



**“CLEAN SKY 2” RACER TECHNOLOGICAL DEMONSTRATOR
FAST COMPOUND ROTORCRAFT:
NEED OF CERTIFICATION & OPERATIONAL RULES EVOLUTION ?**

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Overview

- 1. The CleanSky2 program for Airbus Helicopters**
- 2. Why a fast rotorcraft?**
- 3. The RACER demonstrator configuration**
- 4. How this Fast Rotorcraft is running**
- 5. First analysis of certification requirements**
- 6. Operational aspects**
- 7. Summary and Conclusions**

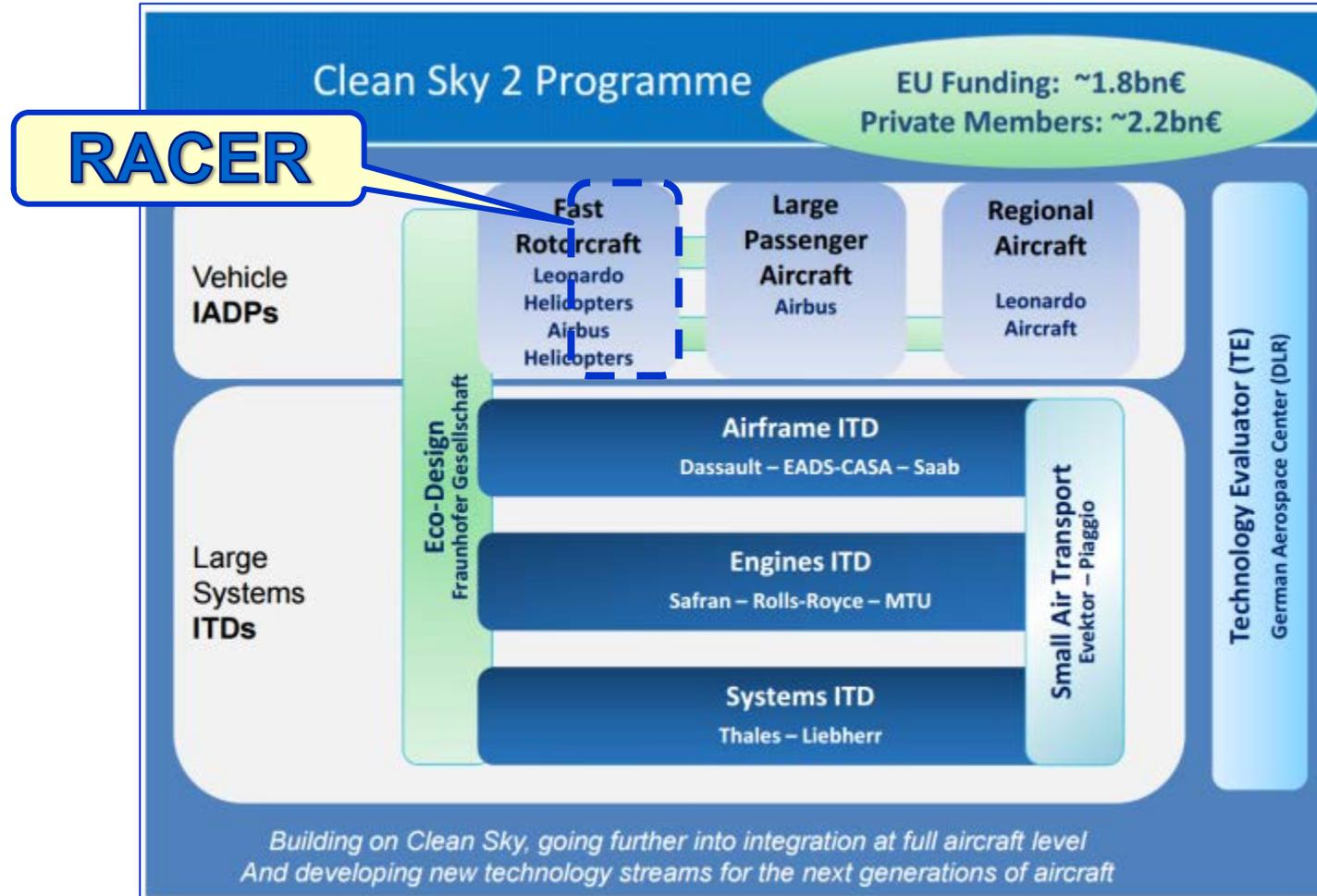


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CleanSky2 program for Airbus Helicopters: RACER Demonstrator



Clean Sky 2 is an European funded Research Program

RACER demonstrator is one of the 2 demonstrators to be built inside the Innovative Aircraft Demonstrator Platform⁽¹⁾ “Fast Rotorcraft”

RACER is based on a compound rotorcraft concept (VTOL⁽²⁾) initially evaluated with the Airbus Helicopters X³ demonstrator

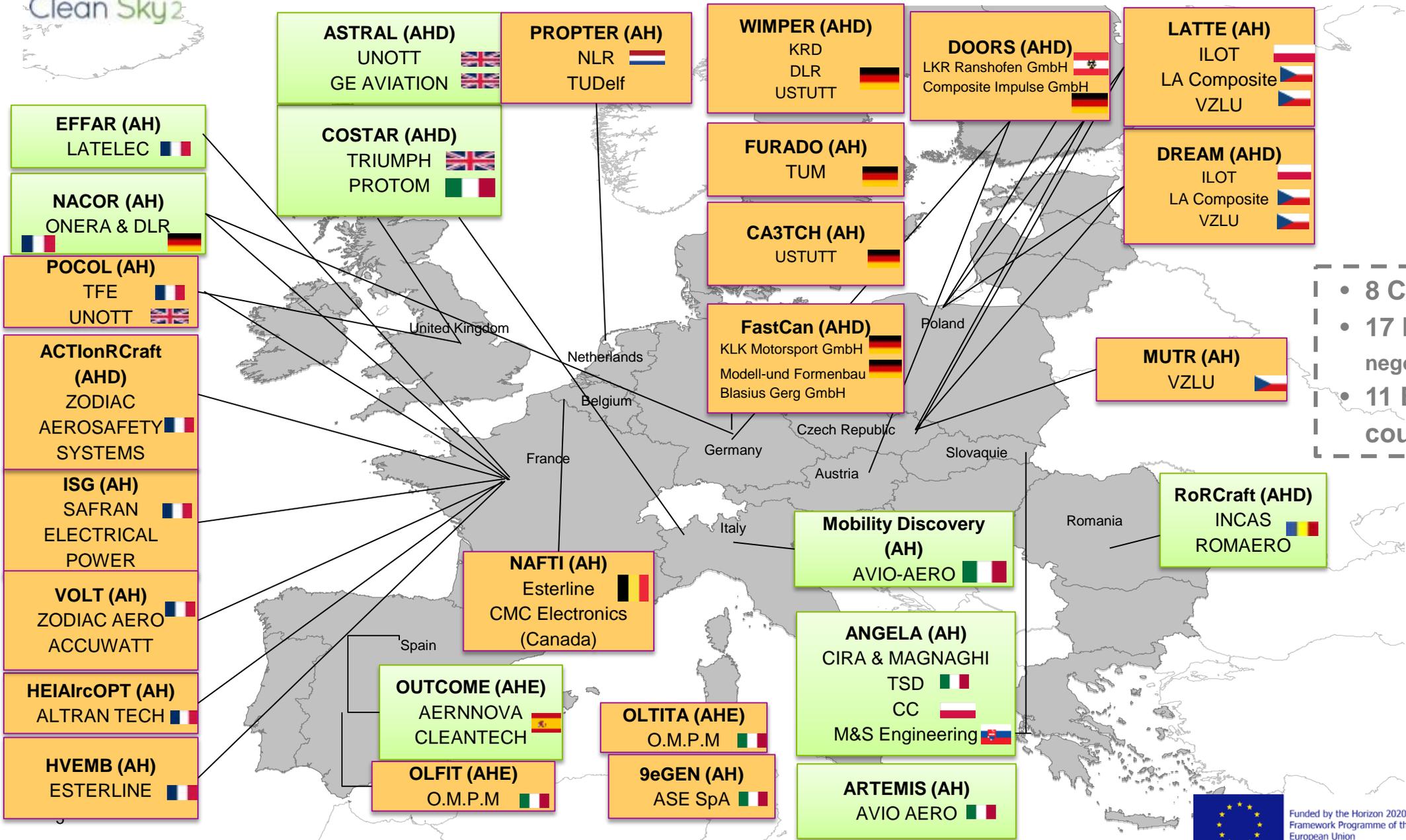
⁽¹⁾ IADP: Innovative Aircraft Demonstrator Platform

