# Aerobatic Sport/Military Trainer Plane

Preliminary Design Review #3

ENG ME408

Felicia Devorris, Carolina Leonard, Rushan Manek, John Morgan

# Introduction/ Background

Aerobatic sport planes are popular with thrill seeking aviators and are used in aerobatics competitions, as well as trainers for military fighters

**Problem Statement / Objective**
Request for Proposal: design and manufacture twenty-five aerobatic aircrafts
Our team will design a sport aircraft that meets the RFP requirements, and can serve as a desirable general aviation product that can meet military requirements

**Aircraft Type / Purpose**
Dual Cert: General Aviation / Military Trainer

**Design Driver(s)**
Max Speed, Turning Performance, Inverted Flight

**Design Challenges**
Taking advantage of the broader market appeal of a dual certification design, without sacrificing the key design drivers of either a General Aviation or Military Trainer aircraft

# Competitive Market

**Military Trainer Certification**
Number of Competitors: 128

**Aerosport Certification**
Number of Competitors: 166

**Dual Certification: Military Trainer/Aerosport**
Number of Competitors: 5

**KEY TAKEAWAY:**
General Aviation/Military Trainer dual certification is essential for providing a marketable design

# Refined Weight Estimate

**Summary - Component Weights**

| Component | Symbol | Fighter | Transport | General Aviation |
|---|---|---|---|---|
| Wing | Wwing | 466 | 381 | 376 |
| Horizontal Tail | Wh-stab | 184 | 42 | 74 |
| Vertical Tail | Wv-stab | 22 | 42 | 31 |
| Fuselage | Wfuse | 385 | 890 | 220 |
| Main Gear | Wmain lg | 173 | 75 | 230 |
| Nose / Tail Gear | Wnose lg | 57 | 26 | 36 |
| Propulsion System | Wpp | 1,228 | 1,228 | 944 |
| Remaining Components | Wrem | 414 | 414 | 341 |
| **Empty Weight** | **We** | **2,929** | **3,098** | **2,252** |
| Design Gross Weight | Wo | 3,043 | 3,043 | 3,043 |
| **Empty Weight Fraction** | **We/Wo** | **0.963** | **1.018** | **0.740** |

# Structural Design and Material Selection

## Design Load Factor

Load Setting Design Factor:

- Acceleration (Loiter - Cruise) (**3.348**)

Design Load Factor:

- 9.0

**Summary - Load Factors**

| Performance Segment | Pressure Altitude | Mach | Max Load Factors |
|---|---|---|---|
| Acceleration (Climb - 1.2*Vstall to climb speed) | 12,000 | 0.092 | 0.346 |
| Acceleration (Loiter - MBE to Cruise speed) | 5,000 | 0.240 | 3.348 |
| Acceleration (Combat - Cruise speed to Max Mach) | 12,000 | 0.250 | 2.786 |
| Instantaneous Turn Rate | 5,000 | 0.230 | 2.919 |
| Sustained Turn Rate | 5,000 | 0.230 | 2.919 |
| Climb - Takeoff | - | - | 0.859 |
| Highest angle-of-attack (a) | 12,000 | 0.250 | 3.167 |
| Max q (dive) | 12,000 | 0.250 | 2.181 |
| Gust Loads (cruise) | 12,000 | 0.188 | 3.251 |
| Maximum Calculated Limit Load Factor | | | 3.348 |
| Regulatory Limit Load Factor | | | 6.000 |
| **Design Load Factor** | | | **9.000** |

# Structural Design and Material Selection Cont.

## Wing Section

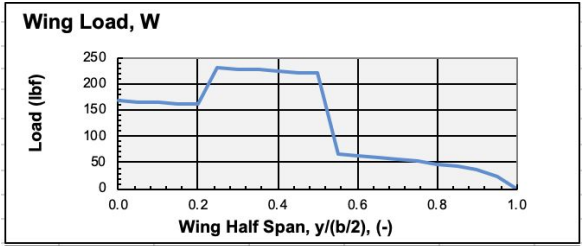
| Summary - Wing Loads | | | |
|---|---|---|---|
| Parameter | Symbol | Units | Value |
| Max Shear | Vmax | lbf | 2,623 |
| Span Location of Max Shear | b vmax | ft | 0.00 |
| Max Moment | Mmax | ft-lbf | **19,017** |
| Span Location of Max Moment | b mmax | ft | 0.00 |

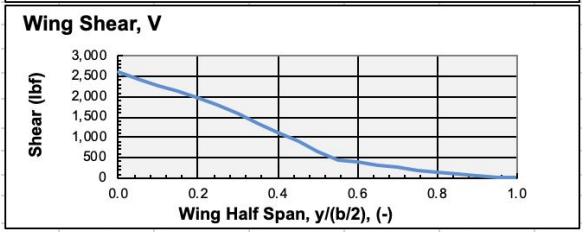
Max Load:

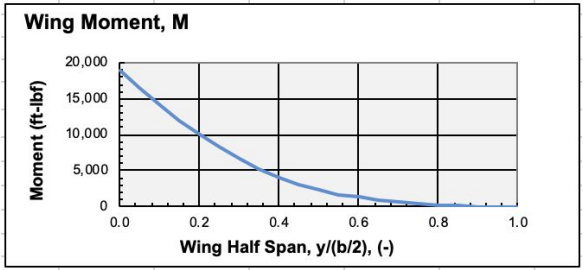
- Occurs between (**0.2 - 0.5**) wing-half span
  - Fuel Load
  - Armament Load

Max Wing Moment:

- Occurs closest to the fuselage



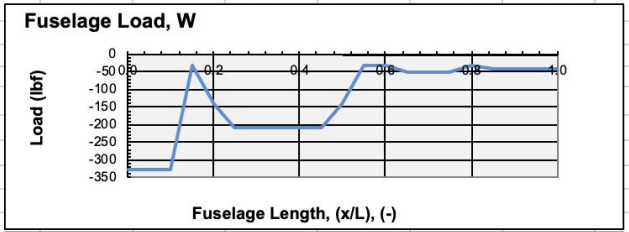



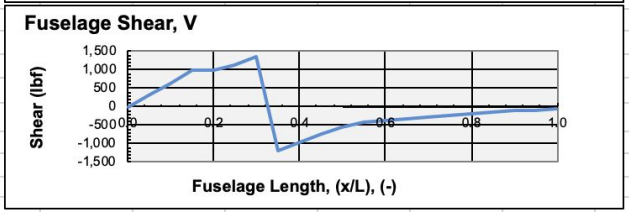
# Structural Design and Material Selection Cont.

