E2Flight Presentation: Concept Electric Flight

Energy Efficient Hybrid Propulsion Concept for Twin Turboprop Aircraft

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Introduction

The main goal of the presentation is to provide an overview on the possibilities to improve the performance of regional twin engine turboprop aircraft by using hybrid propulsion.

The initial discussion covers the basic hybrid concepts:

- Parallel Hybrid Architecture
- Series Hybrid Architecture

The general benefits and drawbacks of each are discussed and an estimate of the potential aircraft-level effect on fuel efficiency is given.

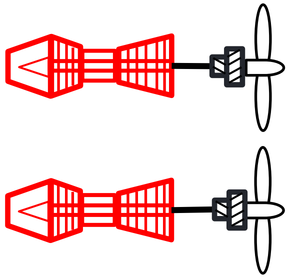
Further follows a discussion on a merged hybrid concept:

- Combined Hybrid Architecture

which incorporates the philosophy of the two basic hybrid concepts to push the limit of the achievable fuel efficiency potential even further.

Propulsion Architectures for a Twin Turboprop

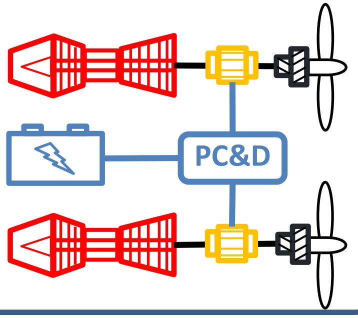
Conventional twin turboprop:
- Propeller driven by gas turbine.
- No power cross-feed.



Weight & complexity increase

Improved propulsion off-design performance

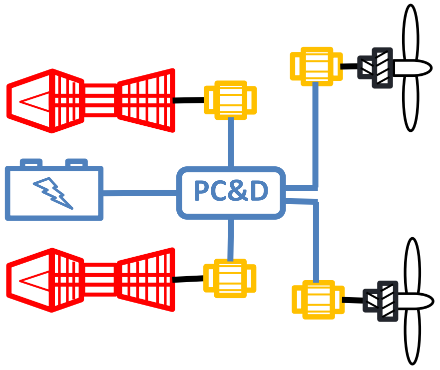
Parallel hybrid propulsion:
- Propeller driven by gas turbine and e-motor + battery.



Weight & complexity increase

Operation & Integration Flexibility

Series hybrid propulsion:
- Propeller driven by e-motor
- Gas turbine generates E-power
- Battery for power boost



Legend:

