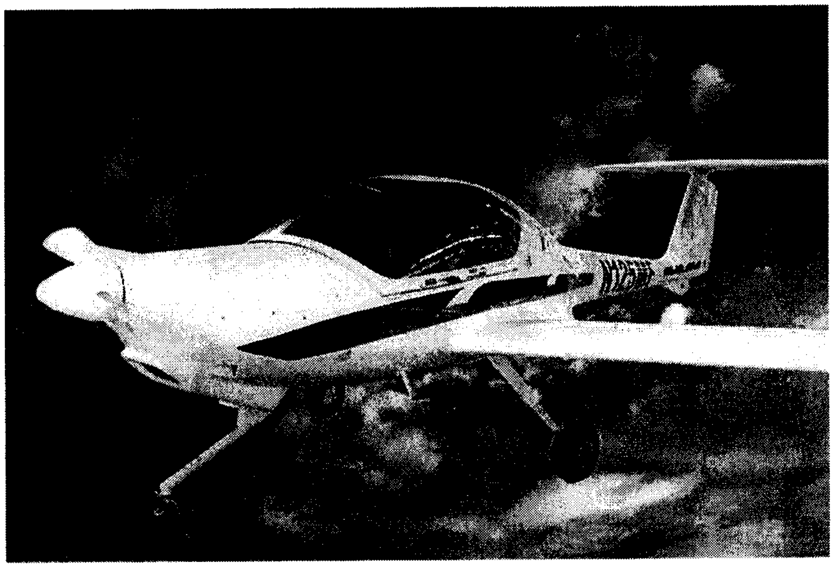
AE-324 Fundamentals of Atmospheric Flight
Fall 2001

Research Project Report
Team #6

Katana 100



Date Submitted: December 7, 2001

Submitted by:
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Monal Merchant
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Submitted to:
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Wichita State University

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Note:

All the equations without specifying the reference are from,
Anderson, John D., Jr. *Introduction to Flight, Fourth Edition.* McGraw-Hill, 2000

Information of the Aircraft (by Monal, Kosuke)

General Information:

Name of the Aircraft:	Diamond Aircraft Katana 100
Price:	$85,000 (Basic Model)
Manufacturer:	Diamond Aircraft Industries 1560 Crumlin Sideroad, London, Ontario, Canada N5V 1S2 Phone: (519) 457-4000 Fax: (519) 457-4021

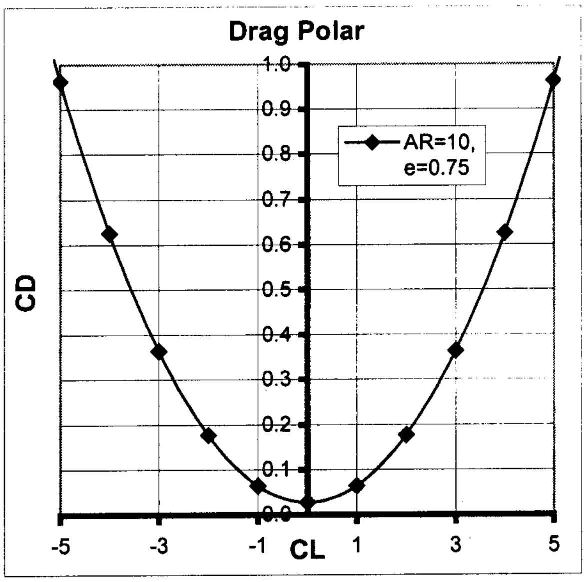
Specifications:

Propeller:		Hoffmann HO-V352F 2-blade, const. speed	
Power Plant:		Bombardier Rotax 912S, 100 hp max	
Length:		23ft 6in	
Height:		6ft 11in	
Wings:	Airfoil:	Wortmann FX 63-137/20 HOAC	
	Wingspan:	35ft 7in	
	Wing area:	125.0ft^2	
	Aspect ratio:	10.0	
	Mean aerodynamic chord:	42.9in.	
	Dihedral:	4°	
	Sweep of leading edge:	1°	
	Height from ground:	3.05ft (Average)	
Ailerons:	Area:	7.08ft^2	
Wing flaps:	Area	13.30ft^2	
Horiz. tail:	Area:	18.21ft^2	4.75ft^2(elevator area)
	Incident angle:	-2.5°	
Vertical tail:	Area:	12.21ft^2	4.59ft^2(rudder area)
Weight:	Empty weight:	1,095 lb	
	Maximum takeoff weight:	1,653 lb	
	Maximum landing weight:	1,653 lb	
Wing Loading:		13.2 lbf/ft^2	
Power Loading:		16.5 lbf/hp	
Fuel Capacity		20.1 gal (19.5 gal useable)	