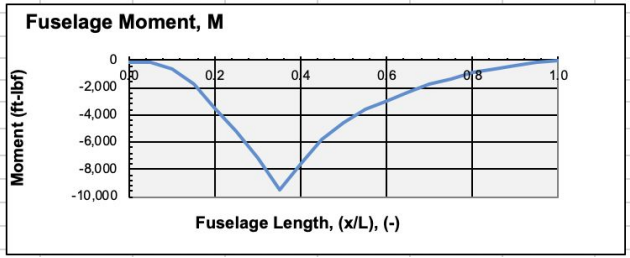
## Fuselage Section

**Summary - Fuselage Loads**

| Parameter | Symbol | Units | Value | |
|---|---|---|---|---|
| Aircraft Center of Gravity Location | $x_{CG}$ | ft | 9.68 | |
| Aircraft Center of Gravity Location | $(x/L)_{CG}$ | - | 0.282 | |
| Static Stability Margin | SM | - | 0.106 | **Stable** |
| Max Positive Shear | Vmax (+) | lbf | 1,359 | |
| Max Negative Shear | Vmax (-) | lbf | -1,162 | |
| Max Shear | Vmax | lbf | 1,359 | |
| Max Positive Bending Moment | Mmax (+) | ft-lbf | -77 | |
| Max Negative Bending Moment | Mmax (-) | ft-lbf | -9,466 | |
| **Max Moment** | **Mmax** | **ft-lbf** | **9,466** | |




Max Load:

- Occurs between (~**0.18 - 0.75**) wing-half span
  - Passenger
  - Retractable Gears

Max Shear:

- Correlated with Passenger & Equipment

# Structural Design and Material Selection Cont.

## Longeron Section

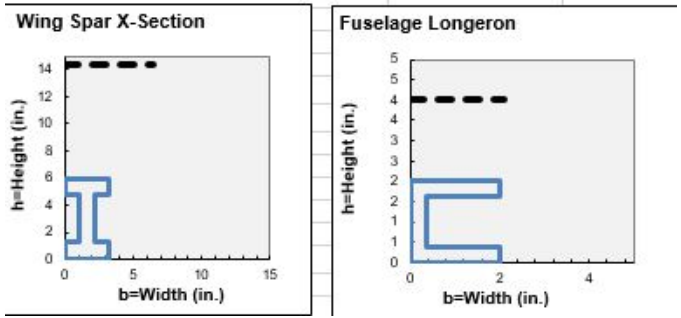
Tensile Strength Ratios:

- Wing Spar: 0.6
- Fuselage Longeron: 0.704

Compression Strength Ratios:

- Wing Spar: 0.690
- Fuselage Longeron: 0.246

| Summary - Structural Design | Wing Skin | Wing Spar | Fuselage Skin | Fuselage Longerons |
|---|---|---|---|---|
| X-Section | n/a | I Beam | n/a | U-Channel (C orientation) |
| Material Group<br>Material | Aluminum Alloy<br>2024-T3 A1 | Aluminum Alloy<br>2024-T3 (clad) | Aluminum Alloy<br>2024-T3 A1 | Aluminum Alloy<br>2024-T3 (clad) |
| Tension $(W_1/W_2)_t$ | 0.879 | 1.000 | 0.879 | 1.000 |
| Compression $(W_1/W_2)_c$ | 0.000 | 1.000 | 0.000 | 1.000 |
| Bending $(W_1/W_2)_b$ | 0.937 | 1.000 | 0.937 | 1.000 |
| Component Weight (lb) | 66 | 1,755 | 73 | 974 |
| Spar Deflection (in.) | X | 0.64 | X | X |
| Spar Deflection (% of half wing span) | X | 0.3% | X | X |
| Spar Height < Wing Thickness ? | X | YES | X | X |
| # of Bulkheads | X | X | X | 9 |
| Bulkhead Spacing (in.) | X | X | X | 48.0 |
| # of Longerons | X | X | X | 12 |
| Longeron Height < Fuse. Wall | X | X | X | YES |