Gas Turbine

Mechanical Shaft

Electric Power Line

Battery

E-Power Control and Distribution

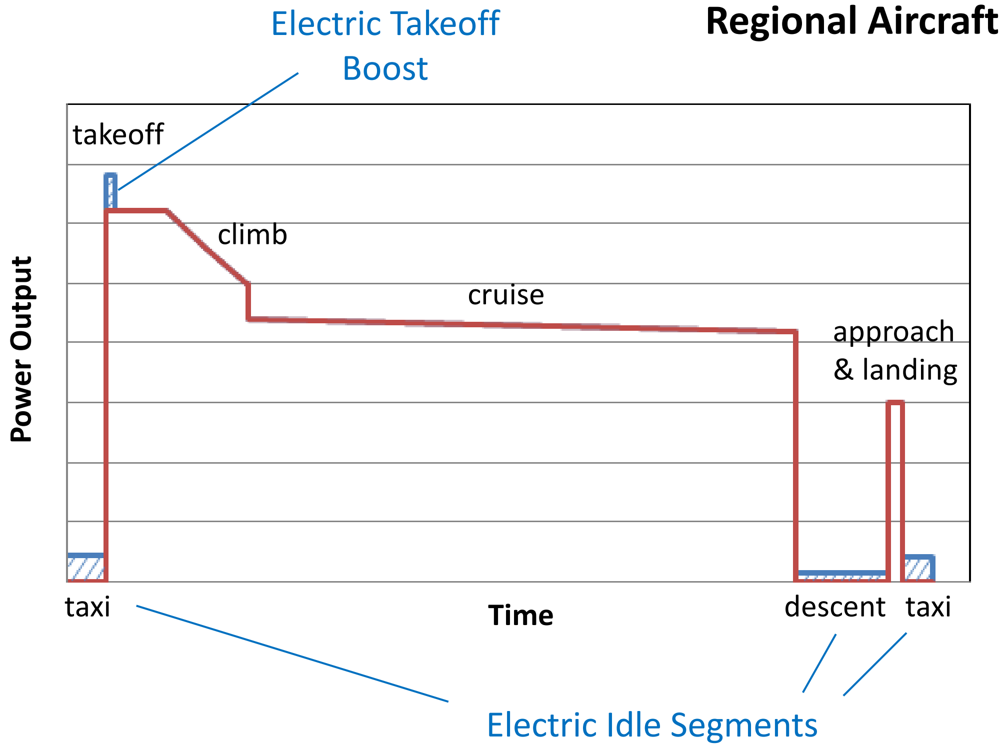
eMotor/Generator

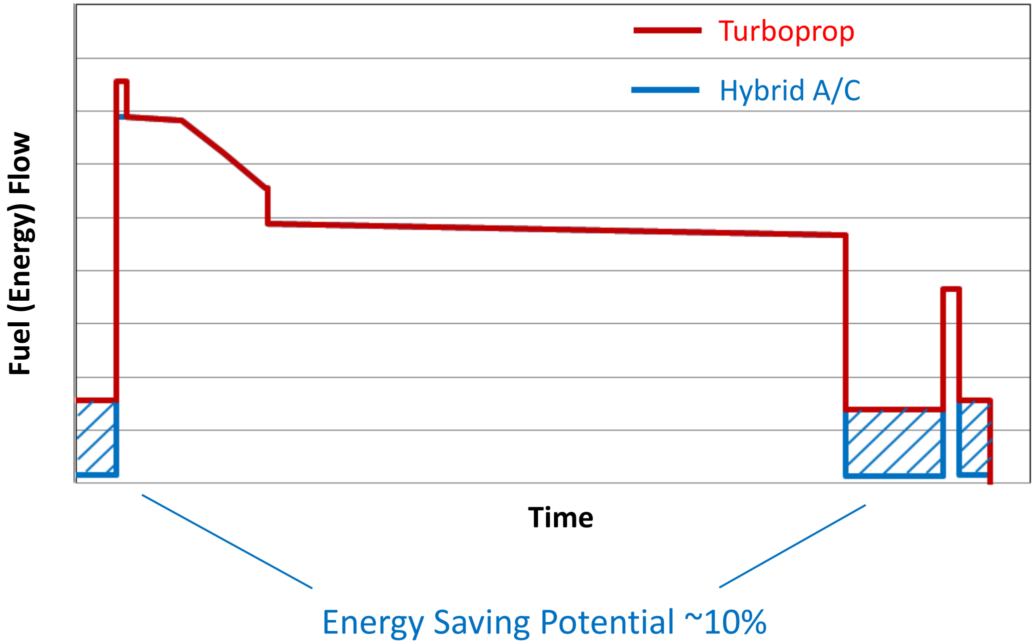
Gearbox

Propeller

Off-Design Efficiency Improvement with Hybrid Propulsion

Regional Aircraft Mission Profile: 500nm

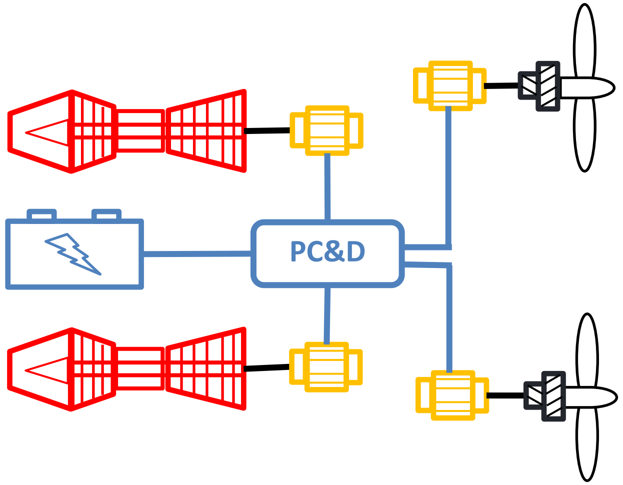




Off-design electric power benefits:

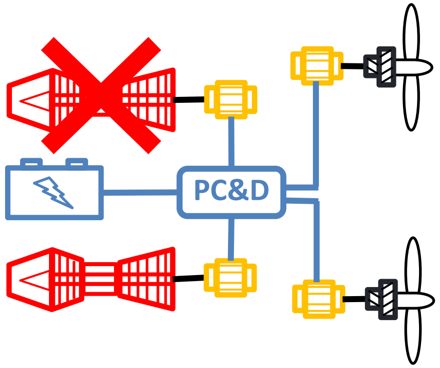
- -10% block fuel potential for <500nm missions (due to taxi & descent).
- Less noise and emissions near airports.
- Relaxed engine takeoff rating.

Series Chain Operation Flexibility

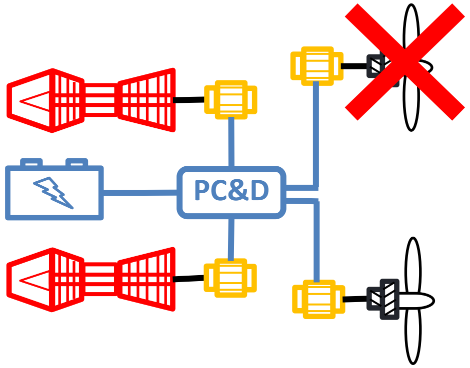


Operational flexibility due to mechanical decoupling

Mitigated One Engine Inoperative Case.

