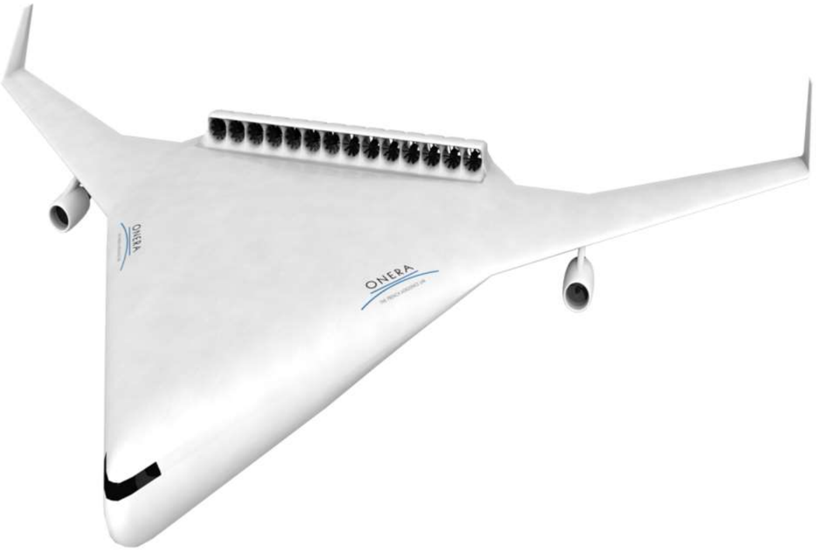
IMOTHEP

GETTING HYBRID ELECTRIC




# IMOTHEP configurations

Sebastien DEFOORT - ONERA

Stakeholders Workshop - 11/11/2020

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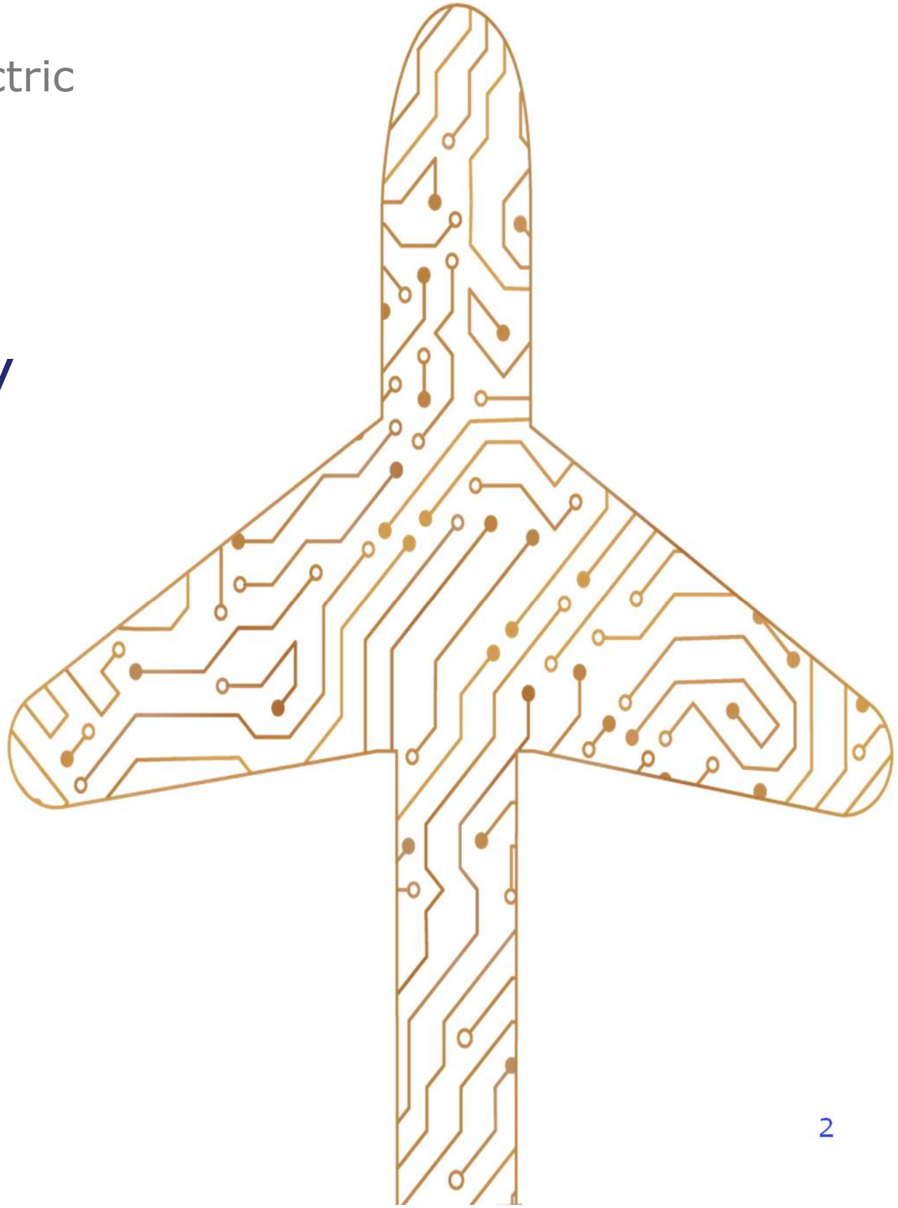

