Potential of Hybrid Helicopter

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European Union Aviation Safety Agency

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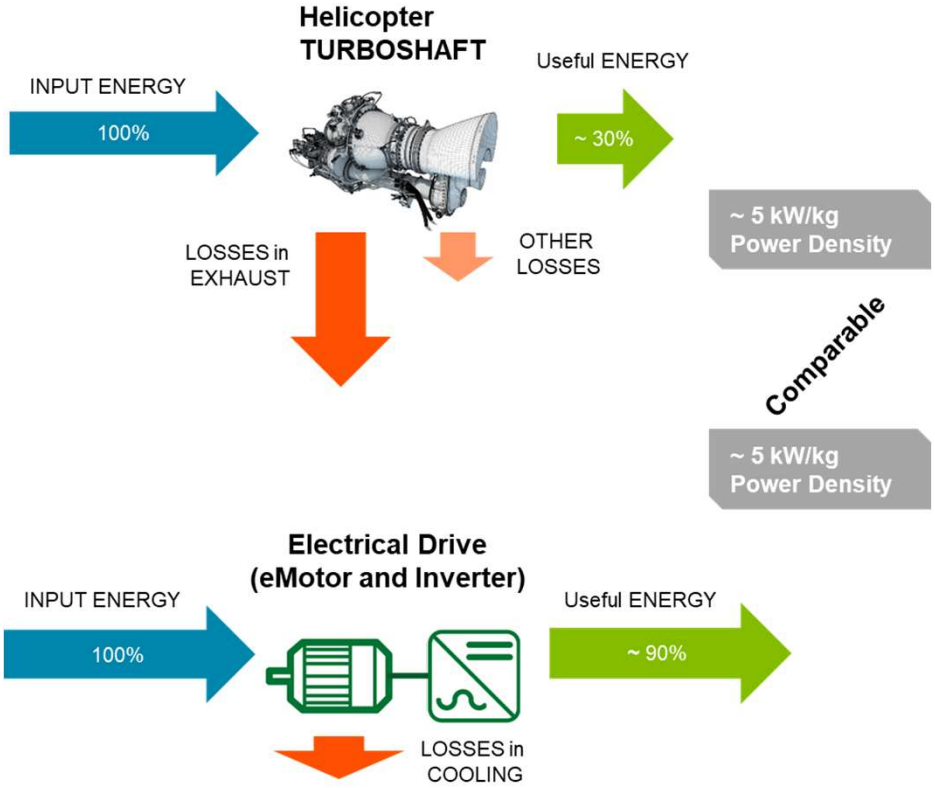
THERMAL vs ELECTRIC propulsion: quick comparison



BUT…

WEIGHT penalty (batteries *):

1kg of = **~ 20kg of**

VOLUME penalty:

System Integration impact due to Energy storage **additional volume**

* considering greater eDrive efficiency (90% vs 30%) in the equation

Despite the better **efficiency** and the comparable **Power Density** vs Turboshafts…

the **Electrical Drives** are heavily penalized by the **poor Electrical Energy Density** (e.g. batteries, Fuel Cells)

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Hybrid Helicopters | *Hybridization functions and power levels*

	Micro	Mild Hybridization		Full Electrification
Hybridization location	Thermal Engine	Main Gear Box		NA (Direct Drive)
ePOWER level	*0 - 50kw (< 1min)*	*100 kW (< 1min)*	*~ 300 kW (few minutes)*	*0,5 - 1MW (Full Electric)*
SAFETY		**Easier Autorotation**	**- Flight continuation - Easier Autorotation**	**Fail Safe (e.g. Multirotors)**
FUEL BURN	**-15% (depends on platforms)**		**CO_2 & NOx**	**ZERO Local Emissions**
NOISE		**- 3dB LOW NR**	**- 3dB LOW NR**	
PERFORMANCEs	**Range / Surveillance time increase**	**HV diagram reduction / MTOW increase**	**- MTOW increase - Power BOOST in Altitude**	
OTHERS			**Turboshaft Maintenance improvements**	**Enable new eVTOL configurations**

