

Solid Oxide Fuel Cells Unmanned Air Vehicles

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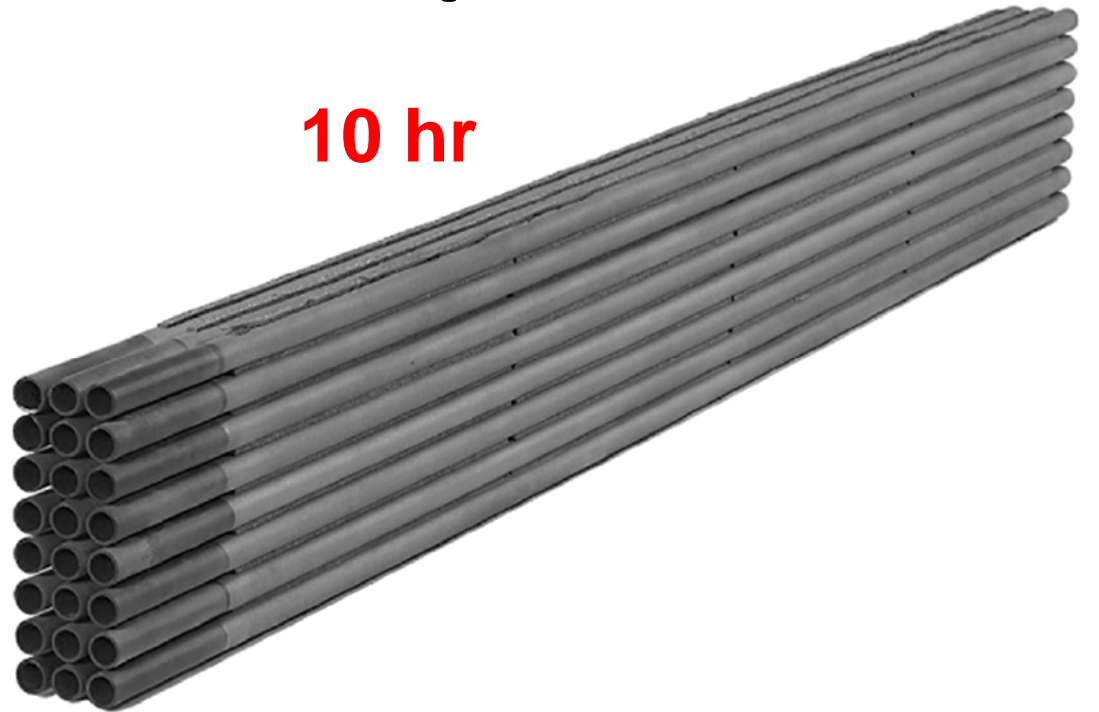
CAN SOFCs WORK?