# INTRODUCTION

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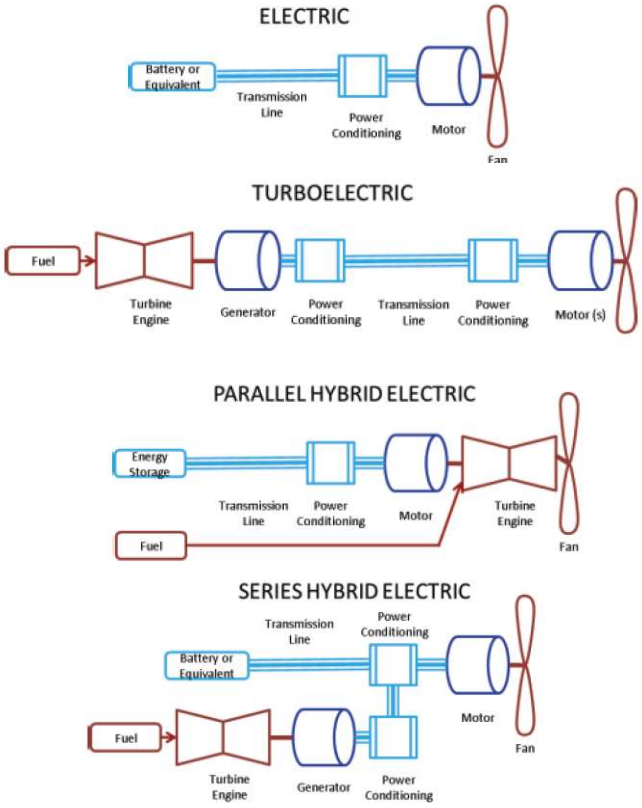
# Motivation to study configurations

## Intersection of electric architectures and configurations

**Aircraft architecture**


Can it be accomodated on conventional tube & wings aircraft without major changes ?

**Electric architectures**

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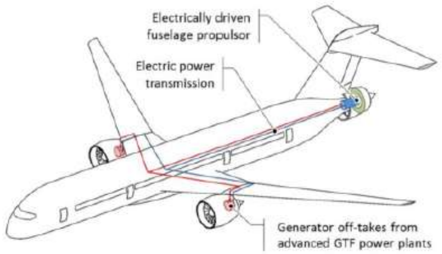
# Motivation to study configurations

- **Intersection of electric architectures and configurations**

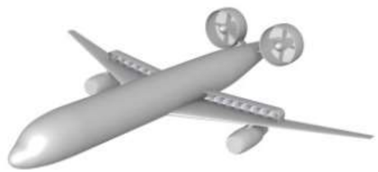
**Aircraft architecture**

Fuselage BLI
(CENTERLINE
H2020 project)



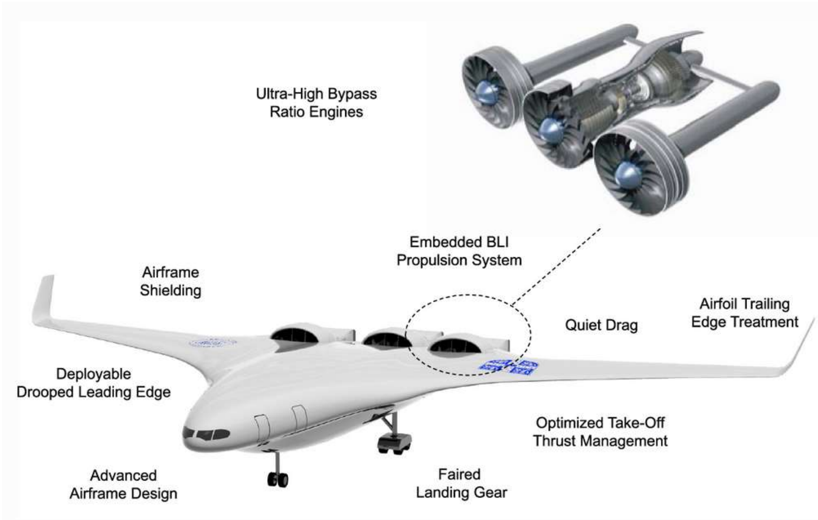

Wing DEP
(NASA X-57
concept)

Propulsive
empennage
(TUD concept)



**Electric architectures**

How can hybridization enable / improve these more efficient aeropropulsive concepts ?



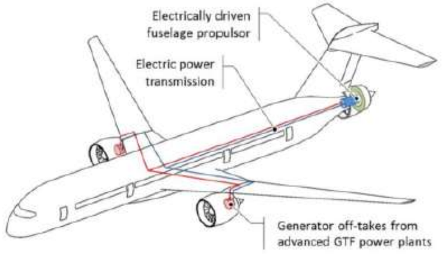

SAX-40 aircraft
(MIT/cambridge), no HEP

# Motivation to study configurations

## Intersection of electric architectures and configurations

| Aircraft architecture | Electric architectures |
|---|---|

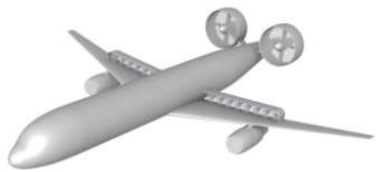
Fuselage BLI (CENTERLINE H2020 project)

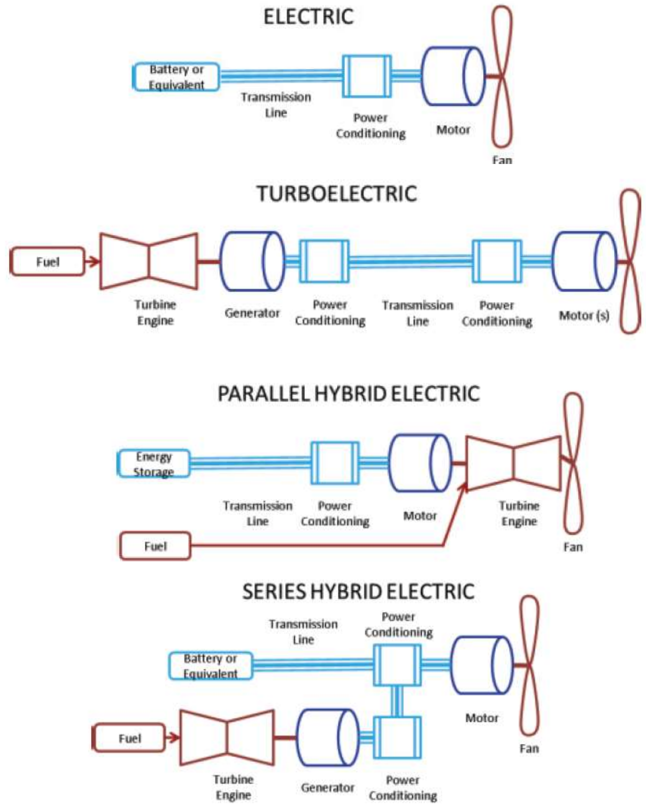



Wing DEP (NASA X-57 concept)

**x**

Propulsive empennage (TUD concept)






What are the best combinations, and the associated benefits ?

