

Energy storage: Ready for take-off?

15th Anniversary HVM 2017 & 4th Graphene New Materials Conference

2-3 November 2017 Cambridge, UK

www.cir-strategy.com/events

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Marine

30,000 commercial and naval vessels use our marine equipment



Power Systems

Reciprocating engines for propulsion and distributed energy systems



Nuclear

Submarine and civil nuclear power plants

Rolls-Royce Product Divisions

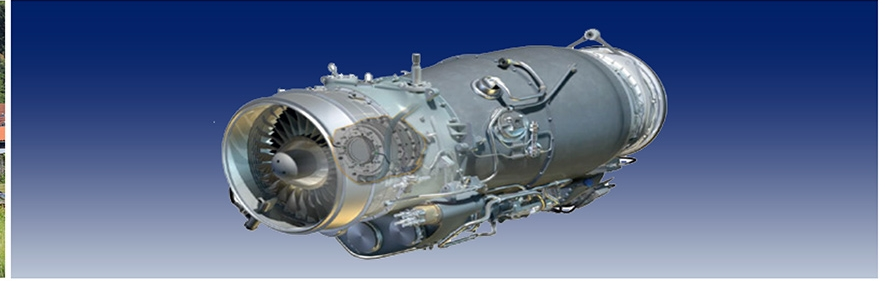


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Electrification is relentless



Hybrid trains



Embedded electrical starter generator (E2SG)



Hybrid ships



Image courtesy of Darpa

Vertical Take-Off/Landing Experimental Plane

Darpa X-Plane



Electrified Aircraft, Future Opportunities

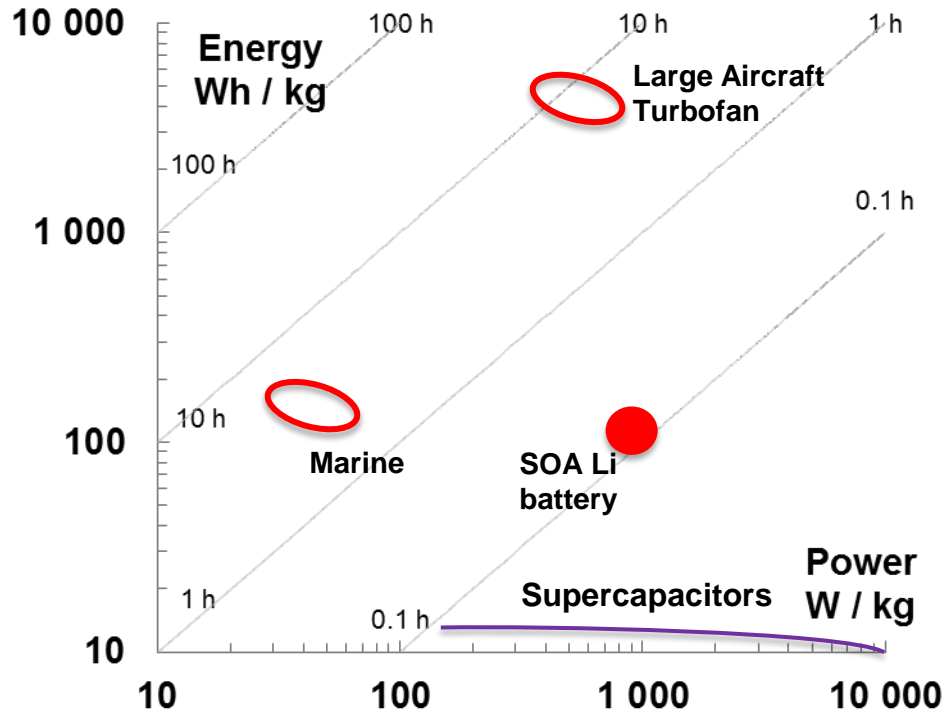
Products	Military	Hybrid turbofan	Hybrid turboprop	Helicopter replacement	Personal mobility
					
Driver	Capability (on-board power)	Efficiency	Local environmental impact	Capability and safety	Capability (time)
Timing	Now	>2030	>2025	>2025	~2020s
Market	Significant	Large (as today)	Unknown	Unknown	Unknown

Helicopter replacement image © Darpa, Personal mobility image © Airbus,



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Characterising Energy Storage



