Design Challenges of High Endurance MALE UAV –

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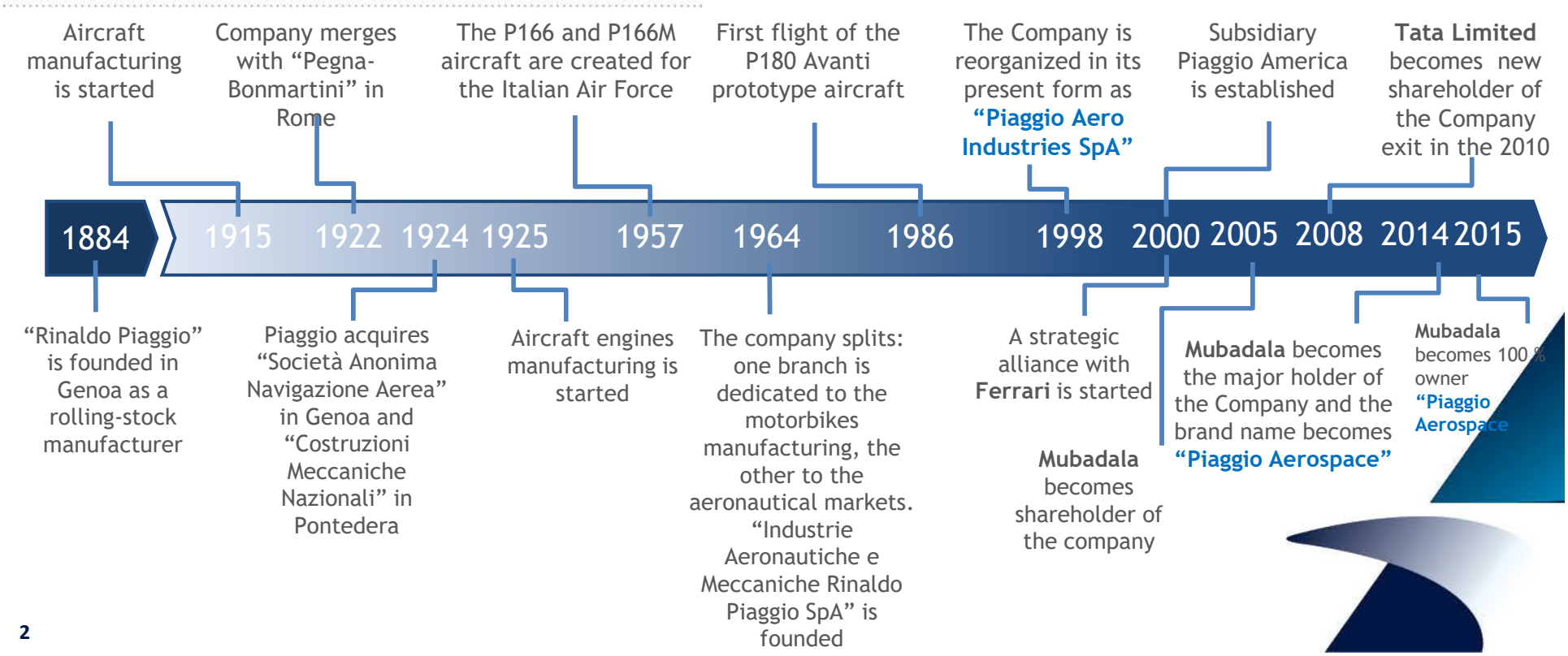
Piaggio Historical background

