Energy storage: Ready for take-off?

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

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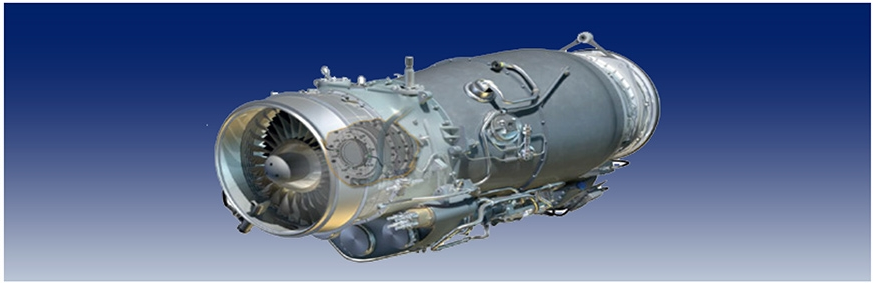
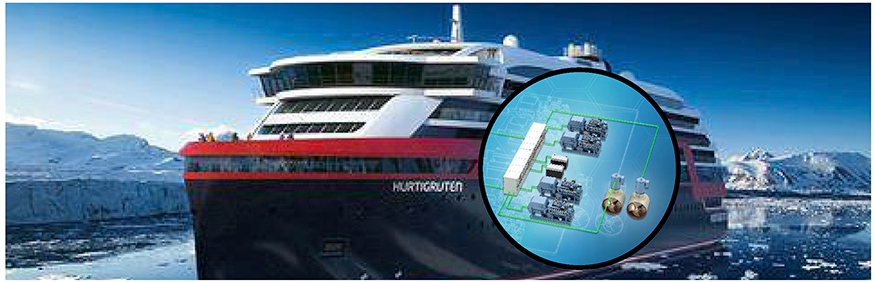
Electrification is relentless

Hybrid trains



Embedded electrical starter generator (E2SG)



Hybrid ships

Darpa X-Plane

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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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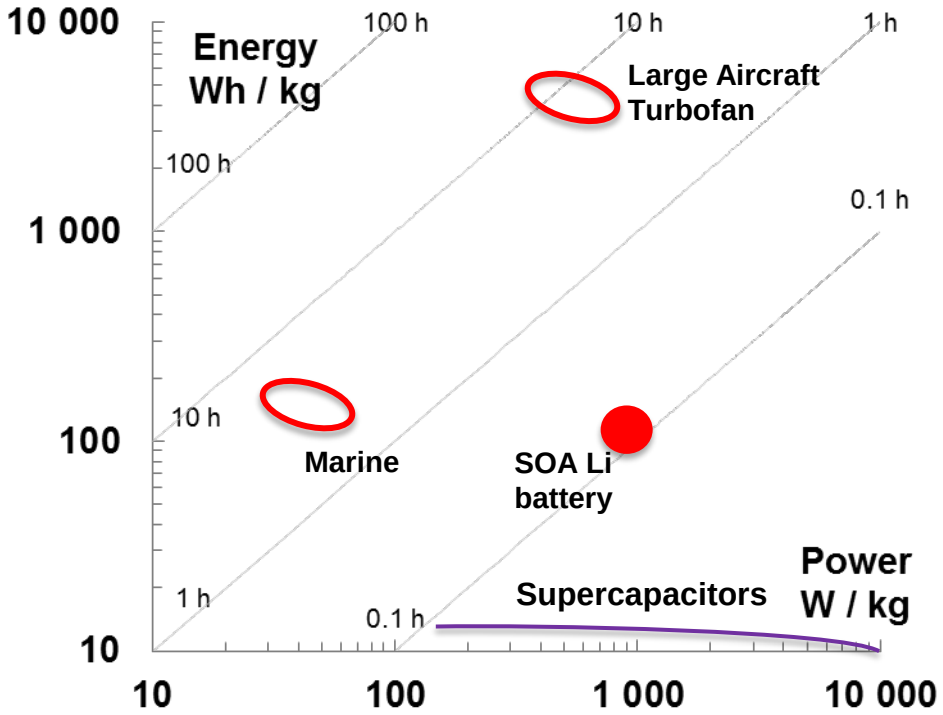
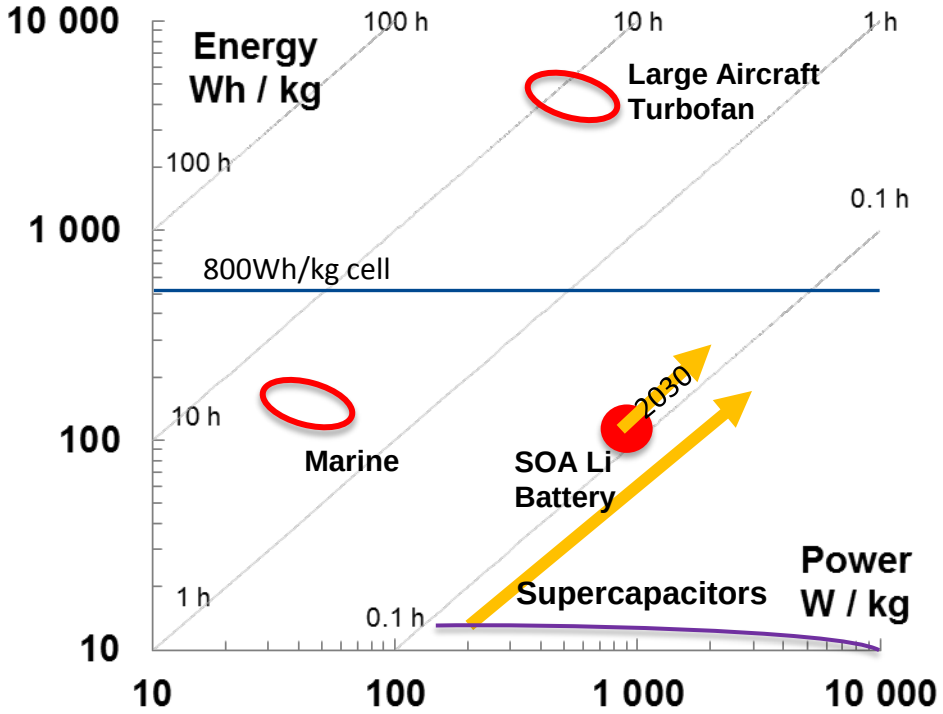
Characterising Energy Storage