- Too long to warm up

10 hr

- Too heavy

10 W/kg





TWO PROBLEMS of UAVs

Range of electric UAVs

Regulations



TWO PROBLEMS of UAVs

Range of electric UAVs

30 minutes

Regulations

2015 significant changes

Two Contributions

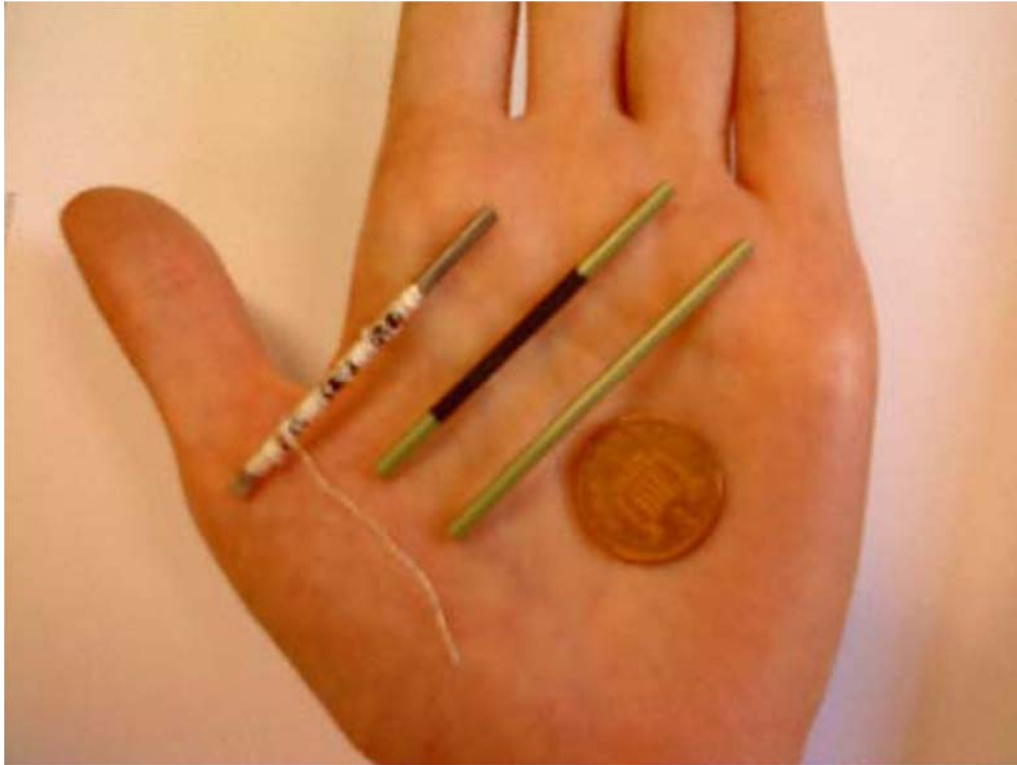
- **Invention**

10 sec warm-up, 100W/kg

- **Company**



ADELAN



Microtubular SOFCs

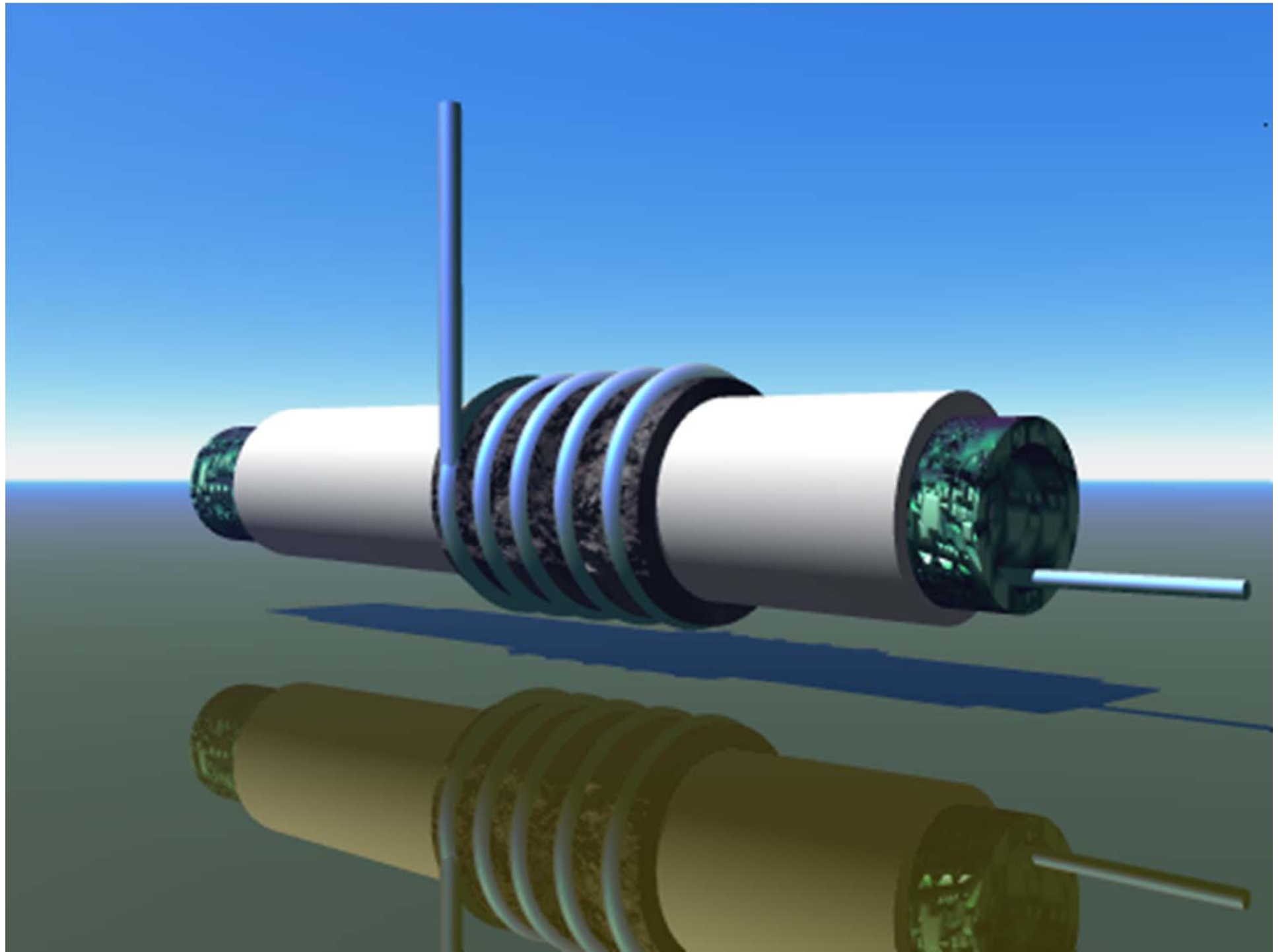
mSOFCs

Invented by KK & MK 1992