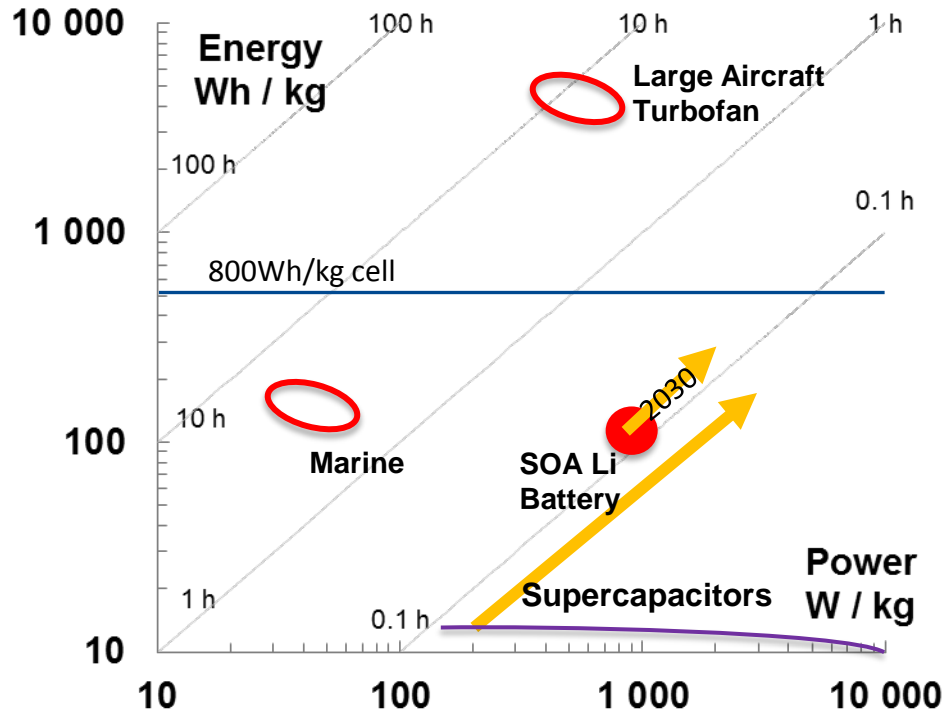
- Requirements are open boxes and circles
- Solutions for mobile applications only work where the requirement doesn't need more power or energy
- Typically system may be half as dense as cell today but this will reduce

Filled items are specific system level solutions



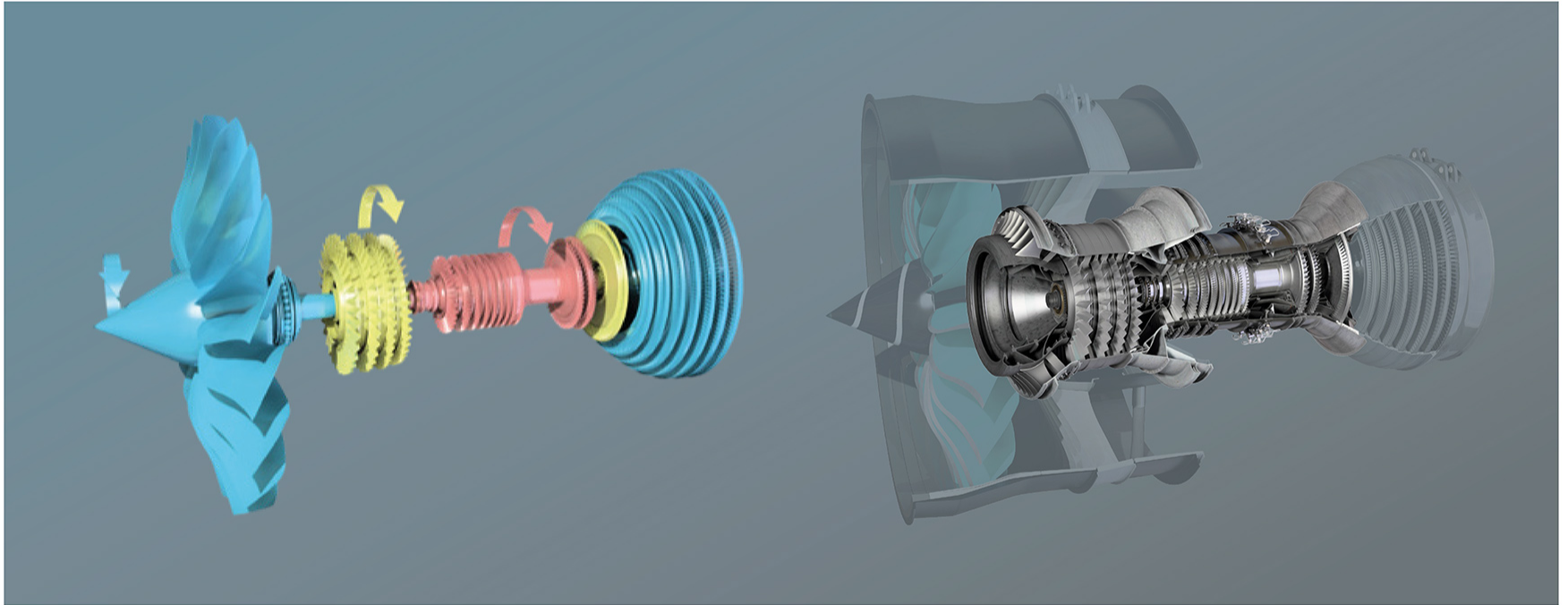
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Can batteries provide all energy storage?