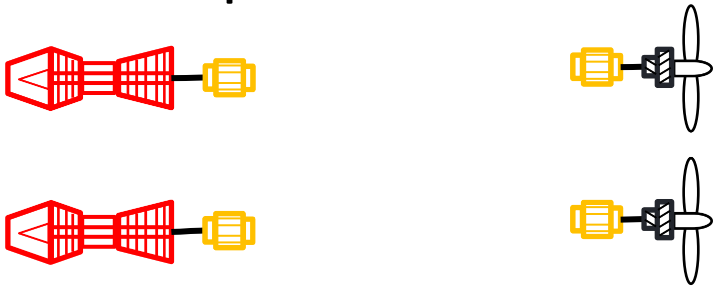


Half power but no prop loss



Half thrust & prop windmilling but full power available

Decoupled Power & Thrust



Optimal RPM

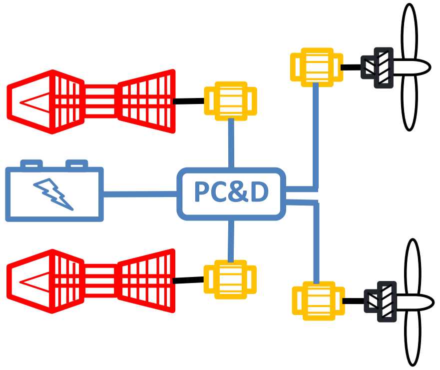
Optimal RPM

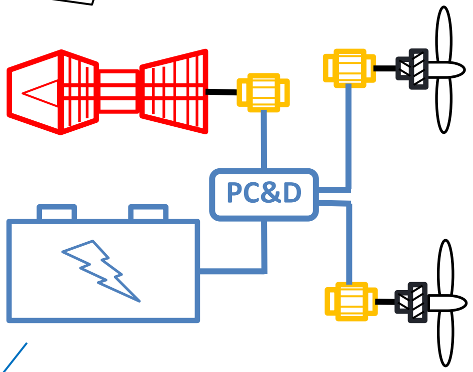
Decoupled RPM optimization for improved performance & more flexible energy management

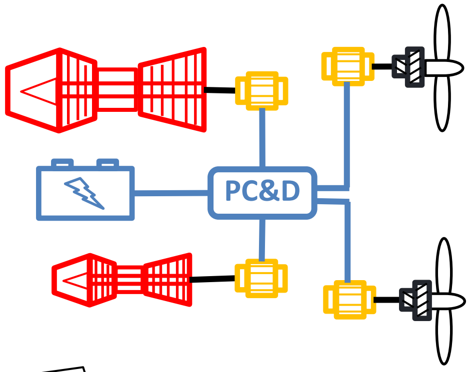
Integration & Configuration Flexibility

One main gas turbine for cruise:
- Improved thermal efficiency due to scaling effects

Design specifics:
- Main Gas Turbine designed for efficiency
- Supporting Gas Turbine designed for min. weight / cycle cost





