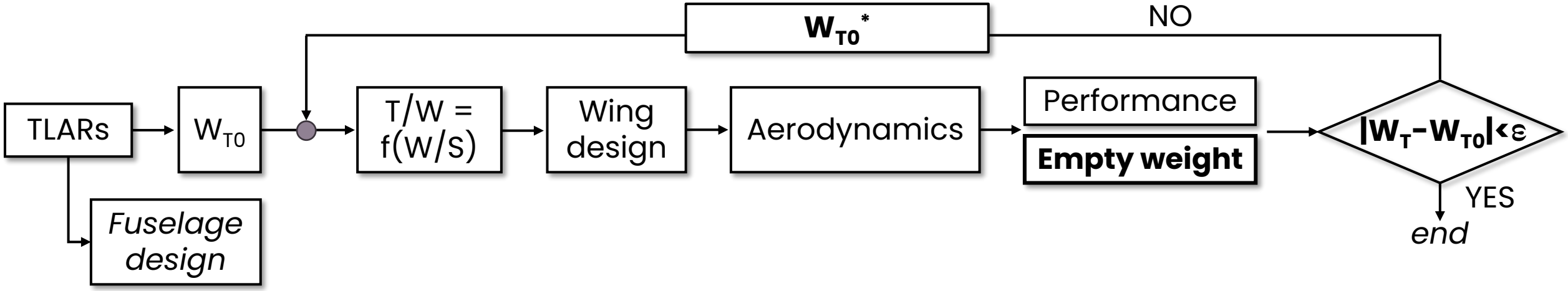
E2. Conceptual design of regional hybrid-electric aircraft

13. Weight update

Karim Abu Salem
karim.abusalem@polito.it

Giuseppe Palaia
giuseppe.palaia@polito.it

Operating empty weight



The **operating empty weight** is the weight of the airplane in a condition **ready to fly**, but with **no fuel or payload** yet taken on board.