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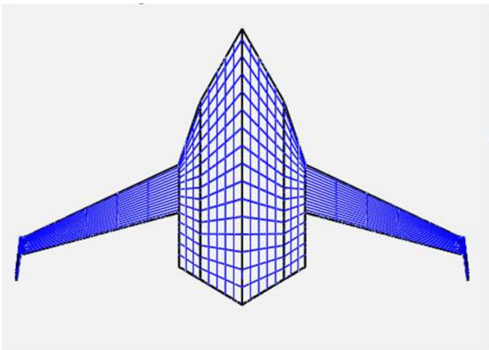
# IMOTHEP design approach

## An iterative OAD process with two objectives :

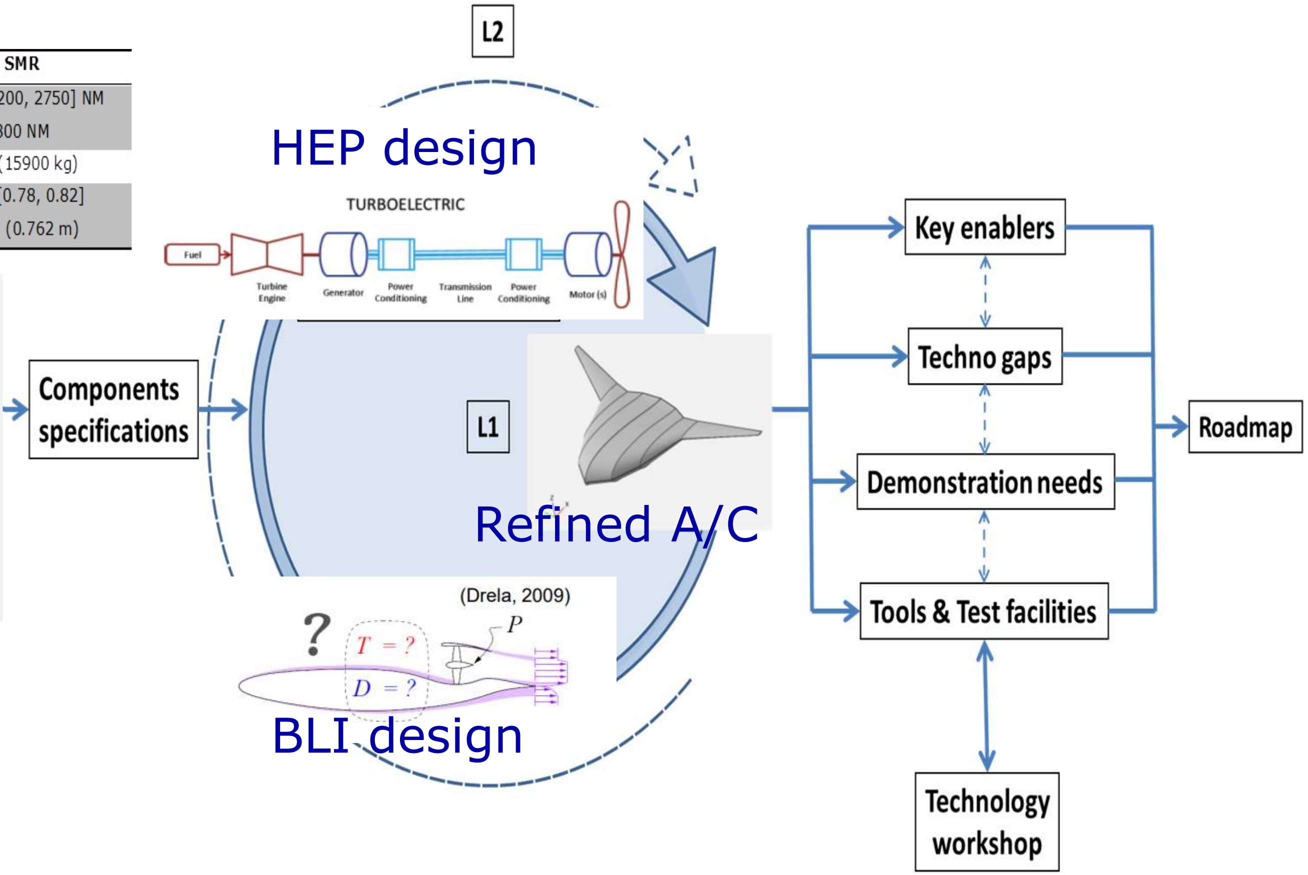
- Derive requirements to the subsystems of the HEP chain
- Integrate realistic figures and continuously update the benefits

TLAR

| | REG | SMR |
|---|---|---|
| Design Range | 400 [400, 600] NM | 1200 [1200, 2750] NM |
| Typical Range | 200 NM | 800 NM |
| Nb PAX (Design Payload) | 40 (4240 kg) | 150 (15900 kg) |
| Design Mach number | 0.4 [0.4, 0.48] | 0.78 [0.78, 0.82] |
| Seat pitch | 30 in (0.762 m) | 30 in (0.762 m) |