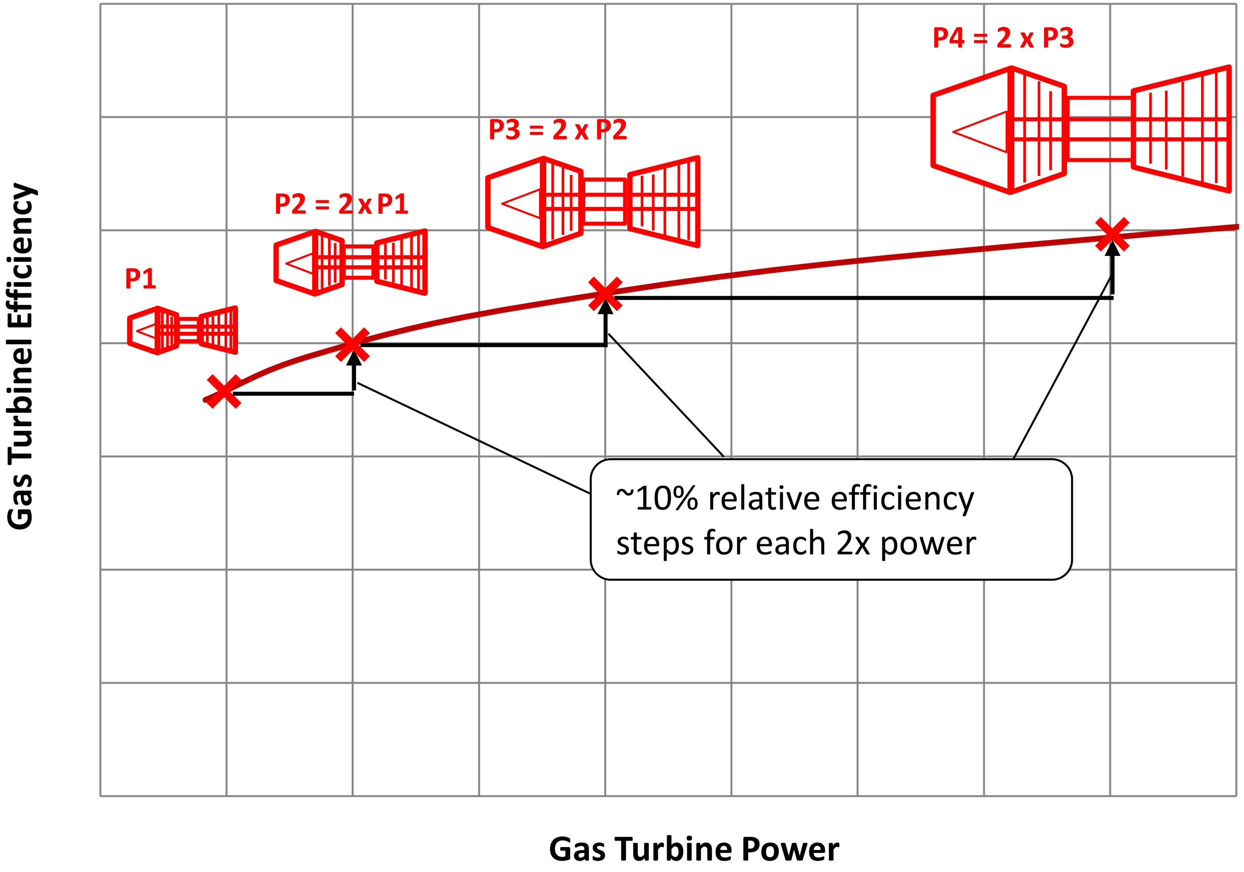


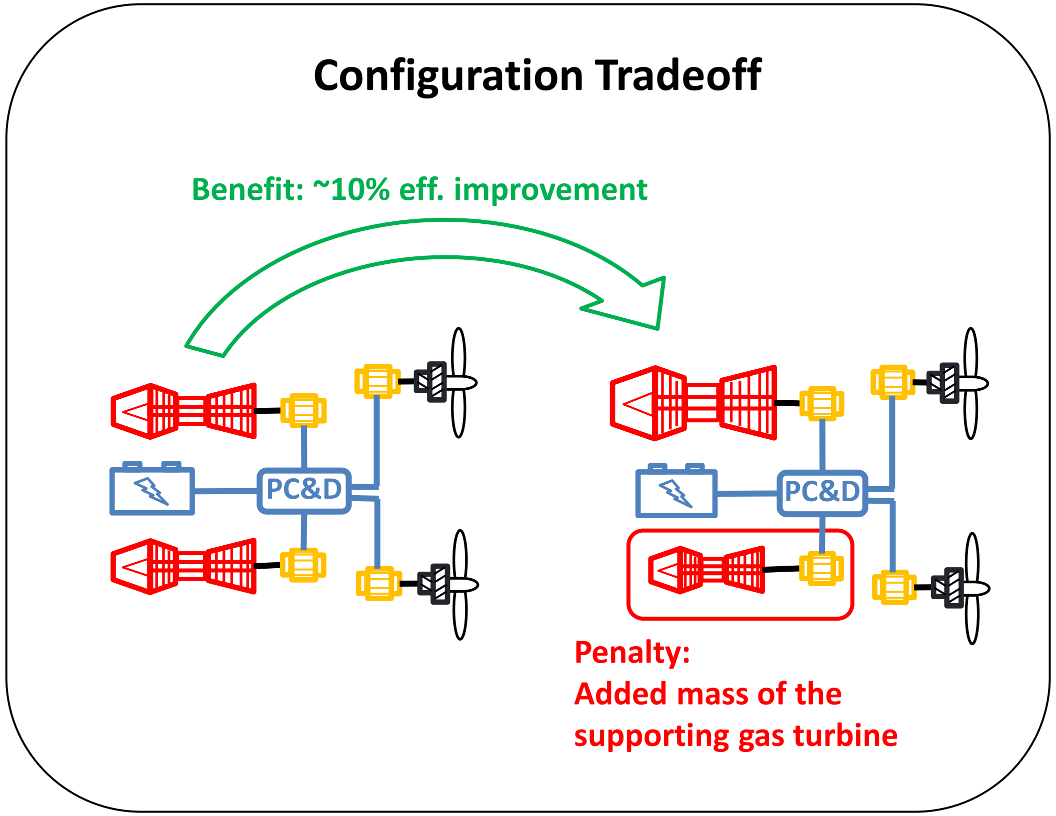
Challenge:
- A bigger battery needed due to diversion in case the gas turbine fails.
- Not a viable tradeoff

Solution
→ supporting gas turbine
- In case the main fails
- for takeoff/climb boost

One Main Gas Turbine vs Two Gas Turbines

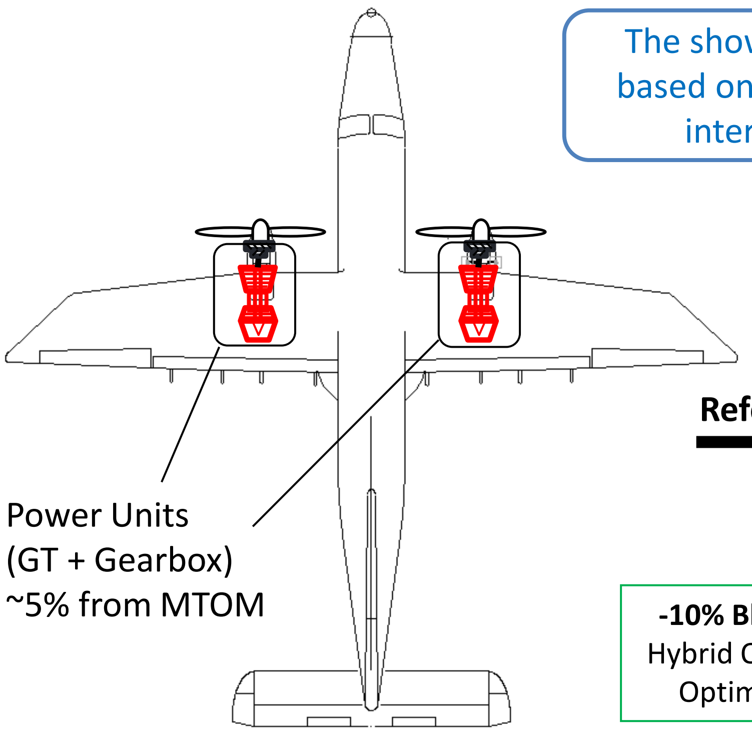
A trend for gas turbines in the regional aircraft class and below observed in previous studies:



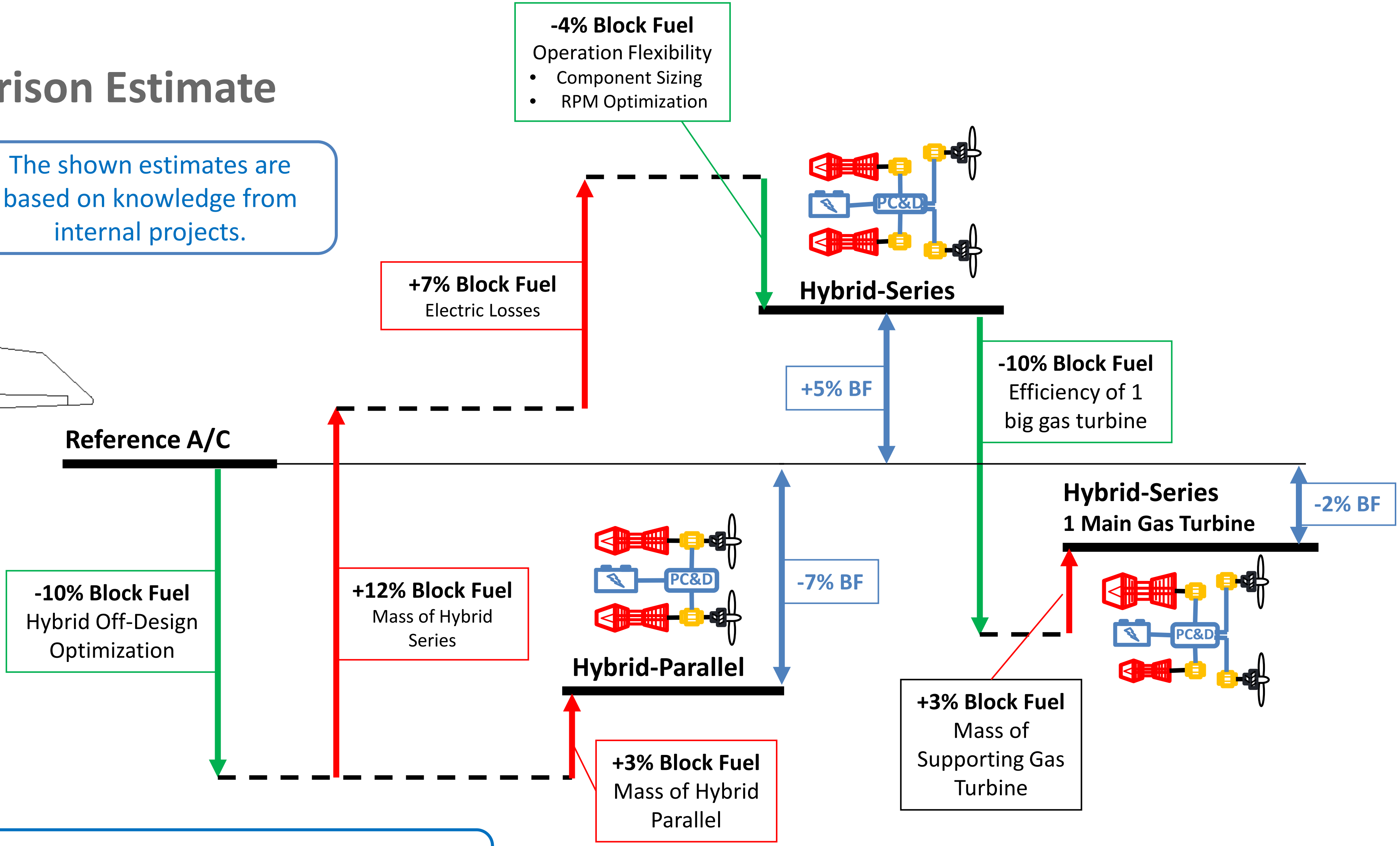


Performance Comparison Estimate

The shown estimates are based on knowledge from internal projects.



Reference: Twin Turboprop



Hybrid-Parallel and Hybrid-Series generally struggle to achieve double-digit block fuel improvement.