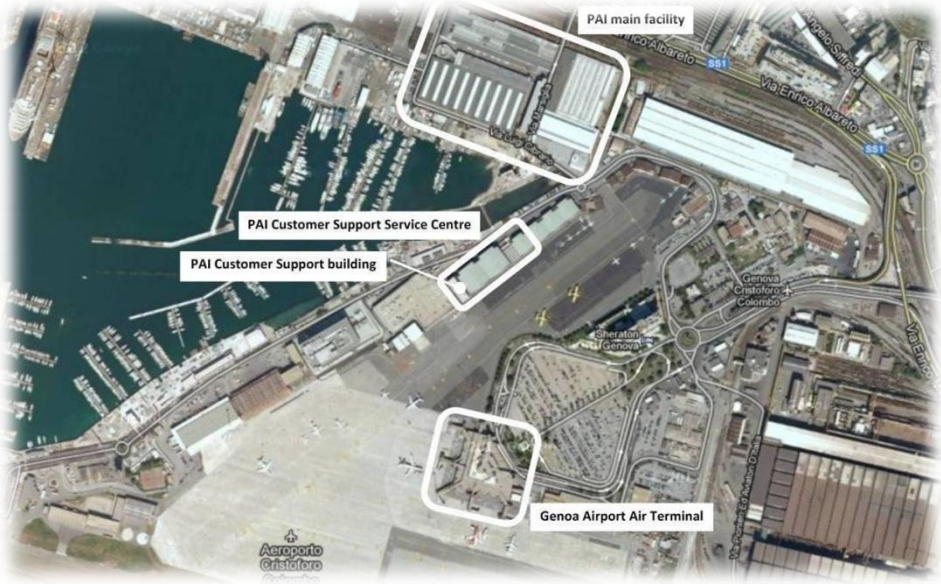


Villanova d'Albenga plant

- New state-of-the art facility
- Designed to implement the latest lean manufacturing technologies
- Total Area: 129.000 sqm
- Current Workforce: 600
- Currently transferred activities:
  - Headquarter
  - Aircraft Design
  - Engine Parts Manufacturing
  - PW200 Engine Assembly & Test
  - Engine MRO
  - Aircraft production (ex Finale Ligure)
  - Laboratories
  - Iron Bird & Aircraft Structural Testing LAB

Genoa Customer Support & Training plant

- Total Area: 5.000 sqm
- Current Workforce: 150
- Activities:
  - P180 Maintenance
  - P166 Maintenance & Upgrade
  - Product Support
  - Training Center for maintenance personnel (MTO) (*)



(*) = Temporarily moved in Genova Aircraft production offices

P.180 AVANTI EVO, evolution of **P.180 AVANTI II**, embodies the following upgrades:

- Low Noise propulsion system (Propellers and Exhaust duct)
- Additional Fuel Tank for Increased Range
- New Landing gear with new steering
- Antiskid
- New Integrated ECS (Environmental Control System)
- New Integral Winglet System
- LED External Lights
- SBAS (Satellite Based Augmentation System) Capability

Range increased by 17% (from 2725 km to 3185 km)

Fuel consumption and CO2 emissions reduced by 3%

Noise reduced by 68% external, 20% internal

Climb performance improved by 3%

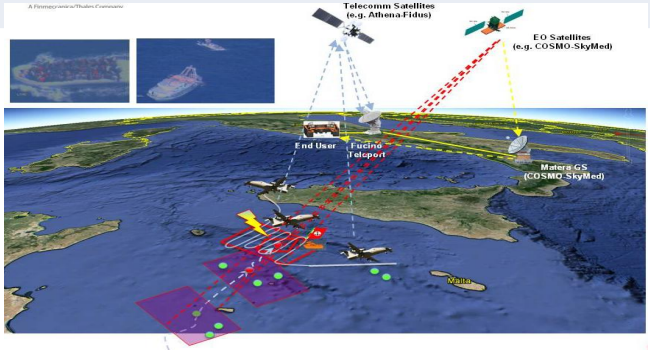
The **Piaggio Aerospace P.1HH HammerHead** is a new, state-of-the-art UAS (Unmanned Aerial System), designed for ISR (Intelligence, Surveillance and Reconnaissance) missions, whose combination of performance and operational characteristics is at the very top end of the UAS MALE category

P.1HH HAMMERHEAD

- VCMS (Vehicle Control & Management System)
- MMS (advanced Mission Management System)
- VCMS and MMS are commanded from a GCS (Ground Control Station) via an airborne Datalink system
- air vehicle command & control by LOS/BLOS (Line Of Sight/Beyond Line Of Sight)
- payload digital encrypted data transmission via RF links/SATCOM

