Zip Aircraft Concepts

Electric Swift Based Concept

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eSwift Concept Strategy

SWIFT: Swept Wing with Inboard Flap Trim

Limited thrust distribution enabled by compact electric motors, with a strategy of placing the thrust where most of the drag is produced to achieve favorable interactions.

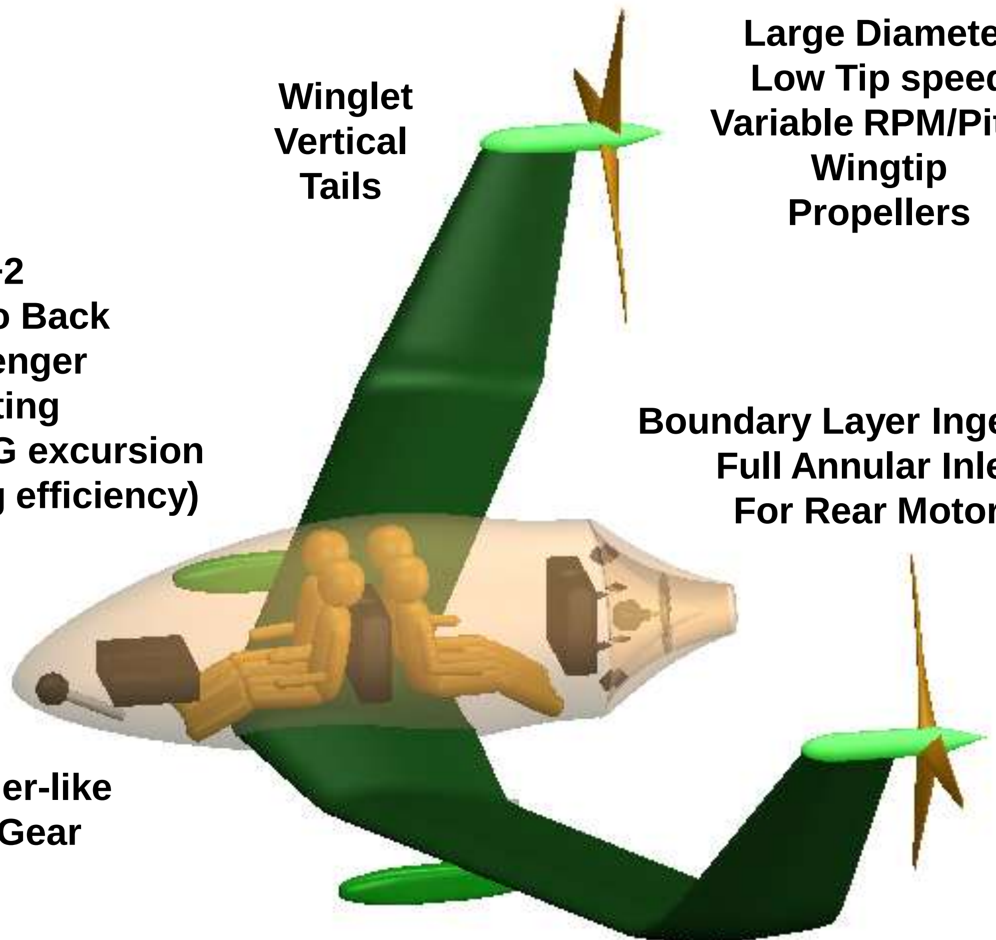
Focuses on energy constrained design and need for high efficiency, with drag reduction in two areas to achieve L/D balance.