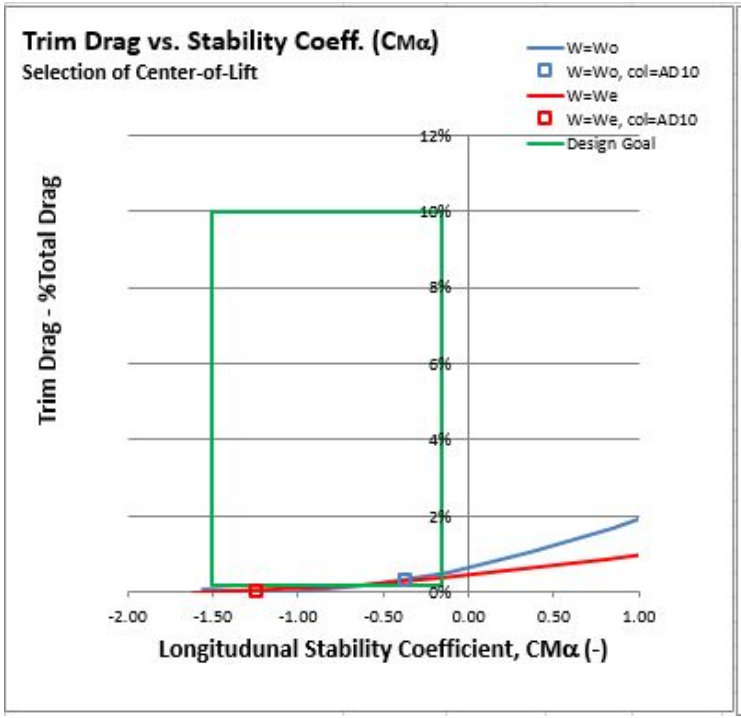


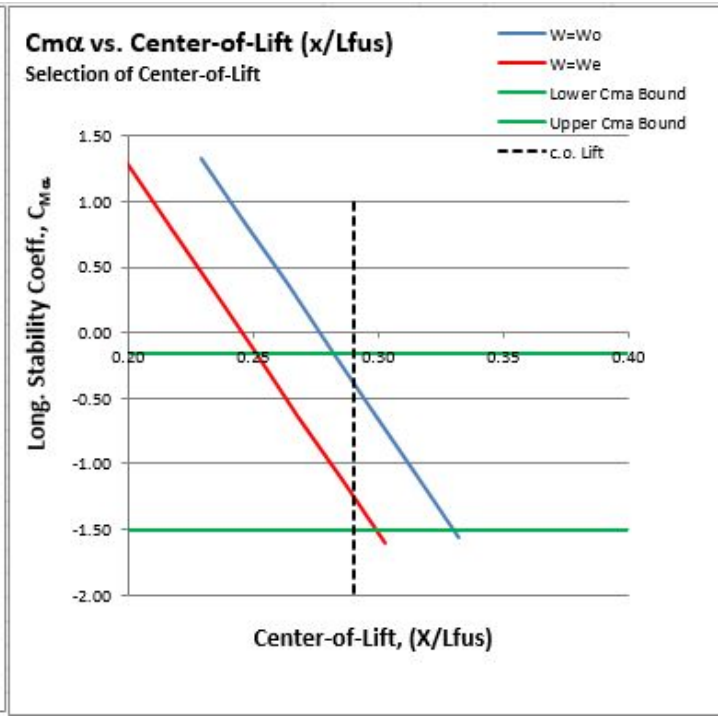
# Static Stability & Control

## Summary - Static Stability & Control

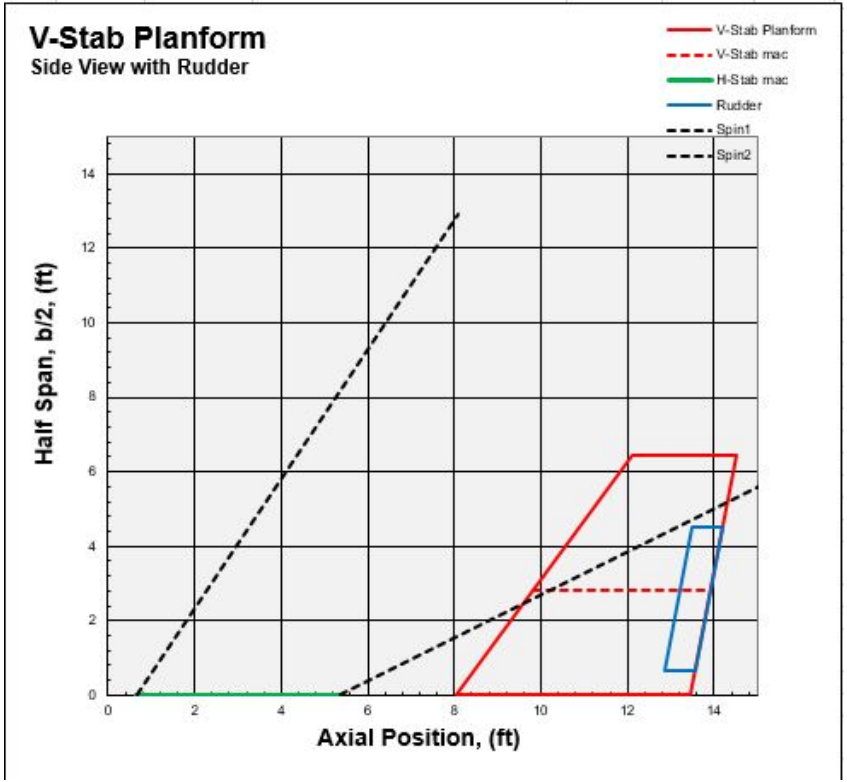
| | Values | | Compliance | | |
|---|---|---|---|---|---|
| **SM and Trim Drag** | at Wo | at We | at Wo | at We | Stability Requirement |
| -Center of Lift | **0.2900** | 0.2900 | | | |
| -Static Margin | 5.4% | 22.4% | **Pass** | **Pass** | SM>0% |
| -Dtrim / Dtotal | 0.3% | 0.0% | **Pass** | **Pass** | Dtrim/Dtot<0.1 |
| **Stability Coefficients** | | | | | |
| -Longitudinal, $C_{m\alpha}$ | -0.3744 | -1.2471 | **Pass** | **Pass** | $-1.5<C_{m\alpha}<-0.16$ |
| -Directional, $C_{n\beta}$ | 0.0891 | 0.0937 | **Pass** | **Pass** | $+0.08<C_{n\beta}<+0.28$ |
| -Lateral, $C_{l\beta}$ | -0.0891 | -0.0936 | **Pass** | **Pass** | $-0.28<C_{l\beta}<-0.08$ |
| **Rudder** | | | | | |
| Rudder TE Sweepback Angle (deg) | 9.4 | | **Pass** | | -12.5 deg<VT sweep<+12.5 deg |
| H-Stab Interference with Rudder | | | **Pass** | | at most 30% overlap. Manual check. See V-Stab side view below. |
| All four (4) SM and Trim Drag Tests: | | | **Pass** | | |
| All six (6) Stability Coefficient Tests: | | | **Pass** | | |
| All eleven (11) Static Stability & Control Tests: | | | **Pass** | | |

# Static Stability & Control Cont.



# Static Stability & Control Cont.



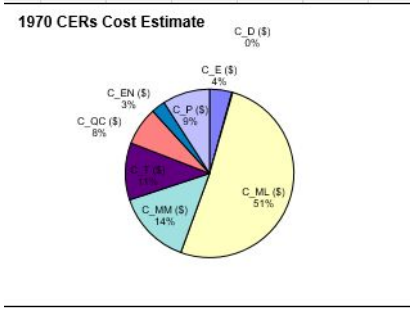
# Cost Estimate

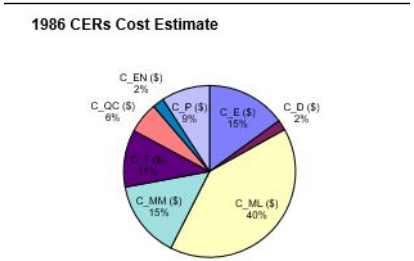
| | Grob G 120TP | Utva Lasta 95N | Pilatus PC-7 | DART-450 | Our Design |
|---|---|---|---|---|---|
| Sell Price | 1 mil | 0.5 mill | 1.5 mil | 3.1 mil | 2.5 mil |
| Amount Produced (per year) | 12 | 3 | 56 | - | 500 |

- N_D = 1
- N_P = 500
- R_D = 0.5

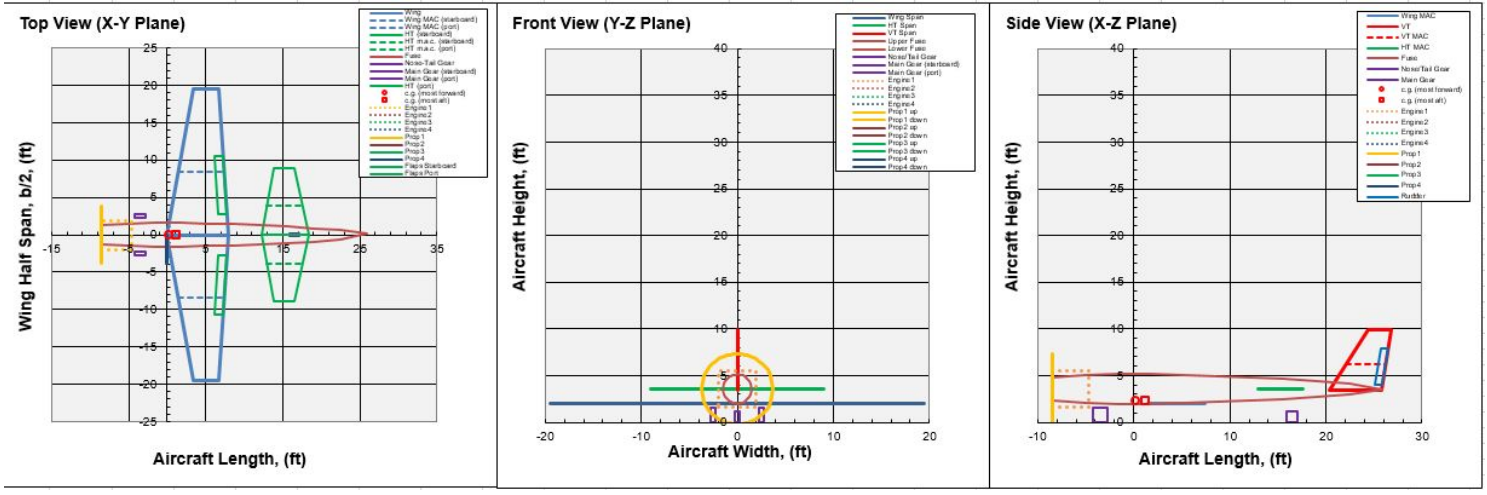
**Summary - Cost Estimate**

| **Assumptions** | | **1970 CER** | **1986 CER** |
|---|---|---|---|
| Year | | 2022 | 2022 |
| Number of Development Aircraft | | 1 | 1 |
| Number of Production Aircraft | | 500 | 500 |
| RTD&E Production Rate (per year) | | 6 | 6 |
| Acquisition Production Rate (per year) | | 12 | 12 |
| Amortization Period (# of ac) | | 400 | 400 |
| **Technology Factors** | **Factor** | **ΔCost ($/ac)** | **ΔCost ($/ac)** |
| Materials Factor (We/Wo) | 0.800 | $449,725 | $562,040 |
| Aerodynamic Efficiency Factor (L/D) | 1.000 | $0 | $0 |
| Propulsion Efficiency Factor (SFC) | 1.000 | $0 | $0 |
| **Configuration Options** | **Features** | **ΔCost ($/ac)** | **ΔCost ($/ac)** |
| Propulsion System Type | conventional | $0 | $0 |
| Propeller Type | constant speed | $0 | $0 |
| Flap Type | slot | $46,126 | $57,645 |
| **Total Aircraft Costs ($/ac)** | | **1970 CER** | **1986 CER** |
| TOTAL Cost Adders | | $495,851 | $619,686 |
| Initial Unit Cost | | **$2,294,752** | **$2,867,847** |
| Final Unit Cost | | $2,143,795 | $2,596,673 |
| Initial Price Markup | | 7% | 10% |
| Profit (%) | | 10 | 10 |