RPAS Users Mission Need

Non Military	Military
Search & Rescue	ISR √
Fisheries control	Force protection √
Damage assessment of Natural disaster	Communications relay√
Scientific and Research related	Electronic support measures√
Pipe/power line surveillance	Electronic counter measures√
Mail freight transport	Training and Exercise √
Critical infrastructure monitoring	Target acquisition √
Law enforcement (incl. Urban area)	Close Air support√

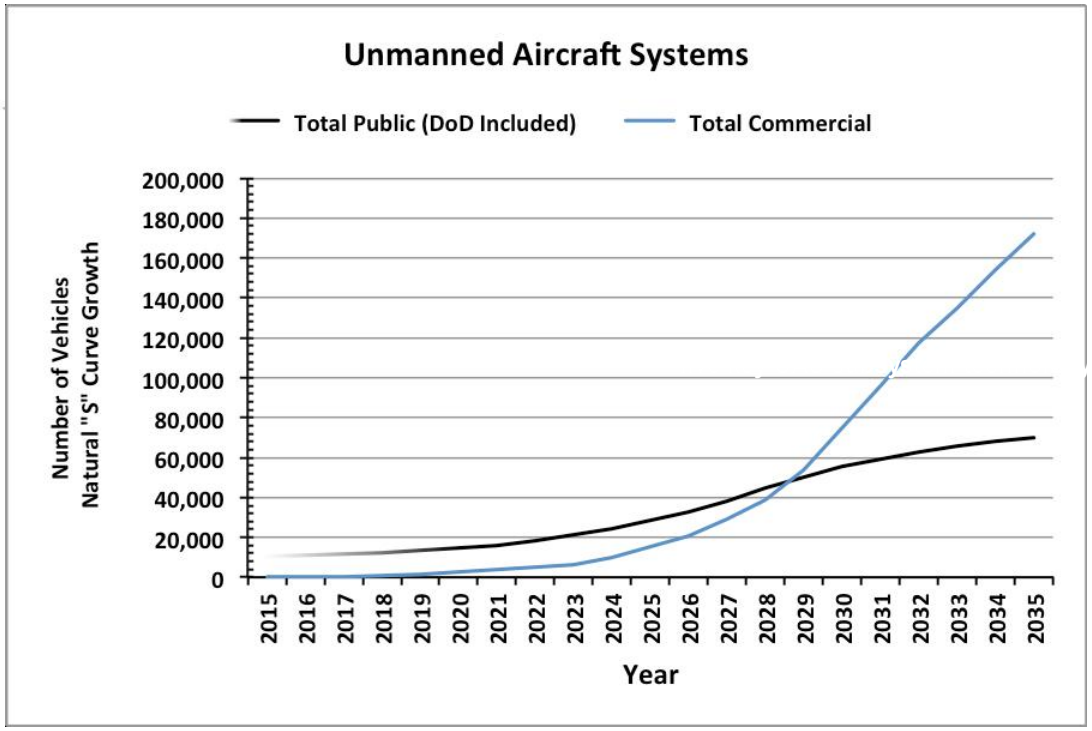