- Fuselage Skin Friction Drag
- Wing Induced Drag

Proven flying wing design (Swift motor-glider by Kroo/Morris-Stanford) that minimizes base concept uncertainty and achieves…

- L/D cruise > 26 (but at low speed)
- L/Dmax = 1.3
- Ultra lightweight (420 lb GW)

eSwift Initial Concept Features



eSwift Concept Approaches

Propulsive Efficiency:

- Boundary Layer Ingestion annular fuselage inlet
- Large diameter, variable rpm/pitch propeller

Aerodynamic Efficiency:

- Limited cooling drag for electric motors
- Wingtip vortex propeller integration
- Improved packing w/ recip engine removal, back-to-back layout
- Proverse fuselage pressure gradient for 60% of body length
- Decreased length main landing gear, with stowed front gear
- Flying wing with battery pods, added wetted area
- Winglet verticals for multi-functional wetted area reduction

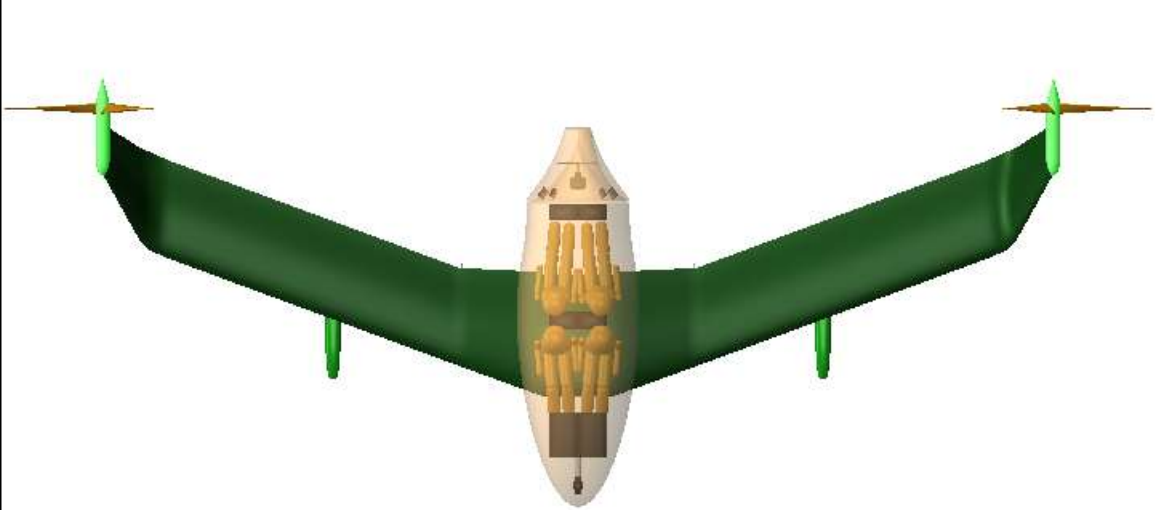
Cost Reduction:

- Lean design with constant chord wing, elimination of empennage structure

Community Noise:

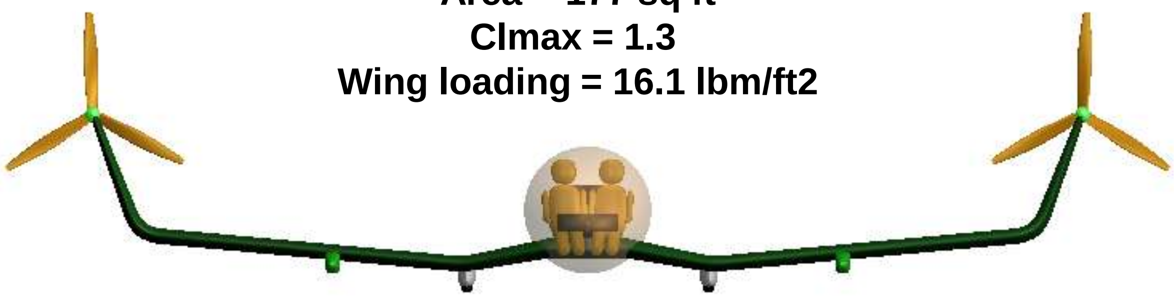
- Low tip speed, high solidity wingtip propellers
- Ducted propulsor with internal liners

eSwift Initial Concept



Span = 38.8 ft
Area = 177 sq ft
Clmax = 1.3
Wing loading = 16.1 lbm/ft2

Prop Diameter = 8 ft
Total Power = 129 hp
SLS thrust = 1043 lbf



eSwift Concept Issues

Wingtip propeller positioning immediately behind the verticals causes wake cutting noise, reduced efficiency, blade fatigue, and potential for blade strike.

