EDISON AEROSPACE LLC

Ag Application | Cargo | Defense

DARPA LIFT CHALLENGE

Engineering Design Analysis

Gasoline Single-Rotor Helicopter — 110 lb Qualifying Mission Design

Prepared by: Gene Avakyan

Founder — Edison Aerospace LLC

https://edison.aero

Design date: July 15, 2026

PUBLIC ENGINEERING RELEASE

Table of Contents

WHY THIS DOCUMENT IS PUBLIC

Edison Aerospace is contributing to the DARPA Lift Challenge from the drawing board rather than the flight line. In lieu of participating in person, the company is publishing this engineering design so its calculations, assumptions, and qualification gates can add lift to the wider aerospace community.

1.0 Engineer Background & Qualifications

Gene Avakyan brings 30 years of experience in technical leadership and innovation, having led teams and projects across Government, Entertainment, Medical, and Cybersecurity industries. He holds a Bachelor of Science degree in Aerospace Engineering from UCLA and an MBA from Pepperdine University.

In the public sector, Gene developed and supported the ERP procurement and contract management software systems that power the City of Los Angeles and the Federal Aviation Administration's contract management programs, managing over $13 billion in combined contracts handled by the systems. He was recognized for his design and development of the Los Angeles City Attorney's office T.O.U.G.H. nuisance property abatement system, used to integrate City, State, and Federal law enforcement efforts in fighting local organized crime.

In the private sector, Gene served as Chief Technology Officer at financial firms and is a member of the FBI's InfraGard public/private partnership for the protection of U.S. Critical Infrastructure. He is the co-founder of the VUGA Group companies.

In the aerospace and unmanned systems domain, Gene founded Edison Aerospace LLC to develop heavy-lift eSTOL aircraft for agricultural, logistics, and defense applications and dual-mode unmanned watercraft for military applications. He has appeared on-stage at the Autonomous Nation and UAS Summit & Expo in North Dakota and presented the Edison Aerospace prototype at the NAAA (National Agricultural Aviation Association) National Convention. This paper focuses on gasoline-powered single-rotor VTOL platforms to achieve payload-to-weight ratios exceeding 4:1 — a target established by the DARPA Lift Challenge.

2.0 DARPA Lift Challenge — Program Overview

2.1 Objective

The DARPA Lift Challenge (https://www.darpa.mil/research/challenges/lift) is a $6.5 million prize competition organized by the Defense Advanced Research Projects Agency. The mission is an aircraft under 55 lb carrying at least 110 lb of plates for four nautical miles, making a controlled ground deposit, and flying one nautical mile without the plates, all within 30 minutes. The course is flown as repeated legs and reversals inside a 100 ft by 1,100 ft lane, not as a straight five-nautical-mile transit. The design sizes energy, time, control, and qualification testing to the released lane geometry.

2.2 Key Requirements

Parameter	Requirement / design interpretation
Aircraft rule weight	< 55 lb including components and fuel; payload excluded
4:1 scoring mass at 110 lb	≤ 27.5 lb aircraft; mission design 26.76 lb
Plate payload	110 lb minimum qualifying payload
Government tracker	Current guide: 2.5 lb; remains for final mile and counts as payload; obtain written weigh-in confirmation
Course	5 NM in repeated legs/reversals inside 100 ft × 1,100 ft lane
Loaded segment	First 4 NM with plates; approximately 22 reversals modeled
Payload deposit	Controlled contact/landing before release; no airdrop
Unloaded segment	Final 1 NM without plates; tracker remains; approximately five reversals modeled
Run time limit	30 minutes
Cruise altitude	150 ft ± 50 ft
Loaded ascent/descent	Completed within 0.5 NM of start/finish zone along the flight path
Unloaded ascent/descent	Completed within 0.2 NM of start/finish zone along the flight path
Flight lane	100 ft × 1,100 ft; green corridor 60 ft × 1,060 ft
Landing/deposit	Aircraft center and payload within their designated 5 ft radius circles
Scoring	Successful payload weight ÷ aircraft weight including power sources
Attempts	Two 90-minute windows; unlimited safe attempts; best successful run retained
Competition	August 2–9, 2026, Dayton, Ohio