Challenges to Market Development

PIAGGIO AEROSPACE

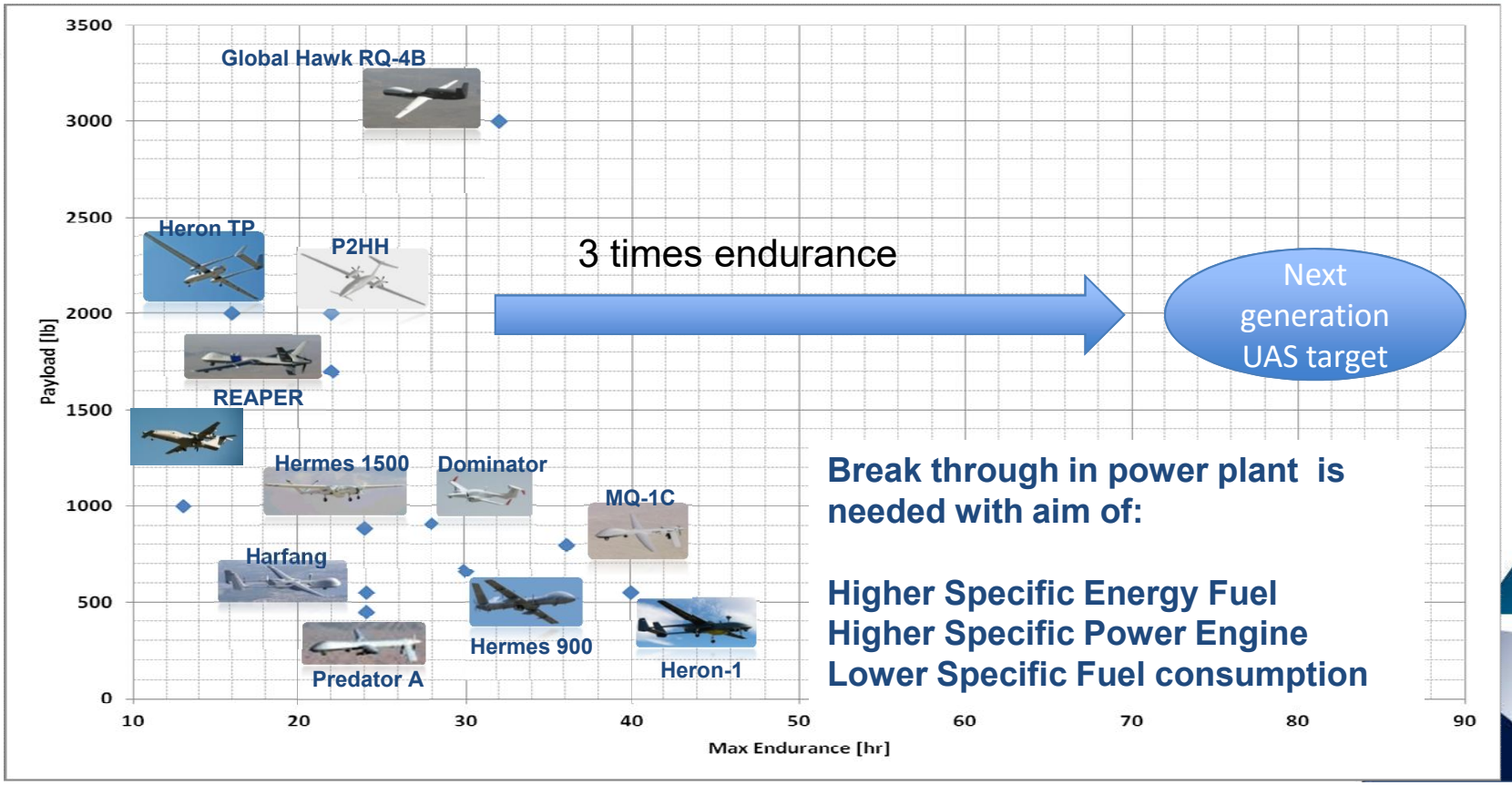
- There are a considerable number of challenges facing the development of a RPAS free market; these include:
  - Regulatory
  - Policy
  - Procedural, social, and environmental concerns.
- Furthermore key to developing RPAS markets is the ability to advance, enable and synergize technologies in:
  - Airframe
  - Propulsion
  - Communications, command and control
  - Sensors
  - Information processing