First sketch



# IMOTHEP design approach

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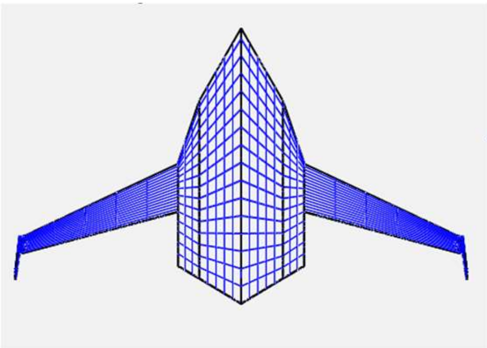

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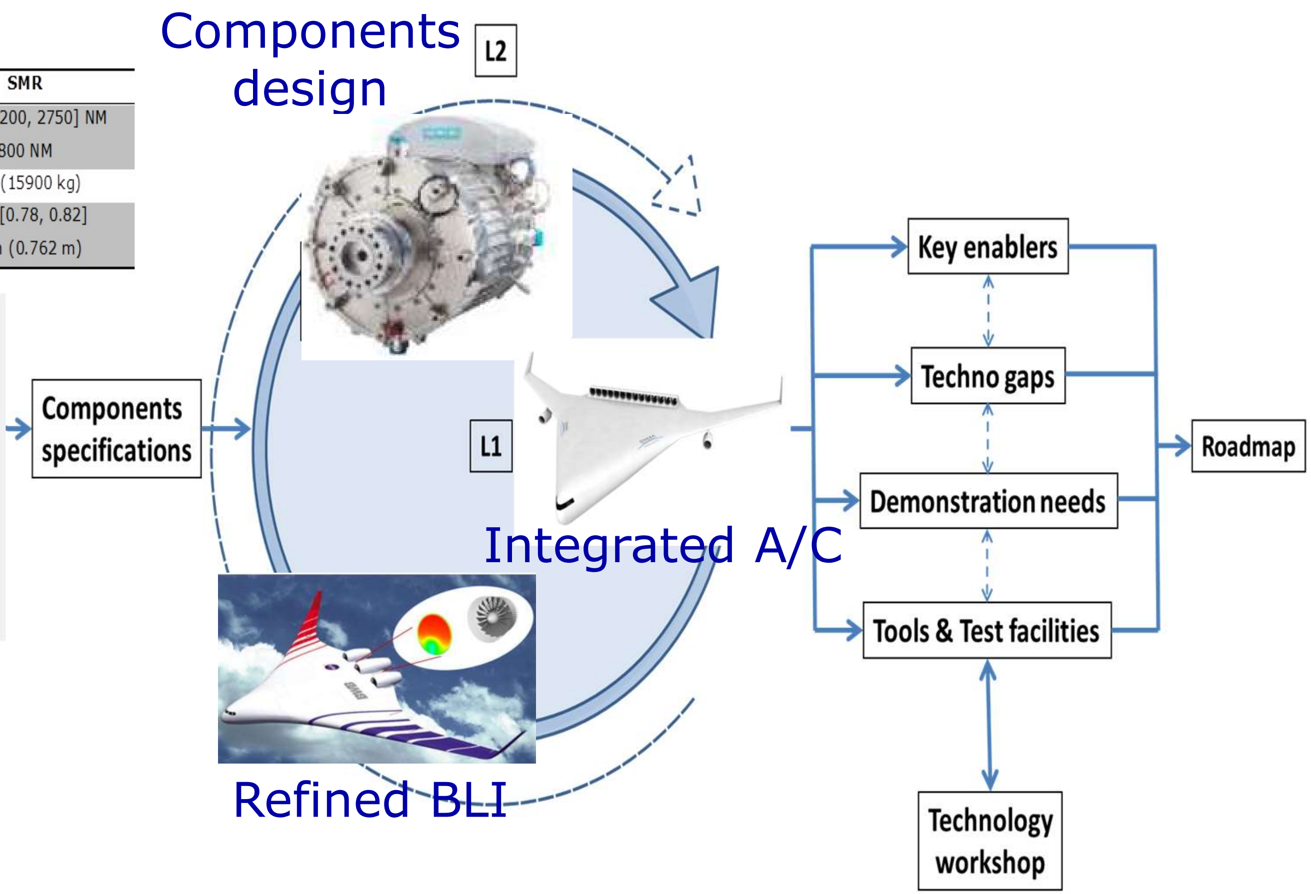