⁽²⁾ VTOL: Vertical Take-Off & Landing





RACER Partnership



- EFFAR (AH)**
LATELEC
- NACOR (AH)**
ONERA & DLR
- POCOL (AH)**
TFE UNOTT
- ACTionRCraft (AHD)**
ZODIAC AEROSAFETY SYSTEMS
- ISG (AH)**
SAFRAN ELECTRICAL POWER
- VOLT (AH)**
ZODIAC AERO ACCUWATT
- HEIAIrcOPT (AH)**
ALTRAN TECH
- HVEMB (AH)**
ESTERLINE

- ASTRAL (AHD)**
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- COSTAR (AHD)**
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- PROPTER (AH)**
NLR TUDelf

- WIMPER (AHD)**
KRD DLR USTUTT

- FURADO (AH)**
TUM

- CA3TCH (AH)**
USTUTT

- FastCan (AHD)**
KLK Motorsport GmbH Modell-und Formenbau Blasius Gerg GmbH

- DOORS (AHD)**
LKR Ranshofen GmbH Composite Impulse GmbH

- LATTE (AH)**
ILOT LA Composite VZLU

- DREAM (AHD)**
ILOT LA Composite VZLU

- MUTR (AH)**
VZLU

- NAFTI (AH)**
Esterline CMC Electronics (Canada)

- Mobility Discovery (AH)**
AVIO-AERO

- RoRCraft (AHD)**
INCAS ROMAERO

- OUTCOME (AHE)**
AERNNOVA CLEANTECH

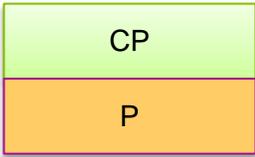
- OLTITA (AHE)**
O.M.P.M

- ANGELA (AH)**
CIRA & MAGNAGHI TSD CC M&S Engineering

- OLFIT (AHE)**
O.M.P.M

- 9eGEN (AH)**
ASE SpA

- ARTEMIS (AH)**
AVIO AERO



- 8 Core-partners
- 17 Partners (+ 5 : negotiations in progress)
- 11 European countries

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Compound rotorcraft objectives: fill a gap mobility

ROTORCRAFT MISSIONS

- EMS, SAR,
- Coast guard
- Disaster relief
- Oil & Gas offshore
- Corporate Transport
- Air Taxi