# Final Design Summary




| Iteration Solvers and Compliance | |
|---|---|
| Mission Analysis (Worksheet 2) | Pass |
| Fuselage Volume (Worksheet 5) | Pass |
| Landing Gear (Worksheet 5) | Pass |
| Engine Selection (Worksheet 7a or 7b) | Pass |
| Propeller Efficiency (Worksheet 7b) | Pass |
| Min Spec Takeoff (Worksheet 8) | Fail |
| Material Structural Integrity (Worksheet 10) | Pass |
| Stability & Control (Worksheet 11) | Pass |

| Overall Aircraft Envelope Dimensions | |
|---|---|
| Length (ft) | 34.35 |
| Width (ft) | 39.00 |
| Height (ft) | 7.31 |

# Requirements

| Requirement | Threshold | Objective | Actual Value | Percentage |
|---|---|---|---|---|
| **Mission Performance** | | | | |
| Max Cruise Speed (ktas) | 120 | 180 | 180 | 100 |
| Design Radius (nm) | 100 | 200 | 200 | 100 |
| Design Endurance (min) | 30 | 60 | 60 | 100 |
| Design # of 360 deg. Max Sust. g turns | 10 | 20 | 20 | 100 |
| Service Ceiling (ft) | 10,000 | 15,000 | 15000 | 100 |
| Glide Slope (deg) | -8 | -3 | –4 | 80 |
| **Takeoff and Landing Performance** | | | | |
| Stall Speed (ktas) | 45 | - | 45 | 0 |
| Takeoff Field Length (ft) | 1,500 | 800 | 2,317 | 0 |
| Landing Field Length (ft) | 1,500 | 800 | 1,289 | ~60 |
| Gear up, AEO rate-of-climb (ft/min) | 300 | - | 250 | 0 |
| Gear up, AEO rate-of-climb (ft/min) | N/A | - | N/A | N/A |
| Gear up, AEO rate-of-climb (ft/min) | N/A | - | N/A | N/A |
| **Maneuver Performance** | | | | |
| Max Sustained Turn Rate (deg/s) | 20 | 30 | 20 | 0 |
| Max Instantaneous Turn Rate (deg/s) | 20 | 30 | 20 | 0 |
| Stall Control | N/A | N/A | N/A | N/A |
| Spin Control | N/A | N/A | N/A | N/A |
| **Sell Price** | | | | |
| Initial Unit Price | 1.25 | 0.75 | - | 2.5 mil |
| Initial Price Mark-Up | 25% | 10% | 10% | 100 |
| **Accommodation** | | | | |
| Non-Expendable Payload, Seats | 1 | 2 | 2 | 100 |
| Passenger Allowance (lb/pax) | 200 | 250 | 400 | 100 |
| Expendable Payload (military version only) | 2 | 4 | 2 | 50 |

**33% of Design Drivers at (O)**

*Items in **RED** below are Design Drivers

# Competitive Assessment

| Per Wikipedia | Grob G 120TP | Utva Lasta 95N | Pilatus PC-7 | DART-450 | Our Design |
|---|---|---|---|---|---|
| **General Characteristics** | | | | | |
| Passengers | 2 | 2 | 2 | 2 | 2 |
| Length (ft) | 27.7 | 26.2 | 32.1 | 35.3 | 34.4 |
| Wingspan (ft) | 33.11 | 31.11 | 34.1 | 38.6 | 39.0 |
| Height (ft) | 8.11 | 9.4 | 10.6 | 11.1 | 7.3 |
| Wing Area (sq ft) | 145 | 139 | 178.7 | 210 | 217.3 |
| Empty Weight (lb) | 2,414 | 1,958 | 2,932 | 2,932 | 1,752.6 |
| Gross Weight (lb) | 3,505 | 2,524 | 5,952 | 5,071 | 3,042.6 |
| **Performance** | | | | | |
| Maximum Speed (mph) | 282 | 214 | 256 | 290 | 207 |
| Cruise Speed (mph) | 270 | 170 | 106 | 260 | - |
| Stall Speed (mph) | 67 | 59 | 74 | 69 | 45 |
| Range (m) | 670 | 720 | 1,630 | 1,700 | - |
| Service Seiling (ft) | 25,000 | 20,000 | 33,000 | 23,000 | 15,000 |
| Rate Of Climb (ft/min) | 2,772 | 1,670 | 2,150 | 2,990 | - |
| **Design Point** | | | | | |
| Wing Loading (lb/ft2) | 24.17 | 18.16 | 23.45 | 24.15 | 14 |
| Power-to-Weight Ratio (hp/lb) | 0.13 | 0.12 | 0.09 | 0.10 | 0.20 |
| **Configuration** | | | | | |
| Wing | Low | Low | Low | Low | Low |
| Tail | Conventional | Conventional | Conventional | Conventional | Conventional |
| Gear | Retractable tricycle | Retractable tricycle | Retractable tricycle | Retractable tricycle | Retractable tricycle |
| Seating | Tandem | Tandem | Tandem | Tandem | Tandem |


Grob G 120TP

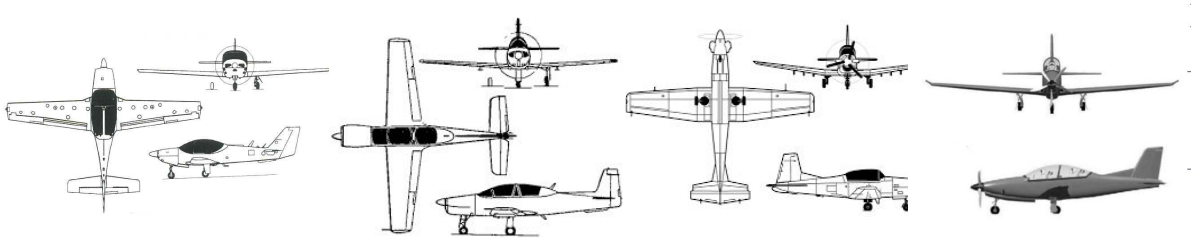

Utva Lasta 95N


Pilatus PC-7


DART-450

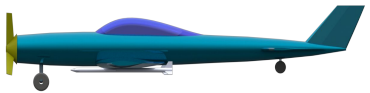
# Competitive Assessment cont.

| | Grob G 120TP | Utva Lasta 95N | Pilatus PC-7 | DART-450 | Our Design |
|---|---|---|---|---|---|
| **Performance** | | | | | |
| AEO Takeoff Field Length* (ft) | 1,125 | 1,440 | 1,935 | 2,000 | 2,317 |
| Landing Field Length* (ft) | 1,532 | 1,840 | 2,050 | 1,300 | 1,289 |
| **Enhanced Lift Design** | | | | | |
| Trailing Edge Flap Type | Slotted/Aileron | - | Split | Double-Slotted | Slotted |
| Leading Edge Lift Device Type | None | None | None | None | None |
| Flap Span-to-Wingspan Ratio | 0.6 | 0.5 | 0.5 | 0.6 | 0.4 |

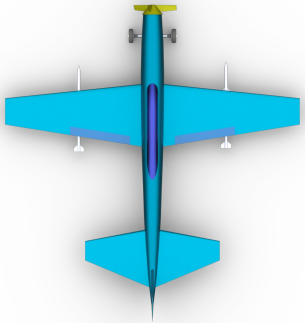


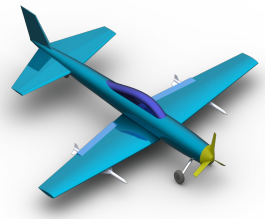
*Assume field lengths are at sea level / ISA / max gross weight and dry concrete.