Wingtip propeller asymmetric thrust engine-out control is mitigated by redundant electric motors with overrun clutch on each prop, with the variable pitch system failing in position, and a sensor to detect significant thrust imbalance. However, the consequence of a failure is significant.

Allowable CG variation of a tail-less configuration is small, which is mitigated through the unique passenger layout and battery nacelle on the CG. However, loading flexibility is significantly reduced (especially for non trained pilots).

Low Clmax of tail-less configuration results in increased wing area and wing parasite drag to achieve the same stall speed, with poor ride quality (W/S).

An additional configuration was developed to reduce these concerns, and provide a comparative assessment between configurations.

eSwift Concept Revisions

Modifications include…

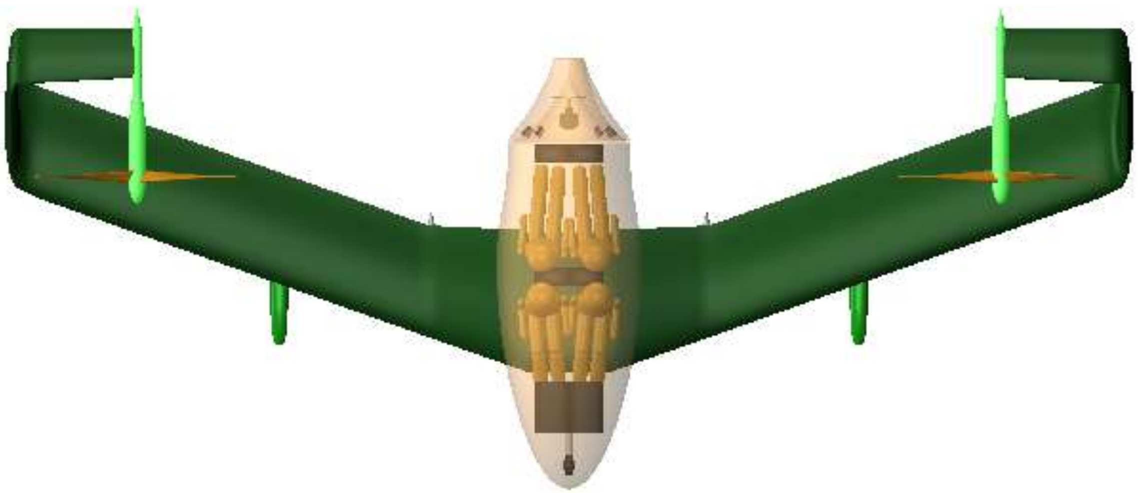
C-wing layout provides a pitching surface with Clmax increase from 1.3 to 1.6, to decrease wing size, as well as greater CG excursion.

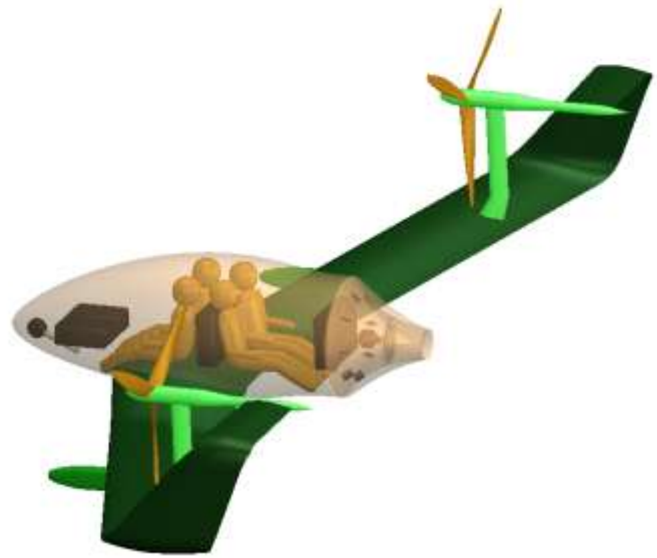
C-wing layout provides a greater effective span and further induced drag reduction – but with increased wing structural complexity.