2.3 Prize Structure

Prize	Amount	Criteria
1st Place	$2,500,000	Highest successful ratio; full award above 4:1, 50% below 4:1
2nd Place	$1,500,000	Second-highest successful ratio; same award multiplier
3rd Place	$1,000,000	Third-highest successful ratio; same award multiplier
Most Revolutionary Aerodynamic Design	$500,000	DARPA expert panel
Most Revolutionary Powertrain Design	$500,000	DARPA expert panel
Most Promising Design	$500,000	DARPA expert panel

3.0 Design Architecture & Rationale

3.1 Architecture Selection: Gasoline Single-Rotor Helicopter

Although VTOL aircraft are not efficient and require far more power-to-weight ratio than purely STOL fixed-wing aircraft, the 100 ft by 1,100 ft flight lane and repeated low-speed reversals favor a VTOL rotorcraft that can reverse course without a large, banked turn. At the released dimensions, the analysis uses approximately 22 loaded and five unloaded end-of-lane reversals; final released coordinates and required turn radii govern. Due to disc loading consideration, the requirements also favor a large, single-rotor aircraft instead of a multi-rotor. The 4.0 m main rotor in the design specified fits inside the lane, but lane containment, crosswind response, and sling-load behavior must be demonstrated over representative geometry.

The mission is a mixed hover, low-speed forward-flight, and reversal task. Straight-leg distance at 7.8 m/s requires approximately 19.8 minutes, but a conservative eight-second allowance for each of approximately 27 reversals raises the modeled mission to about 26.4 minutes before contingency. The energy model separately charges loaded and unloaded reversals rather than hiding them inside a straight-line cruise estimate.

Three architectures were evaluated:

Architecture	Advantages	Limitations	Decision
Multirotor (hex/octo)	Simple control allocation Commercial motors and propellers	Higher total propulsion-system mass for the required endurance Many high-power components Small-rotor efficiency penalty	Not selected
Compound helicopter (wing + single rotor)	Low-speed rotor lift Potential cruise benefit	Wing and transition hardware add weight Limited benefit at approximately 8 m/s in repeated loops	Not selected
Pure single-rotor helicopter (gas engine)	Approximately 5 kg/m² disk loading Efficient low-speed lift Compact course reversals Fuel energy suited to mission duration	Custom flight-critical drivetrain Single-engine power loss risk Autorotation and sling stability require demonstration	SELECTED

3.2 Key Design Decisions

1. Gasoline Engine over Electric Propulsion

The unique requirements of this mission do not favor electric propulsion. Gasoline provides approximately 12,000 Wh/kg of chemical energy. At the planning BSFC of 500 g/kWh, one kilogram of fuel delivers about 2,000 Wh of brake-shaft energy, equivalent to roughly 16.7% overall conversion efficiency. Compared with approximately 200 Wh/kg delivered by a 220 Wh/kg LiPo system, the fuel-only energy advantage is about 10:1, before accounting for engine, drivetrain, battery, and cooling-system mass. This is the consistent basis used in the mission fuel budget.

2. Single Large Rotor over Multiple Small Rotors

At the 110 lb design point, the 4.0 m rotor has a disk loading of approximately 5.0 kg/m² including the government tracker. This reduces induced power, but the assumed figure of merit is not credible without defined blade geometry and test data. The preliminary blade definition in Section 3.3 is therefore an analysis input and an acceptance-test article, not a production claim.

3. DA-120 Twin-Cylinder Gas Engine

The current Desert Aircraft DA-120 manufacturer page specifies 11.7 hp (8.72 kW), 2.25 kg bare weight, and a 1,300–6,900 RPM operating range. The design point uses 6,500 engine RPM and 500 rotor RPM, requiring approximately 13.0:1 overall reduction. The manufacturer does not publish a power curve on that page; installed hot-day continuous output of at least 7.41 kW at the selected RPM remains a dyno acceptance criterion rather than an assumed fact.