faster heat-up time is main feature of this technology

smaller diameter gives a higher power density, 100W/kg

but it is more difficult to make the connections for larger numbers of cells



SOFC DEMONSTRATOR



UAVs powered by Fuel Cells

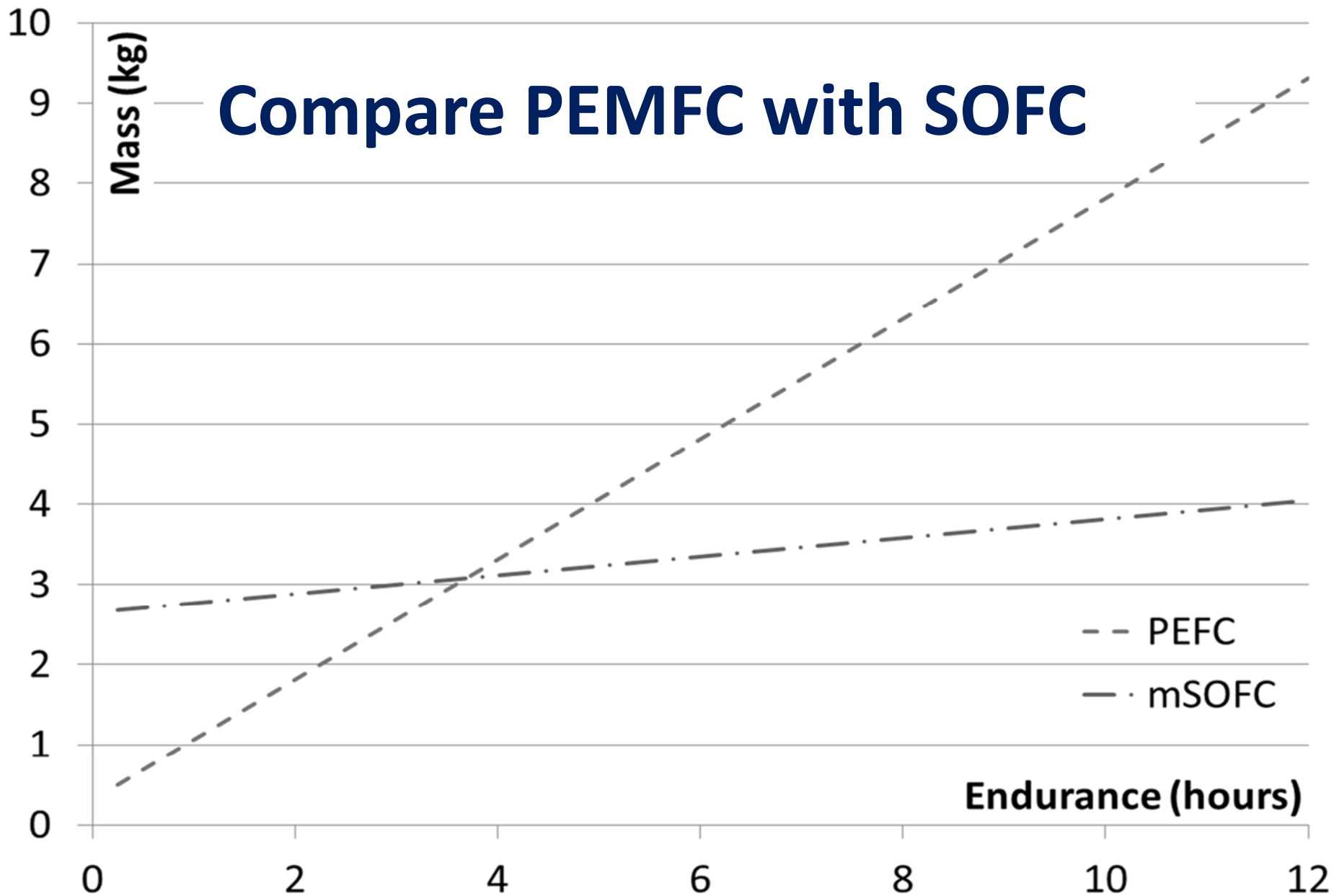
34 Polymer FCs
Eg HyFish



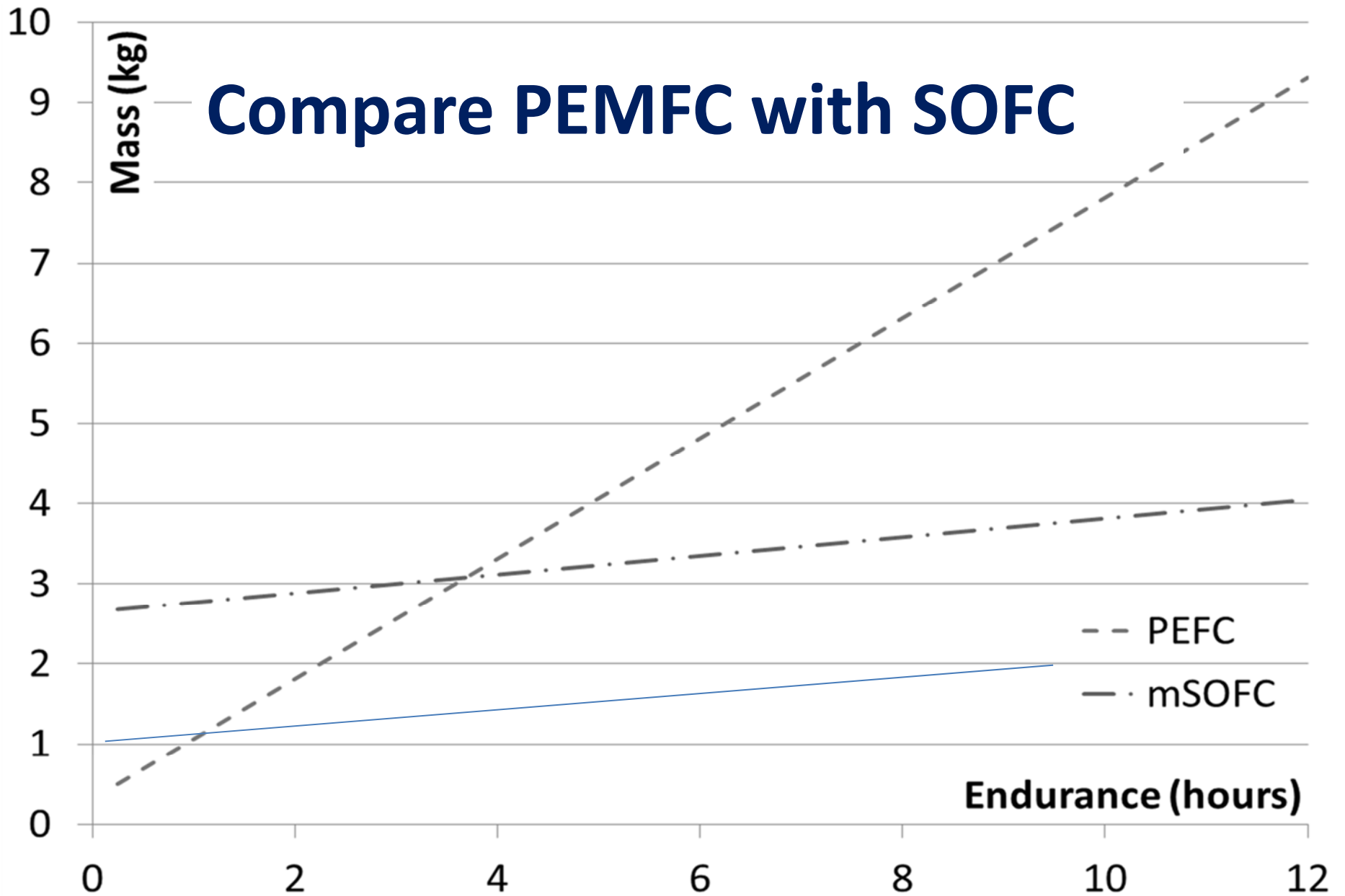
2 SOFC
Eg Lockheed-
Martin Stalker



Compare PEMFC with SOFC

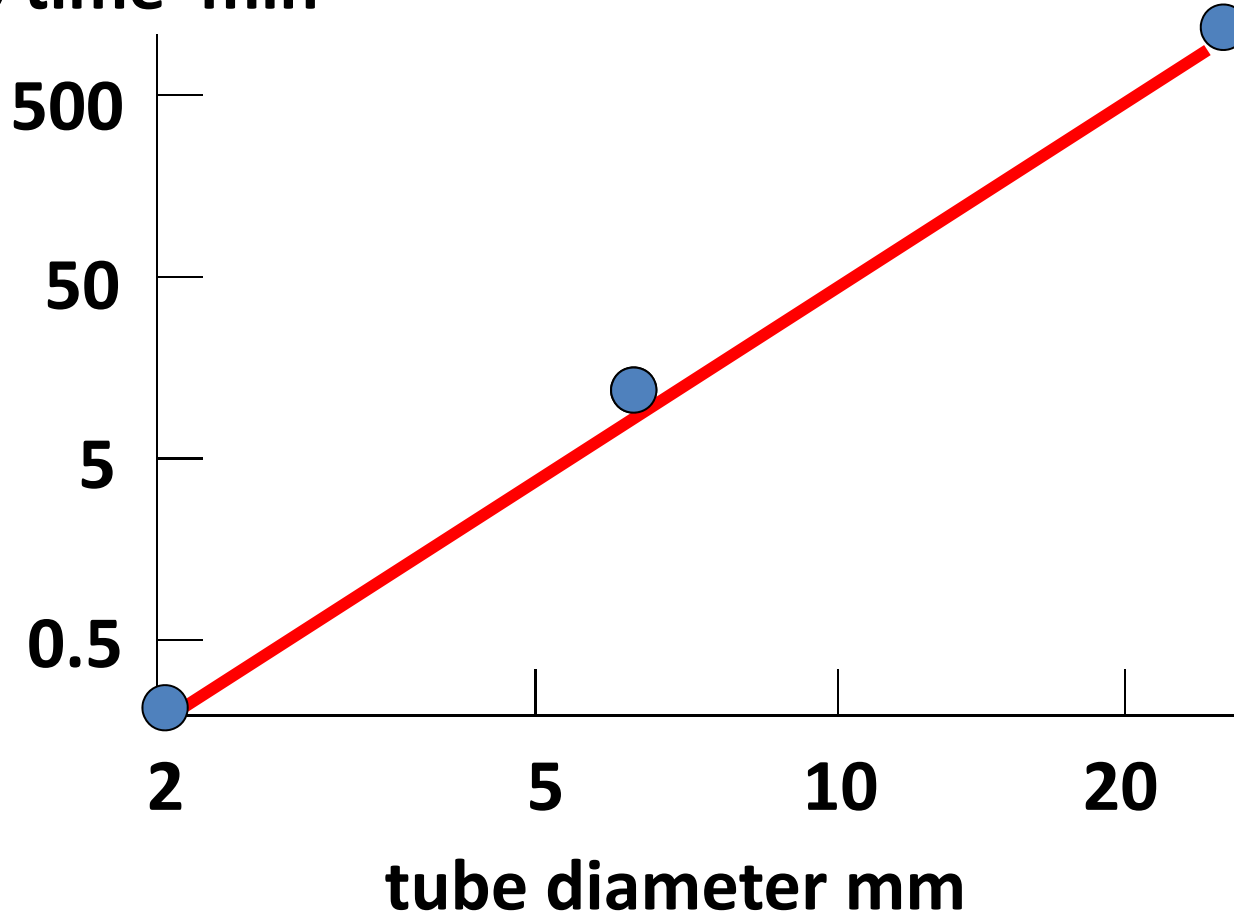