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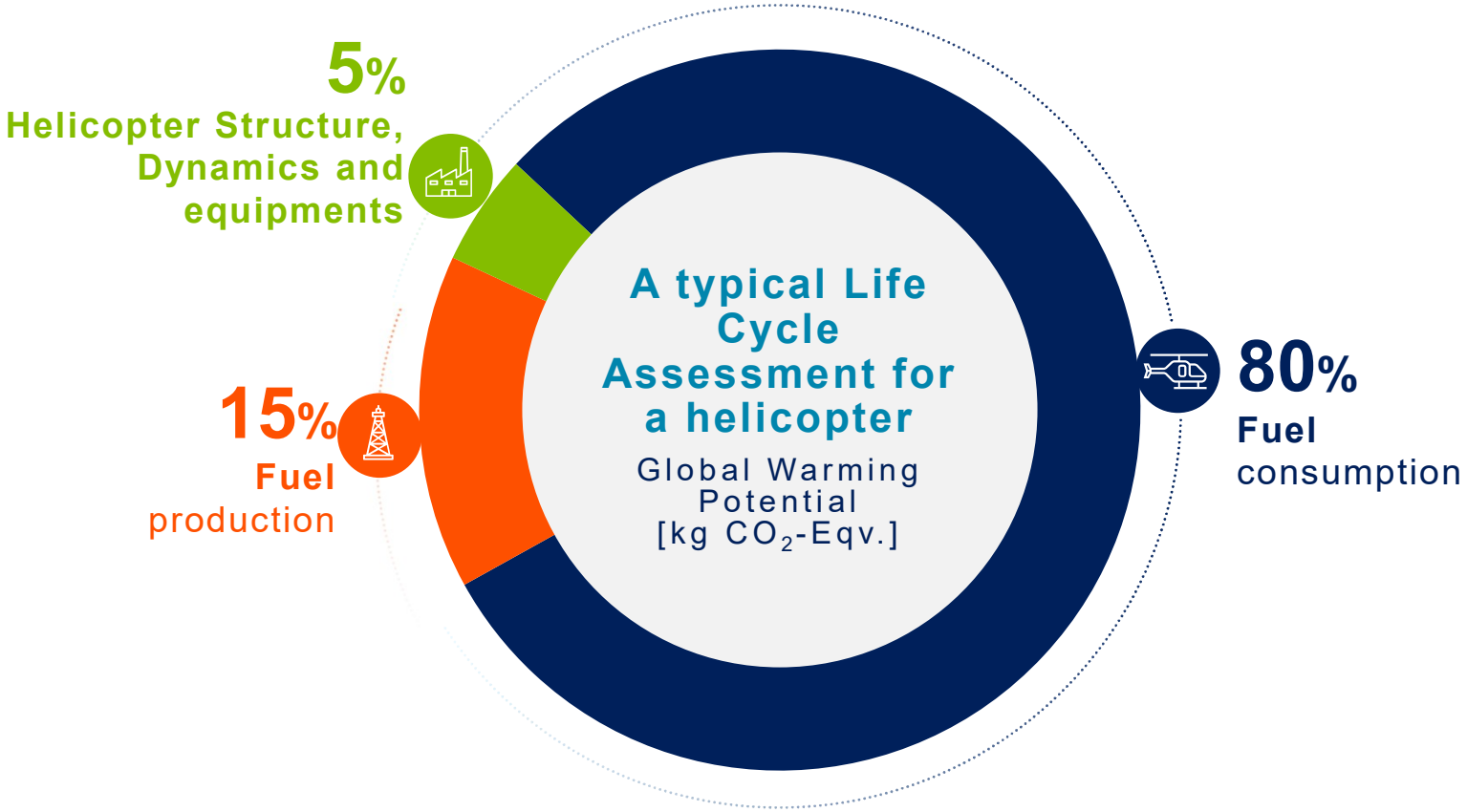
The sources of helicopter CO_2 emissions



Assumptions ..... **255 l/h** Fuel consumption ..... **305 h/year** Flight hours ..... **30 years** Life span

Fuel consumption (80%) is **the dominating source of CO_2** emissions throughout a helicopter's life, followed by Fuel Production (15%)