4. 4.0 m Rotor Diameter

The 4.0 m rotor uses two purpose-built 2,000 mm blades at 500 RPM, giving a 104.7 m/s tip speed. At the design hot-day temperature basis, speed of sound is approximately 351 m/s and tip Mach is approximately 0.30. Maximum-thrust results remain analytical ceilings until blade stall, structural load, and figure-of-merit behavior are measured across collective.

3.3 Preliminary Main-Rotor Geometry

Analysis geometry: two blades; radius 2.00 m; 0.25 m root cutout; chord tapered from 0.180 m at the cutout to 0.110 m at the tip; blade area approximately 0.254 m² each; solidity $\sigma \approx 0.040$; NACA 23012 or a documented equivalent rotorcraft airfoil; and approximately −10° linear twist from $r/R = 0.25$ to the tip. Collective and cyclic ranges are set from blade-element analysis, swash geometry, and stall testing rather than assumed from a generic helicopter setup.

Qualification requires a representative blade pair to achieve FM ≥ 0.72 at the 110 lb condition, remain below the approved sectional lift limit, and pass root, centrifugal, flapping, overspeed, and fatigue proof tests. If measured FM falls with increasing collective, the measured curve replaces the constant-FM model.

3.4 Tail-Rotor Clearance and Center of Gravity

The tail-rotor hub is located at a 2.30 m moment arm from the main shaft. With a 0.25 m tail-rotor radius, the inward tip is 0.05 m outside the 2.00 m main-rotor radius. The tail boom and drive are included in the weight budget. Engine, fuel, and avionics packaging must place the loaded and unloaded center of gravity inside the measured swash/trim envelope without ballast; static CG and tail-boom bending/torsion tests are mandatory.

4.0 Weight Budget

The weight budget totals 12.14 kg (26.76 lb), including the 2.30 m tail system, approximately 1.8 L fuel tank, and 1.15 kg of mission fuel. The plates-only score is 4.11:1, leaving approximately 0.74 lb to the 27.5 lb aircraft weight corresponding to a 4:1 score with 110 lb of plates.

Component	Weight (kg)	Weight (lb)
ROTOR SYSTEM		
2× 2000 mm purpose-built CF main blades	1.10	2.43
Rotor hub + swashplate + feathering hardware	1.05	2.31
Main shaft + bearings + autorotation hub	0.80	1.76
POWERPLANT		
DA-120 engine with exhaust + ignition	2.70	5.95
Centrifugal clutch	0.16	0.35
2-stage 13.0:1 belt reduction and pulleys	0.55	1.21
Cooling, throttle servo, governor + RPM sensing	0.32	0.71
TAIL		
2.30 m reinforced CF tail boom	0.35	0.77
Torque drive + bearings + tail gearbox	0.33	0.73
0.50 m variable-pitch tail rotor assembly	0.18	0.40
AIRFRAME		
CF/Kevlar equipment pod	0.55	1.21
Wide-stance landing gear	0.45	0.99
Engine/mast frame, bearing supports, guards, fasteners	0.90	1.98
AVIONICS & ELECTRICAL		
Pixhawk-class controller + GPS/compass	0.15	0.33
3× cyclic/collective servos, ≥18 kg·cm each	0.21	0.46
Tail servo, ≥12 kg·cm and ≤0.05 s/60°	0.075	0.17
Receiver + telemetry	0.05	0.11
Separate flight-control and ignition batteries	0.32	0.71
RID + independent kill switch	0.12	0.26
PDB, regulators, wiring and engine sensors	0.105	0.23
PAYLOAD RELEASE		
Positive-retention hook + servo + low-stretch sling	0.30	0.66
FUEL		
Gasoline/oil mission fuel	1.15	2.54
Approx. 1.8 L tank + plumbing	0.22	0.49
AIRCRAFT DESIGN TOTAL	12.14	26.76
110 lb PLATES + 2.50 lb TRACKER	51.03	112.50
PHYSICAL TAKEOFF MASS	63.17	139.26