Wingtip propeller positioning further inboard eliminates wake ingestion and blade strike potential, while reducing potential engine-out thrust asymmetry.

Wingtip propeller provides increased velocities on upper surface of outboard wing to increase wing lift effectiveness with power (but Clmax on approach still limited).

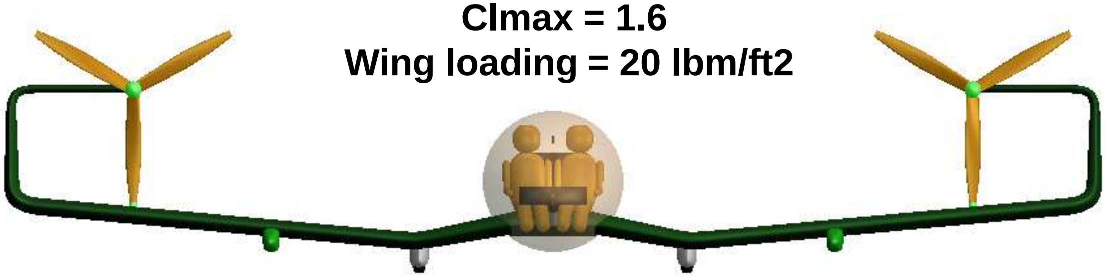
eSwift-2 Concept





Span = 38.8 ft
Area = 145 sq ft
Clmax = 1.6
Wing loading = 20 lbm/ft2

Prop Diameter = 8 ft
Total Power = 128 hp
SLS thrust = 1043 lbf



eSwift-2 Concept Benefits

Propulsive Efficiency:

BLI annular fuselage inlet (Fuse PropEfficiency from 85 to 130%)

Large, variable rpm/pitch propeller (Wingtip PropEfficiency from 85 to 95%)

Aerodynamic Efficiency:

Limited cooling drag for electric motors (-5% total drag)

Wingtip vortex propeller integration (Cd induced -15%)

Improved packing efficiency (-18% Fuselage wetted area)

Proverse fuselage pressure gradient (Fuselage 30% laminar flow)

Decreased main, stowed front landing gear (-70% landing gear drag)

Flying wing with battery pods, added wing area (+22% wing parasite drag)

Winglet verticals non-planar effect (-12% Cd induced)

Cost Reduction:

Lean design with constant chord wing, elimination of horizontal tail

Community Noise:

Low tip speed, high solidity wingtip propellers

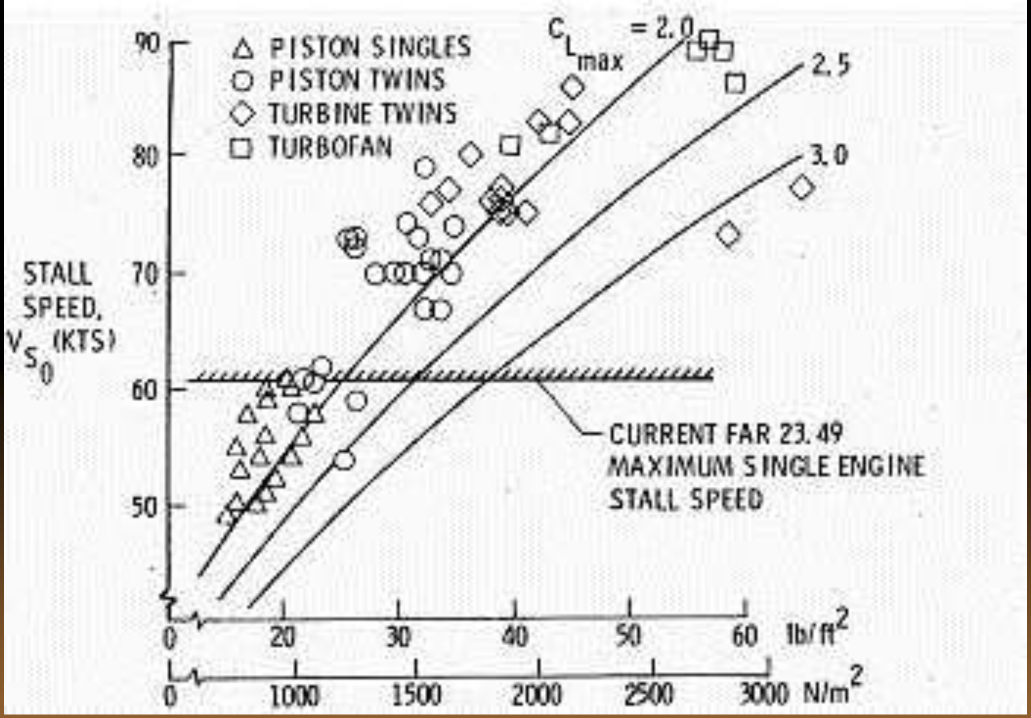
Ducted propulsor with internal liners

eSwift Concept (150 mph, 8000 ft)

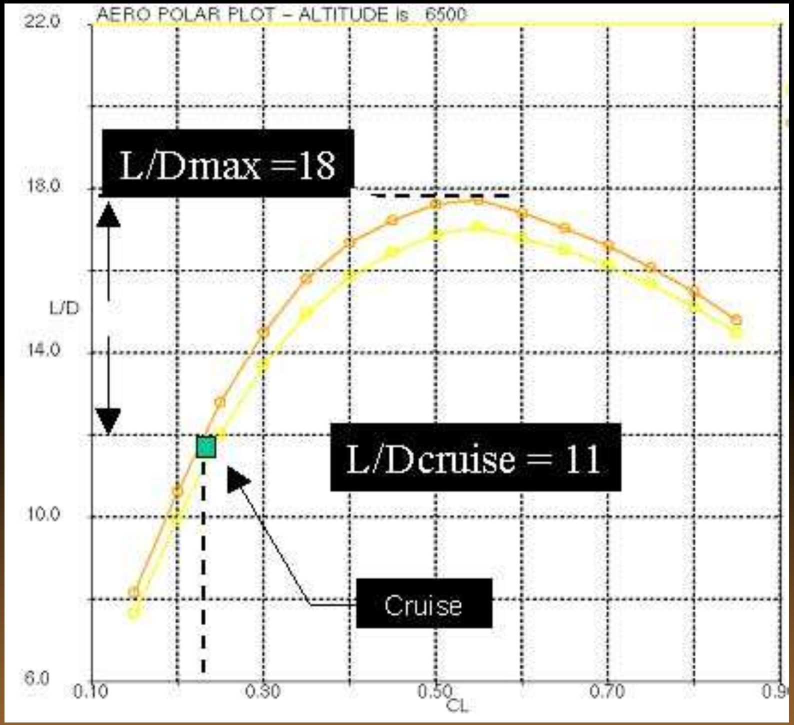
	SR-20	eSwift-2	
Weights (lbs)			
Gross	3015	2850	
Empty	2080	1650	
Payload	840	840	
Fuel/Batteries (400 Whr/kg)	95	360	
Aerodynamics:			
L/D	18.0	26.4	
Propulsion:			
Total Power Required (hp)	200	128	
BLI Duct		12	
Wingtip Props		116	
Cruise Power Required (hp)	79	51	
Energy			
Total Required (kWhr)	382	65	(5.9x)
Cost ($)	67.40	6.14	(11x)

Higher Performance Zip Concepts

$$R_1 = \eta \frac{L}{D} \left(\frac{W_{\text{bat}}}{W} \right)_1 \frac{u\kappa}{g}$$



Stall Speed vs Wing Loading and CLmax



SR-22 Drag Polar