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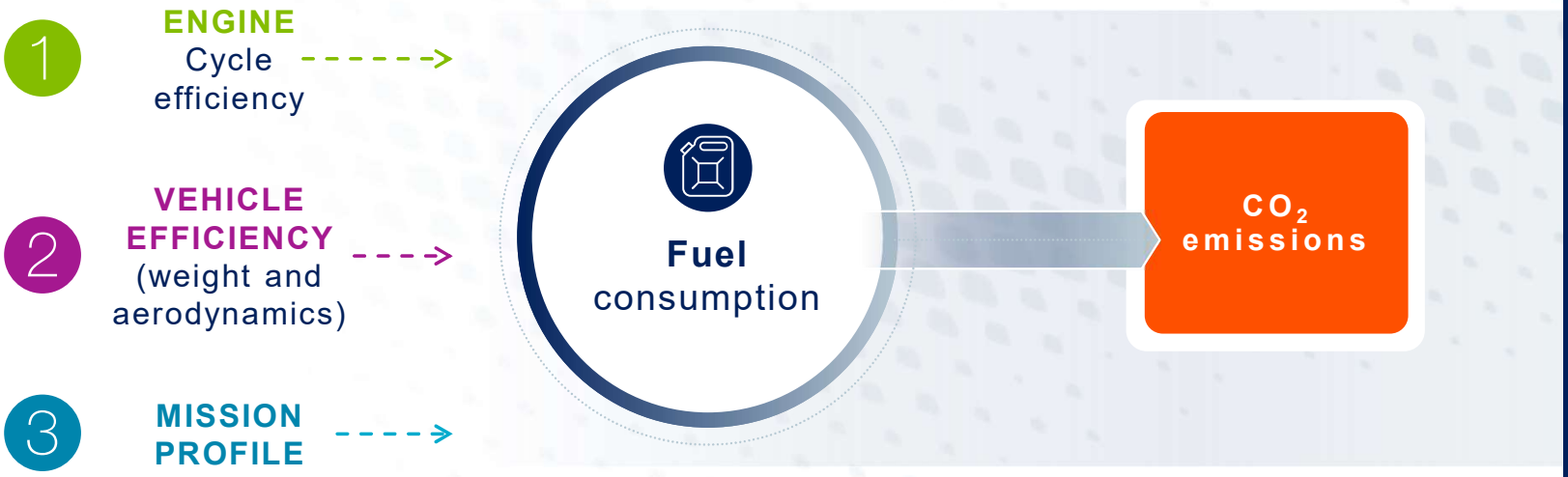
The sources of helicopter CO_2 emissions

Focus on propulsion



Engine and **Vehicle efficiencies,** as well as **Mission Profiles,** are directly linked to **fuel consumption**

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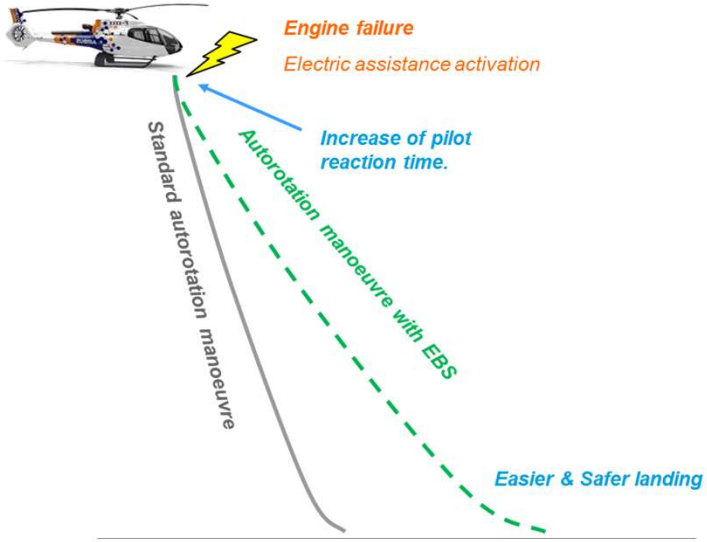
Hybridization for Airbus Helicopters – ***First Step***