# CONFIGURATIONS UNDER STUDY

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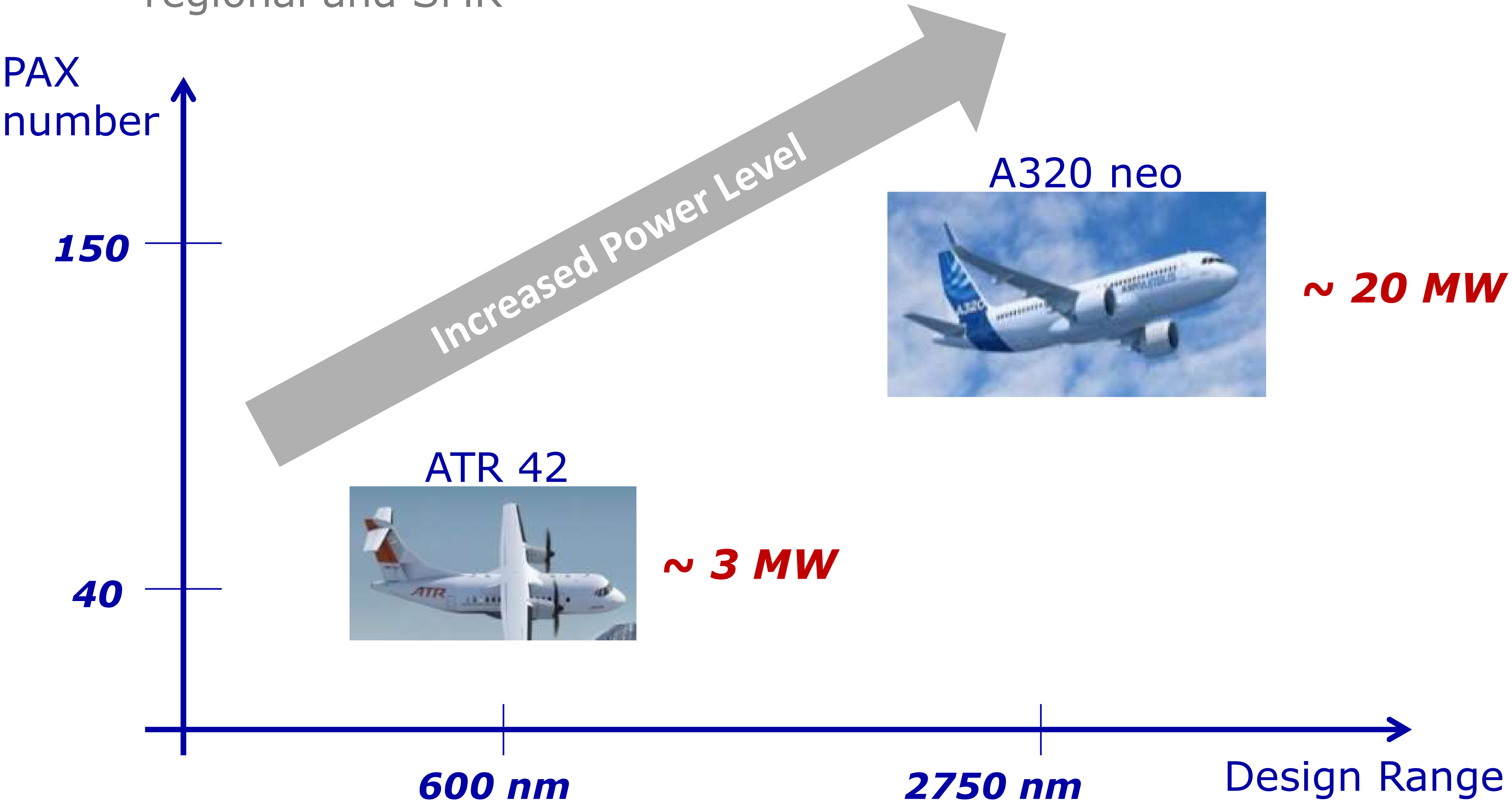
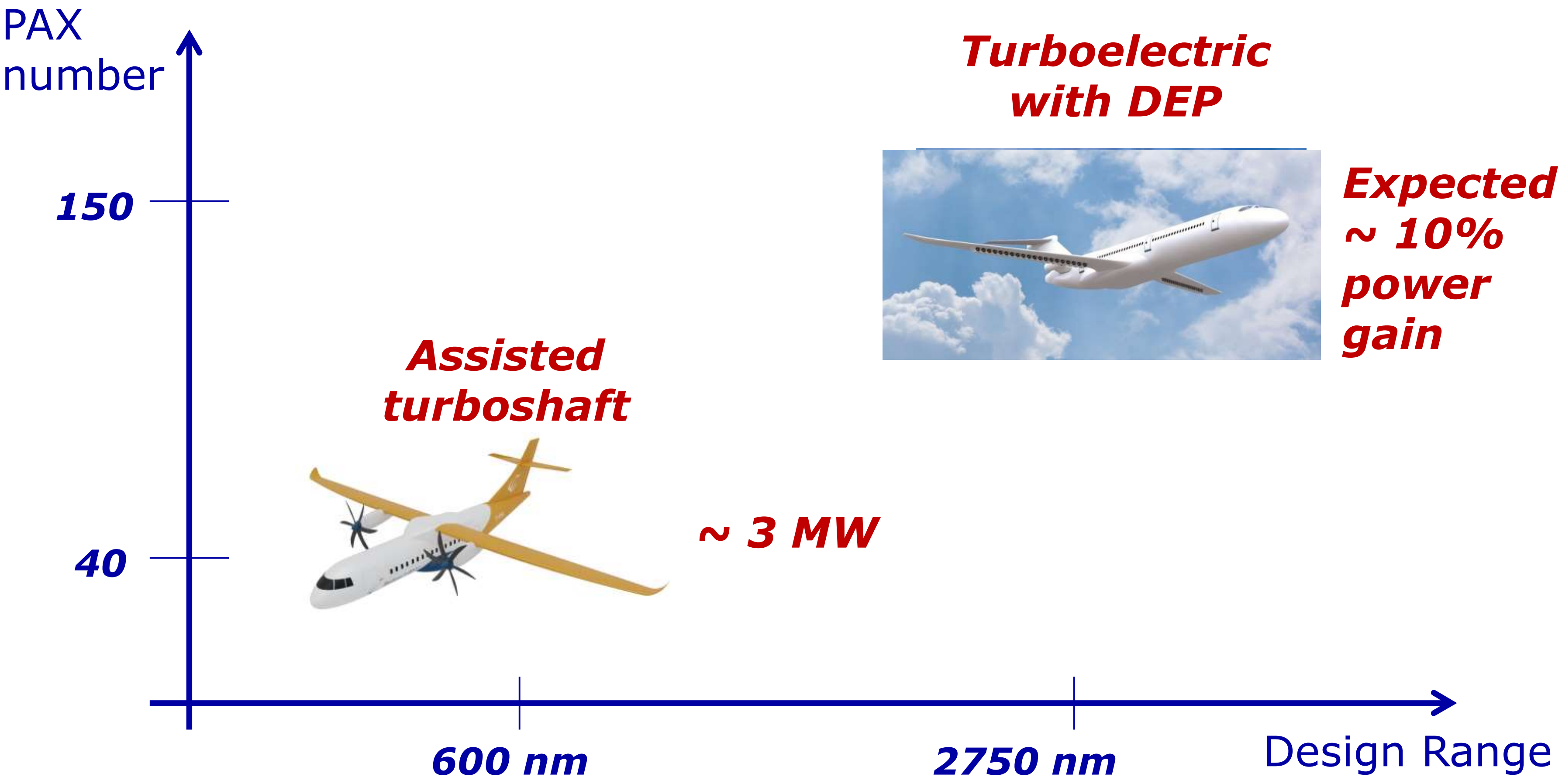
# Configurations