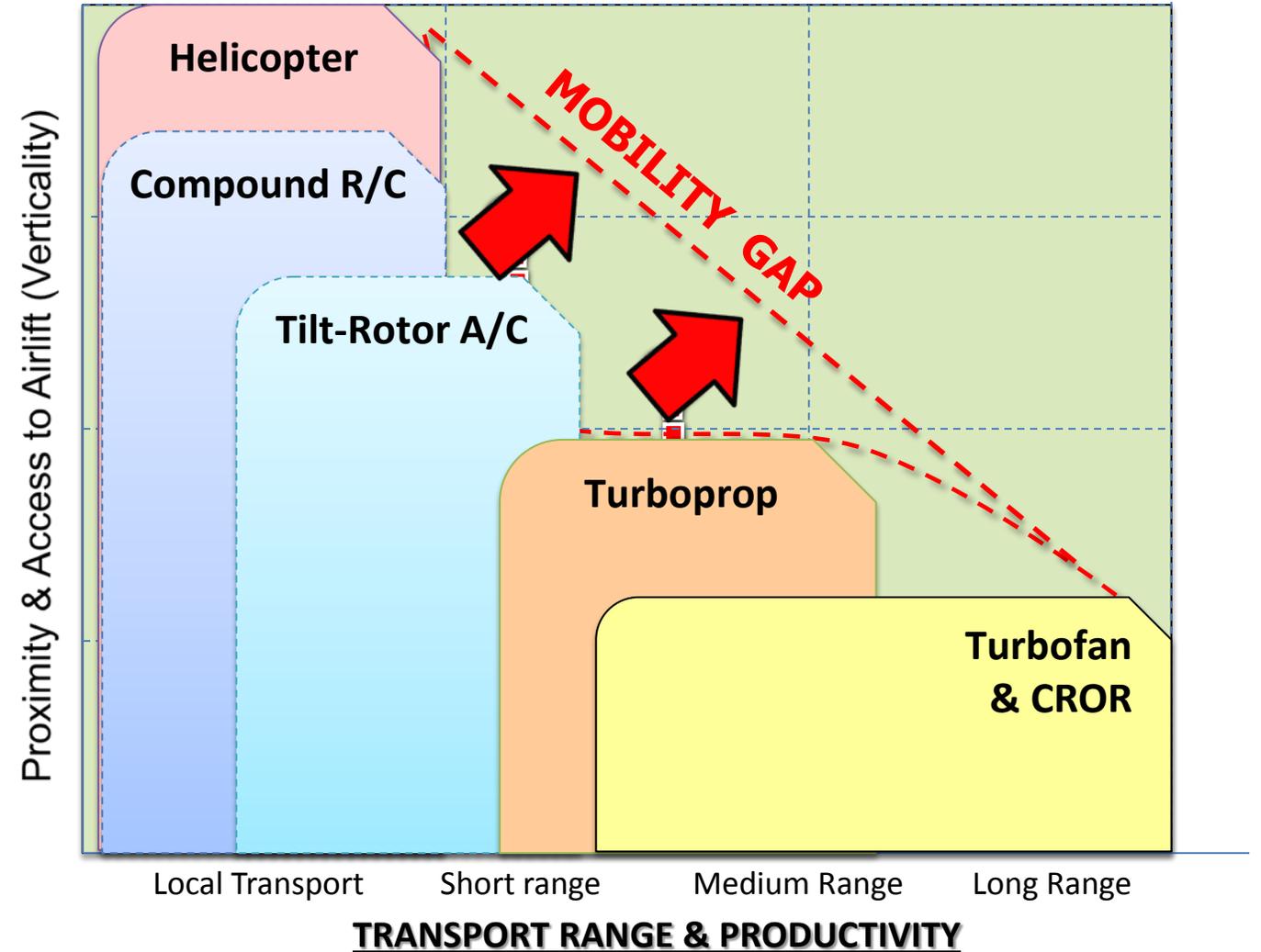
AIRFIELD

Unprepared Area
Helideck
(Door-to-Door transport)