Operating empty weight

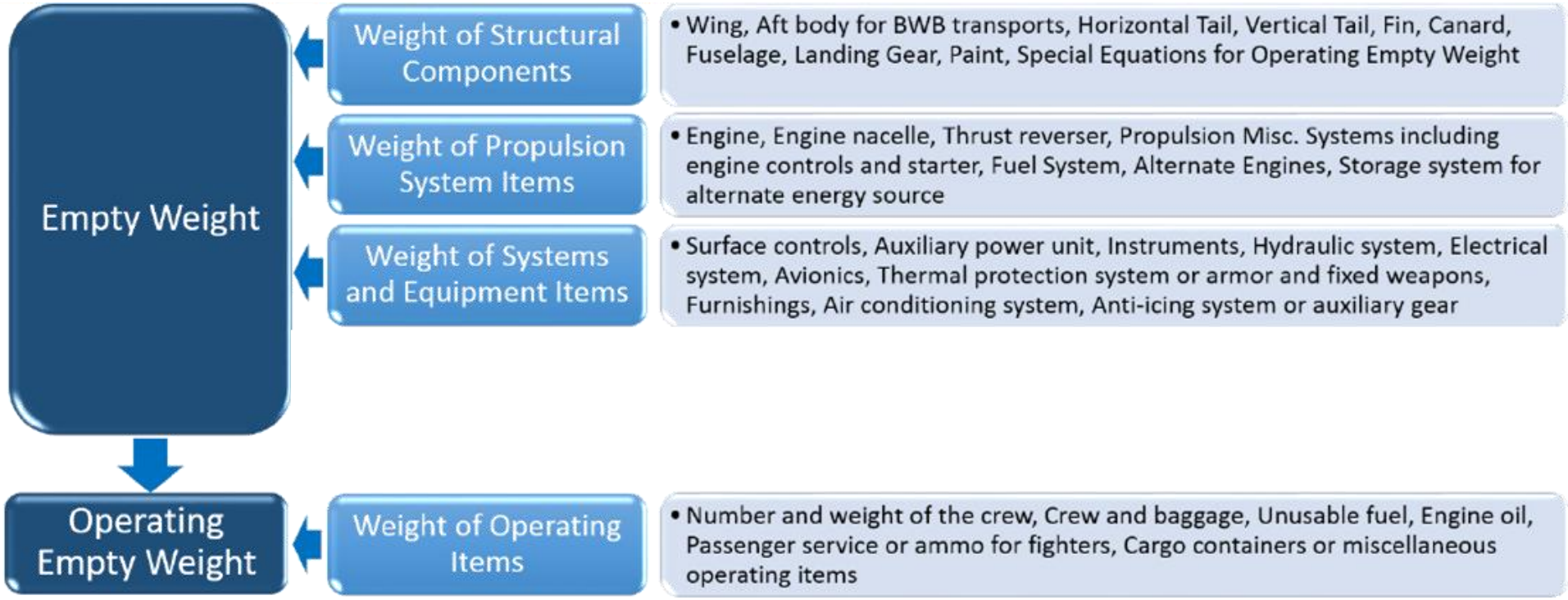
Aircraft operating empty weight

Structural mass
Wing
Tail
Fuselage
Landing gear

Propulsion
Engine and Nacelle

Systems
Fuel, Hydraulic, Electric, Pneumatic, Anti-icing, Instruments, Avionics, Engine

Operating
Furnishing, Services
Crew and attendants



Operating empty weight - Powertrain

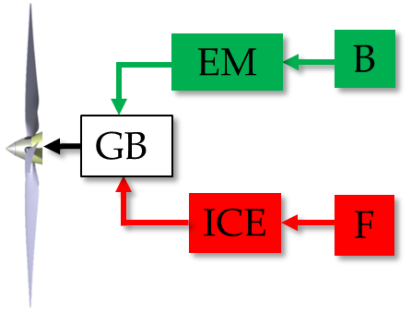
Aircraft operating empty weight

Structural mass
Wing
Tail
Fuselage
Landing gear

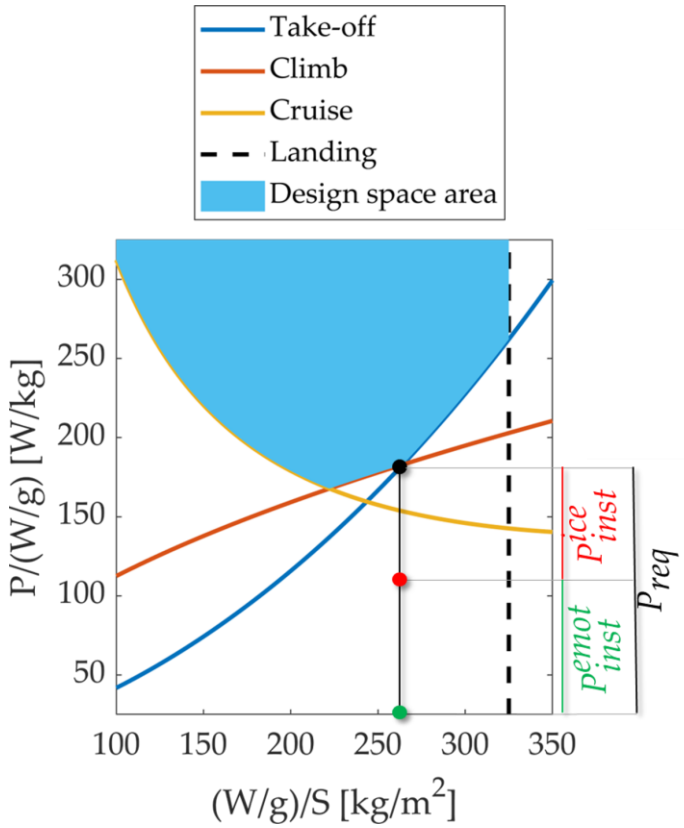
Propulsion
Engine, Nacelle and Prop.

Systems
Fuel, Hydraulic, Electric, Pneumatic, Anti-icing, Instruments, Avionics, Engine