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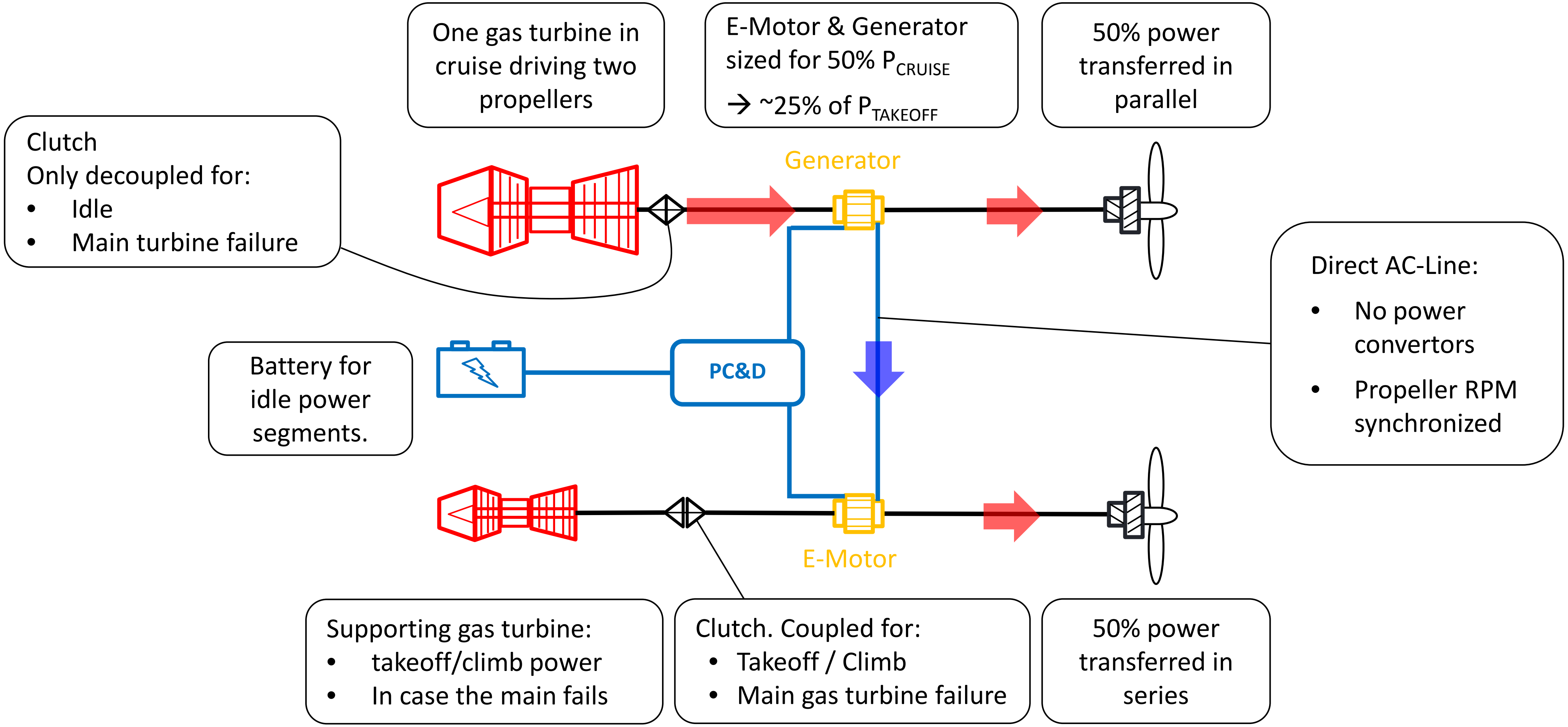
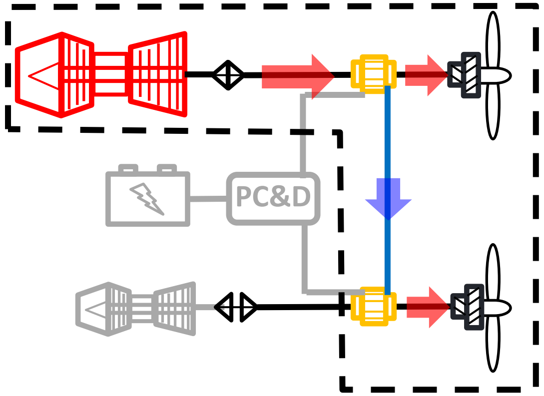
Hybrid Combined Architecture Concept



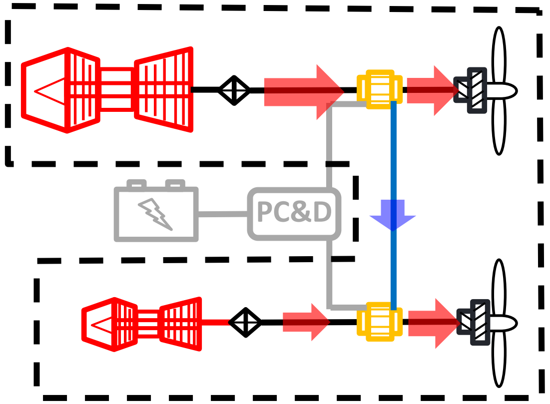
Hybrid-Split Architecture Operation

Design Point (Cruise)



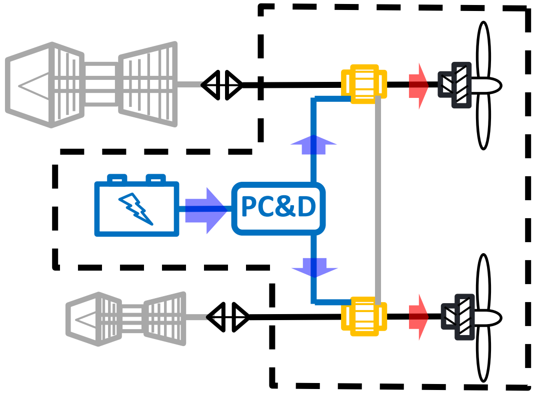
- Main gas turbine drives both propellers.
- Supporting gas turbine turned off & decoupled by clutch.
- Battery turned off.