Heliport
Local airfield

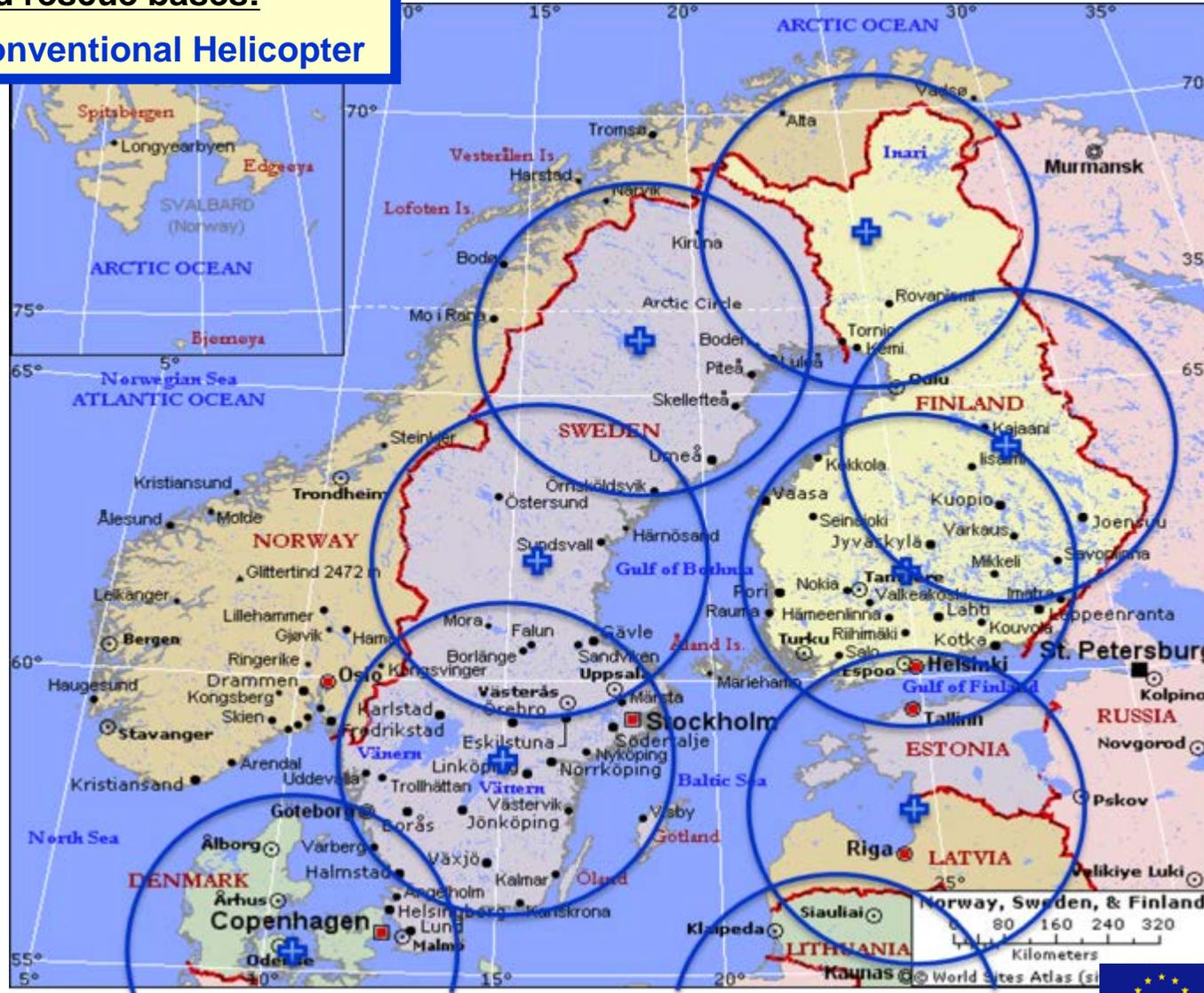
Regional
Airport

Large
Airport



Fast Rotorcraft: save more people with lower infrastructure

**Required rescue bases:
8 bases with conventional Helicopter**

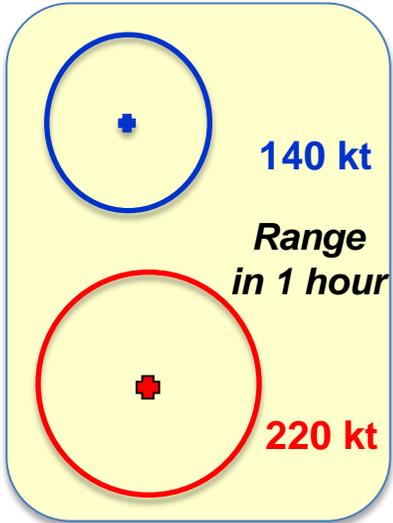
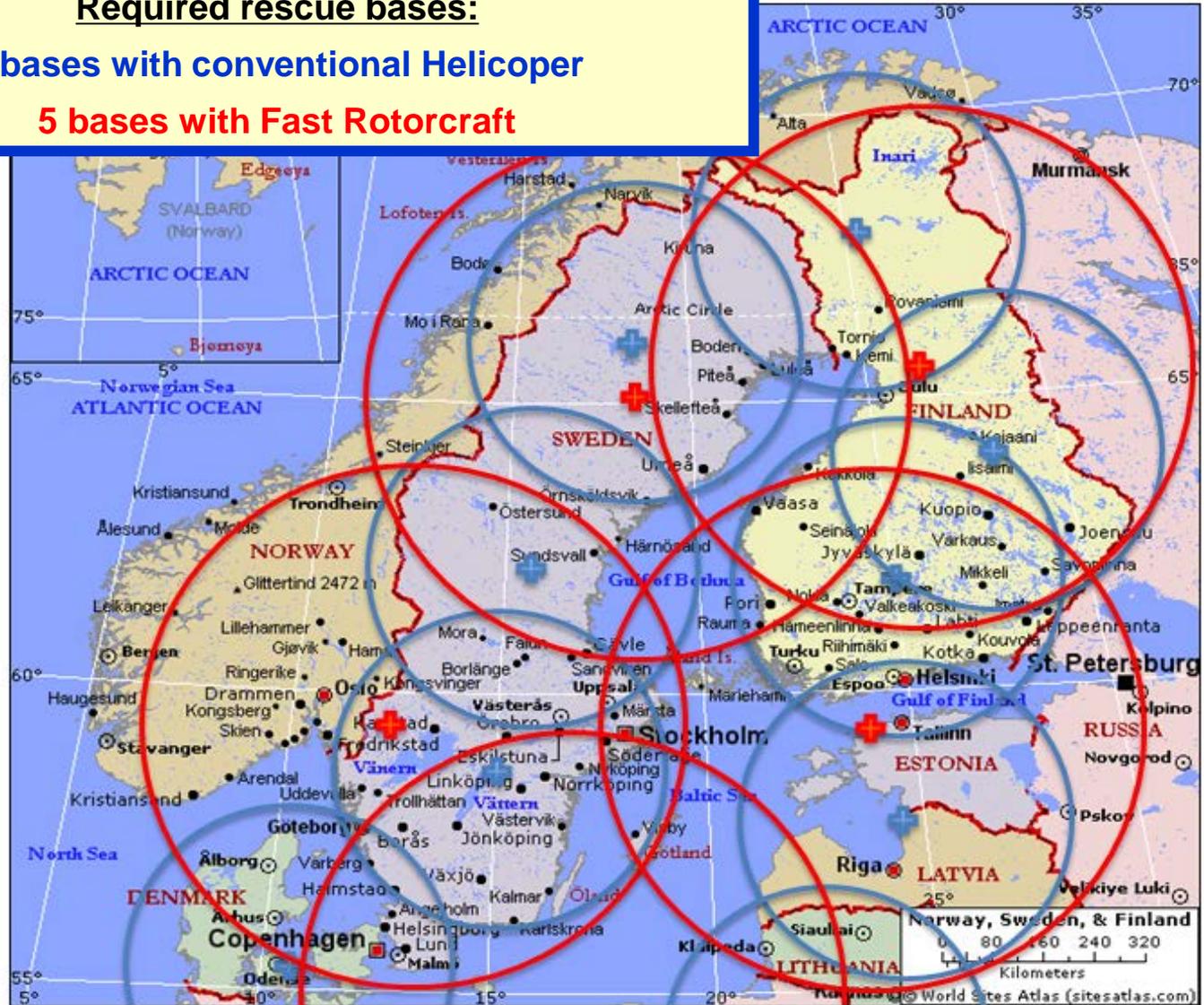


140 kt
Range
in 1 hour

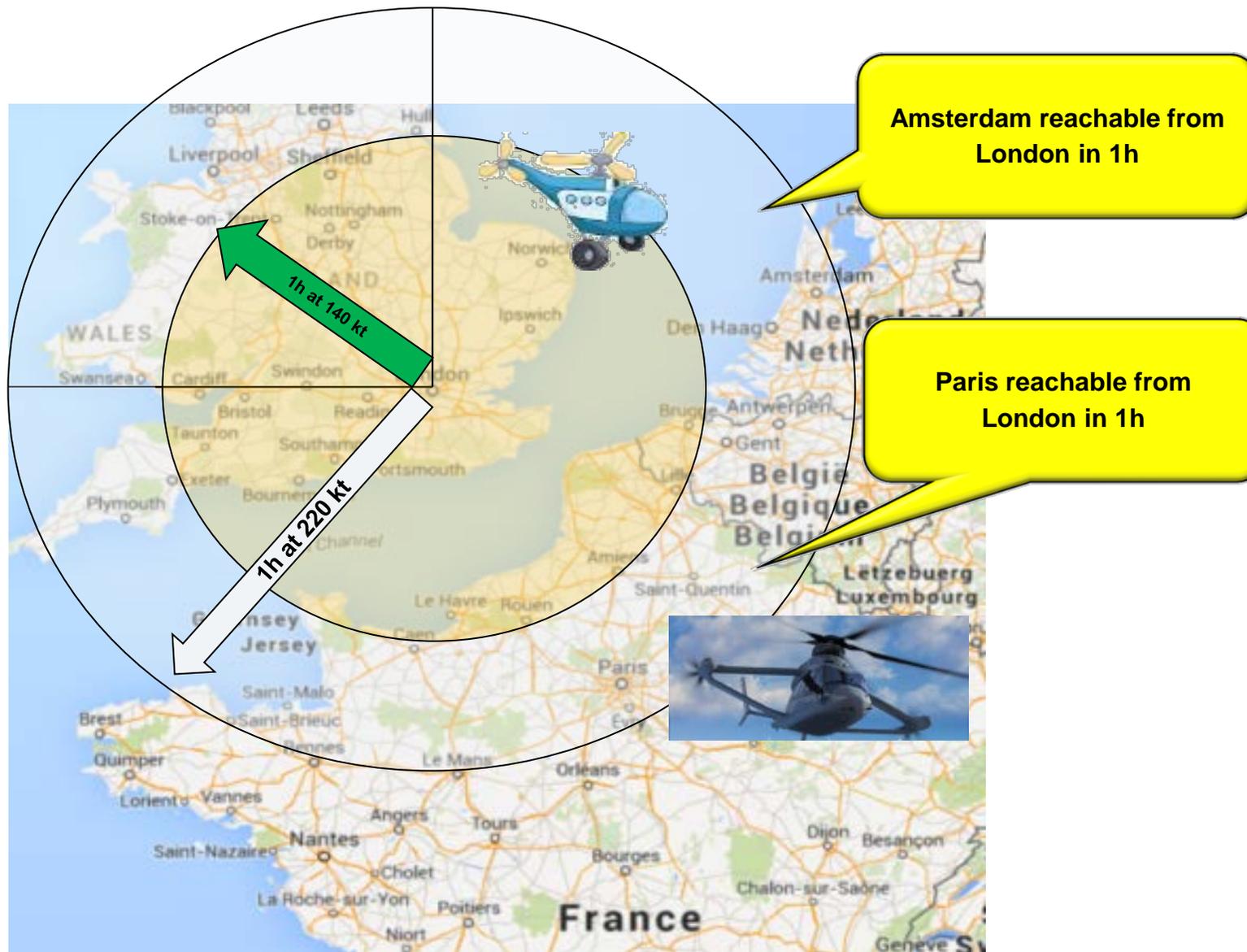


Fast Rotorcraft: save more people with lower infrastructure

Required rescue bases:
8 bases with conventional Helicopter
5 bases with Fast Rotorcraft