Forecast for Commercial Market UAS

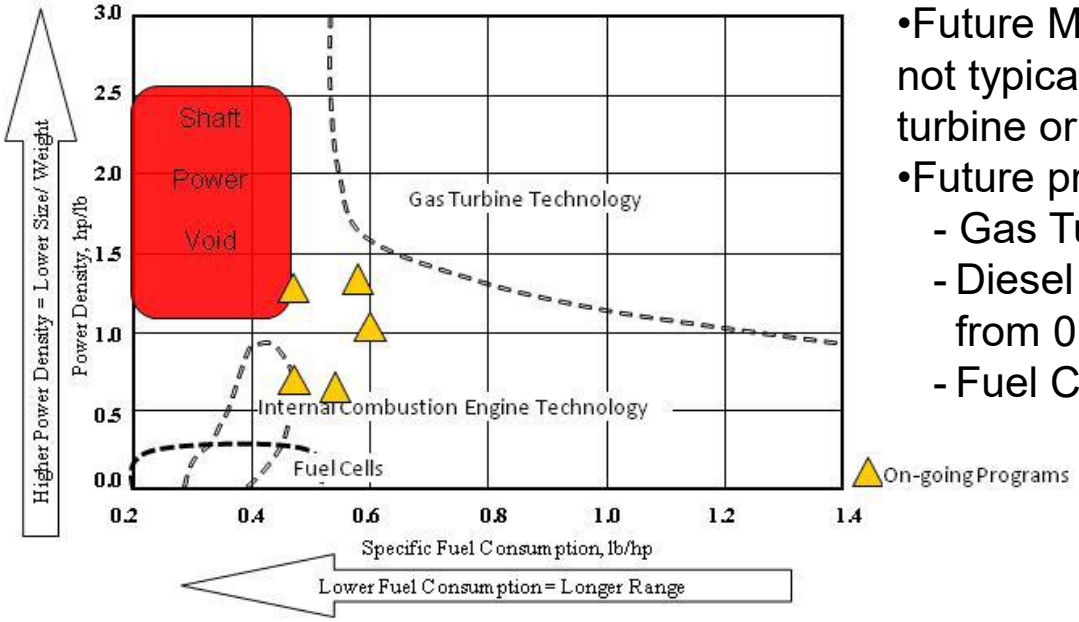


As markets are defined and refined, it is expected that beginning in the 2022 to 2023 period commercial sales of UAS vehicles