- **Supporting missions and configurations :**
  - Address two levels of power requirements (and expected EIS) : regional and SMR



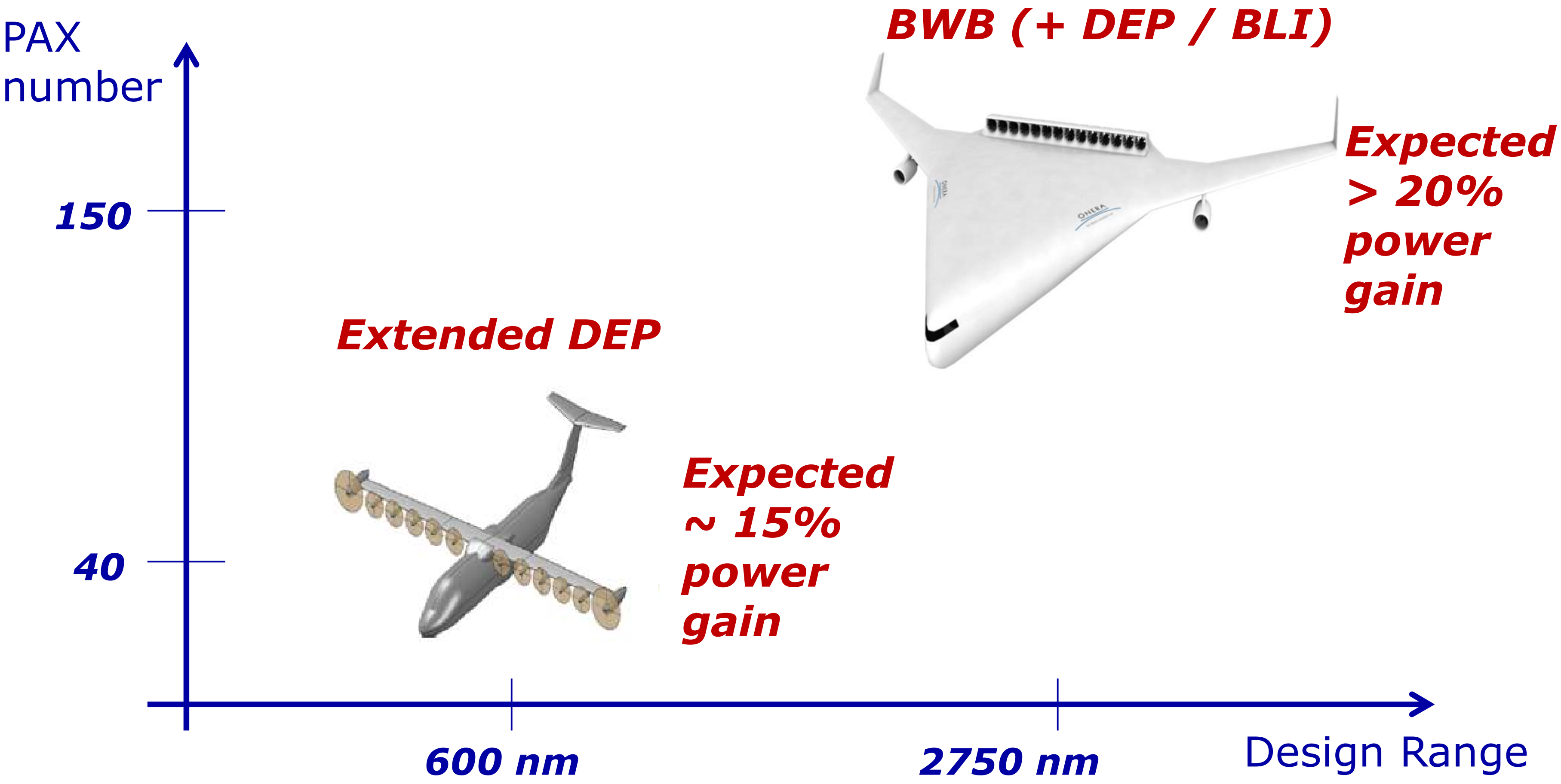
# Configurations

- **Supporting missions and configurations :**
  - 1st evolution : limited change in A/C architecture



# Configurations

- **Supporting missions and configurations :**
  - More aggressive evolution : increased architecture novelty