Fast Rotorcraft: new perspectives for door to door pax transport



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The X³ demonstrator technology

Reuse logic of X³ demonstrator: Go fast and at very reduced development cost, by reusing existing AH fleet components, and focus innovation only on specific fields

2 x RTM 322 engines

AH 155 Main Rotor (not any modification)

Specific horizontal stabilizer and vertical fins

Main Gearbox derived from H175

AH Dauphin fuselage

Wing specifically developed to bring 40 to 50% of the total lift

Transmission gearboxes developed specifically for the lateral rotors

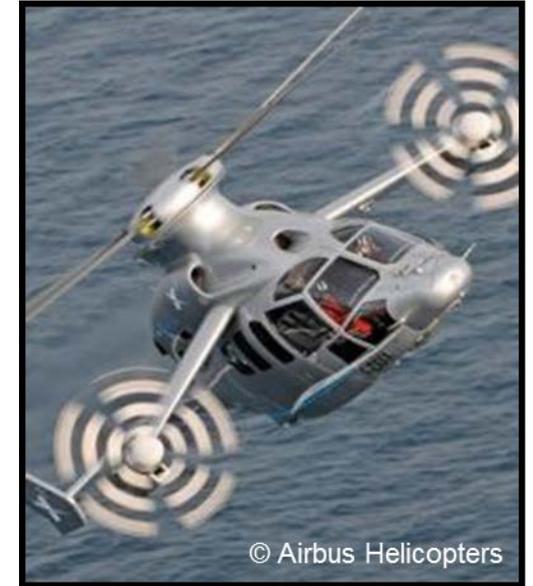
Off-the-shelf Propellers (lateral rotors) taken from turboprop aviation (thrust & anti-torque functions)



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CAPABILITIES OF THE FORMULA – X³ ACHIEVEMENTS

- 1st flight: 6th September 2010
- Last flight: 23rd July 2013
- Total of 157 flight hours (199 flights)
- TAS: 255kt in level flight
263kt in descent
- Z σ : 13000ft
- Vertical speed: + 8000ft / min @ 110kt (+45° nose up)
- 8000ft/min @ 160kt (-30° nose down)
- Roll attitude: +/- 60° up to 210kt in (level flight)
-100° during wingovers (flight demo)
- Loads factor: 2.3g @ 150kt
- Rotor RPM: 282 to 312 rpm in hover
288 to 312 rpm in level flight @ 220kt
- Max Mach number at blade tip: 1,02
- Max advance ratio (μ) = 0.67
- Autorotation feasibility demonstrated: descent rate @ 2800 ft/min
- Dozens of helicopter pilots flown X³ and piloted it very easily



RACER technological demonstrator objectives

Not an airplane, better than a helicopter: a compound rotorcraft that retains the best of both.

Unique capabilities:

- Hover/Vertical flight: as good as an helicopter
- Cruise speed exceeding 220 kt (410 km/h)

Meet expectations for citizens' health & safety, door-to-door mobility, environment protection:

- Shorter time for Rescue & Emergency, Air Taxi
- Acoustic footprint & CO2 emission lower than helicopter (*)
- Eco-friendly materials, greener life cycle

This comprehensive demonstration will:

- De-risk the integration of this new configuration thru the supply chain
- Pave the way for development & marketing of a competitive product