Next Generation UAS MALE Persistence Increase

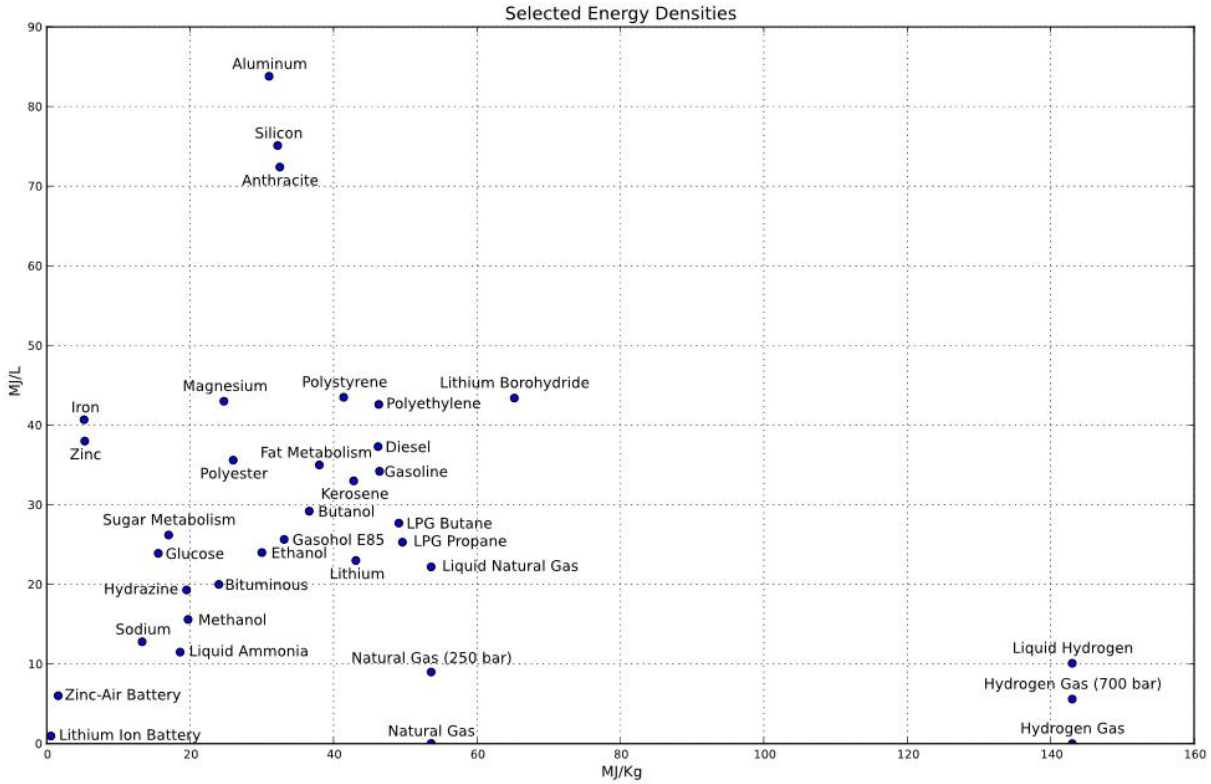


Future UAS MALE Power Requirements



- Future MALE design space powerplant not typically addressed by either gas turbine or piston engine systems.
- Future progress are in the range of:
  - Gas Turbine reduce SFC 15-30%
  - Diesel Power increase power density from 0,5 to 1
  - Fuel Cell offer significantly lower SFC

Higher Specific Energy Fuel



Hydrogen gas has the *highest specific energy* but *the lowest energy* density

Obtain higher energy density using compressed hydrogen

Liquid H2 Powered

<u>Boeing Phantom Eye</u> high-altitude, long-endurance unmanned aircraft system

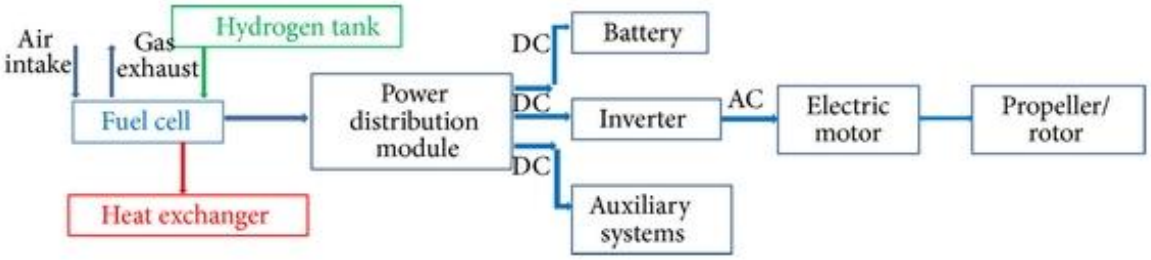
Demonstrates the potential of a "stratospheric, persistent directed energy" platform.

Performed nine flights with 54,000 ft altitude and 9hrs endurance

<u>Question</u>:

Is liquid H2 power plant able to cope with both propulsion and non propulsion power requirements ?

Propulsive and Non Propulsive Architecture and Power requirements



MALE UAS need a significant non propulsive power (50+ KW) for auxiliary (anti-ice, flight control etc.) and surveillance systems (Radar, EO/IR etc.)

Propulsive power required depending on the speed, altitude, payload but not less than 500 KW total.

Higher Specific Electrical Power Engine

•Electrical motors today are considered limited drive unit, despite their undoubted merits, such as:

-Efficiency
-Quiet operation,
-Beneficial power and torque characteristics,
-Pro-ecological character
-Relatively low costs of investment
-High reliability

•Siemens new prototype electric motor specifically designed for aircraft that weighs in at just 50 kg (110 lb) and is claimed to produce about 260 kW

•Twin engines solution could allow MALE UAS up to 9 tons MTOW of which 5 tons for powerplant+fuel budget

Requirements for Fuel Cell to Power MALE UAV

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PEM fuel cells have achieved specific power of up to 1.2 kW/kg in the 100 kW range that is 8 times less Li-ion Battery