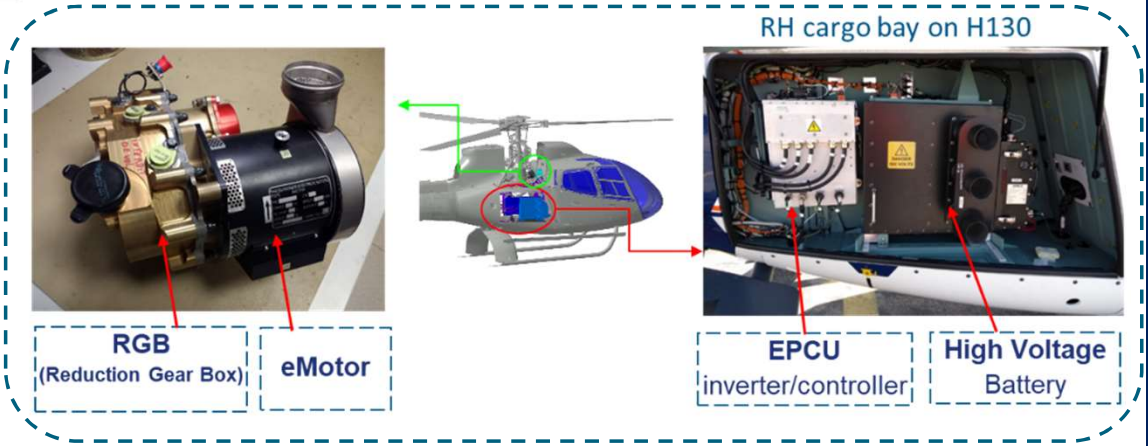
Engine Back-Up System (EBS)
100 kW / 30s Power class



Successfully TESTED on FlightLab in 2021/22

MATURITY status: TRL6 in 2022

- ❑ **PERFORMANCES** (+1 Pax payload as target)
- ❑ **Autonomous activation** after Engine Failure
- ❑ Acceptable **Empty Weight impact**
- ❑ **First step** into **parallel hybridization** for helicopters



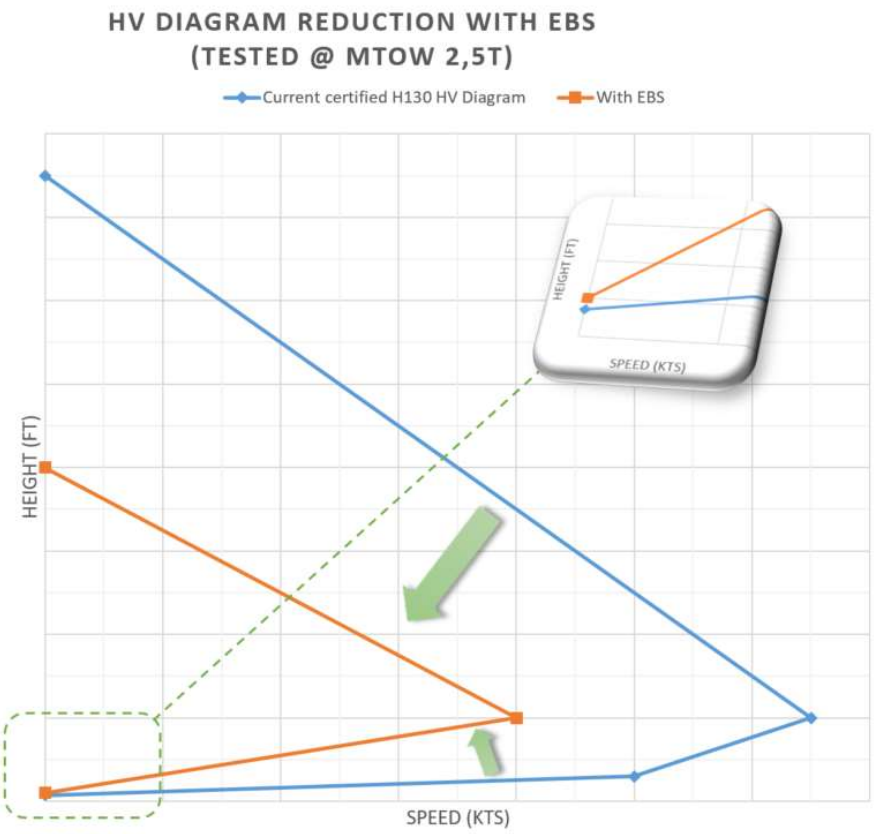
- **Hybridization as <u>Safety Enhancer</u> in case of Engine Failure**
- **Hybridization as <u>Performance Enhancer</u> (e.g.MTOW increase, HV diagram reduction)**
- **<u>Certification discussions</u> ongoing with EASA**