(*) *Same Max take-off weight class*



**Continue with RACER
To prepare a competitive product**



The RACER demonstrator configuration



Main rotor head

- Full fairing

H-tail

- Minimization of wake impact
- Small horizontal surface

Tail boom

- Asymmetric cross section
- Improved hover performance

Lateral rotors

- Pusher configuration
- Rotor disc out of cabin area

Pilot door

Sliding door

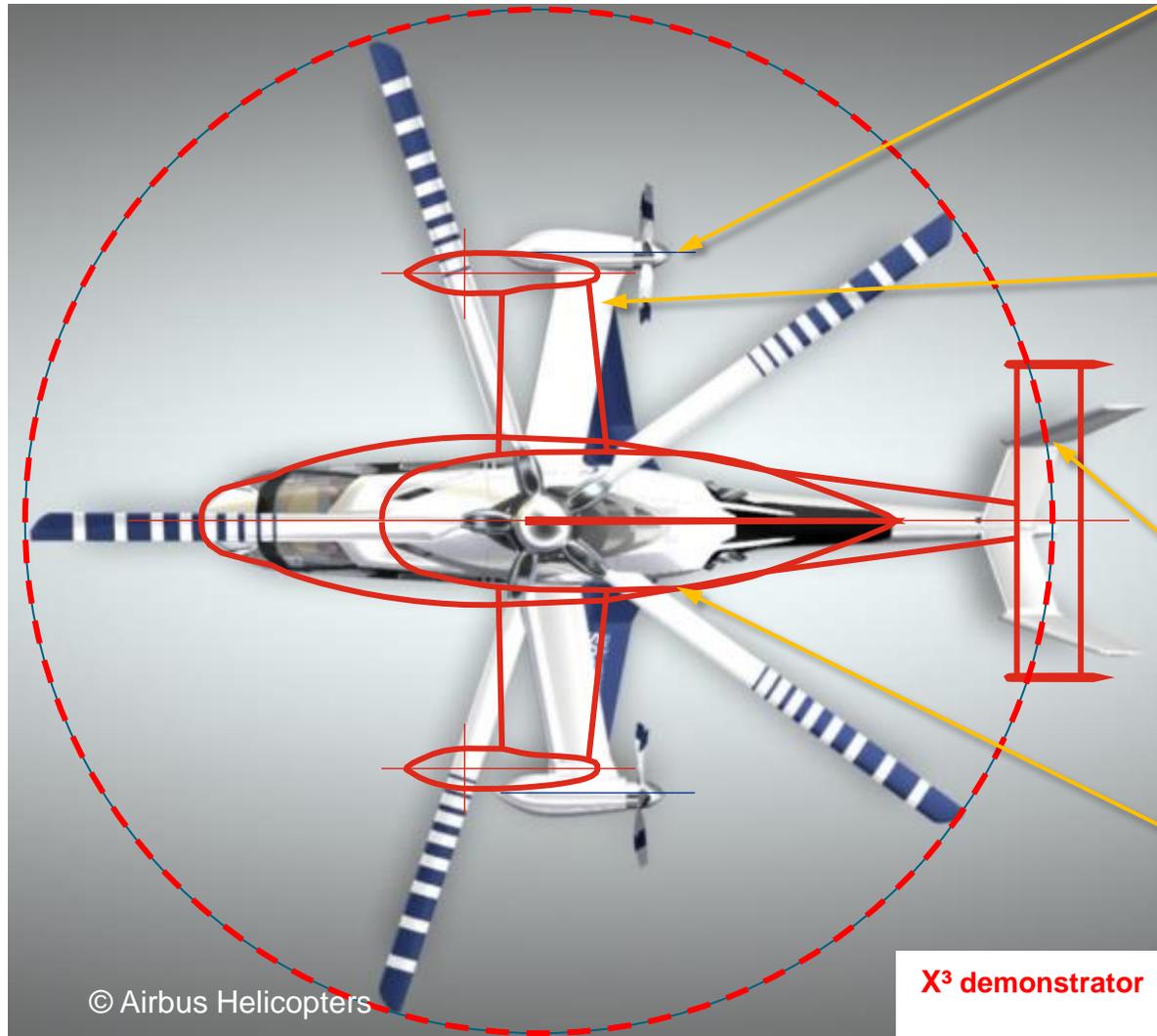
Luggage door

→ Free and safe boarding / hoisting / emergency area

Box wing

- High stiffness
- Lower wing is physical barrier
- High aerodynamic efficiency in hover and cruise
- Houses drive shaft and landing gear

From X³ to CS2/RACER



Lateral rotor

- thrust and anti-torque in hover
- lever arm increased for better anti-torque efficiency

Upper Wing swept back + Lower wing in aft position

- improved pitching stability
- LG integration

Horizontal stabilizer size reduced thanks to a more narrow fuselage and wing's aft position

- H-tail for wake impact minimisation
- anti-torque in cruise

Decreased fuselage width for drag reduction and pitch axis stability

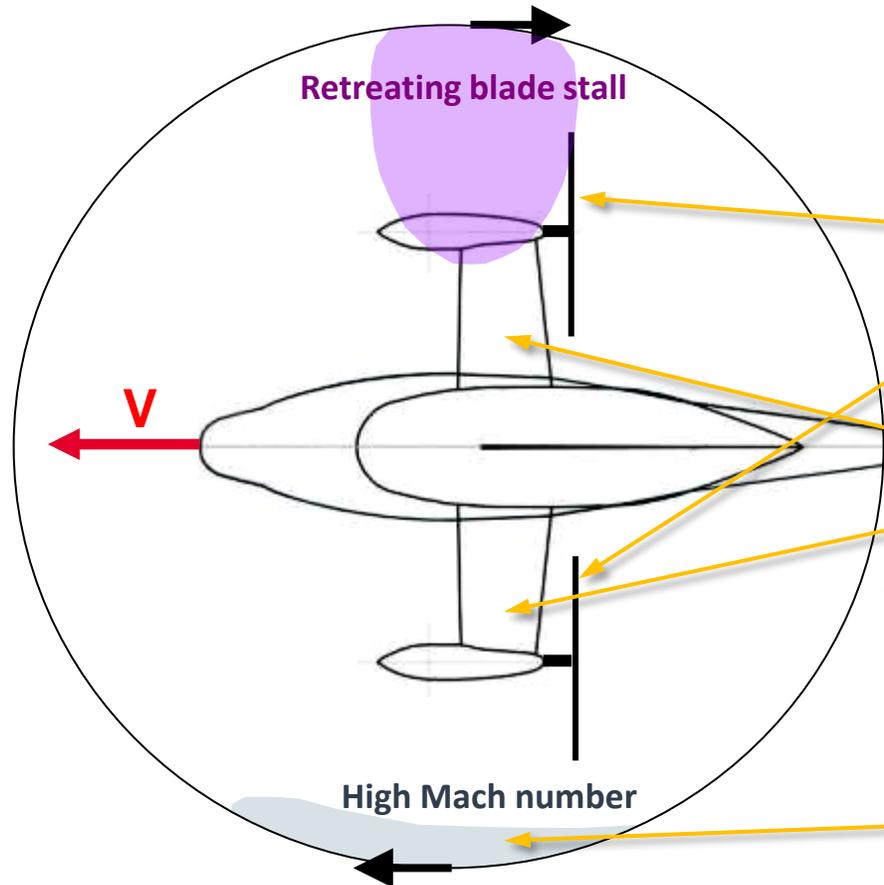
X3 demonstrator rescaled to fit with the same rotor diameter as CS2/RACER

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High speed limitations: Mach number on advancing side + retreating blade stall



Controls:

- Main rotor: collective, roll, pitch as conventional helicopter
- Propellers: yaw, propulsion

Thrust compounding

Lateral rotors for high-speed **propulsion** (compensate retreating blade stall) and **anti-torque** in hover

