number of components in a power system may provide weight advantages to the design, but may additionally limit the redundant features of the power system, creating higher-risk of single fault failure and resulting in accidents from an aircraft failing during flight.

[0006] In general, it would be advantageous to provide for improved aircraft designs which allow for weight and cost savings, while providing beneficial safety and redundant design features to maintain a safe and reliable aircraft.

BRIEF SUMMARY

[0006a] According to a first aspect, there is provided an electric aircraft including: a fuselage; at least one wing coupled to the fuselage; a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position; a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme, wherein each of the first subset of the plurality of tilting mechanisms include a fail-safe mechanism, wherein upon a first actuator failure or a tilting mechanism failure, the first group of tilting fans move to the vertical lift position.

[0006b] According to a second aspect, there is provided an electric aircraft including: a fuselage; at least one wing coupled to the fuselage; a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position; a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme, wherein the first subset of the plurality of tilting mechanisms further include a drive shaft located within the at least one wing, the drive shaft operably coupling the first actuator to the first group of tilting fans.

[0006c] According to a third aspect, there is provided an electric aircraft including: a fuselage; at least one wing coupled to the fuselage; a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position; a plurality of tilting mechanisms, each of the plurality of tilting

mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme, wherein the first actuator includes a compressor and wherein the first subset of the plurality of tilting mechanisms further includes hydraulic lines that connect the first subset of the plurality of tilting mechanisms to the first actuator.

[0006d] According to a fourth aspect, there is provided an electric aircraft including: a fuselage; at least one wing coupled to the fuselage; a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position; a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme, wherein the first group of tilting fans consists of a plurality of front tilting fans provided on a leading edge of the at least one wing, wherein the plurality of tilting fans further include a plurality of aft tilting fans provided on a trailing edge of the at least one wing, wherein the plurality of aft tilting fans are configured to passively move from the vertical lift position to the forward flight position, wherein the plurality of aft tilting fans are mechanically independent from one another.

[0006e] According to a fifth aspect, there is provided an electric aircraft including: a fuselage; at least one wing coupled to the fuselage; a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position; a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme, wherein the coupling scheme is diametrically symmetric with respect to a center of gravity of the electric aircraft, wherein the coupling scheme includes all of the plurality of tilting mechanisms, the first group of tilting fans include all of the plurality of tilting fans, and such that the first actuator tilts all of the plurality of tilting fans.

[0006f] According to a sixth aspect, there is provided an electric aircraft including: a fuselage; at least one wing coupled to the fuselage; a plurality of tilting fans coupled to the at least one wing,

wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position; a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme, a second group of tilting fans among the plurality of tilting fans; and a second subset of the plurality of tilting mechanisms, each of the second subset of the plurality of tilting mechanisms coupled with at least one tilting fan of the second group of tilting fans, wherein the first actuator tilts the first group of tilting fans and the second group of tilting fans.

[0007] The described embodiments relate generally to an aircraft with vertical takeoff and landing capability. In particular, the embodiments provide an aircraft with one or more tilting fans which provide vertical and horizontal thrust in a controlled fashion for hover, transition and cruise (horizontal) flight.

[0008] Embodiments generally provide improved devices, systems, and methods for an aircraft with a plurality of tilting fans. More specifically, techniques disclosed herein provide a VTOL aircraft (e.g. an electric VTOL aircraft) with a plurality of tilting fans that can tilt between a horizontal position for vertical lift movement and a vertical position for forward flight movement. Various structures and configurations are provided which may allow for actuation and control of the various tilting fans which may further the means of design efficiency, reduced cost and safety, and improved flight comfort and performance, for example.

[0009] In some embodiments, the VTOL aircraft (hereinafter “aircraft”) may be powered by various power units. For example, in various embodiments, the aircraft may have at least one power source providing energy to various components of the aircraft. For example, the aircraft may be electrically powered, such as with one or more batteries. An electrical power mechanism may provide electrical power to one or more motors, actuators, or other powered aspects of the aircraft.