# 3D Model Renders



| Dimensional Envelope | |
|---|---|
| **Height (ft)** | 7.31 |
| **Length (ft)** | 34.35 |
| **Width (ft)** | 39.00 |





# Appendix

# Propeller Design

| Per Wikipedia | **Grob G 120TP** | **Utva Lasta 95N** | **Pilatus PC-7** | **DART-450** | **Our Design** |
|---|---|---|---|---|---|
| Manufacturer | MT-Propeller | Hartzell | Hartzell | MT-Propeller | - |
| Model | MTV-5-1-D-C-F-R(A)/CFR210-56 | HC-C2YR-4CF/FC 8475-8 | HC-B3TN-2/T10173C-8 | - | - |
| Diameter (in.) | 82.7 | 72.6 | 84.9 | - | 82.5 |
| Mount | - | - | - | - | - |
| # of blades | 5 | 2 | 3 | 5 | 3 |
| Rotational Speed (takeoff) | 2500 | 2700 | 2200 | - | 1,906 |
| Rotational Speed (cruise/loiter) | 2500 | 2700 | 2200 | - | 1,906 |
| Type | Constant Speed | Constant Speed | Constant Speed | Constant Speed | Constant Speed |

# Engine Selection

| Per Wikipedia | **Grob G 120TP** | **Utva Lasta 95N** | **Pilatus PC-7** | **DART-450** | **Our Design** |
|---|---|---|---|---|---|
| Manufacturer | Rolls-Royce | Lycoming | Pratt & Whitney | Ivchenko-Progress Motor | GE Aviation |
| Model | M250-B17F | AEIO-580-B1A | PT6A-25A | AI-450S | M60-1D-2 |
| Mount | Dynafocal | Dynafocal | Dynafocal | Dynafocal | - |
| Weight (lbs) | 158 | 446 | 353 | 286.6 | 426 |
| # of Engines | 1 | 1 | 1 | 1 | 1 |
| Power (hp) | 420 | 315 | 550 | 495 | 504 |
| Diameter (in) | 19 | 42.18 | 19 | 27.64 | 25.6 |
| Type | Turboshaft | Recip | Turboprop | Turboprop | Turboprop |
| Length (in) | 38.8 | 37.32 | 62 | 43.62 | 64.94 |
| SFC (uninstalled) | 0.67 | 0.37 | 0.63 | - | 0.69 |





# Summary Ch 2

**Summary - Aircraft Weights**

**Design Mission Weights**

Conceptual Design Presentation Design

| | |
|---|---|
| Propulsion System Type: | Conventional=Engine+Propulsor |
| Propulsor Type: | Unducted Propulsor |
| Engine Type: | Reciprocating Piston Engine, normally aspirated |

| **Weights** | Symbol | Value | W/Wo Fraction |
|---|---|---|---|
| Empty Weight (lb) | We | 1,752.6 | 0.5760 |
| Payload (lb) | Wp | 776.0 | 0.2550 |
| -Expendable | Wpe | 376.0 | 0.1236 |
| -Non-expendable | Wpne | 400.0 | 0.1315 |
| Consumable Energy, Fuel Load (lb) | Wf or $W_{CE}$ | 514.0 | 0.1689 |
| -Mission Fuel Burned | Wfb | 484.9 | 0.1594 |
| -Reserves Fuel | Wr | 24.2 | 0.0080 |
| -Trapped Fuel | Wtf | 4.8 | 0.0016 |
| Non-consumable Energy, Batteries (lb) | $W_{NE}$ | 0.0 | 0.0000 |
| Design Takeoff Gross Weight (lb) | Wo,guess | 3,042.6 | 1.0000 |
| Design Takeoff Gross Weight (lb) | Wo,calc | 3,042.6 | 1.0000 |
| ERROR = Wo,calc - Wo,guess | | **0.0** | 0.0000 |

**Summary - Mission Analysis**

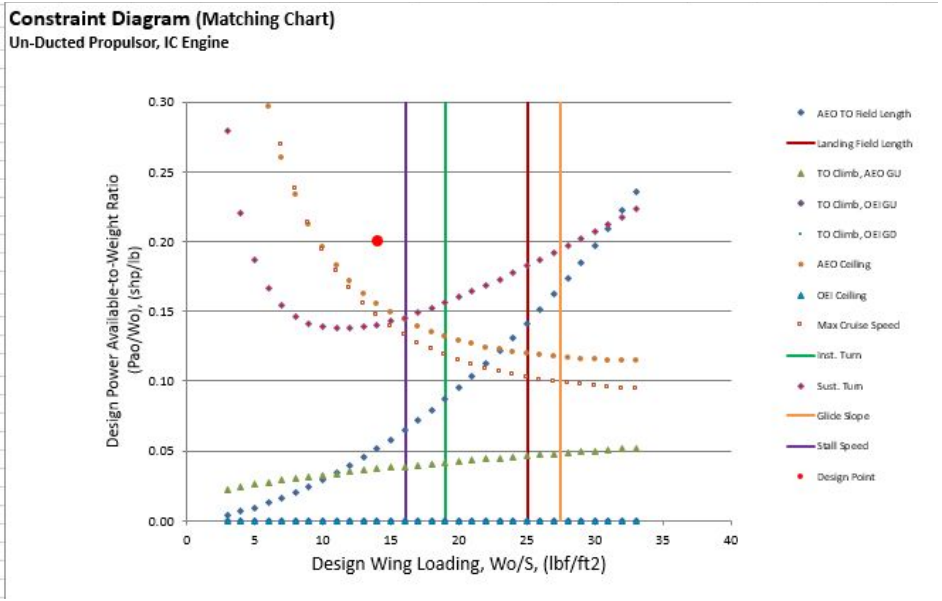
**Time, Energy and Distance**

**Conceptual Design Presentation Design**

| | |
|---|---|
| Propulsion System Type: | Conventional=Engine+Propulsor |
| Propulsor Type: | Unducted Propulsor |
| Engine Type: | Reciprocating Piston Engine, normally aspirated |

| Segment | (min) Time | (lb) (Fuel Burned) Consumable Energy | (lb) (Batteries) Non-Consumable Energy | (nm) Distance |
|---|---|---|---|---|
| Start-up & Takeoff | 2.0 | 30.4 | 0.0 | 0.0 |
| Climb+Accel1 | 9.9 | 21.3 | 0.0 | 0.0 |
| Cruise1 | 75.8 | 144.9 | 0.0 | 200.0 |
| Loiter 1 | 30.0 | 58.6 | 0.0 | 0.0 |
| Climb+Accel2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maneuvers (sustained g turning) | 6.0 | 8.7 | 0.0 | 0.0 |
| Drop | 0.0 | 0.0 | 0.0 | 0.0 |
| Loiter2 | 30.0 | 57.5 | 0.0 | 0.0 |
| Climb+Accel3 | 1.8 | 1.9 | 0.0 | 0.0 |
| Cruise2 | 75.8 | 138.8 | 0.0 | 200.0 |
| Loiter3 | 10.0 | 11.9 | 0.0 | 0.0 |
| Land and Taxi In | 2.0 | 11.0 | 0.0 | 0.0 |
| **Totals** | **243.4** | **484.9** | **0.0** | **400.0** |