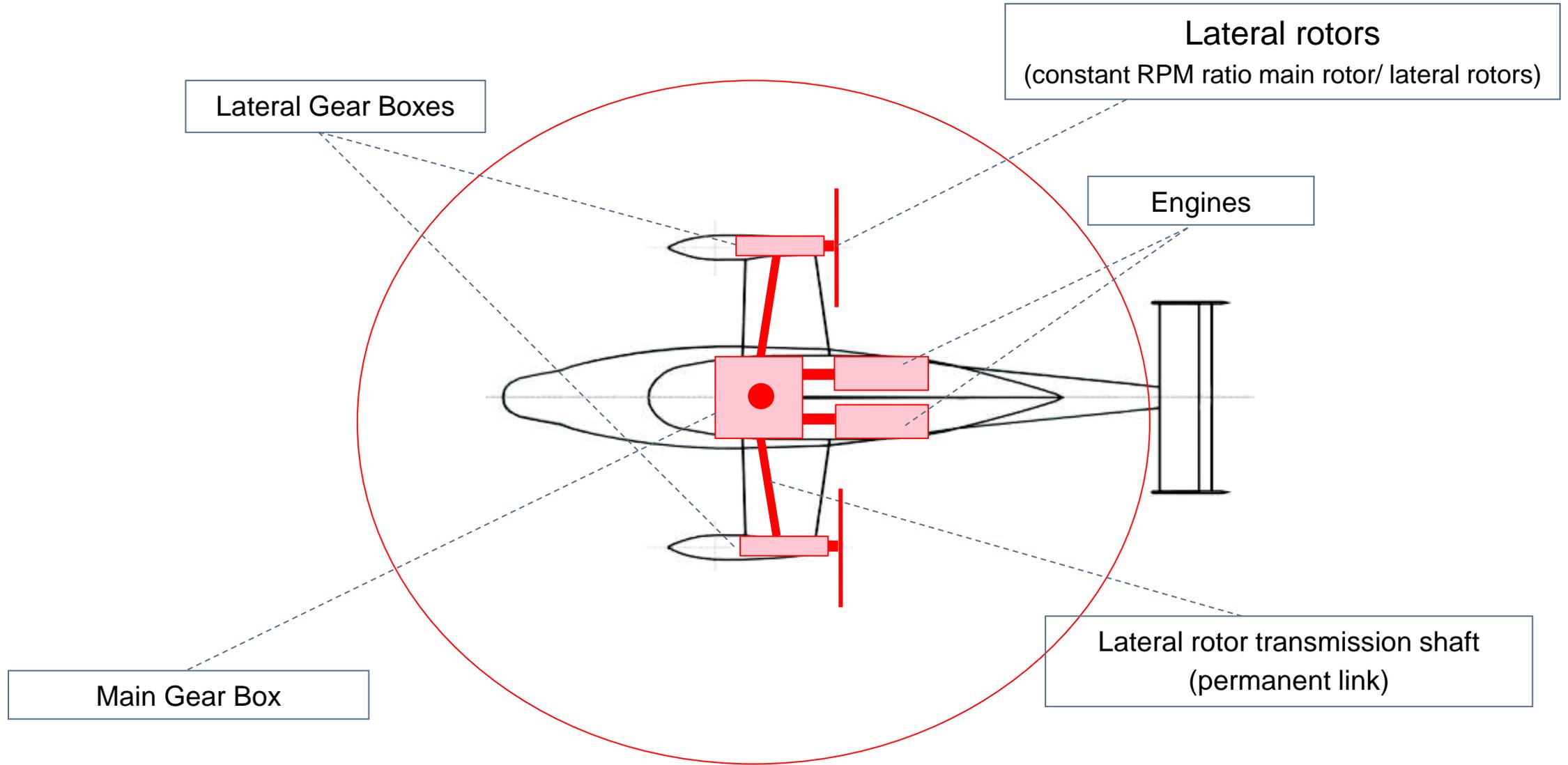
Lift compounding

Wings to develop **additional lift** to unload main rotor at high speed (compensate loss of lift initiated on retreating side)

Trimmable tail surfaces to adjust pitch & yaw balancing

Slowing down the main rotor at high speed to avoid drag divergence on advancing blade

RACER Drive system



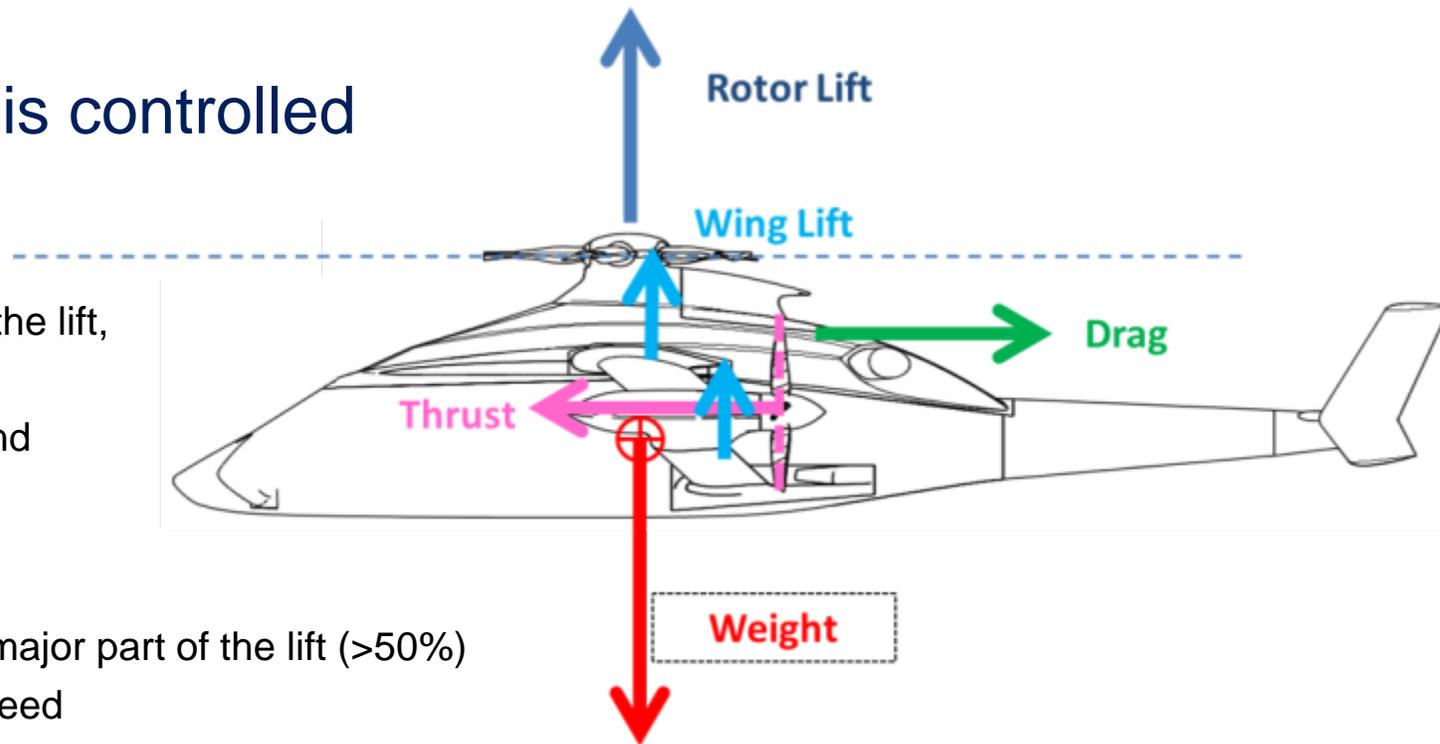
How RACER is flying and how it is controlled

Hover:

- Main rotor driven by engines and MGB is providing the lift,
- Lateral rotors insure anti-torque and yaw control
- Lift, roll and pitch controls are insure by collective and cyclic main rotor pitch controls

Forward flight:

- Main rotor driven by engines and MGB is providing major part of the lift (>50%)
- Wing is providing a part of the lift increasing with speed
- Lateral rotors insure yaw control and the thrust to compensate the drag
- Roll and pitch control are insured by cyclic main rotor pitch control
- Main rotor collective pitch is kept constant in forward flight ($V > 40\text{kt}$) including for climb or descent, excepted for autorotation
- Tail surface controlled by auto-pilot are trimming the steady-state attitude of aircraft



No change of configuration between hover and forward flight
Control principles similar to conventional helicopters

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PRELIMINARY ANALYSIS TO DEFINE CERTIFICATION BASIS

The target of RACER demonstrator is to show the feasibility of an operational aircraft based on the concept evaluated with X³

The feasibility of certification is part of the demonstration

To prepare it, Airbus Helicopters performed a preliminary assessment of the potential certification basis applicable to this formula

This activity has been launched as soon the general architecture has been frozen: a dedicated working group has been set-up including:

- Airbus Helicopters Certification experts
- Airbus Helicopters Compliance Verification Engineers (CVE's)
- External experts team including former EASA experts

This working group provided a draft certification basis by end of 2016
used as reference during RACER Preliminary design activity

WHAT TYPE OF AIRCRAFT: REVIEW OF CS DEFINITIONS

Rotorcraft (as defined in CS definitions – Amt2): means a heavier-than-air aircraft that depends principally for its support in flight on the lift generated by one or more rotors.