[0010] According to various embodiments, the aircraft may include a fuselage. The fuselage may make up the central body of the aircraft. In various embodiments, the fuselage may provide for various layouts, such to provide for a cockpit, a passenger compartment, and/or a storage area. As such, the fuselage may have one or more bulkheads which divide various sections of the

CLAIMS

1. An electric aircraft comprising:

a fuselage;

at least one wing coupled to the fuselage;

a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position;

a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and

a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme,

wherein each of the first subset of the plurality of tilting mechanisms comprise a fail-safe mechanism, wherein upon a first actuator failure or a tilting mechanism failure, the first group of tilting fans move to the vertical lift position.

2. The electric aircraft of claim 1, further comprising one or more support elements coupled underneath the at least one wing and spanning crosswise from the at least one wing, wherein a front tilting fan of the plurality of tilting fans and an aft tilting fan of the plurality of tilting fans are coupled to opposite ends of a first support element of the one or more support elements, wherein the front tilting fan is provided at a leading edge of the at least one wing, the aft tilting fan is provided at a trailing edge of the at least one wing.

3. The electric aircraft of claim 2, wherein a first tilting mechanism among the plurality of tilting mechanisms is coupled to the front tilting fan and the aft tilting fan, wherein the first tilting mechanism is provided within the first support element.

4. The electric aircraft of claim 2, further comprising:

at least a second actuator coupled to a second subset of the plurality of tilting mechanisms,

wherein the first subset of the plurality of tilting mechanisms consists of a first tilting mechanism such that the first actuator is coupled to the first tilting mechanism and provided within the first support element.

5. The electric aircraft of claim 2, wherein a first tilting mechanism among the plurality of tilting mechanisms is coupled to at least one of the front tilting fan or the aft tilting fan, wherein the first tilting mechanism includes a four bar linkage and is provided within the first support element.

6. The electric aircraft of claim 1, wherein the first subset of the plurality of tilting mechanisms further comprise a drive shaft located within the at least one wing, the drive shaft operably coupling the first actuator to the first group of tilting fans.

7. The electric aircraft of claim 1, wherein the first actuator comprises a compressor and wherein the first subset of the plurality of tilting mechanisms further comprises hydraulic lines that connect the first subset of the plurality of tilting mechanisms to the first actuator.

8. The electric aircraft of claim 7, wherein each of the first group of tilting fans comprises a respective tilting mechanism of the first subset of the plurality of tilting mechanisms.

9. The electric aircraft of claim 1, wherein the first group of tilting fans consists of a plurality of front tilting fans provided on a leading edge of the at least one wing.

10. The electric aircraft of claim 9, wherein the plurality of tilting fans further comprises a plurality of aft tilting fans provided on a trailing edge of the at least one wing, wherein the plurality of aft tilting fans are configured to passively move from the vertical lift position to the forward flight position, wherein the plurality of aft tilting fans are mechanically independent from one another.

11. The electric aircraft of claim 10, further comprising:

a support element coupled to the at least one wing;

a passive tilting mechanism coupled to an aft portion of the support element, the passive tilting mechanism further comprising:

an arm rotatably coupling a given aft tilting fan of the plurality of aft tilting fans to the support element;

a spring element spanning the given aft tilting fan and the support element, wherein the spring element is configured to cause the arm to rotate when horizontal thrust exceeds a threshold thrust value; and

at least one travel limiting stop configured to limit a rotation angle of the arm.

12. The electric aircraft of claim 11, wherein the passive tilting mechanism is configured to reduce an aerodynamic drag in the forward flight position by causing a plurality of blades of the given aft tilting fan to fold together while in forward flight position.

13. The electric aircraft of claim 1, wherein the coupling scheme is diametrically symmetric with respect to a center of gravity of the electric aircraft.

14. The electric aircraft of claim 13, wherein the coupling scheme includes all of the plurality of tilting mechanisms, the first group of tilting fans comprise all of the plurality of tilting fans, and such that the first actuator tilts all of the plurality of tilting fans.