# Summary Ch 3



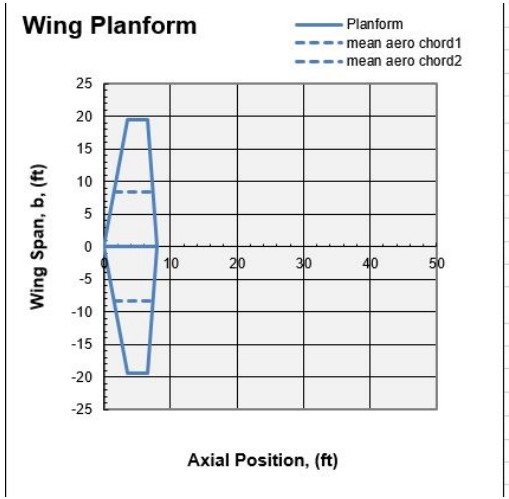

**Summary - Design Point Selection**

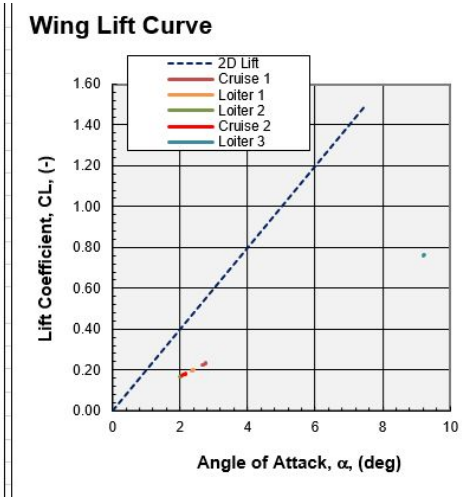
Takeoff Climb Specs=Civil: FAR Part 23

| Requirement | Units | Value |
|---|---|---|
| AEO Takeoff Field Length | ft | 800 |
| Landing Field Length | ft | 1,500 |
| TO Climb, AEO Gear Up | fpm at SL | 300 |
| TO Climb, OEI Gear Up | - | - |
| TO Climb, OEI Gear Down | - | - |
| AEO Ceiling | ft | 15,000 |
| OEI Ceiling Ceiling | ft | 0 |
| Max Cruise Speed | ft/sec | 267 |
| Max Cruise Speed | nm/hr | 158 |
| Max Cruise Mach | - | 0.3 |
| Instantaneous Turn Rate | deg/s | 20.0 |
| Sustained Turn Rate | deg/s | 20.0 |
| Glide Slope | deg/s | -4 |
| Stall Speed | nm/hr | 45 |

| Design Point | Units | Value |
|---|---|---|
| Wing Loading, Wo/S | lb/ft2 | 14 |
| AEO Uninstalled ENGINE Power Available-to-Weight Ratio, Pa | shp/lb | 0.200 |
| AEO Uninstalled SPU Power Available-to-Weight Ratio, Pao/W | shp/lb | 0.000 |
| Reference Wing Area, S | ft2 | 217.3 |
| AEO Uninstalled Power Available, SLS Max, Po | shp/eng | 608.5 |
| AEO Uninstalled Power Available, SLS Max, Po | shp/spu | 0.0 |

# Summary Ch 4




**Drag Bucket:**

| | |
|---|---|
| Average CL: | 0.4645 |
| Max CL: | 0.7634 |
| Min CL: | 0.1656 |
| Extent of Bucket, ΔCL: | 0.5978 |

**Summary - Main Wing Design**

| **Wing Design Parameters** | Symbol | Units | Value |
|---|---|---|---|
| Taper Ratio | λ | - | 0.400 |
| Sweep Angle | $\Lambda_{\Delta E}$ | deg | 10.0 |
| Max thickness-to-chord ratio | (t/c)max | - | 0.150 |
| Interference Factor | Qwing | - | 1.250 |
| Aspect Ratio | A | - | 7.0 |
| | | | |
| **Wing Geometry** | | | |
| Reference Area (trapezoidal) | S | ft2 | 217.3 |
| Wetted surface area | Swet | ft2 | 446.6 |
| Span | b | ft | 39.0 |
| Root Chord | cr | ft | 8.0 |
| Tip Chord | ct | ft | 3.18 |
| Mean Aerodynamic Chord | cbar | ft | 5.9 |

# Summary Ch 5

**Summary - Fuselage Design**

| **Dimension Data:** | Symbol | Units | Value |
|---|---|---|---|
| Fuselage Shape FLAG | - | - | 1 |
| Max Diameter | d | ft | 3.12 |
| Inverse Fineness Ratio | l/d | | 11.00 |
| Fineness Ratio | f=d/l | - | 0.0909 |
| Nose/Total Length | (x/L)nose | - | 0.2 |
| Tail/Total Length | (x/L)tail | - | 0.7 |
| Power Series Factor | n | - | 0.5 |
| Interference Factor | Q | - | 1.0000 |
| Roughness Height | k | ($10^{-5}$ ft) | 0.50 |
| Wave Drag Efficiency Factor, Ewd | Ewd | - | 1.35 |
| Total Fuselage Length | Lfus | ft | 34.4 |
| Max Cross-Sectional Area | Amax | ft2 | 7.7 |
| Length of Nose Section | l,nose | ft | 6.9 |
| Length of Tail Section | l,tail | ft | 10.3 |
| Length for Wave Drag Calc. | l,wave | ft | 17.2 |
| Form Factor | F | - | 1.0726 |
| Total Wetted Area | Swet | ft2 | 248.1 |
| Total Volume | V | ft3 | 172.3 |

**Summary - Landing Gear Design**

| Item | Symbol | Units | Value | Status |
|---|---|---|---|---|
| Design Gross Weight | Wo | lb | 3,043 | - |
| Wheel Base = B | B | ft | 20.0 | - |
| Wheel Track = T | T | ft | 5.0 | - |
| Rear fuselage clearance requirement - Hc>7.87 in. | Hc | in | 22.0 | Pass |
| Ground Mobility (Steering) Min Requirement - Bm,min/B>=0.05 | Bm,min/B | - | 0.23 | Pass |
| Ground Mobility (Steering) Max Requirement - Bm,max/B<=0.20 | Bm,min/B | - | 0.18 | Pass |
| Overturn angle (generally f ot >25 deg is recommended) | f,ot | deg | 35.1 | Pass |
| Ground Conrollability requirement - T > Tmin | Tmin | ft | 2.5 | Pass |
| Ground Conrollability requirement - f,ot > f,ot min | f,ot min | deg | 19.5 | Pass |
| Ground Stability requirement - T > Tmin | Tmin | ft | 1.5 | Pass |