HELICOPTERS

Hybridization for Airbus Helicopters – ***First Step***

Engine Back-Up System (EBS)
100 kW / 30s Power class

TEST RESULTS



TEST LOGIC

- ✓ HV diagram point have been performed **with and without** EBS assistance, always at 2,5t MTOW
- ✓ HV diagram testing has been performed by the crew trying to maintain an **equivalent level of piloting difficulty** for the same manoeuvre
- ✓ The tests have shown a **significant decrease of the « Dead Man » zone** (see graph)
- ✓ This reduction can be **translated into additional MTOW** by the simulation models (target: 1 additional PAX)

KEY GAINS:

+3ft for LOW POINT

-350ft for HIGH POINT

-25Kts for KNEE POINT

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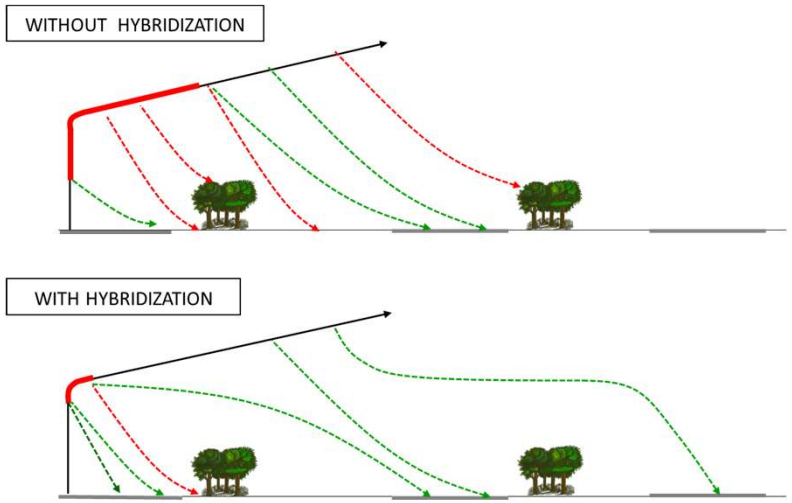
Hybridization for Airbus Helicopters – ***Second Step***

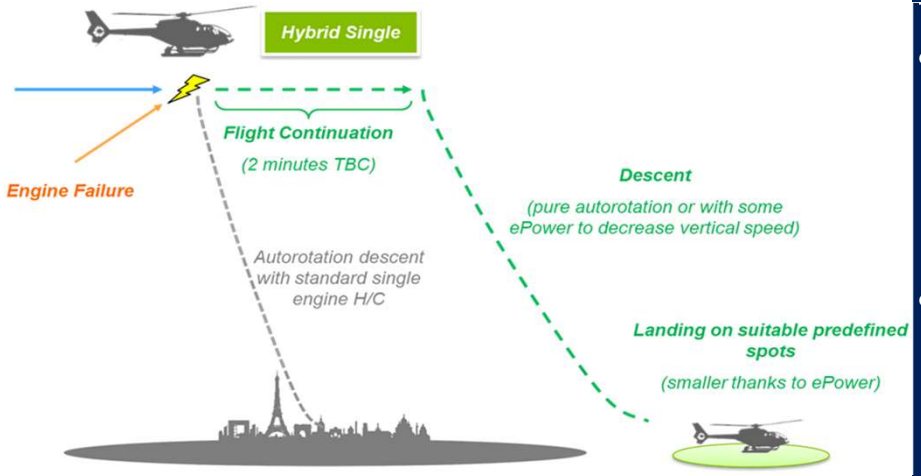
Parallel Hybrid

300kW / 2 min Power class

Possible exposure time reduction at Take –Off



Enroute safety and operational enhancements



What's Key?

