Centro Ricerca Energia e Ambiente

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# Design and optimization of hybrid electric power systems for unmanned aerial vehicles

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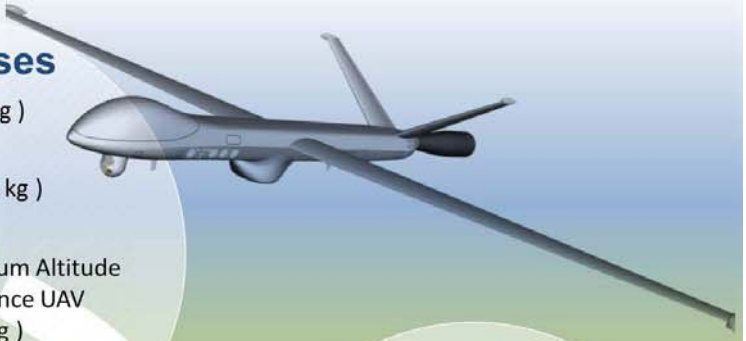


## Test cases

A quadcopter (11.2 kg )

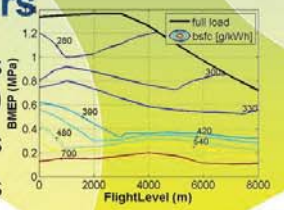
A hexacopter (16.8 kg )

A generic Medium Altitude Low Endurance UAV (500 kg )

General Atomics Predator RQ(1020 kg )

## Models for engines & motors

- A library of fuels and engines (**piston**, turbine, rotary )
- A library of electric machines
- PEM and advanced fuel cells
- Reference stationary maps
- Scaling techniques

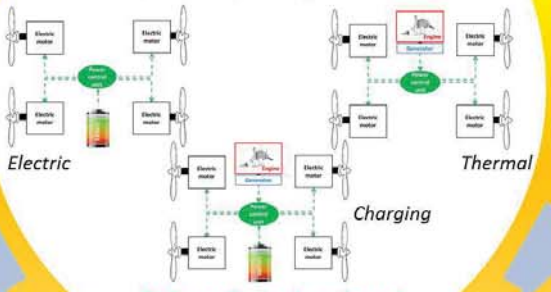



## Design procedure


## THE IDEA

Parallel & Series hybrid power systems

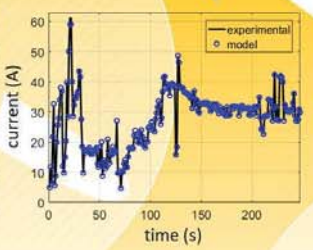
1) Three operating modes




2) An optimized on-board battery charging system

## Modeling the battery

A modified version of the Shepherd model, extensively validated against experimental data of Lithium-polymer and Zebra batteries in charge and discharge.




## Optimization

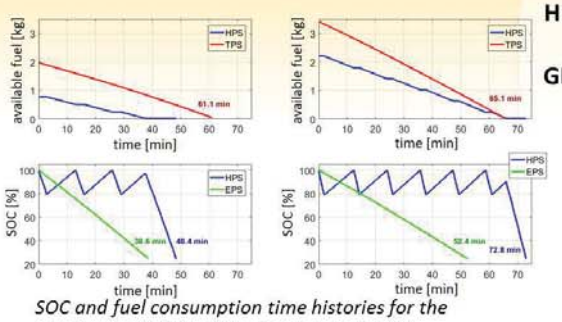
**INPUTS**:
→Engine size;
→ Battery capacity and voltage;
→ Hybridization ratio;
→ Energy management strategy

**GOAS**:
↑Endurance in electric flight
↑ Fuel economy in hybrid mode
↓Takeoff mass
↓ Additional volume

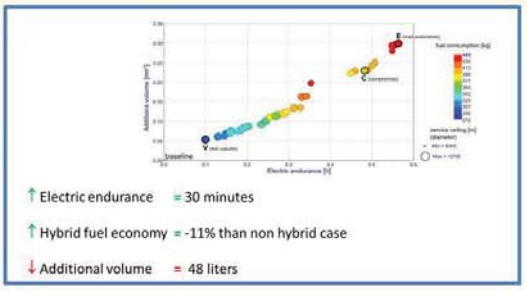
**CONSTRAINTS**:
↔ Battery rating

## Results & conclusions

**QUADCOPTER**: best results with the thermal power system.
**HEXACOPTER:** best endurance (72.7min) with the hybrid electric system.
**GENERIC MALE:** electric endurance 0.5h, Fuel economy + 12%
Overall mass: +20%
**PREDATOR RQ1:**




*SOC and fuel consumption time histories for the quadcopter (left) and the hexacopter (right)*



↑ Electric endurance = 30 minutes

↑ Hybrid fuel economy = -11% than non hybrid case

↓ Additional volume = 48 liters