# Summary Ch 5 Cont'd

**Summary - Fuselage Volume**

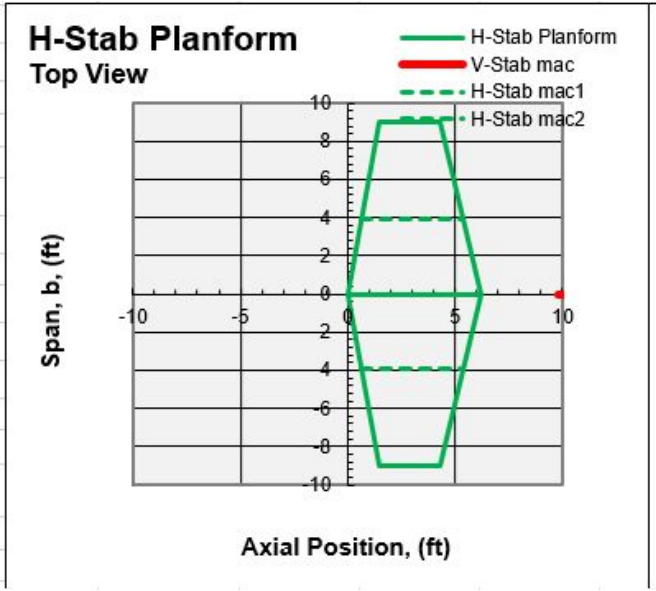
| | | (ft3) Volume | % of Total | |
|---|---|---|---|---|
| 1 Passenger Accommodation | | 12.8 | 8% | |
| Pax Compartment | | 3.8 | 2% | |
| Galley | | 0.0 | 0% | |
| Lavatory | | 0.0 | 0% | |
| Cargo Hold | | 6.0 | 4% | |
| Cabin/overhead | | 3.0 | 2% | |
| 2 Crew Accommodation | | 26.0 | 15% | |
| 3 Energy Stored in Fuselage | | 0.0 | 0% | |
| 4 Propulsion System | | 87.2 | 52% | |
| 5 Wing Attachments | | 29.7 | 18% | |
| 6 Landing Gear | | 0.0 | 0% | |
| Nose / Tail | | 0.0 | 0% | |
| Main Undercarriage | | 0.0 | 0% | |
| 7 Internal Armament | | 0.0 | 0% | |
| 8 Fuel as Payload (for Tanker only) | | 12.6 | 7% | |
| | **Total Required Fuselage Volume** | **168.2** | | |
| | Fuselage Volume per Aero Calcs | 172.3 | | |
| | Delta = Calculated - Required | 4.0 | **0.024** | **Pass** ← |

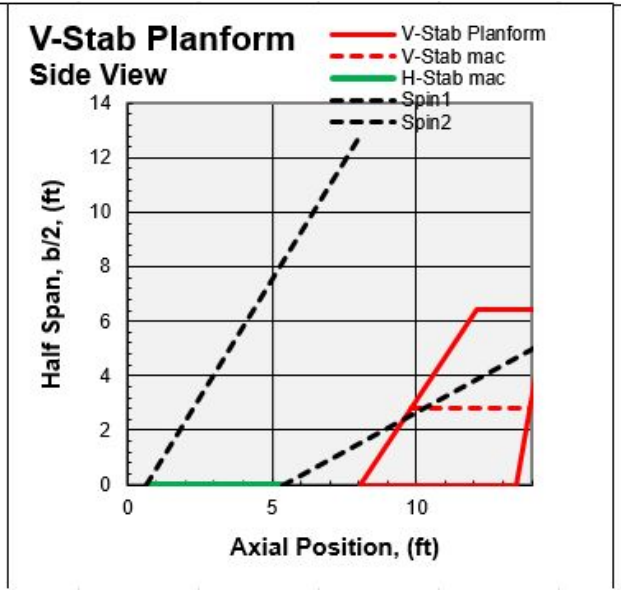
# Summary Ch 6

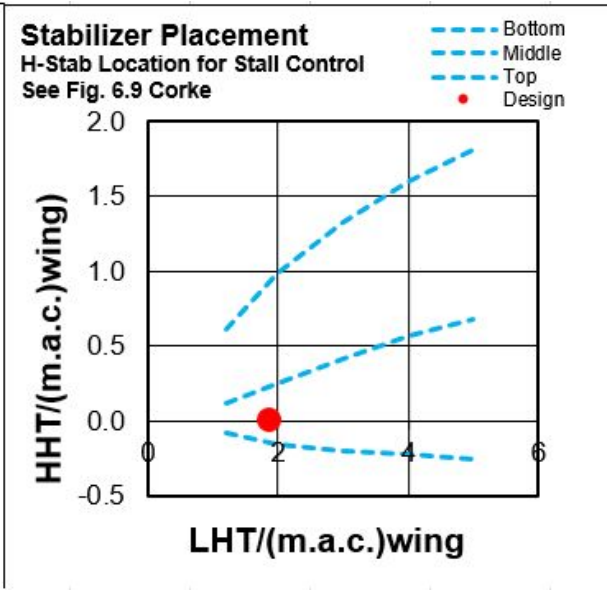
| Summary - Emmpenage Design | | | Horizontal Stabilizer | Vertical Stabilizer |
|---|---|---|---|---|
| **Design Parameters** | Symbol | Units | Value | Value |
| Type FLAG | - | - | 1 | 1 |
| Taper Ratio | $\lambda$ | - | 0.450 | 0.450 |
| Leading Edge Sweep Angle | $\Lambda_{LE}$ | deg | 9.500 | 32.000 |
| Max thickness-to-chord ratio | (t/c)max | - | 0.090 | 0.090 |
| Aspect Ratio | $A_{HT}$ & $A_{VT}$ | - | 4.0 | 1.65 |
| Sizing Coefficient | $C_C$, $C_{HT}$ or $C_{VT}$ | - | 0.700 | 0.0600 |
| Moment Arm = $L_C$, $L_{HT}/L_{fus}$ or $L_{VT}/L_{fus}$ | $L_C$, $L_{HT}/L_{fus}$ or $L_{VT}/L_{fus}$ | | 0.325 | 0.588 |
| Drag Adder - Hinge Gaps | - | - | 1.10 | 1.10 |
| Height of the stabilizers | $H_{HT}$ and $H_{VT}$ | ft | 0 | 0 |

| Stabilizer Geometry | | | | |
|---|---|---|---|---|
| Configuration | - | - | Conventional | Conventional |
| # of Surfaces | - | - | 1 | 1 |
| Interference Factor | $Q_{HT}$ & $Q_{VT}$ | - | 1.050 | 1.050 |
| Scaling Coeff. = $C_{HT}/C_{HT,conv}$ & $C_{VT}/C_{VT,conv}$ | | - | 1.000 | 1.000 |
| Reference Area (trapezoidal) | S | ft2 | 80.6 | 25.2 |
| Wetted surface area | Swet | ft2 | 163.1 | 51.0 |
| Span | b | ft | 17.95 | 6.45 |
| Root Chord | cr | ft | 6.19 | 5.39 |
| Tip Chord | ct | ft | 2.79 | 2.43 |
| Mean Aerodynamic Chord | cbar | ft | 4.70 | 4.10 |

# Summary Ch 6 Cont.



# Summary Ch 7

| Summary - Engine and SPU Selection | | | | |
|---|---|---|---|---|
| **Turboprop or Reciprocating Piston** | | | | |
| Engine Type | | | Reciprocating (Internal Cumbustion + Propeller) | |
| | | | TP/PP Reference Engine | TP/PP SCALED Engine |
| | Symbol | Units | Value | Value |
| Number of Engines | Neng | - | - | 1 |
| Reference Engine Manufacturer | - | - | | GE Aviation |
| Reference Engine Model | - | - | - | M60-1D-2 |
| AEO Uninstalled ENGINE Power-to-Weight Ratio | Po/Wo | shp/lb | - | 0.200 |
| AEO Uninstalled ENGINE Power, SLS ISA Max | Po | shp/ac | - | 608.5 |
| Uninstalled ENGINE Power, SLS ISA Max | Po | shp/eng | 504.0 | 608.5 |
| Uninstalled ENGINE Thrust, SLS ISA Max | To | lb/eng | | 532.7 |
| **Engine Scale Factor** | SF | - | - | **1.2074** |
| Uninstalled SFC at SLS, ISA, MRP | cp | lbm/hr/shp | 0.690 | 0.660 |
| Bare Engine Weight | Weng | lb/eng | 426 | 876.3 |
| Engine Length | Leng | in. | 64.96 | 45.8 |
| Engine Diameter | Deng | in. | 25.6 | 46.5 |
| | | | | |
| Number of SPU's | Nspu | - | - | 0 |
| Reference SPU Manufacturer | - | - | | n/a |
| Reference SPU Model | - | - | | n/a |
| AEO Uninstalled SPU Power-to-Weight Ratio | Po/Wo | shp/lb | - | 0.000 |
| AEO Uninstalled SPU Power, SLS ISA Max | Po | shp/ac | - | 0.0 |
| Uninstalled SPU Power, SLS ISA Max | Po | shp/spu | 13.4 | 0.0 |
| Uninstalled SPU Thrust, SLS ISA Max | To | lb/spu | 106.8 | 0.0 |
| **SPU Scale Factor** | SF | - | - | **0.0000** |
| Uninstalled specific energy | Hb | W-hr/kg | 150.0 | 150.0 |
| Total Propulsion system (engine + spu) weight | Wpp | lb/ac | | 1,180.6 |
| Total Propulsion system (engine + spu) volume | Vpp | ft3/ac | | 0.0 |