- ❑ Hybridization **secures the use of fuel-efficient Single Engine helicopters** by adding new operational capabilities and safety features
- ❑ **Reversible** System → in flight **battery charging** capability → helicopter **availability** advantage
- ❑ **Multiple optimisation opportunities allowed by Hybridization**: emissions reduction (CO2 / NOx) in specific flight phases, power boost, noise reduction, Thermal Engine Maintenance reduction , etc…
- ❑ **Certification aspects** under discussion with **EASA**

MATURITY status:

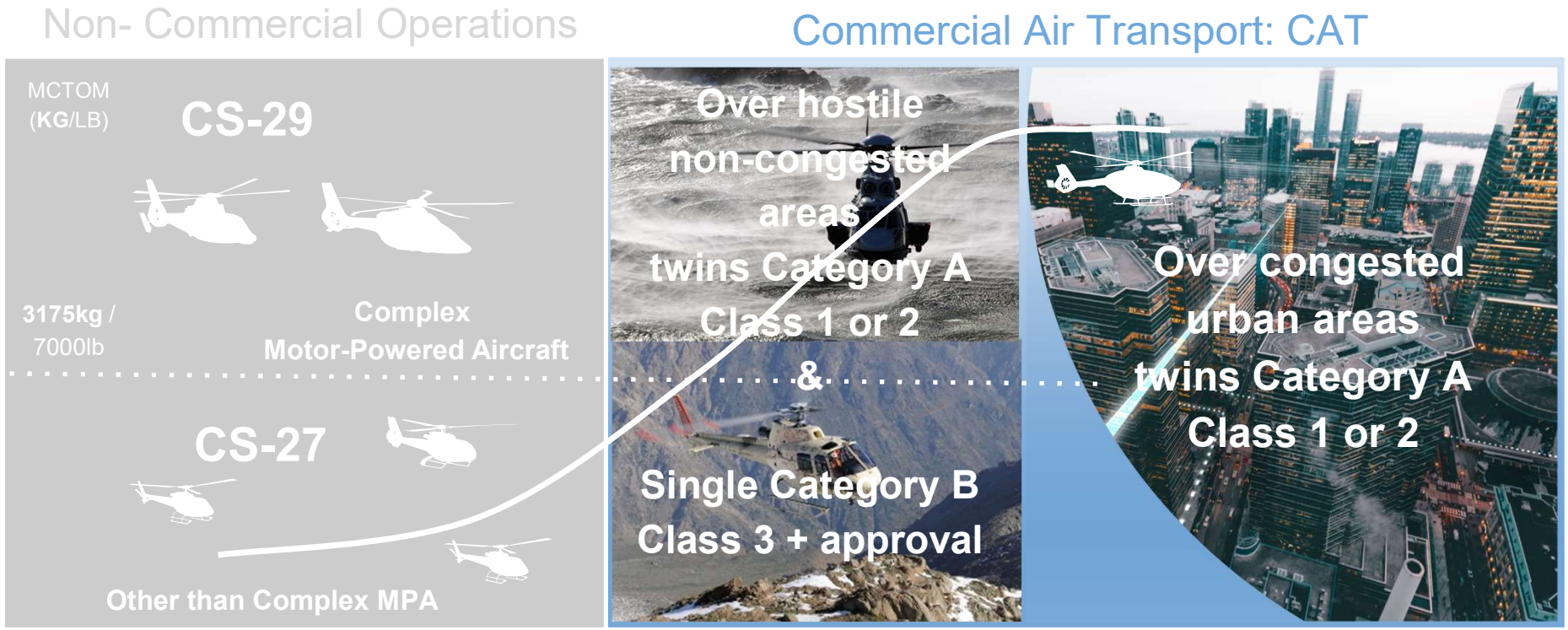
TRL4 planned in 2024

TRL6 planned ~ 2026

- **Hybridization as Safety Enhancer in case of engine failure "enroute" or after take-off/ during landing**
- **Hybridization as enabler for Propulsion System and Vehicle optimizations**
- **Hybridization as Operational Enabler for Flight over congested/hostile areas (Single Engine)**

EASA helicopters operational requirements

- Proportionate to operational risk and public exposure
- balancing overall operational risks with specific risks associated with engine failures



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Performance regulation (EU) 965/2012 Commercial Air Transport	Congested & Hostile
Performance Class 1 Stay-up capability following critical engine failure (Category A certification) Mandatory if: MOPSC>19	Single Engine
Performance Class 2 Same as Class 1 except for TO&L Possible To/from Public Interest Site (PIS) (*)	
Performance Class 3 Not allowed if MOPSC >9 Not allowed (1) out of sight of the surface;(2) at night; (3) when the ceiling is less than 600 ft; or (4) when the visibility is less than 800 m	Not allowed to/from **Fly-over allowed at heights permitting ASFL**
(*) CAT.POL.H.305 **Approval** Operations without an assured safe forced landing capability (ASFL)	**Non-congested & Hostile** allowed on single engine under **CAT.POL.H.420** approval

Congested area

In relation to a city, town or settlement, any area which is substantially used for residential, commercial or recreational purposes.

