



The Next Challenge: High Power Electric Aircraft Propulsion

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Challenges of Power Electronics Systems for Sustainable Aviation

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Relationship to Past Work

Advanced Air Transport Technology Project / Aircraft Electrification Subproject

Technical Challenges (TCs) are NASA's way of framing aeronautic research goals
Emerging Technical Challenges (eTCs) are valuable pieces of non-TC work

TC 2014-2018 ***"Does electrification provide a net benefit?"***

- ✓ TRL-2 concept
- ✓ Underlying technologies
- ✓ Not flight-like

TC 2019-2024 answered: ***"Can it fly?"***

- ✓ Flight-like
- ✓ High voltage systems at altitude
- ✓ Commercially viable
- ✓ Full electric powertrain design and integration issues

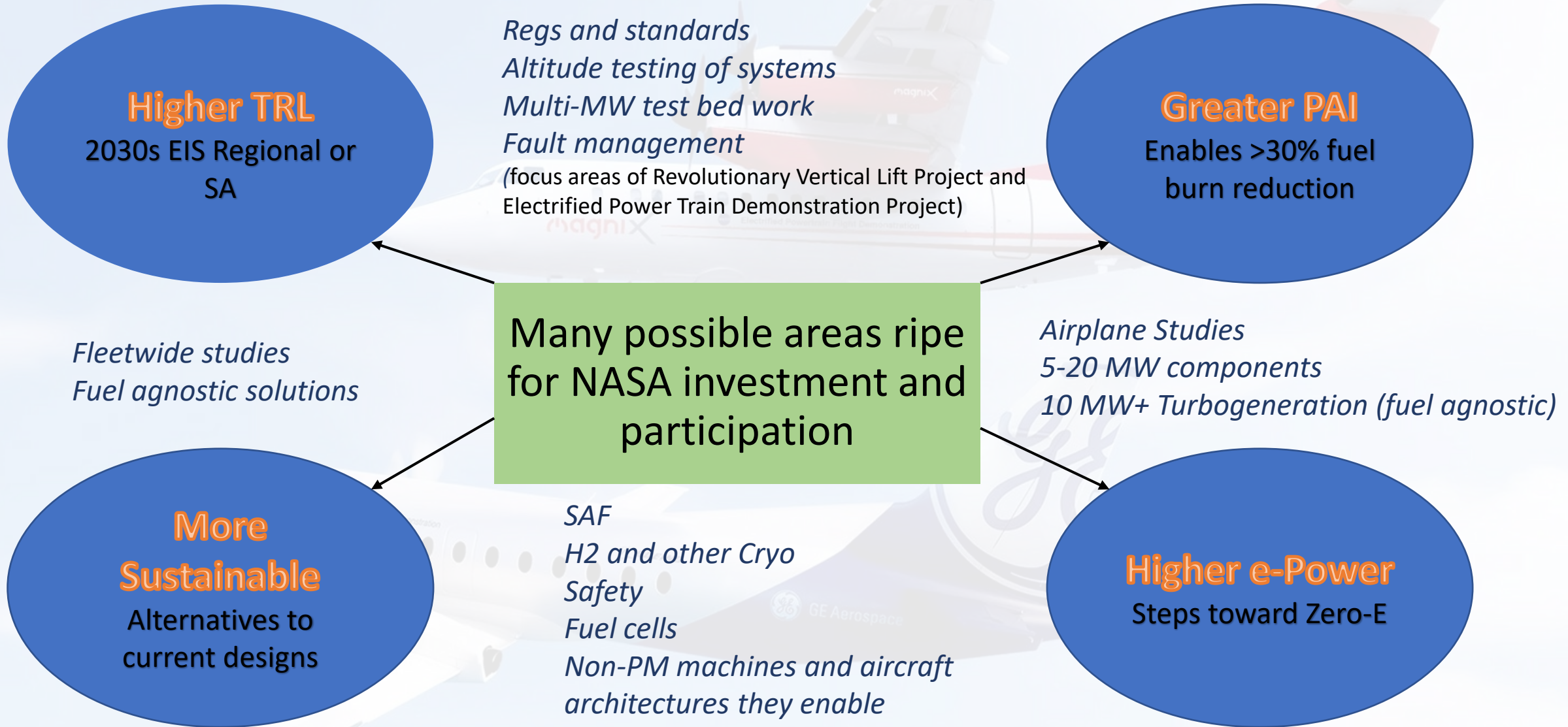
eTC to 2024 addressed ***"What are the enduring challenges?"***
What will it take to be safe, reliable and certifiable?"

The next TC ('25-'30) furthers NASA's goals by

- Developing high power electrified propulsion to substantially reduce or eliminate the use of fossil fuels
- Looking beyond 2030s *and* beyond "just" SAF
- Helping to put US on path to net zero greenhouse gas emissions

This TC will help answer, ***"Can EAP help meet 2050 aviation climate goals?"***
and the sub-question ***"Is superconducting machine technology ready to contribute?"***

Electrified Aircraft Propulsion: What are the next steps?