| Propeller Type | - | **constant speed** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| No. of Blades, B | - | 3 | 3 | 3 | 3 | 3 | | 3 |
| Diameter, D | ft | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | | 7.5 |
| Prop Rotational Speed, N | rpm | 1,906.3 | 1,906.3 | 1,906.3 | 1,906.3 | 1,906.3 | | 1,906.3 |
| Blade Pitch, $\theta_{3/4}$ | deg | 31.63 | 29.62 | 29.53 | 31.44 | 13.82 | | 16.01 |
| Blade Twist, $d\theta/dx$ | deg | -25.0 | -25.0 | -25.0 | -25.0 | -25.0 | | -25.0 |
| Disk Loading | lb/ft2 | 6.9 | 6.9 | 6.7 | 6.6 | 3.4 | | 12.1 |
| Solidity $\sigma = bc/\pi R$ | - | 0.1005 | 0.1005 | 0.1005 | 0.1005 | 0.1005 | | 0.1005 |
| Altitude | ft | 12,000 | 5,000 | 5,000 | 12,000 | 3,000 | | 0 |
| Delta Temp, ambient | degC | 0 | 0 | 0 | 0 | 0 | | 0 |
| Freestream Velocity, V | ktas | 158.3 | 149.6 | 149.6 | 158.3 | 65.5 | | 54.0 |
| CT - Thrust Coefficient | - | 0.0582 | 0.0469 | 0.0454 | 0.0553 | 0.0219 | | 0.0702 |
| CP - Power Coefficient | - | 0.0748 | 0.0579 | 0.0563 | 0.0713 | 0.0135 | | 0.0357 |
| **Efficiency - $\eta$** | - | **87.3%** | **85.9%** | **85.7%** | **87.0%** | **75.5%** | | **75.3%** |
| Power Required = Pr | shp/ac | 170.6 | 164.0 | 159.4 | 162.7 | 40.6 | | 117.5 |
| Thrust | lb/ac | 306.5 | 306.7 | 297.4 | 291.1 | 152.2 | | 532.7 |
| | | | | | | | | |
| Drag | lb/ac | 306.5 | 306.7 | 297.4 | 291.1 | 152.2 | | |
| Drag/Thrust | - | **1.0000** | **1.0000** | **1.0000** | **1.0000** | **1.0000** | | |
| | | Pass | Pass | Pass | Pass | Pass | | |
| Installed Power Available =Pa | shp/eng | | | | | | | 532.7 |
| Pr/Pa | - | | | | | | | **1.0000** |
| | | | | | | | | Pass |
| | | | | | | | | |
| | | | | | | All six(6) flight segments: | | **Pass** |

# Summary Ch 8

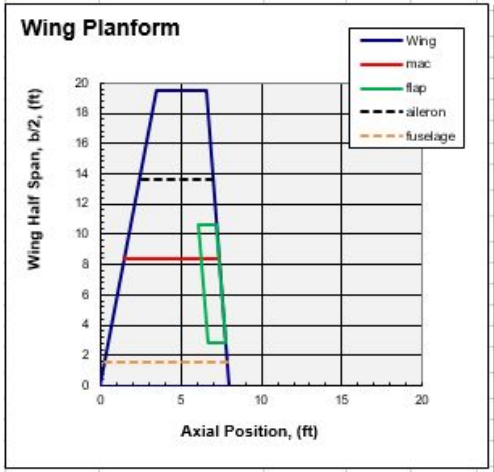
**Summary - Takeoff and Landing**

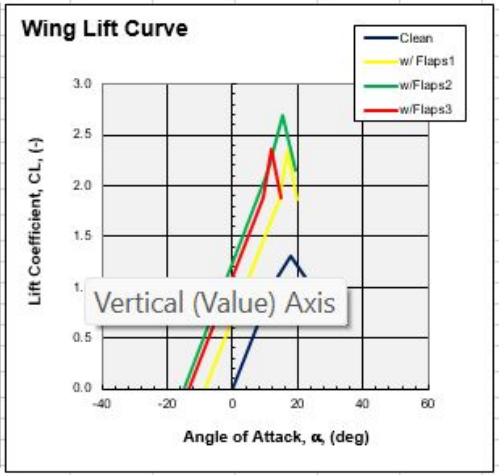
| Parameter | Units | Takeoff | Landing |
|---|---|---|---|
| Pressure altitude | ft | 0.0 | 0.0 |
| Delta ambient temperature from ISA | deg C | 0.0 | 0.0 |
| Gross Weight | lb | 3,043 | 3,043 |
| Stall speed | nm/hr | 42.0 | 39.2 |
| Lift Coefficient (@Vto and Vtd) | - | 1.934 | 1.591 |
| Gear Type | - | Fixed | Fixed |
| Flap Type | - | slot | slot |
| Ref. Wing Area | ft2 | 217.3 | 217.3 |
| Wing Loading | lb/ft2 | 14.0 | 14.0 |
| | | | |
| **Field Lengths** | | | |
| Ground roll / braking distance | ft | 1,053 | 564 |
| Rotation / free roll distance | ft | 234 | 258 |
| Transition distance | ft | 96 | 46 |
| Climb / approach distance | ft | 934 | 421 |
| Total takeoff / landing distance | ft | **2,317** | **1,289** |
| | | | |
| **Flight Path Angles** | | | |
| AEO climb angle @ Vto | deg | 2.92 | - |
| AEO climb angle @ Vobs | deg | 3.00 | - |
| OEI climb angle @ Vobs | deg | n/a | - |
| AEO approach angle @Vobs | deg | - | -6.42 |
| | | | |
| **Certification Requirements** | | | |
| **Takeoff Climb Specs=Civil: FAR Part 23** | | | |
| Gear Up, AEO Min Spec | FAIL | | |
| Gear Up, OEI Min Spec | N/A | | |
| Gear Down, OEI Min Spec | N/A | | |

# Summary Ch 9

**Summary - Flap Design**

| | Flaps1 | Flaps2 | Flaps3 | Takeoff | Landing | Units |
|---|---|---|---|---|---|---|
| Type of TE Flaps | slot | slot | slot | slot | slot | - |
| LE Flaps | No | No | No | No | No | - |
| Flap Area / Wing Area, Swf/Sw | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | - |
| Flap Deflection Angle, δf | 20.00 | 40.00 | 60.00 | 20.00 | 40.00 | deg |
| Flap Chord / Wing Chord, cf/c | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | - |
| Flap Span / Wing Span, bf/b | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | - |
| CL,max | 2.340 | 2.688 | 2.358 | **2.340** | **2.688** | - |
| ΔCDo, flaps | 0.0036 | 0.0126 | 0.0252 | **0.0036** | **0.0126** | - |



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