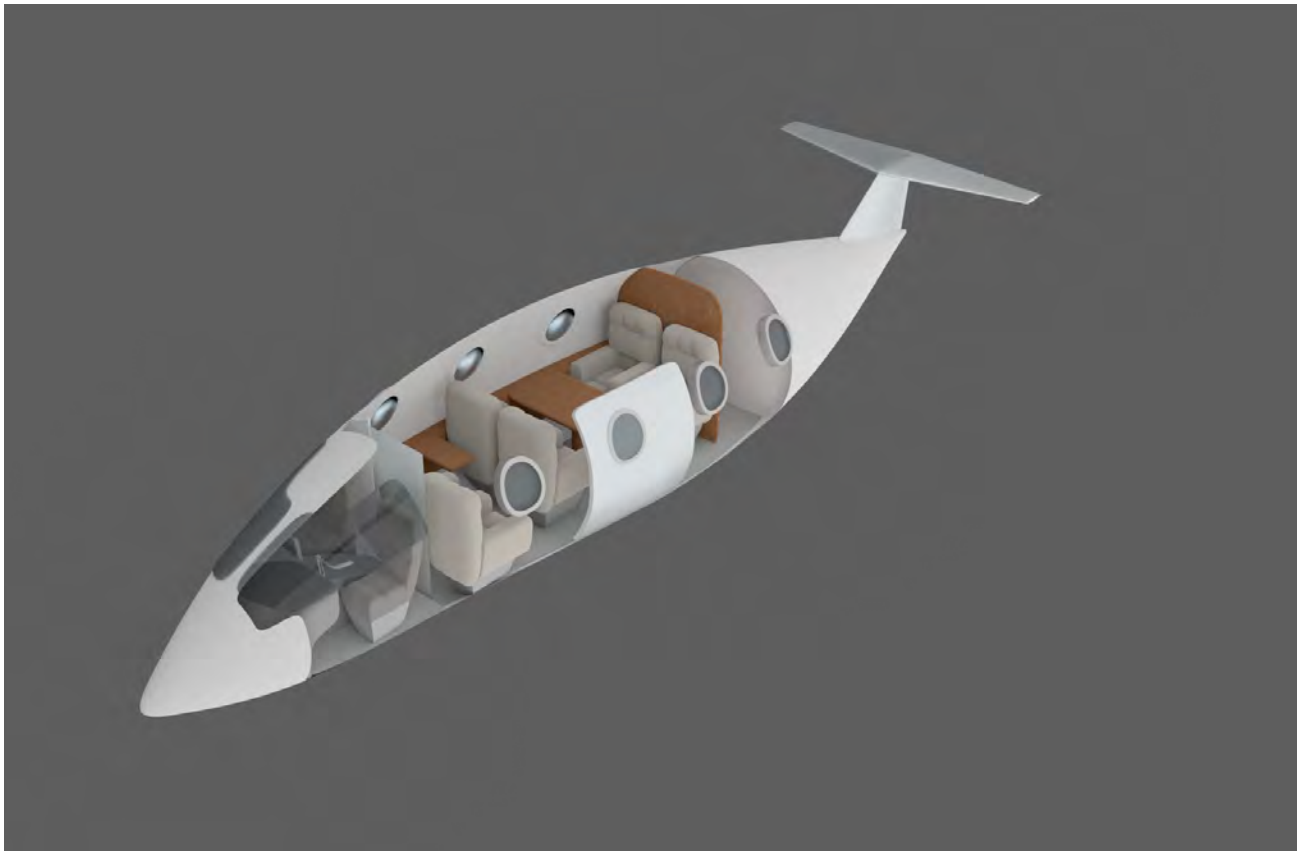
Two gearboxes are employed with a reduction ratio of 60:1.

The first, inside the nacelle, distributes mechnical power between the propeller and the rotr shafts.

The second, placed in the root section of the wing, reduces the shaft angular velocity

The two gearboxes are jointed together by a double CV joint aluminum shaft, running along the wing.

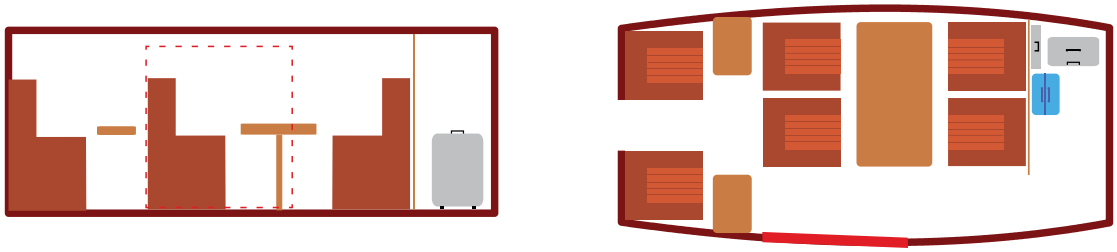

52.5 ft
9.31 ft
9.65 ft
37.7 ft
12.14 ft
7,9 ft
51 ft
29.8 ft
21.32 ft
1.65 ft
9.51 ft
20.66 ft



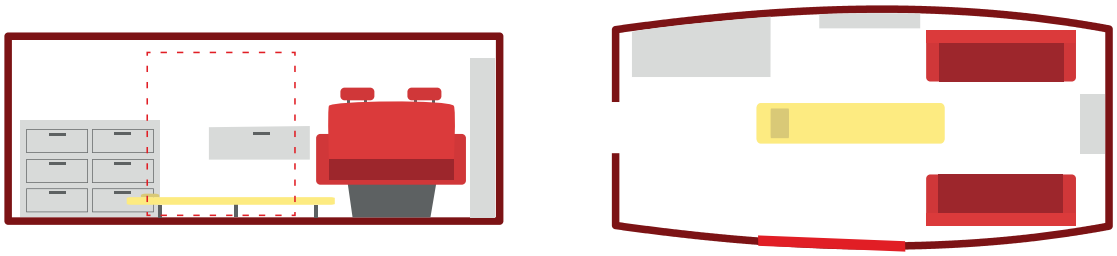
Every interior detail has been carefully designed to grant maximum comfort and leave all the necessary room.