Compare PEMFC with SOFC



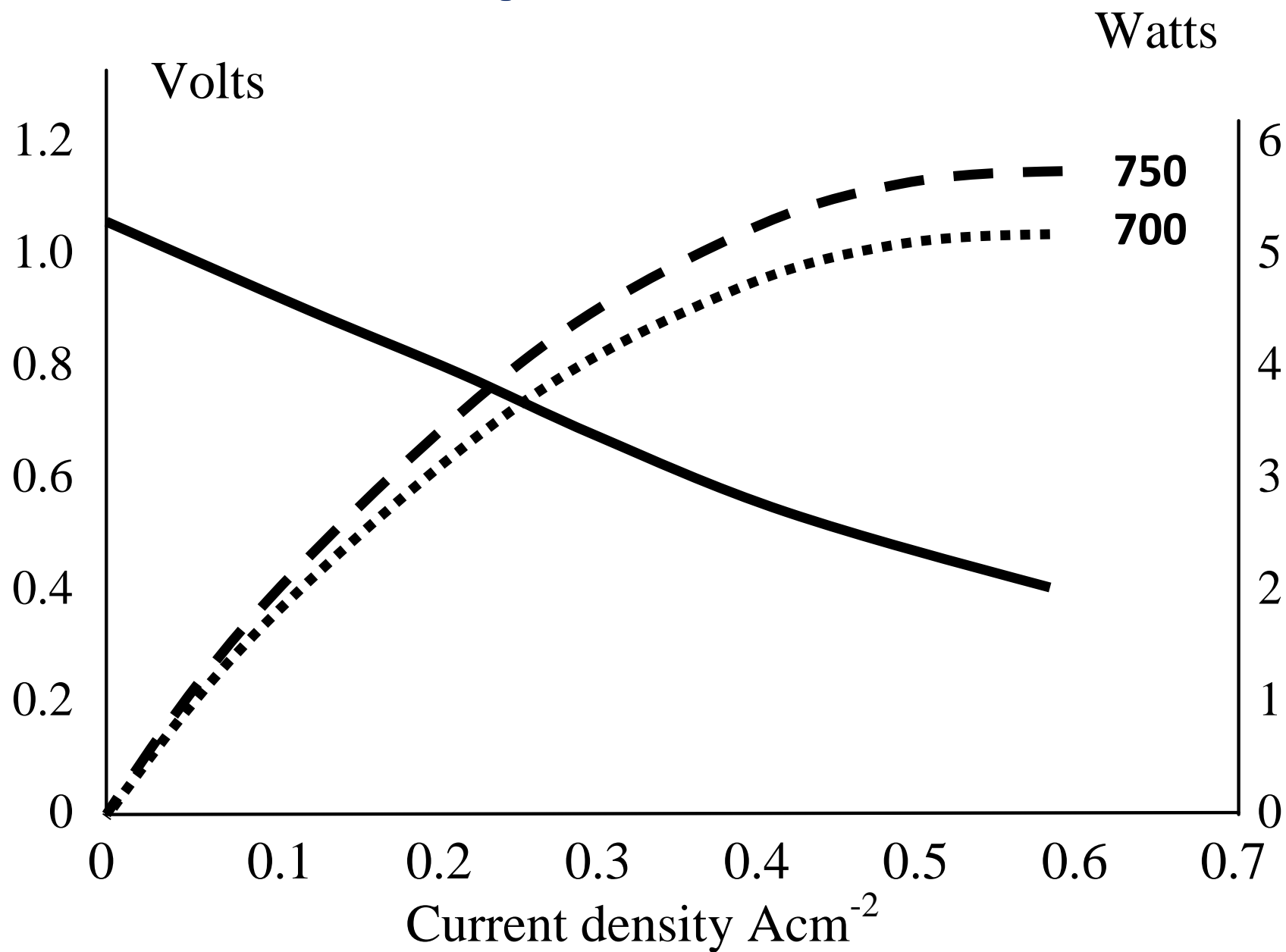
START-UP TIME vs TUBE DIAMETER

Start-up time min



Cell test arrangement

SOFC performance



Substack Design

upstream region for CPOX

20mm fibre insulation