Operating
Furnishing, Services
Crew and attendants



$$H_P = \frac{P_{inst}^{emot}}{P_{inst}^{ice} + P_{inst}^{emot}}$$



Operating empty weight - Powertrain

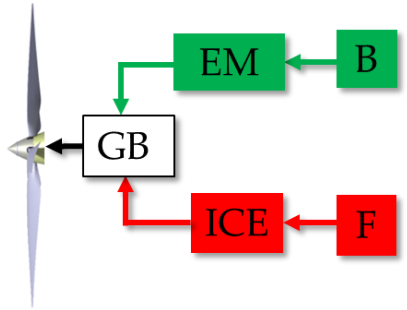
Aircraft operating empty weight

Structural mass
Wing
Tail
Fuselage
Landing gear

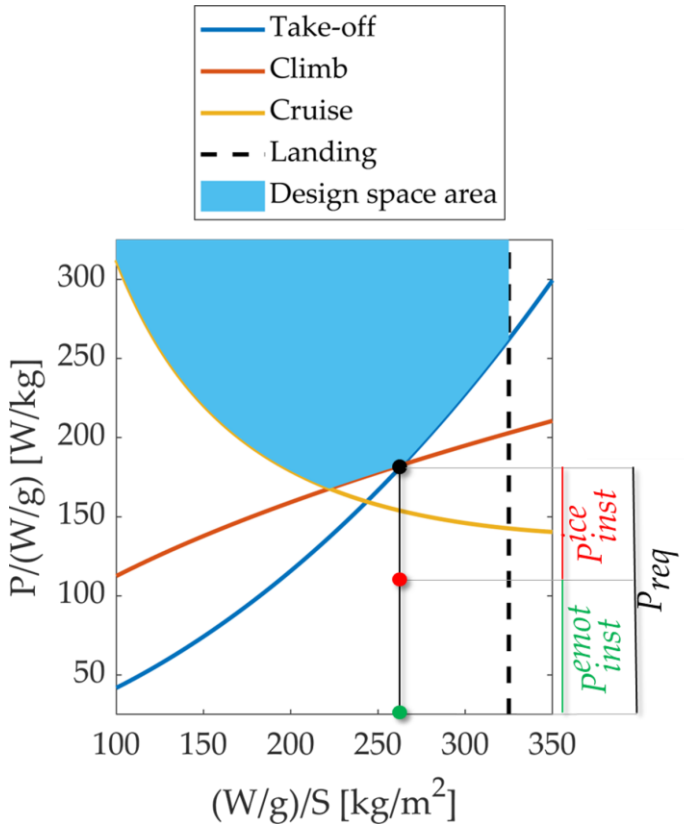
Propulsion
Engine, Nacelle and Prop.

Systems
Fuel, Hydraulic, Electric, Pneumatic, Anti-icing, Instruments, Avionics, Engine

Operating
Furnishing, Services
Crew and attendants



$$H_P = \frac{P_{inst}^{emot}}{P_{inst}^{ice} + P_{inst}^{emot}}$$



Thermal Engine Update

$$W_{ice} = N_{prop} \frac{\frac{P_{inst}^{ice}}{N_{prop}} - 12970}{3878}$$

$W_{ice} = mass\ of\ thermal\ engines\ [kg]$

$P_{inst}^{ice} = installed\ power\ of\ t.es.\ [W]$

Operating empty weight - Engine

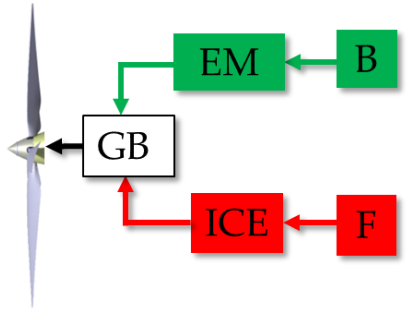
Aircraft operating empty weight

Structural mass
Wing
Tail
Fuselage
Landing gear

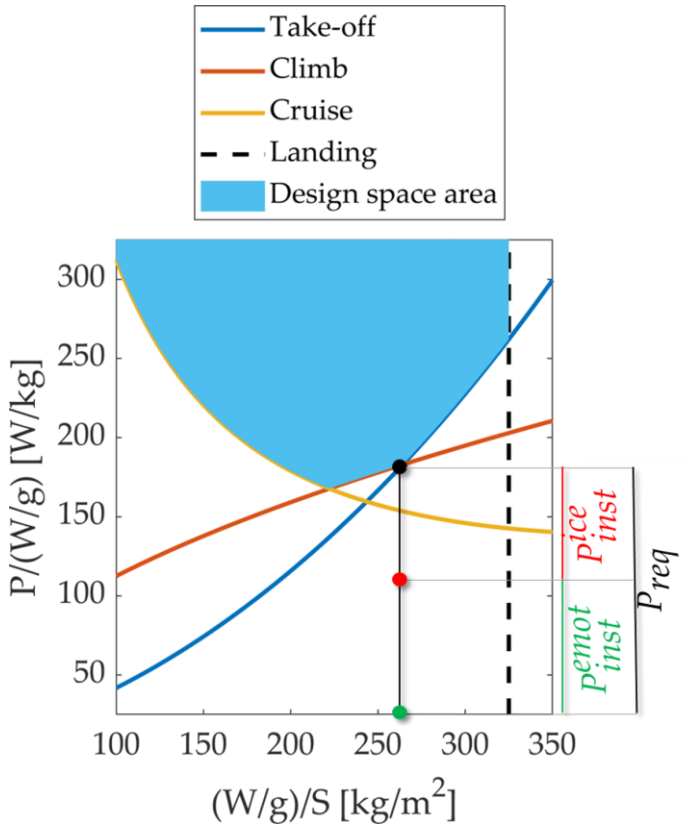
Propulsion
Engine, Nacelle and Prop.