Helicopter: (as defined in CS-definitions – Amt2): means a rotorcraft that, for its horizontal motion, depends principally on its engine - driven rotors.

RACER is a Rotorcraft, then CS-29 Large Rotorcraft shall be the basis for Certification for such an aircraft

SPECIAL CONDITIONS

As RACER configuration includes specificities in comparison with conventional helicopter, several Special conditions can be expected

As RACER configuration includes some systems close of those used on aeroplane, a reference to an aeroplane regulation could be useful

RACER is an aircraft of less than 8618 kg MTOW and will accommodate less than 19 passengers .

CS-23 Normal, Utility, Aerobatic, and Commuter Category Aeroplanes, this airworthiness code is applicable to:

(1) Aeroplanes in the normal, utility and aerobatic categories that have a seating configuration, excluding the pilot seat(s), of nine or fewer and a maximum certificated take-off weight of 5670 kg (12 500 lb) or less;

and

(2) Propeller driven twin-engined aeroplanes in the commuter category that have a seating configuration, excluding the pilot seat(s), of nineteen or fewer and a maximum certificated take-off weight of 8618 kg (19 000lb) or less.

CS-25: Large aeroplane (as defined in CS definitions – Amt2): means an aeroplane of more than 5700kg maximum certificated take-off weight. The category “ large aeroplane” does not include the commuter aeroplane category.

When a reference to an Airplane regulation is needed, RACER configuration is more relevant of CS-23 Normal, Utility, Aerobatic, and Commuter Category Aeroplanes

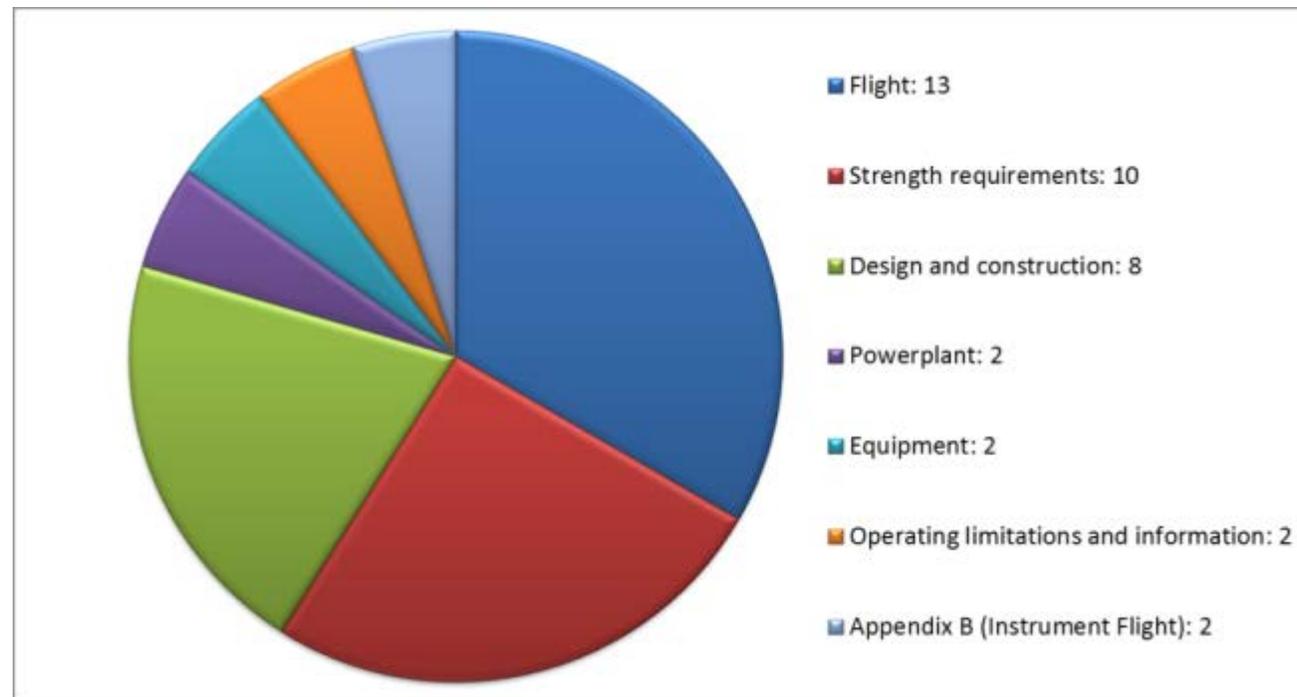
POTENTIAL CERTIFICATION BASIS

The working group identified 42 paragraphs of CS-29 to be adapted or to be completed by specific mean of compliance.

CS-23 and CS-P (Propellers) have been also analysed:

17 paragraph's of CS-23 and 4 paragraph's of CS-P have been considered for Special conditions proposals

A total of 39 Draft Special Conditions have been written distributed as below within CS29 Subparts



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OPERATIONNAL ASPECTS

RACER can be operated as an helicopter, using the same air operation regulations:

- Take-off and landing from clear airfield, unprepared flat surface and helipad (ground and elevated)
- Compliant with CS-29 Category A requirements allowing Class 1 or 2 operation
- Use for helicopter emergency medical service (HEMS) or helicopter hoist operations (HHO).
- Integration in air traffic
- Flight in VFR and IFR
- Precision approach and landing
- Flight in Icing conditions (when suitable protection is installed)

But taking advantages specific to the formula:

- Higher cruise speed capability facilitating the integration in the air traffic
- Higher rate of climb or descent, higher manoeuvrability allowing quicker compliance with air control requirements
- These capabilities will be also used to propose optimised trajectory to reduce the noise foot-print

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Summary and Conclusions

- No need to create new certification rules for fast compound rotorcraft based on the design of RACER Technological Demonstrator:
- CS-29 Large Rotorcraft will be the baseline
- Need to develop a set of Special Conditions to cover specific features of this rotorcraft
- Helicopter operational rules remain applicable even if the formula is offering new capabilities for customer operation



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Thank you!

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- the JU for the funding of the CleanSky2 research program
- all involved Airbus Helicopters departments
- all the members of the working group preparing draft certification basis