MALE needs minimum fuel cell in the range of 250-300 KW (twin fuel stack)

Specific Power must be of 2.5KW/Kg in the 250-300 KW range

Requirements for LH2 storage MALE UAV

Development of a large, lightweight, reusable cryogenic liquid storage tank is crucial to meet for long flight duration of MALE UAV

Material selection, manufacturing and fabrication process are also a key factor

Research in the area of storage of LH2 for aircraft and spacecraft has been conducted for many years but still a need of research in the durable, lightweight cryogenic propellant storage and feed systems are required to enable the development of hydrogen-fueled MALE UAV.

The weight budget for feasible UAV MALE of 3-4 days endurance must be less than 1 ton.

Conclusion

Could the feasibility to implement 3 times endurance in a MALE UAV

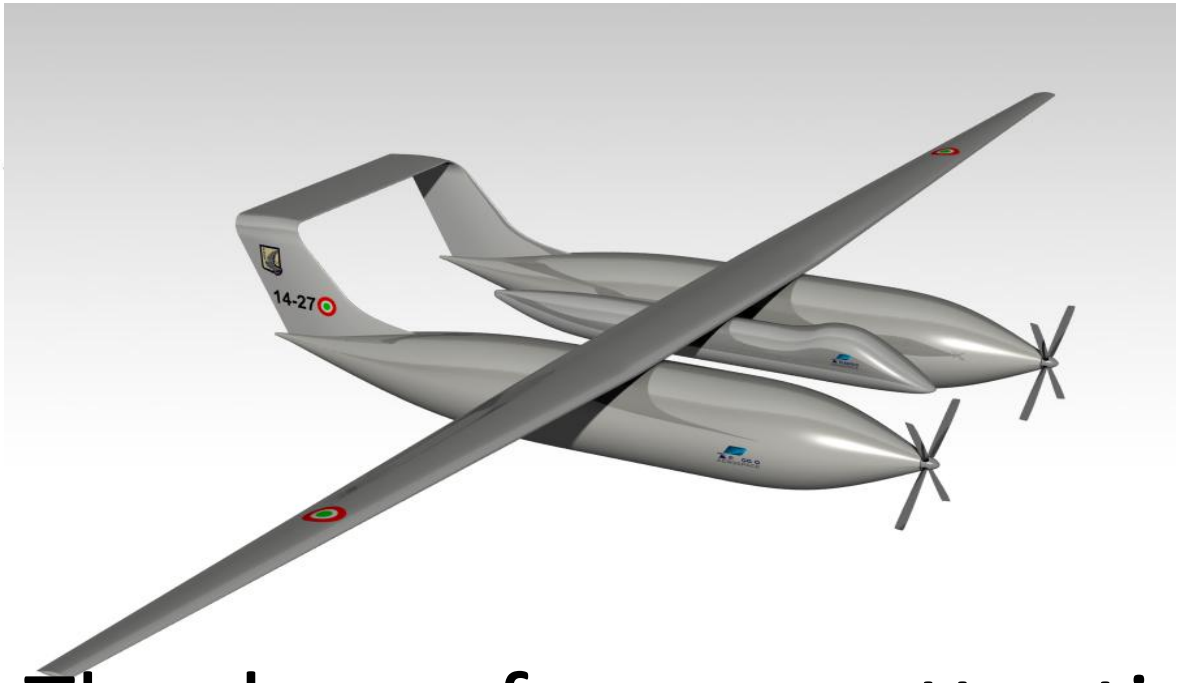
The answer is yes but the following efforts in research must be achieved:

Fuel cell technology is still immature at large size but can be improved in terms of weight, volume, and costs reductions for propulsive and non propulsive power need.

In the case of a MALE UAV, it is essential to minimize the weight of the overall propulsion system including the LH2 storage system.

Reliability and Safety must be a key factor to meet the requirements of efficient and safe operation

Hydrogen Fuel Cell Electrical Powered MALE



Thank you for your attention!

Questions ?