Non-Hostile environment

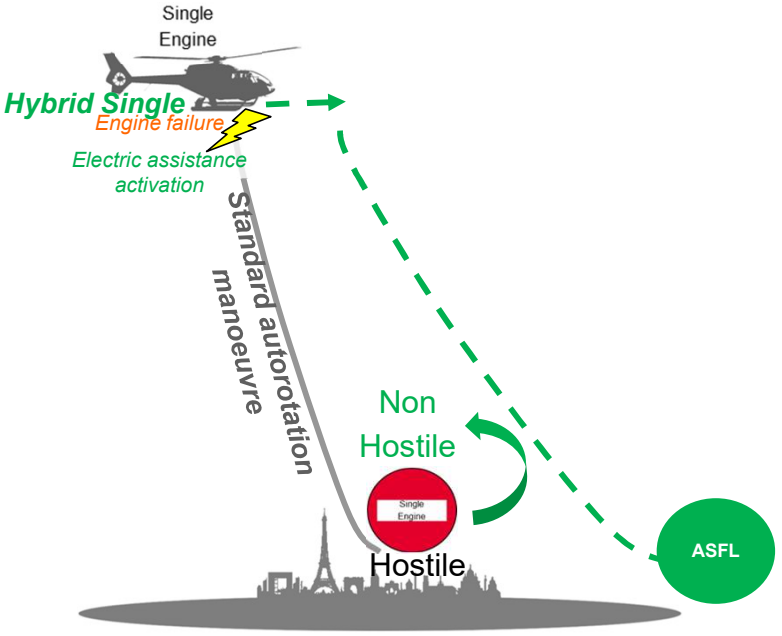
An environment in which:

a) a safe forced landing can be accomplished because the surface and surrounding environment are adequate;

b) the helicopter occupants can be adequately protected from the elements;

c) search and rescue response/capability is provided consistent with anticipated exposure; and

d) the assessed risk of endangering persons or property on the ground is acceptable.



- **Hybridization ensures extended safe forced landing capability**
- **New helicopter routes along ASFL sites are made possible**
- **Additional safety margin to facilitate the approvals under CAT.POL.H.305**
- **Operating rules to be adapted**

Hybrid Helicopter Technology: Summary of benefits & challenges

+ Safety

- Automatic start upon thermal engine failure **compensate for delayed pilot response time** in case of engine failure leading to unsuccessful autorotation
- **Limited Safe Flight & Landing (LSFL**) additional capability upon critical engine failure

- Safety & Certification costs

- The extra weight of the additional electric propulsion system reduces the usable payload and **increases operating costs** on typical single engine missions
- **Certification framework** for high voltage hybrid propulsion system is **not readily available**

+ Environmental benefits

- Electrical engines do not produce harmful emissions and waste less energy as heat
- Less noise/CO2 emission compared to twin helicopter for same payload
- Potential enabler for low noise operation (lower Rotor speed in cruise)

- Electric Propulsion for aviation low maturity

- High battery weight driven by low energy density compared to fossil fuels
- Battery usage to be controlled for an acceptable life (number of cycles)
- Current Power/Endurance/Weight trade-off limits potential operating scenario

+ New potential operating scenario

- LSFL may be used to optimize the low level routes over urban/congested area

- Rulemaking needed

- Regulatory framework for VTOL capable aircraft (mostly full electrical) does not cover the specificities of hybrid electric helicopters
- Current helicopters operating regulations need be revisited to promote hybrid helicopter operations over congested environment and EASA RMT.0318 re-started

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Take away

- The recognized benefits of hybrid technology on helicopters in terms of safety/environment are not fully compensating the development and operating costs.
- The new operational capabilities need to be translated into new concepts of operations to bring value to the end users.
- Similar to the « Net Safety Benefit » principle of EASA certification memorandum: Environmental and safety benefits to be credited in Certification and Operations to incentivize the early adoption of the new hybrid technology on helicopters.

Thank you

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