3D printed anode manifold

Porous manifold/burner/HEX

Skywalker plastic plane



2 m wingspan UAV



Testing UAV skywalker



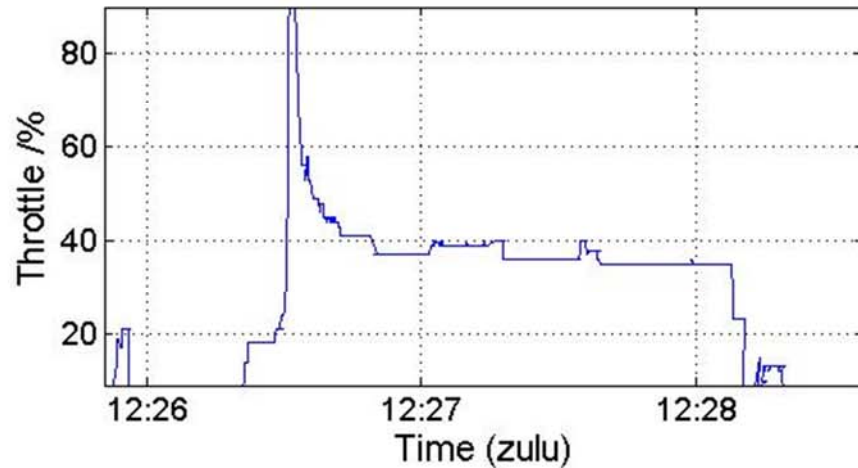
Skywalker X8 with SOFC + propane tank installed