Systems
Fuel, Hydraulic, Electric, Pneumatic, Anti-icing, Instruments, Avionics, Engine

Operating
Furnishing, Services
Crew and attendants



$$H_P = \frac{P_{inst}^{emot}}{P_{inst}^{ice} + P_{inst}^{emot}}$$



Electric Motor (NEW!!)

$$W_{emot} = \frac{P_{inst}^{emot}}{EMPD}$$

$W_{emot} = mass\ of\ electric\ motors\ [kg]$
$P_{inst}^{emot} = installed\ power\ of\ e.ms.\ [W]$
$EMPD = electric\ motor\ power\ density\ [W/kg]$

EMPD =16 kW/kg

Operating empty weight - Nacelle

Aircraft operating empty weight

Structural mass
Wing
Tail
Fuselage
Landing gear

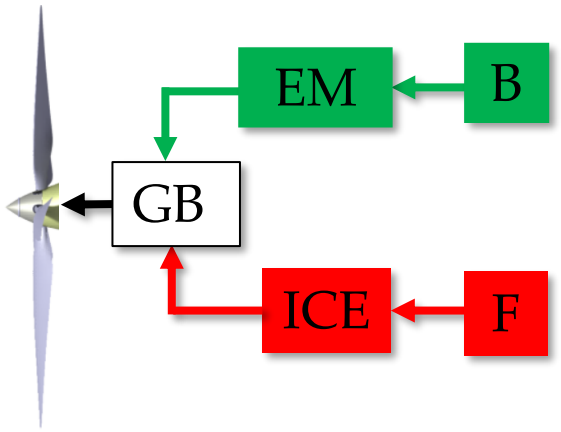
Propulsion
Engine, Nacelle and Prop.

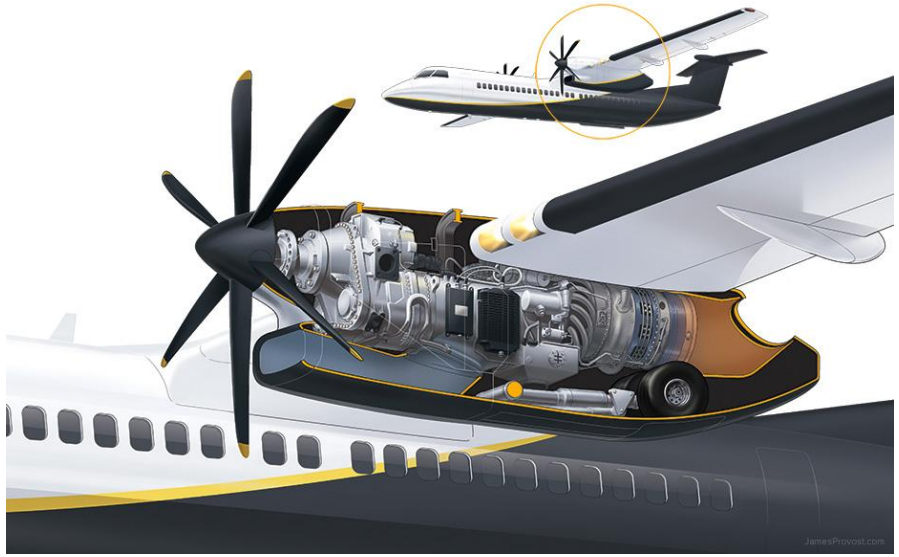
Systems
Fuel, Hydraulic, Electric, Pneumatic, Anti-icing, Instruments, Avionics, Engine

Operating
Furnishing, Services
Crew and attendants

$$W_{nac} = K \times (P_{inst}^{ice} + P_{inst}^{emot})$$

$$K = 0.14 \frac{lb}{hp}$$





Operating empty weight - Propeller

Aircraft operating empty weight

Structural mass
Wing
Tail
Fuselage
Landing gear

Propulsion
Engine, Nacelle and Prop.