5.0 Qualifying-Condition Hover Performance

5.1 Disk Loading

Design condition: 110 lb plate payload, 12.14 kg aircraft, and 2.50 lb government tracker. Physical takeoff mass = 63.17 kg.

$$DL = W / A = (63.17 \times 9.81) / (\pi \times 2.0^2) = 49.3\ N/m^2 = 5.03\ kg/m^2$$

This disk loading is substantially lower than that of an R22 at maximum gross weight. It reduces induced power but does not by itself establish rotor efficiency; blade solidity, twist, airfoil, Reynolds number, and profile drag must be verified by test.

5.2 Induced Velocity (Momentum Theory)

$$v_i = \sqrt{(W / (2\rho A))} = \sqrt{(619.6 / (2 \times 1.12 \times 12.57))} = 4.69\ m/s\ \text{(Dayton hot-day design density)}$$

5.3 Hover Power

Design assumptions: air density ρ = 1.12 kg/m³, approximately representative of a hot August day at Dayton elevation; main-rotor FM = 0.72 only at the qualifying test point; tail rotor diameter = 0.50 m with FM_tail ≥ 0.55; 2.30 m tail moment arm; drivetrain efficiency η = 0.88; and 0.10 kW accessories.

$$P\_ideal,main = W \times v_i = 619.6 \times 4.69 = 2.91\ kW$$

$$P\_main = P\_ideal,main / FM = 2.91 / 0.72 = 4.04\ kW;\ \text{calculated tail power} \approx 0.53\ kW;\ \text{accessories} = 0.10\ kW$$

$$P\_engine,hover = (4.04 + 0.53 + 0.10) / 0.88 \approx 5.31\ kW\ \ (72\%\ \text{of the 7.41 kW installed-power gate})$$

5.4 Maximum Thrust & T/W Ratio

With FM artificially held at 0.72, the model gives analytical supported-mass ceilings of approximately 78.2 kg at 7.41 kW and 86.7 kg at 8.72 kW. These are not thrust predictions: blade loading, stall, governor droop, cooling, and drivetrain limits can only reduce the usable values. Qualification uses the measured FM-versus-thrust curve.

$$\text{Ceiling } T/W\_hot = 78.2 / 63.17 = 1.24\ \text{at the qualifying condition; rated-power ceiling } T/W \approx 1.37.$$
$$\text{Measured maneuver margin, not the ceiling, governs release to flight.}$$

Plate payload	Physical mass*	Hover brake power	Ceiling T/W	Aircraft weight	Score**	Status	Decision
110 lb	63.17 kg	5.31 kW	1.24	26.76 lb	4.11:1	MISSION	Qualify after Section 10.7 tests
130 lb	72.24 kg	6.54 kW	1.08	26.76 lb	4.86:1	STRETCH	Measured margin required
150 lb	81.31 kg	7.88 kW	0.96	26.76 lb	5.60:1	NO-GO	Cannot hover at design power
160 lb	85.85 kg	8.59 kW	0.91	26.76 lb	5.98:1	NO-GO	Outside installed-power gate

The qualification target is the 110 lb configuration. Constant-FM ceiling T/W falls to approximately 1.08 at 130 lb and below 1.0 at 150 lb. A stretch attempt is authorized only if measured performance and control margin exceed the Section 10.7 gates.

6.0 Cruise & Mission Energy Analysis

6.1 Forward Flight Power

Forward-flight power is not assumed to be a fixed percentage of hover power. The mission budget sets a 4.5 kW acceptance limit for loaded straight legs at 7.8–8.0 m/s and separately assigns 5.6 kW for each eight-second loaded reversal. Unloaded reversals are budgeted at 2.5 kW. All values include rotor, tail, drivetrain, payload drag, and control effects and must be verified over the real 100 ft by 1,100 ft lane geometry.