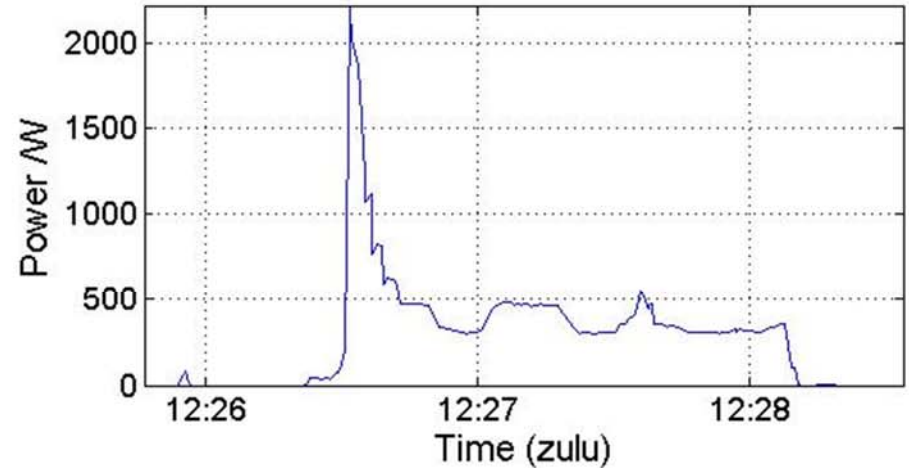


Mission testing

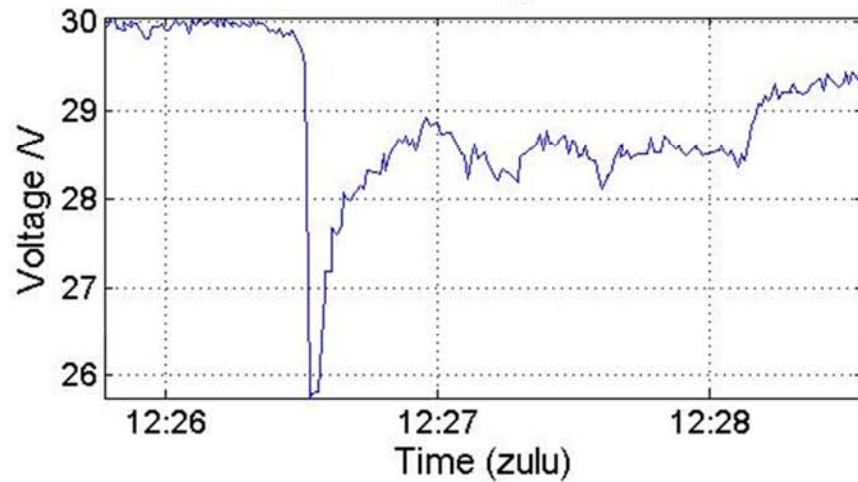
Throttle



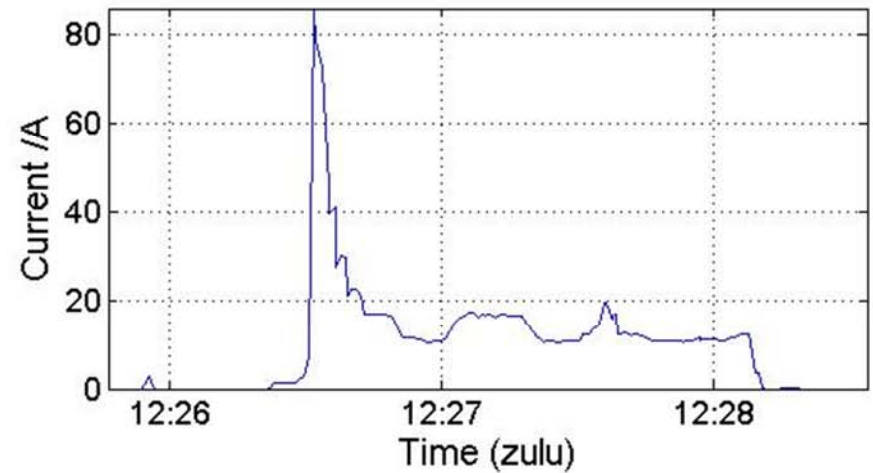
Power



Voltage



Current



Mission Planner 1.2.53 mav 1.0

[Flight Data](#)
[Flight Planner](#)
[Configuration](#)
[Simulation](#)
[Firmware](#)
[Terminal](#)
[Help](#)
[Donate](#)

UDP: [dropdown] 115200 [dropdown]
 [Link Stats...](#)
Connect

105 120 SE 150 158 165 S 195 210

99% 12:02:36

AS 14.2 GS 15.3

Bat 0.03v 0 A 0.86%

GPS: 3D Fix

Dir: 214 Vel: 3

119

hdop: 1.6 Sats: 9

52.7450496 -1.2197616 118.84 Tuning Auto Pan Zoom 17.4

The image displays the Mission Planner software interface. At the top, there is a menu bar with icons for Flight Data, Flight Planner, Configuration, Simulation, Firmware, Terminal, and Help, along with a 'Donate' button. Below the menu is a toolbar with a 'Connect' button and a 'Link Stats...' link. The main interface is divided into several sections. On the left, there is a 3D terrain view showing a green field and a blue sky. The terrain is marked with a grid and a red line indicating the current altitude. The right side of the main interface shows a map with a flight path (blue lines) and a red arrow indicating the current position. The map includes a compass rose and a scale bar. At the bottom, there are four circular gauges: VSI (Vertical Speed Indicator), Speed, Alt (Altitude), and a heading indicator. The bottom status bar shows the current coordinates, heading, and zoom level.

SOFC UAV



CONCLUSIONS

- **SOFC UAV can operate on propane**
10 min start; 100W/kg power density
Propane beats hydrogen by a factor 6
- **UAV is successfully extended in range**
- **Lightweighting is key requirement**