Systems
Fuel, Hydraulic, Electric, Pneumatic, Anti-icing, Instruments, Avionics, Engine

Operating
Furnishing, Services
Crew and attendants

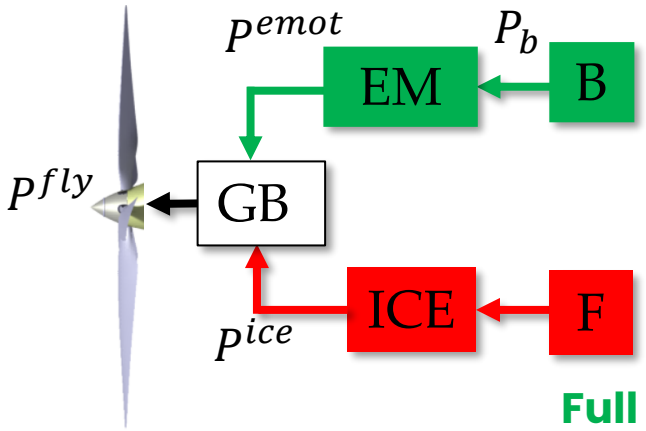
$$W_{prop} = 0.1256 N_{prop} \left(12.0546 \frac{P_{inst}^{ice} + P_{inst}^{emot}}{N_{prop}} \right)^{0.782}$$

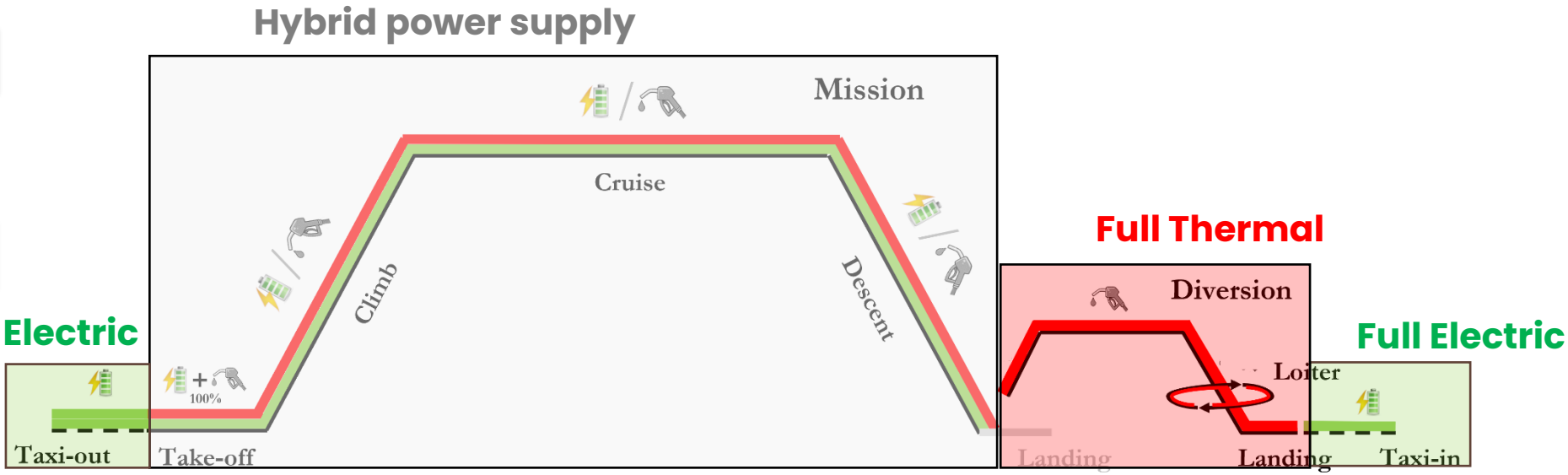
$P_{inst}^{ice} = installed\ power\ of\ thermal\ engines [hp]$

$P_{inst}^{emot} = installed\ power\ of\ electric\ motors [hp]$

$W_{prop} = weight\ of\ propellers\ [lb]$

Battery mass





$$\dot{W}(t_k) = -k_c\, P^{ice}(t_k)$$

$$P^{ice} = f(\Phi^{ice})$$

$$P_b = P^{emot}/(\eta_{em})$$

$$\dot{E}_b(t_k) = P_b(t_k)$$

$$W_b = \frac{\int_0^t P_b\, dt}{(SOC_{in} - SOC_{fin})BED}$$

Battery mass [kg]

100 %

20 %

Battery energy density [J/kg]

End