Mission acceptance criterion: average loaded straight-leg brake power ≤ 4.5 kW and average loaded reversal brake power ≤ 5.6 kW, with approximately 22 loaded and five unloaded reversals, eight seconds per reversal, and 500 RPM maintained within the approved governor tolerance.

6.2 Conservative Mission Energy Budget (110 lb payload)

Mission phase	Engine brake power	Duration	Fuel @ 500 g/kWh
Takeoff + loaded climb	5.6 kW	30 s	23 g
Loaded straight-leg distance (4 NM)	4.5 kW	950 s	594 g
Loaded reversals (22 × 8 s)	5.6 kW	176 s	137 g
Loaded descent + ground deposit	5.2 kW	60 s	43 g
Unloaded climb	2.5 kW	30 s	10 g
Unloaded straight-leg distance (1 NM)	1.5 kW	237 s	49 g
Unloaded reversals (5 × 8 s)	2.5 kW	40 s	14 g
Final descent + landing	1.5 kW	60 s	13 g
TOTAL	1.767 kWh	1,583 s / 26.4 min	884 g

Fuel carried: 1.15 kg in an approximately 1.8 L tank. Lane-aware planned burn at 500 g/kWh is 884 g, leaving 266 g (23% of carried fuel). At 550 g/kWh, projected burn is 972 g, leaving 178 g (15%).

Mission time: approximately 26.4 minutes, including 22 loaded and five unloaded eight-second reversal allowances plus a realistic 30-second unloaded climb. This leaves about 3.6 minutes to the 30-minute run limit; the complete lane-geometry mission must be demonstrated before competition.

6.3 Specific Fuel Consumption

No manufacturer BSFC map is assumed. Planning uses 500 g/kWh with a 550 g/kWh sensitivity until an installed-engine test provides measured fuel flow. The qualification gate is a complete flight over the released lane geometry, including all reversals, climbs, deposit, and final landing; a straight-line or stationary endurance simulation is not acceptable. Competition is a no-go if that mission consumes more than 1.00 kg of fuel.

7.0 Qualification and Payload Limits

The DARPA scoring formula is:

$$Score = Payload\ Weight\ (lb)\ /\ Aircraft\ Weight\ (lb,\ including\ power\ sources)$$

The aircraft is designed to complete a 110 lb qualifying run. Four-to-one is the threshold for a full objective award to a top-three finisher, not a qualifying-score gate. The current Competitors page says the 2.5 lb government tracker counts as payload even when the compact form is attached to the aircraft. Because Rules 4.1 and 4.5 separately define plates and attachment hardware, the team should obtain written confirmation of the exact weigh-in arithmetic before relying on tracker credit.

Plate payload	Aircraft weight	Physical MTOW*	Ceiling T/W	Score**	Qualification
110 lb	26.76 lb	139.26 lb	1.24	4.11:1	Mission design
130 lb	26.76 lb	159.26 lb	1.08	4.86:1	Not pre-qualified
150 lb	26.76 lb	179.26 lb	0.96	5.60:1	No-go
160 lb	26.76 lb	189.26 lb	0.91	5.98:1	No-go

At 12.14 kg (26.76 lb), the conservative plates-only score is 4.11:1. If DARPA applies the current Competitors-page statement and counts the 2.5 lb tracker as payload, the displayed score would be approximately 4.20:1. If the tracker were instead charged to aircraft weight, the score would be approximately 3.76:1; this is a sensitivity case requiring written resolution, not the current published interpretation.

7.1 Competition Attempt Strategy

Each team has two 90-minute windows, may make as many safe attempts as time permits, and retains its best successful run. The first priority is therefore to bank a completed 110 lb run, even if as-built weight growth places the score slightly below 4:1. Only after a qualifying score is recorded should a higher-payload attempt be considered.

A stretch attempt must use the approved design and is limited by measured hot-day power, tail authority, fuel, vibration, sling stability, and lane-reversal data. The model does not pre-authorize 130 lb; the stretch payload is selected from demonstrated margin after the 110 lb mission succeeds.