Plenty of work left in MW-class however NASA needs to help move us to higher benefits

R&D Focus – High Power EAP



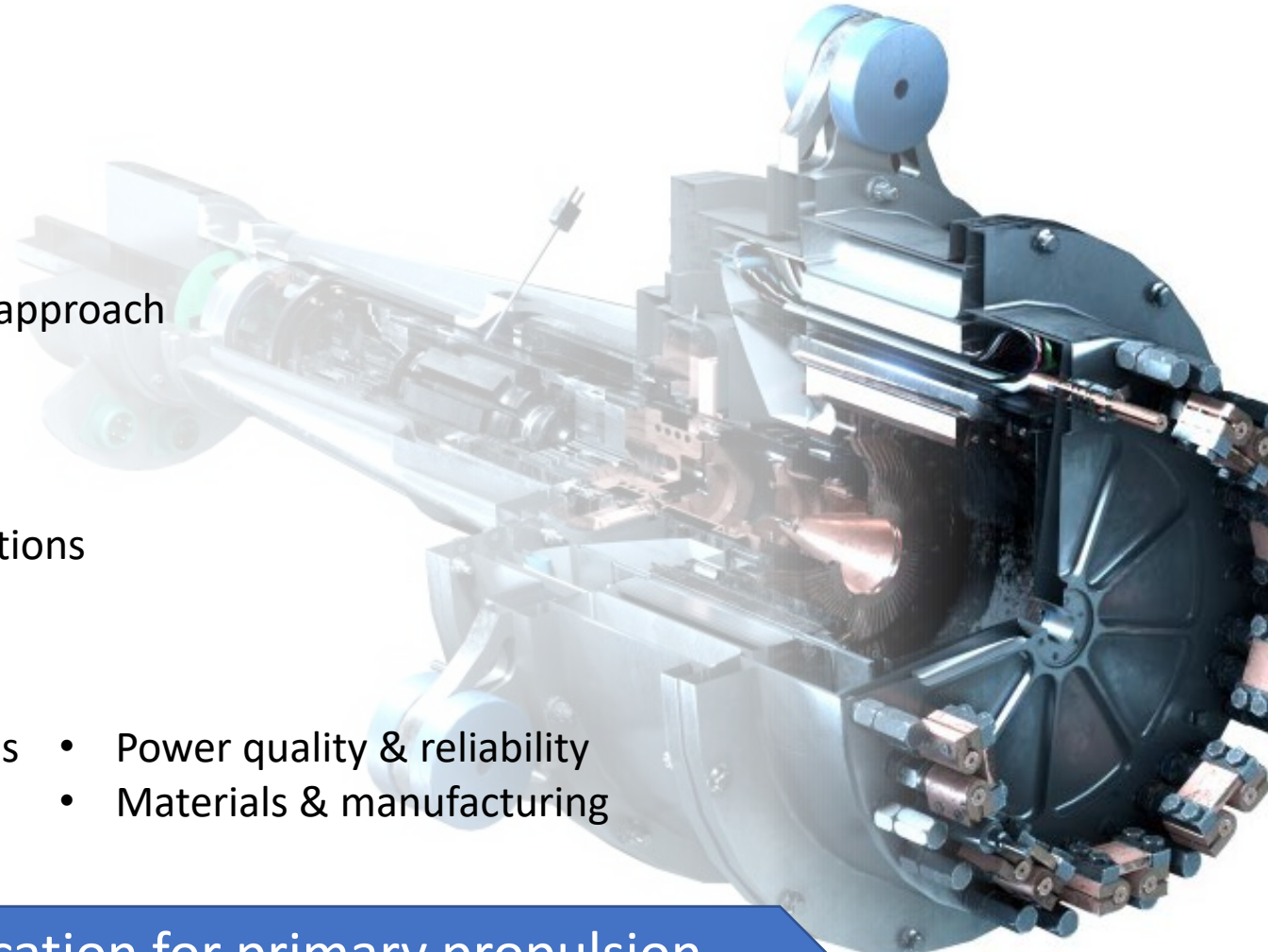
- *Superconducting motor, drive and corresponding technologies capable of driving a 5 MW fan*
- *System analysis and integration studies of one or more high power EAP concepts*
- *Controls and fault management studies of high power EAP systems*

Robust Superconducting (SC) Systems

- Preliminary design for 5 MW machine
- Cryogenic stator design
 - Low AC loss winding, stator thermal management approach
- Thermal management and cooling approach
- Robust cryo-capable 5 MW drive
- SC machine and drive TRL 3 demo
 - Down-select among fully SC and fully cryogenic options
 - Subscale for demo

Key Challenges

- Low AC loss stator
- Issues arising from high current
- Safe high voltage systems
- Weight
- Thermal management
- Power quality & reliability
- Materials & manufacturing



5 MW Motors enable electrification for primary propulsion

What does this mean for power electronics?

- Machine metrics tend to drive development
 - Power electronics serves the machine and must be designed to purpose (a continued theme)
- Low inductance machines
 - Requires low total harmonic distortion to reduce losses in the machine
- Cryogenic temperature operation of superconductors
 - Need to decrease losses and/or redirect heat
 - Cannot push heat to the machine
 - Likely means cryogenic operation of the power electronics
 - Issues with bridging cryo-ambient environments
- Higher currents enable higher power machines
 - > 3-10 X increase in current delivered to/from the machine
 - $P_{loss} = I^2 R$: managing losses is paramount