Takeoff / Climb



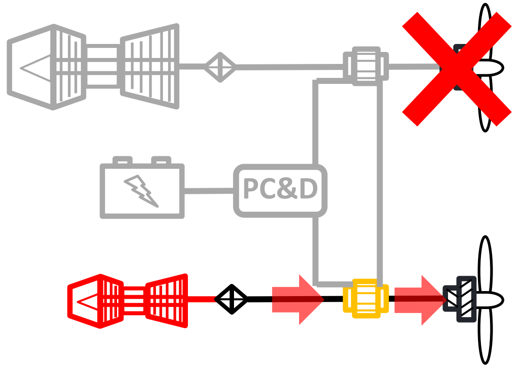
- Main gas provides power to both propellers.
- Supporting gas turbine provides power to one propeller (in parallel).
- Battery turned off.

Idle – Taxi / Descent



- Both gas turbines turned off & decoupled.
- Battery powers both propellers.

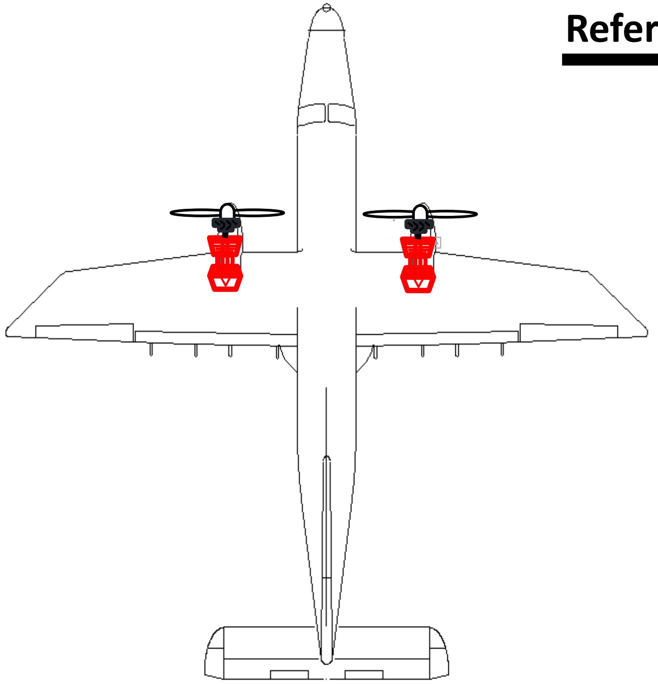
Worst Case Failure



- Gearbox is jammed – both propeller and main gas turbine cannot be used.
- Supporting gas turbine powers operating propeller mechanically (as in conventional turboprop).
- Battery turned off.