15. The electric aircraft of claim 1, wherein the first subset of the plurality of tilting mechanisms comprise a plurality of primary cylinders operably coupled with the first actuator, wherein each one of the plurality of primary cylinders is operably coupled to a secondary cylinder of a plurality of secondary cylinders that is operatively coupled to a given tilting fan of the first group of tilting fans, wherein the plurality of secondary cylinders are configured to receive hydraulic pressure from the plurality of primary cylinders.

16. The electric aircraft of claim 15, further comprising a second actuator operably coupled with the plurality of secondary cylinders in parallel with the first actuator, such that a given actuator of the first and second actuators each tilt the given tilting fan of the first group of tilting fans.

17. The electric aircraft of claim 1, further comprising:

a second group of tilting fans among the plurality of tilting fans; and

a second subset of the plurality of tilting mechanisms, each of the second subset of the plurality of tilting mechanisms coupled with at least one tilting fan of the second group of tilting fans.

18. The electric aircraft of claim 17, wherein the first actuator tilts the first group of tilting fans and the second group of tilting fans.

19. The electric aircraft of claim 17, further comprising:

a second actuator coupled to the second subset of the plurality of tilting mechanisms, wherein the second actuator tilts the second group of tilting fans coupled to the second subset of the plurality of tilting mechanisms simultaneously.

20. An electric aircraft comprising:

a fuselage;

at least one wing coupled to the fuselage;

a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position;

a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and

a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme,

wherein the first subset of the plurality of tilting mechanisms further comprise a drive shaft located within the at least one wing, the drive shaft operably coupling the first actuator to the first group of tilting fans.

21. An electric aircraft comprising:

a fuselage;

at least one wing coupled to the fuselage;

a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position;

a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and

a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme,

wherein the first actuator comprises a compressor and wherein the first subset of the plurality of tilting mechanisms further comprises hydraulic lines that connect the first subset of the plurality of tilting mechanisms to the first actuator.

22. An electric aircraft comprising:

a fuselage;

at least one wing coupled to the fuselage;

a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position;

a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and

a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme,

wherein the first group of tilting fans consists of a plurality of front tilting fans provided on a leading edge of the at least one wing,

wherein the plurality of tilting fans further comprises a plurality of aft tilting fans provided on a trailing edge of the at least one wing, wherein the plurality of aft tilting fans are configured to passively move from the vertical lift position to the forward flight position, wherein the plurality of aft tilting fans are mechanically independent from one another.

23. An electric aircraft comprising:

a fuselage;

at least one wing coupled to the fuselage;

a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position;

a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans; and

a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme,

wherein the coupling scheme is diametrically symmetric with respect to a center of gravity of the electric aircraft,

wherein the coupling scheme includes all of the plurality of tilting mechanisms, the first group of tilting fans comprise all of the plurality of tilting fans, and such that the first actuator tilts all of the plurality of tilting fans.

24. An electric aircraft comprising:

a fuselage;

at least one wing coupled to the fuselage;

a plurality of tilting fans coupled to the at least one wing, wherein the plurality of tilting fans are configured to move between a vertical lift position and a forward flight position;

a plurality of tilting mechanisms, each of the plurality of tilting mechanisms coupled with at least one tilting fan among the plurality of tilting fans;

a first actuator coupled to a first subset of the plurality of tilting mechanisms, wherein the first actuator tilts a first group of tilting fans coupled to the first subset of the plurality of tilting mechanisms simultaneously, wherein the first subset of the plurality of tilting mechanisms are identified among the plurality of tilting mechanisms according to a coupling scheme,

a second group of tilting fans among the plurality of tilting fans; and

a second subset of the plurality of tilting mechanisms, each of the second subset of the plurality of tilting mechanisms coupled with at least one tilting fan of the second group of tilting fans,

wherein the first actuator tilts the first group of tilting fans and the second group of tilting fans.