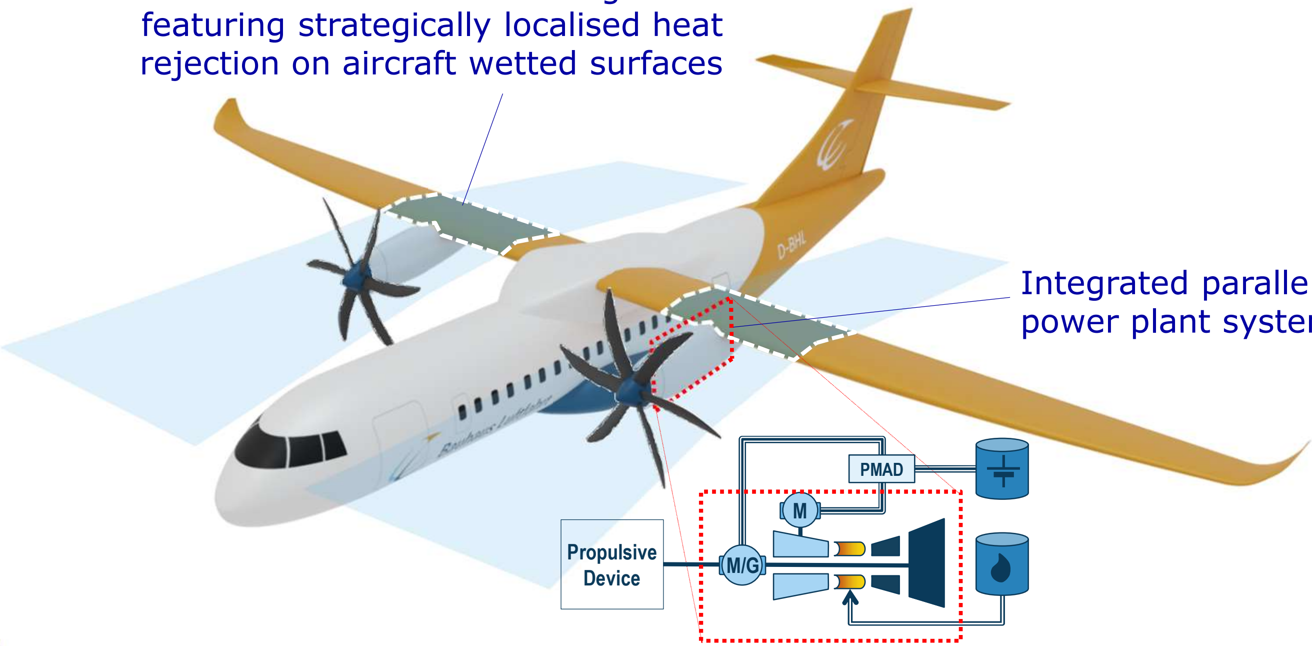
# REG-CONS Aircraft Configuration

Bauhaus Luftfahrt
Neue Wege.

## Hybrid-electric aircraft with assisted turbo-shaft engine

- Study focus: mission strategy, hybridization degree, technology advancement of electrical components, thermal management system

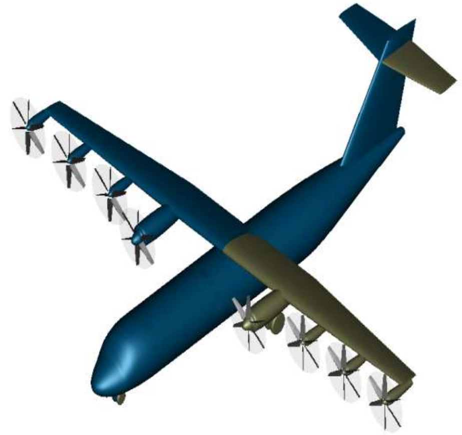
Electric waste heat management featuring strategically localised heat rejection on aircraft wetted surfaces



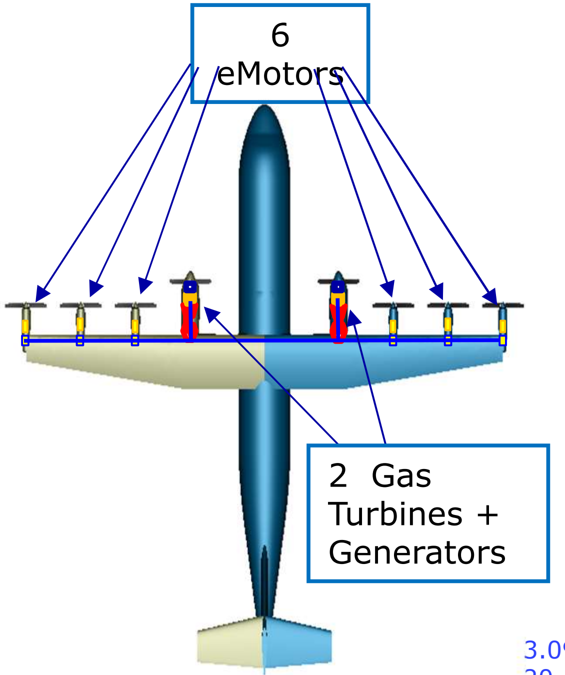

Integrated parallel hybrid power plant system

# REG-RAD Aircraft Configuration

## Hybrid chain with DEP



- Partial turboelectric architecture assumed.
- 8 propellers.
- 2 gas turbines.
- 2 inner propellers – driven by the gas turbines.
- 2 generators driven by the gas turbines in parallel.
- 6 e-motors driven by the generators.
- Simplified mass & efficiency modelling – to be aligned with project assumptions.
- No battery assumed currently, but can be directly added to this architecture.



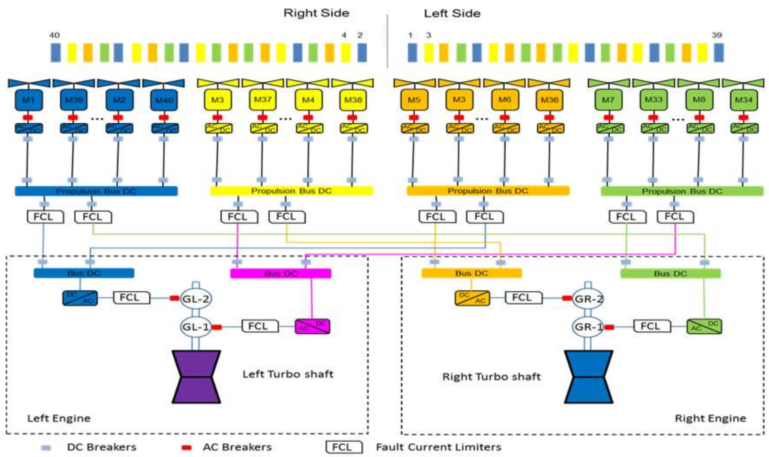
# SMR-CONS Aircraft configuration

ONERA
THE FRENCH AEROSPACE LAB

## DRAGON concept:

- Inherits from studies conducted within CS2-LPA (see [1] and P. Schmollgruber's presentation)
- Turboelectric architecture with 2 gas tubines and 26 / 40 e-motors