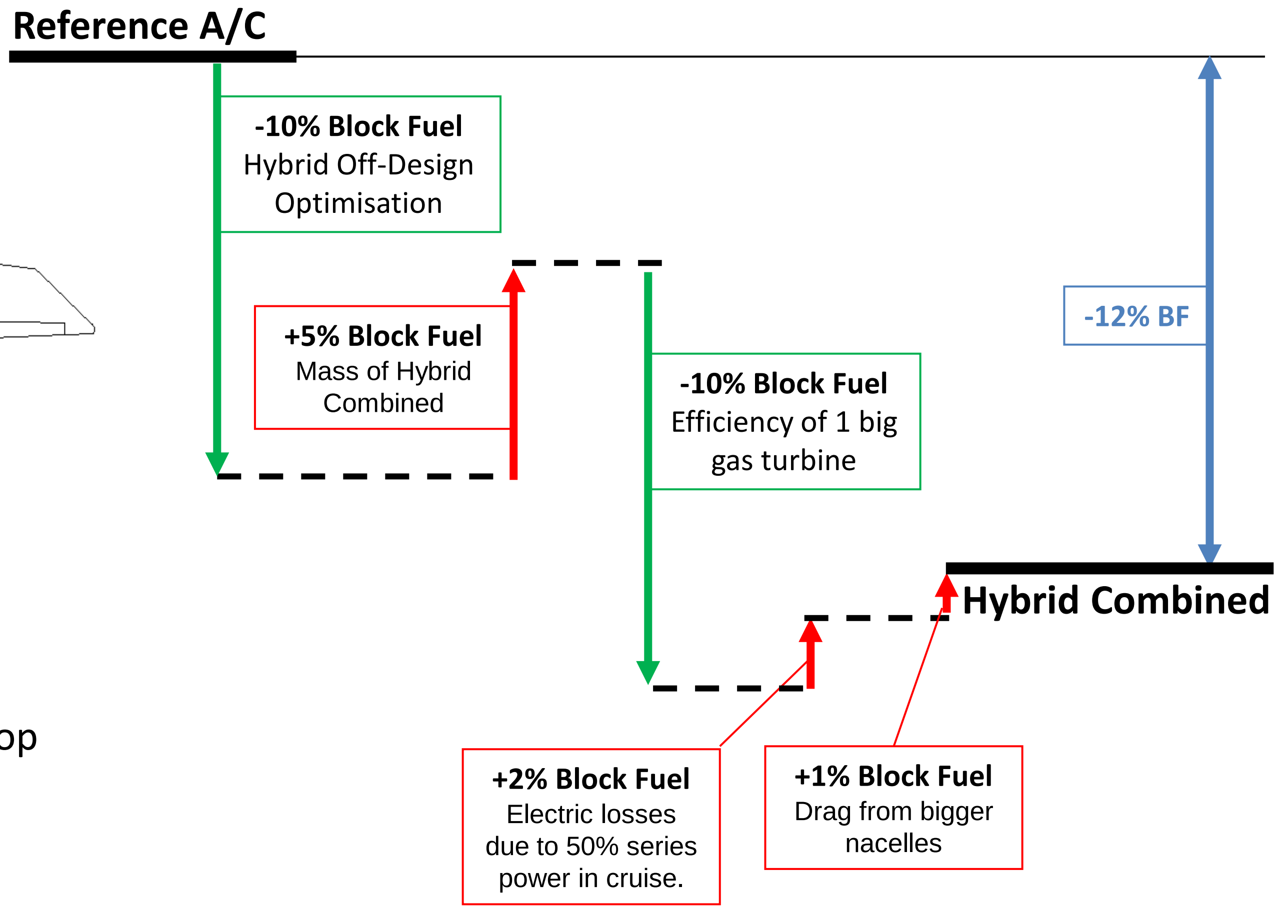
Hybrid-Split Architecture Performance

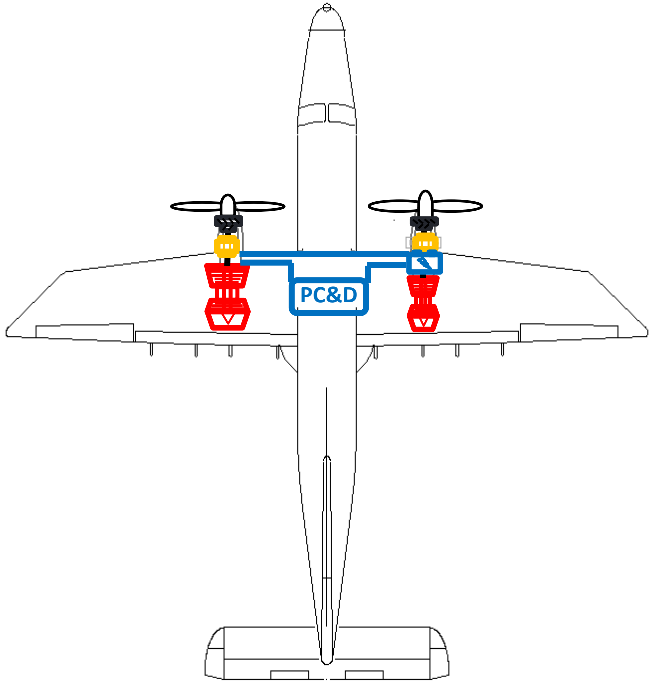
The shown estimates are based on knowledge from internal projects.



Reference: Twin Turboprop

Power Units ~ 5% MTOM





Integrated Hybrid Combined

Over 10% block fuel saving possible with hybrid combined architecture.

Conclusions

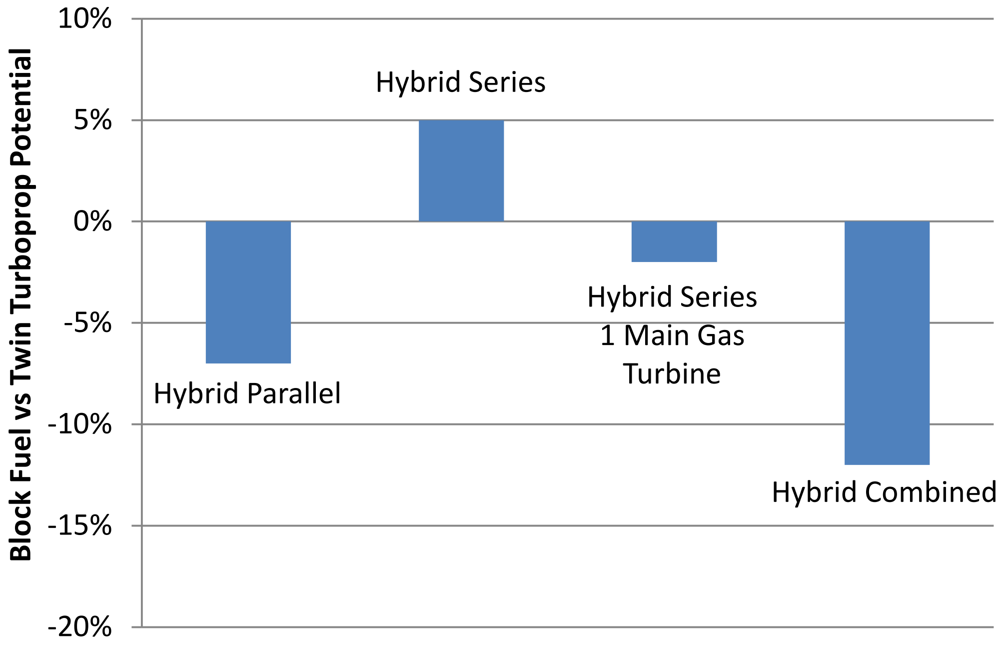
It was shown that by making use of the advantages of both parallel and series hybrid concepts, the **combined hybrid architecture** is potentially able to achieve a **double-digit block fuel benefit**.

Main technological bricks of the hybrid combined concept:

- Off-design operation optimization.
- One main gas turbine instead of two in cruise.

Constraints of the hybrid combined concept:

- Regional and commuter class aircraft.
- Twin engine operation.
- Increased benefits on shorter missions.



Thank you for your attention!