8.0 Mission Fuel Budget & Timeline

8.1 Mission Profile

Step	Description	Altitude	Duration	Cumulative
1	Vertical takeoff + loaded climb	0 → 150 ft	30 s	0:30
2	Four-NM lane course: 950 s straight + 22 × 8 s reversals	150 ± 50 ft	18.8 min	19:16
3	Loaded descent to payload zone	150 → 0 ft	30 s	19:46
4	Ground contact, release confirmation and deposit	Ground	30 s	20:16
5	Unloaded climb	0 → 150 ft	30 s	20:46
6	One-NM lane course: 237 s straight + 5 × 8 s reversals	150 ± 50 ft	4.6 min	25:23
7	Final descent and vertical landing	150 → 0 ft	60 s	26:23
8	Mission margin to 30-minute run limit	—	3.6 min	30:00

8.2 Fuel Summary

Parameter	Design value
Fuel type	Gasoline + manufacturer-approved 2-stroke oil mix
Tank capacity	Approximately 1.8 L
Fuel carried	1.15 kg
Planning BSFC	500 g/kWh; 550 g/kWh sensitivity
Lane-aware mission burn	884 g at 500 g/kWh
Reserve	266 g / 23% of carried fuel
Sensitivity reserve	178 g / 15% at 550 g/kWh
Go/no-go limit	Full representative-lane mission ≤ 1.00 kg and ≤ 28 min

9.0 Component Selection (Off-the-Shelf)

The design combines commercial components with custom flight-critical rotor, transmission, tail, and structure hardware. Commercial availability does not establish suitability. Every custom or adapted flight-critical component requires drawing control, material traceability, proof loading, inspection criteria, and representative endurance testing before flight.

9.1 Propulsion & Rotor

Part	Design specification	Weight	Est. price
DA-120 or verified equivalent	Manufacturer: 11.7 hp, 1,300–6,900 RPM; dyno gate applies	2.70 kg installed	$1,500
Purpose-built main blades	2 × 2,000 mm; 180→110 mm taper; −10° twist; NACA 23012/equivalent	1.10 kg	$1,200
Rotor hub + swashplate	7075-T6 or verified equivalent; load-rated	1.05 kg	$700
Main shaft + autorotation	Dual bearings, overrunning clutch, RPM sensing	0.80 kg	$350
Centrifugal clutch	Torque-rated with guarded engagement	0.16 kg	$120
2-stage belt reduction	Approx. 13.0:1 from 6,500 to 500 RPM; ≥1.5× mission torque	0.55 kg	$300
Cooling + engine control	Forced-air shroud, throttle servo, governor and CHT	0.32 kg	$250

9.2 Tail Assembly

Part	Design specification	Weight	Est. price
Tail boom	2.30 m mast-to-tail-hub reinforced CF; bending/torsion and CG verified	0.35 kg	$150
Tail drive	Torque tube/belt, bearings and speed-increasing gearbox	0.33 kg	$340
Tail rotor assembly	0.50 m diameter, variable pitch, approximately 4,500 RPM; servo excluded	0.18 kg	$80

9.3 Airframe

Part	Design specification	Weight	Est. price
Equipment pod	CF/Kevlar; serviceable fuel and avionics access	0.55 kg	$350
Landing gear	Wide stance; controlled plate contact and release clearance	0.45 kg	$200
Primary frame and hardware	Engine/mast frame, bearing supports, guards and fasteners	0.90 kg	$450

9.4 Avionics & Control

Part	Design specification	Weight	Est. price
Flight controller + GPS	Pixhawk-class controller with isolated mounting	0.15 kg	$250
3 cyclic/collective servos	≥18 kg·cm each; current monitoring	0.21 kg	$450
Tail servo	≥12 kg·cm, ≤0.05 s/60°, thermal margin verified	0.075 kg	$150
Receiver + telemetry	Independent command and MAVLink telemetry links	0.05 kg	$75
Flight-control battery	Dedicated pack sized from measured servo load	0.20 kg	$60
Ignition battery	Electrically isolated dedicated pack	0.12 kg	$40
RID module	FAA-compliant broadcast module	0.05 kg	$40
Independent kill switch	Hard CDI ground circuit plus supervised relay	0.07 kg	$60