- Work to be conducted within IMOTHEP:
  - Refinement of component power level upon flight / safety criterions
  - Full review of electric architecture and inclusion of variants (eg. with batteries)
  - Detailed design of components including transient effect and thermal management




1.*"Multidisciplinary Design and performance of the ONERA Hybrid Electric Distributed Propulsion concept (DRAGON)",* P. Schmollgruber, D. Donjat, M. Ridel, I. Cafarelli, O. Atinault, C. François, B. Paluch. AIAA2020-0501 Scitech 2020 Forum

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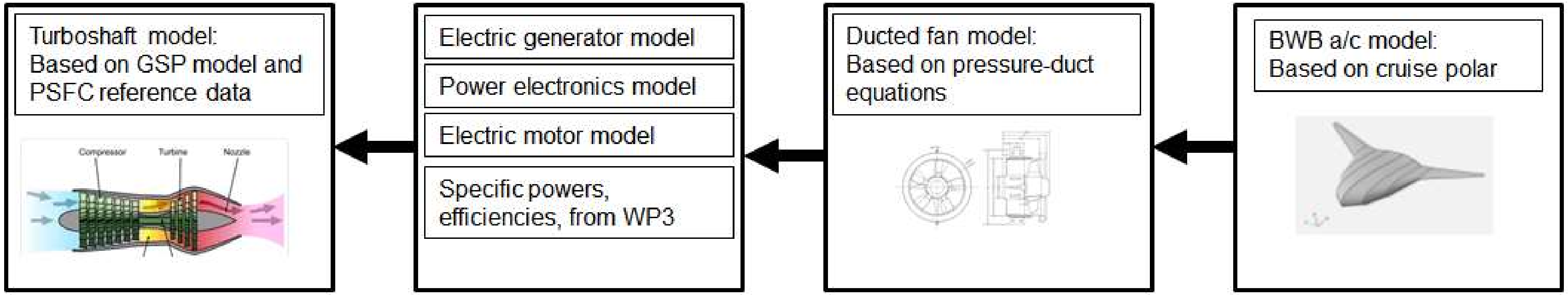
# SMR-RAD Aircraft configuration

## Reference: turboelectric hybrid chain

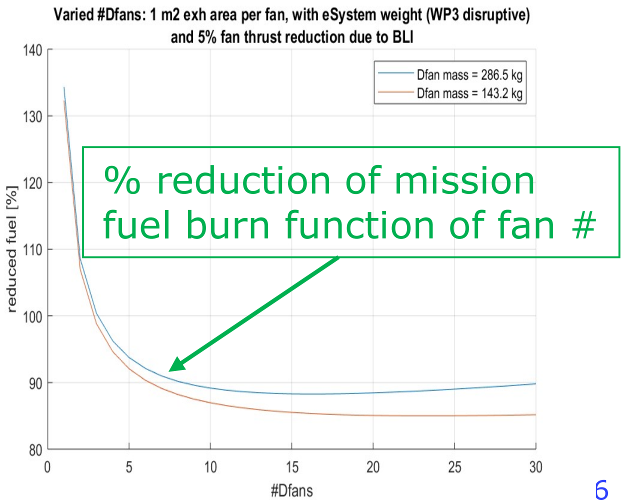
- Modelling of BWB airframe specificities and inclusion of HEP components with similar performances as for REG-CONS




- Relative mission fuel burn effects by including additional assumptions of system losses/benefits

- Sensitivity to aeropropulsive integration effects, highly sensitive at that stage

- Other HEP architectures to be investigated



# PERSPECTIVES

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# Perpectives

## Main orders of magnitude delivered

- Provide a basis for electric architecture definition and component sizing (e-motors, cables, batteries, generators, turboshafts,…)

  **-> Consistent aircraft integration, power level expectations confirmed**

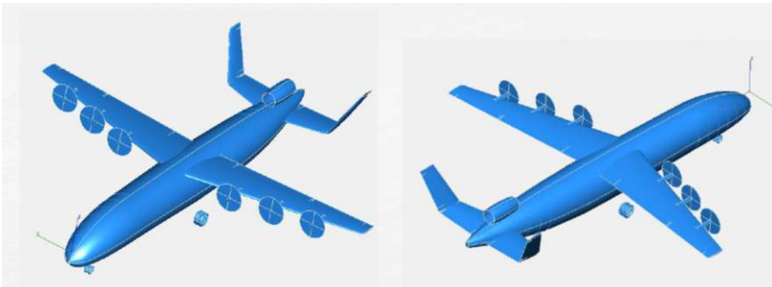
| | REG-CONS[1] | REG-RAD[2] | SMR-CONS[3] | SMR-RAD[4] |
|---|---|---|---|---|
| Power required on selected flight points | Total a/c level shaft-power [MW]:<br>TO: **2.8** / 2.95*<br>MC: **1.6** / 2.5* | Total a/c level shaft-power [MW]:<br>TO: 2.5<br>TOC: 2.3<br>MC:2.1 | Total a/c level shaft-power of electric motors [MW]:<br>TO: 18.2<br>TOC: 10.7<br>MC: 10.1 | Total a/c level shaft-power [MW]:<br>TO:33.2<br>TOC:10.<br>MC: 8.<br>See the Leap model table below for the context of these values. |

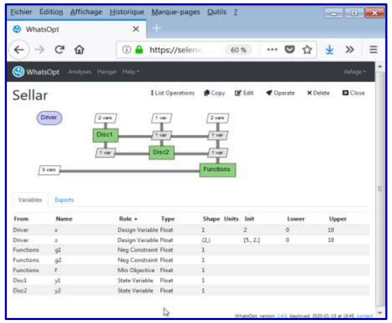
- Define initial geometries for aero-propulsive integration

  **-> High impact of uncertainties on DEP and BLI evaluation**

## Refined loops to be conducted

- Loop 1 : incorporate parametric models from technological WP and use multidisciplinary design approaches to consolidate results
- Loop 2 : defined consolidated CAD and refined performances of components, including transient behaviour



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