- 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

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…

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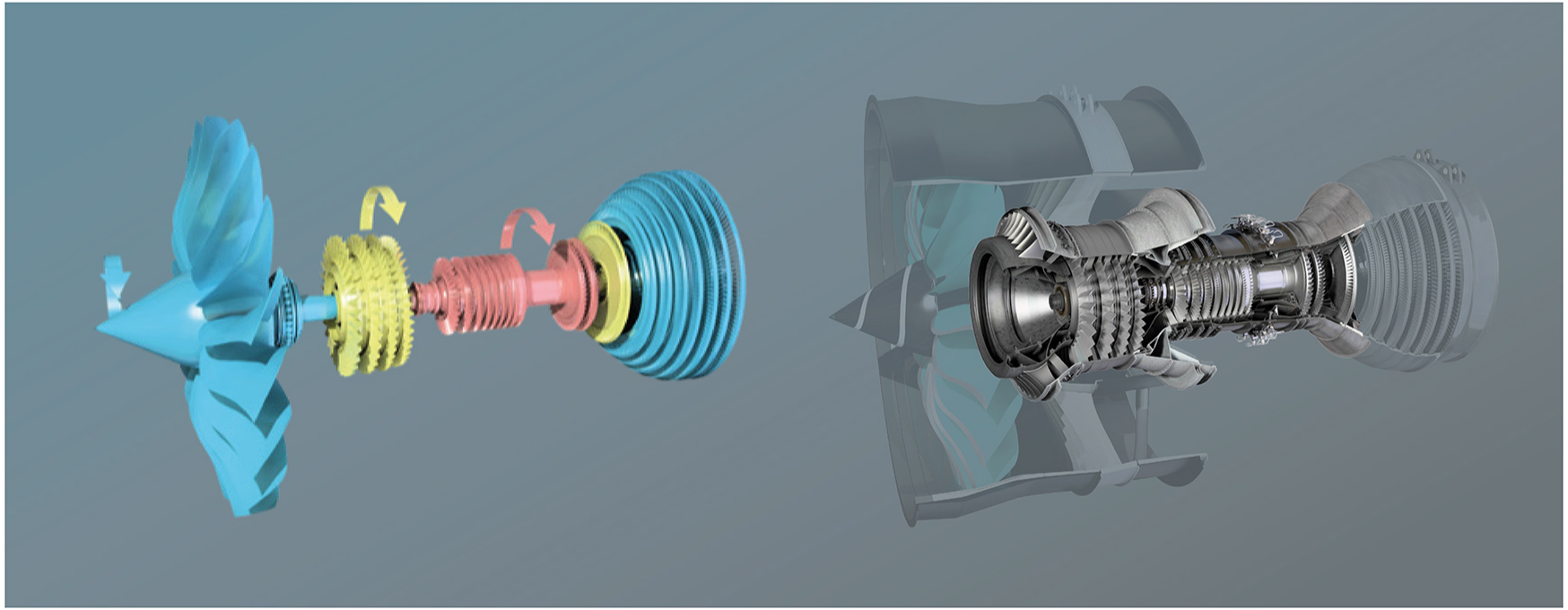
A modern core engine has ~1MW per HP blade