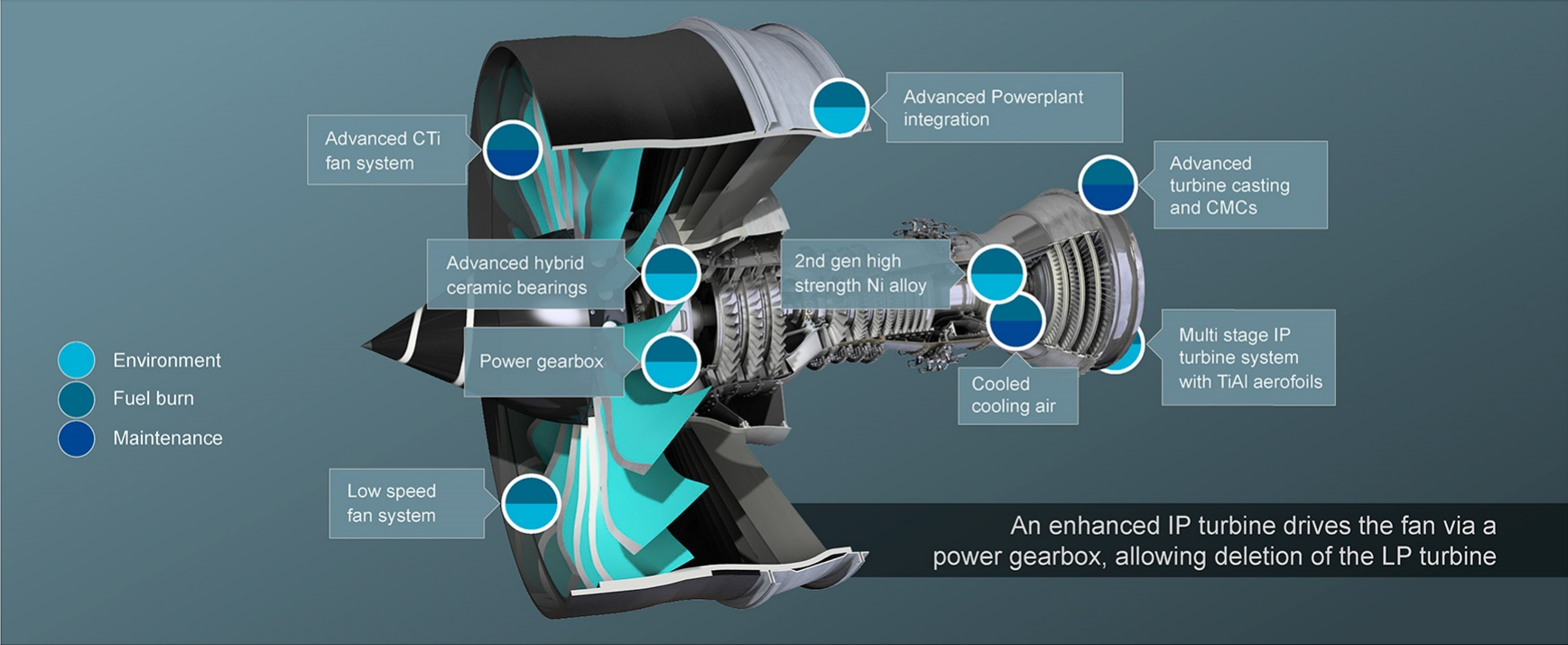
- Today's batteries don't come close
- Future development still leaves a huge gap for the most demanding applications
 - Trans-ocean aero engines miss on Wh/kg
- A little background on what the challenge is...