Pilot comfort is guaranteed by the wide angles of view and the glass cockpit which allowing situation awareness.

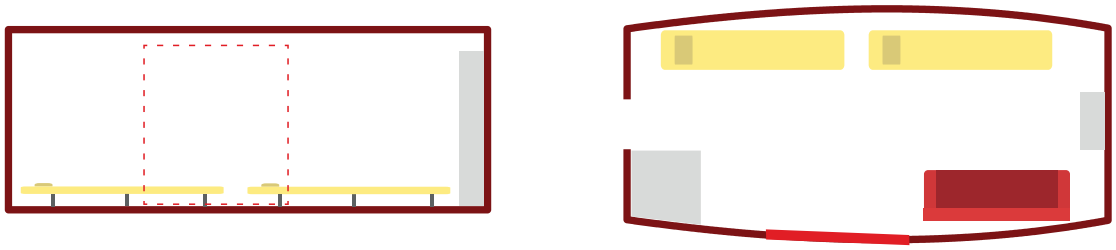
Business and air taxi



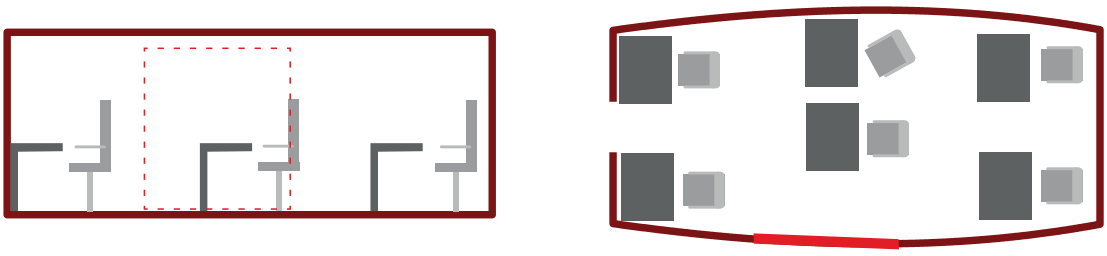
Search and rescue



Emergency medical service



Law enforcement



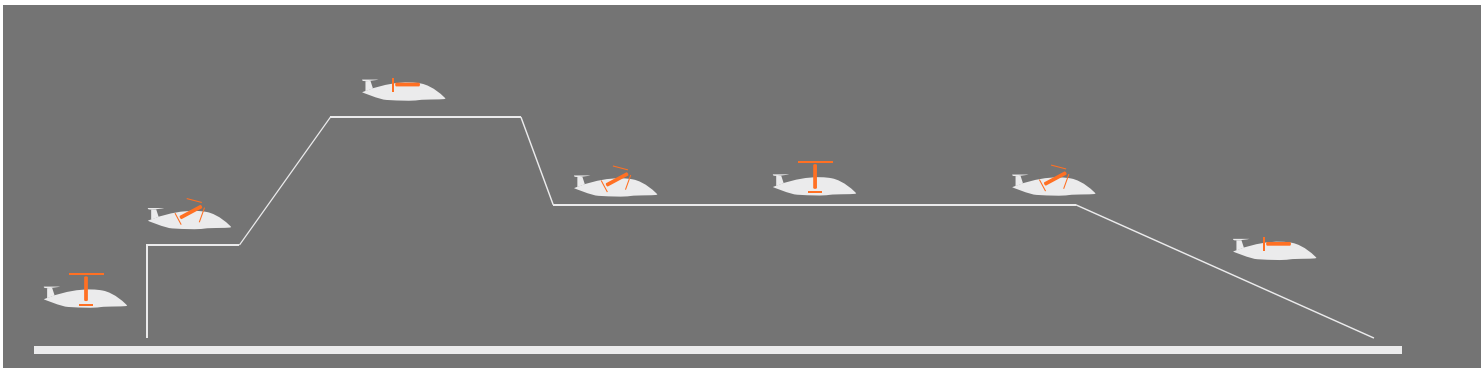
“Nibbio” is intended for different type of mission being able to offer not only high performance but also versatility and interior comfort in any situation.

RFP requirements and mission profile

The 31st AHS RFP specified some design point that must be satisfy.

- High sustained speed: the RFP states that the aircraft must sustained high speed flight at TAS between 300 kt and 400 kt.
- Hover efficiency: aircraft hover efficiency within 25% of the ideal power loading.
- Lift-to-drag ratio requirements: lift-to-drag ratio must be no less than 10.
- Weight requirements: maximum gross weight between 10,000 lb and 12,000 lb.
- Useful load & payload requirements: no less than 40% gross weight useful load and no less than 12.5% gross weight must be granted.

Useful load is defined as the aggregate weight of the fuel, flight crew and test equipment, and payload.



Performance

- MTOW of 11,020 lb

Optimized for hover efficiency, speed and lift-to-drag ratio

- MTOW hover efficiency: 0.86 (da rivedere)
- MTOW maximum sustained speed: 399 KTAS at 85% MCP - 20,850 ft
- maximum lift-to-drag ratio: 19.45 @ msl

Good VTOL rate of climb: 1700 ft/min

High aircraft rate of climb of 4500 ft/min till 10,000 ft