Laying the foundation for UltraFan

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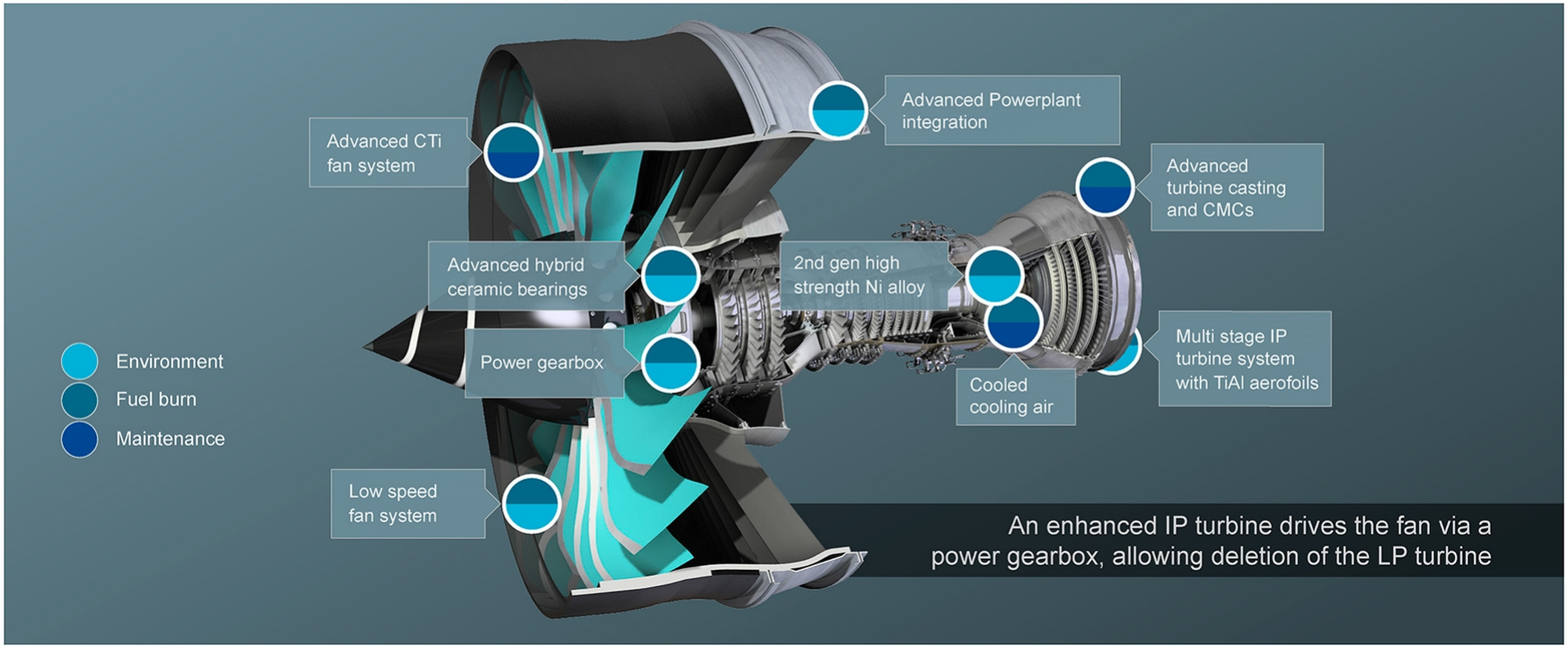
UltraFan and its gear box