PDB, regulators + wiring	Redundant regulated rails and fused distribution	0.065 kg	$120
Engine/rotor sensors	Rotor RPM, engine RPM, CHT and fuel measurement	0.04 kg	$100

9.5 Payload Release & Fuel

Part	Design specification	Weight	Est. price
Payload attachment	Positive-retention hook, ground-release interlock and low-stretch sling	0.30 kg	$150
Fuel tank + plumbing	Approx. 1.8 L, baffled/clunk pickup, filtered and vented	0.22 kg	$100
Mission fuel	1.15 kg gasoline/oil mix	1.15 kg	$13

9.6 Cost Summary

Category	Estimated cost
Engine, cooling and controls	$1,750
Main rotor and reduction system	$2,670
Tail system including tail servo	$720
Airframe and landing gear	$1,000
Avionics, electrical and sensors excluding tail servo	$1,195
Payload and fuel systems	$263
Proof-test hardware, spares and instrumentation	$2,245
TOTAL ESTIMATED BUILD/QUALIFICATION COST	$9,843 (approximately $9,850), excluding labor and major test equipment

10.0 Key Design Notes & Safety

10.1 Autorotation Safety

The centrifugal clutch and overrunning autorotation hub allow the main rotor to freewheel after engine or drivetrain power loss. They do not guarantee a safe landing. Autorotation capability depends on rotor inertia, blade mass distribution, entry response, forward speed, gross weight, and flare timing. Because autonomous autorotation is not treated as an available operational feature, engine loss requires an immediate pilot emergency response and remains a primary residual risk until demonstrated flight testing establishes a safe operating envelope.

10.2 Engine Cooling

The DA-120 requires forced-air cooling in this installation. The cooling fan and shroud are sized as part of the installed-power system, and cylinder-head temperature must be logged. A 10-minute ground run at maximum expected continuous power followed by a full mission-duration test, at representative ambient temperature, is required before payload flight.

10.3 Vibration Isolation

The twin-cylinder engine reduces some vibration but remains a strong periodic excitation source. The flight controller is isolated, and harmonic-notch filtering is driven from measured engine/rotor RPM rather than a fixed assumed 108 Hz frequency. Qualification includes vibration spectra at idle, governor engagement, hover, loaded forward flight, and payload release.

10.4 Flight Control Configuration

ArduPilot TradHeli supports the required collective/cyclic configuration. The flight-control setup uses an RPM-sensed governor mode and a tuned throttle curve. Normal radio, navigation, and control failsafes may command RTL or LAND only while propulsive power remains available; no automatic autorotation or powered auto-land is claimed after engine loss.

Parameter / function	Design setting	Purpose
FRAME_CLASS	Single Heli / TradHeli	Collective/cyclic single-main-rotor control
H_RSC_MODE	4 — internal RPM governor	Closed-loop ICE rotor-speed control
H_RSC_GOV_RPM	500 RPM	Main-rotor governed setpoint
H_RSC_THRCRV_*	Tuned before governor enable	Safe feed-forward fallback and load response
H_RSC_CRITICAL	Set from measured safe rotor RPM	Low-RPM detection and takeoff inhibition
H_COL_ANG_MIN/MAX	Set from blade and swash geometry	Verified collective limits without binding/stall
H_CYC_MAX	Start ≤6°; expand only by test	Lane control without excessive blade loading
Harmonic notch	RPM-sensor tracked	Reject measured engine/rotor harmonics
Normal failsafes	RTL/LAND only with power available	No automatic autorotation claim

10.5 Kill Switch

A hardware kill switch independently grounds the CDI ignition circuit and is accessible to the RPIC and Lane Coordinator. Activating it removes propulsive power and may require an emergency autorotation;

it is a containment device, not a benign landing command. Its wiring and operation must be verified before each flight window.