A modern core engine has ~1MW per HP blade



Laying the foundation for UltraFan

UltraFan and its gear box

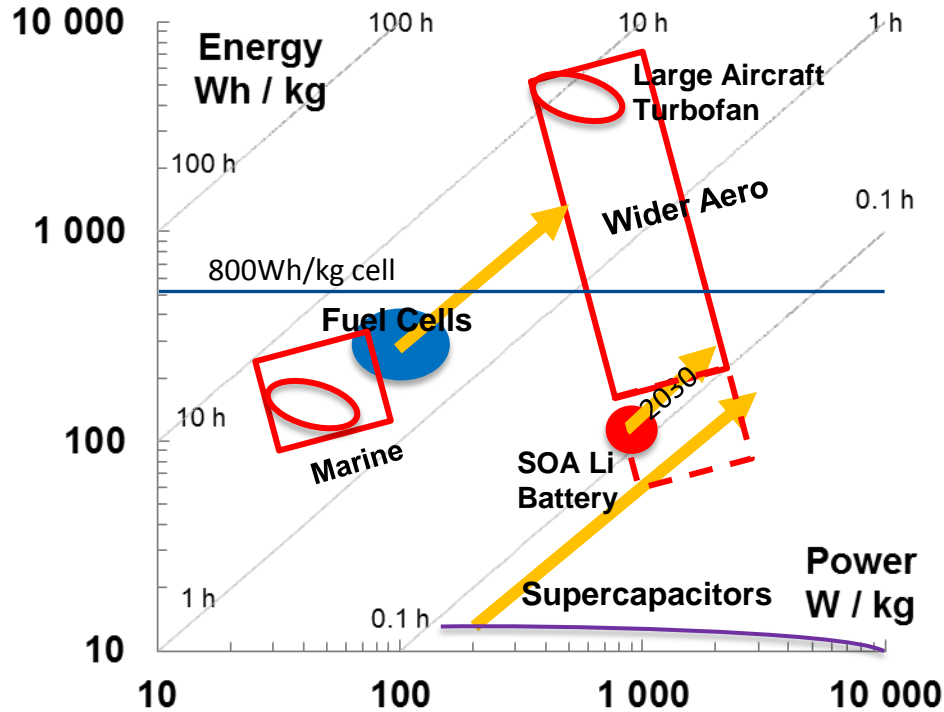


The torque of a 6MW wind turbine



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But batteries can play a big role in flight

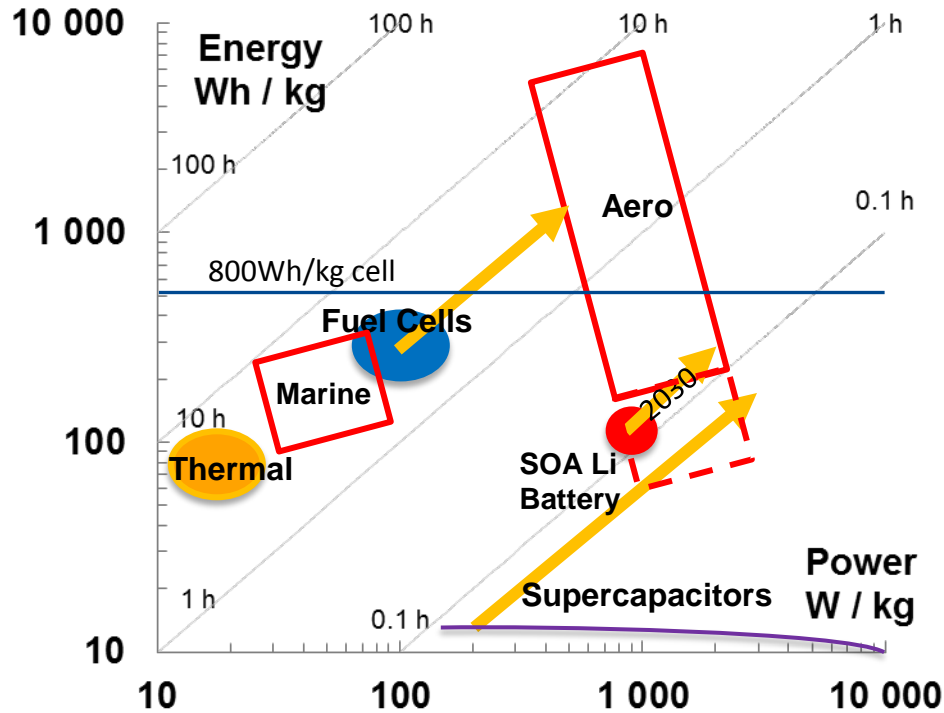


- Smaller, shorter range systems need less energy
 - Unmanned systems need less energy again
- Other solutions can bridge some of the gap
- Graphene may play a significant role here



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Energy storage – need a range of solutions



- Other applications have missions that require fuel + engine or fuel cell
 - Cities that take more than ~hour to cross
 - Marine vessel movements ~10 hours
- Who charges the batteries ?
 - Renewables where infrastructure permits
 - Thermal storage, SMRs at transmission level / branches
 - Engines, Large batteries & Fuel Cells at the leaves

Conclusions

- The push for cleaner energy and renewables links strongly to electrical technology and energy storage
- Energy storage is key in enabling hybrid and fully electrical flight
 - Larger scale solutions and longer missions make greater demands on storage
- Expected incremental improvements in battery capability enable smaller scale solutions
 - Higher performance batteries and fuel cells are needed as well as other energy storage solutions

Thank You



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