The torque of a 6MW wind turbine

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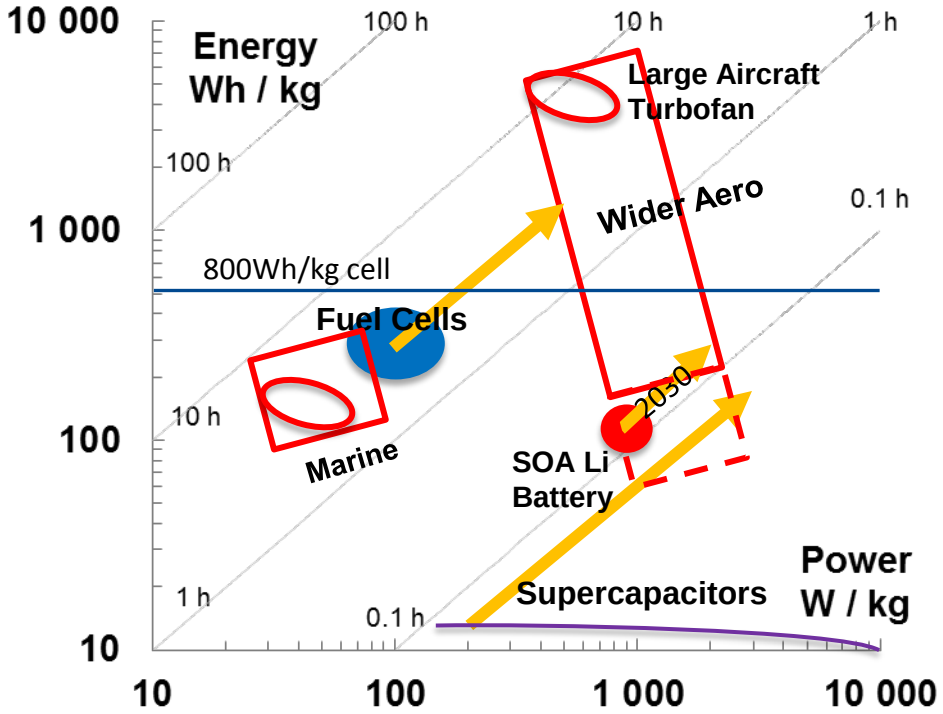
But batteries can play a big role in flight



- 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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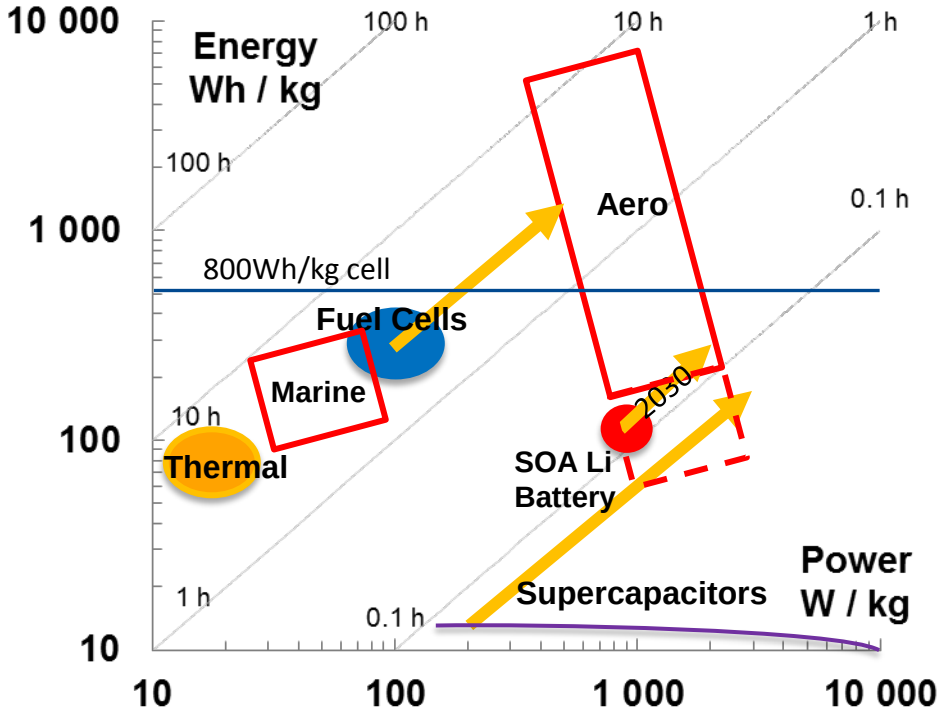
Energy storage – need a range of solutions



- 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

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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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