10.6 Payload Attachment

The barbell plates are carried at a single point below the aircraft using a low-stretch sling and positive-retention hook. The release is inhibited until ground contact is confirmed. The complete attachment remains aircraft weight under Rule 4.5. Sling length, loaded/unloaded CG, plate orientation, yaw authority, pendulum damping, and 2.30 m tail-boom clearance must be validated through progressive taxi, tether, hover, and real-lane loop testing.

10.7 Qualification and Go/No-Go Criteria

The design does not use battery jettison. Competition flight with 110 lb is authorized only after all qualification gates below are met:

- As-built aircraft weight with the full 1.15 kg fuel load is no more than 27.0 lb, retaining margin to the 27.5 lb plates-only 4:1 threshold.
- Installed engine testing demonstrates at least 7.41 kW continuous at the selected approximately 6,500 engine RPM and design hot-day condition, with stable 500 rotor RPM, acceptable cylinder-head temperature, and no clutch or belt distress.
- The defined 0.180-to-0.110 m tapered-chord rotor demonstrates hover brake power no greater than 5.5 kW at 63.17 kg, FM $\geq$ 0.72 at that point, acceptable FM decay through the maneuver range, and adequate blade, hub, mast, and drivetrain margins.
- The 2.30 m tail-rotor installation has positive main/tail disk clearance, acceptable loaded and unloaded CG, and at least 20% remaining yaw-control margin at maximum qualifying collective without servo overheating.
- A full 100 ft by 1,100 ft representative-lane mission, including approximately 22 loaded and five unloaded reversals, consumes no more than 1.00 kg of fuel and finishes within 28 minutes. Straight-line endurance testing does not satisfy this gate.
- The aircraft completes progressive 25%, 50%, 75%, and 100% payload tests, followed by the complete 110 lb five-nautical-mile lane-geometry mission, without unresolved anomalies before any stretch attempt.
- Obtain written DARPA confirmation of tracker form, tracker mass, payload-versus-aircraft treatment, and exact scoring arithmetic before final weigh-in planning.

11.0 Conclusion

The Edison Aerospace design targets the 110 lb qualifying mission at an estimated aircraft weight of 12.14 kg (26.76 lb), including the 2.30 m tail system and 1.15 kg mission fuel load. With a 2.50 lb tracker, physical takeoff mass is approximately 63.17 kg. The 1.12 kg/m³ model predicts 5.31 kW hover brake power; the 1.24 constant-FM thrust-to-weight result is an analytical ceiling pending rotor testing.

The design leverages three key engineering insights:

1. The gasoline system uses a consistent 500 g/kWh basis, equivalent to about 2,000 Wh/kg of fuel brake energy and a fuel-only advantage of roughly 10:1 over delivered LiPo energy. The lane-aware mission carries 1.15 kg of fuel and includes every modeled reversal.

2. The 4.0 m main-rotor geometry specifies chord taper, solidity, twist, airfoil, and root cutout. The 0.50 m tail rotor is placed at a 2.30 m moment arm for positive disk clearance. Both are subject to structural, aerodynamic, CG, and control-margin testing.

3. The manufacturer confirms 11.7 hp and a 1,300–6,900 RPM range. A 13.0:1 reduction at approximately 6,500 RPM is the design basis, but 7.41 kW installed hot-day continuous power must be demonstrated on the actual exhaust, cooling, governor, and reduction system.

The estimated build/qualification cost is approximately $9,850 excluding labor and major test equipment. The estimate includes the complete tail system, fuel system, proof-test hardware, spares, and instrumentation. The platform is not mission-capable until every Section 10.7 gate is passed.

Engineering conclusion: the design has a credible analytical path to completing the 110 lb mission, including the real lane reversals, a 26.4-minute time model, and adequate planned fuel in both the 500 and 550 g/kWh cases. The conservative plates-only score is approximately 4.11:1. The first competition objective is a successful 110 lb run; any reach attempt follows only after measured margins and a banked qualifying score.

EDISON AEROSPACE LLC

PUBLIC ENGINEERING RELEASE