Aircraft Performance:

The aircraft Drag polar (by Kosuke)

The drag polar of the aircraft is determined as the right figure from the reasoning below.



The Profile drag $C_{D,0}$ was derived from the catalog value of the level flight at 7,500ft with 75% power setting. The aircraft flies at 123 KTAS (207ft/s), since TAS stands for True Air Speed, the value is believed to be accurate. The Rotax 912S engine has the maximum power output of 100hp, so the power setting of 75% should produce 75hp at the sea level. To interpolate the power available at the 7,500ft, use

$$P_{A,alt} = \left(\frac{\rho_{alt}}{\rho_{SL}}\right) P_E \eta \left(\frac{\%}{100}\right) = \left(\frac{0.0018975}{0.0023769}\right)(55000)(0.85)\left(\frac{75}{100}\right) = 27990 \qquad \text{(EQN 1.1)}$$

Where,

$P_{A,alt}$	Power available at an altitude (lbf-ft/s)
P_E	Engine power at sea level (100hp = 55,000lbf-ft/s)
ρ_{alt}	Density of air at an altitude (0.0018975slugs/ft^3 @7,500ft)
ρ_{SL}	Density of air at sea level (0.0023769slugs/ft^3)
η	Propeller efficiency (0.85, see Appendix C)
%	Power setting in %, between 0 ~ 100%

In a non-accelerated level flight, these two statements are true.

$$T = D, \quad \text{also} = \tfrac{1}{2}\rho_\infty V_\infty S C_D, \quad \text{or} = P / V_\infty \qquad \text{(EQN1.2a,b,c)}$$

$$L = W, \quad \text{also} = \tfrac{1}{2}\rho_\infty V_\infty S C_L \qquad \text{(EQN1.3a,b)}$$

Where,

T	Thrust (lbf);	D	Drag (lbf)
L	Lift (lbf);	W	Weight (lbf)
ρ_∞	Density (slugs/ft^3);	V_∞	Airspeed (ft/s)
S	Area of the wings (125 ft^2);	P	Power Required/Available
C_D	Coefficient of Drag;	C_L	Coefficient of Lift

Using the equation 1.2c, the drag force on the airplane can be calculated as,

$$D = P_A / V_\infty = 134.82 \text{ lbf}$$

The coefficient of lift is determined by using the equation 1.3a, and 1.3b, (W=1,653 lbf).

$$C_L = \frac{2L}{\rho_\infty V_\infty^2 S} = \frac{2W}{\rho_\infty V_\infty^2 S} \qquad \text{(EQN 1.4)}$$

From the calculation, the **C_L = 0.3233**

Observing the equation 1.2 and 1.3, the ratio D/W is equal to C_D/C_L, The coefficient of drag (C_D) can be found from this relationship.

$C_D = TC_L / W = (134.823)(0.3233)/(1653) =$ **0.026** (EQN 1.5)

According to Raymer (See Appendix A), the Oswald efficiency of straight wing airplane can be approximated by using the formula described below.

$e = 1.78(1 - 0.045AR^{0.68}) - 0.64$ (EQN 1.6)

Since the aspect ratio (AR) of Katana 100 is 10.0, so the **Oswald efficiency is 0.756.**

The profile of drag ($C_{D,0}$) is derived from the equation below,

$$C_D = \left(C_{D,0} + \frac{C_L^2}{\pi e AR}\right) = \left(C_{D,0} + \frac{(0.3233)^2}{\pi(0.756)(10)}\right) \qquad \text{(EQN 1.7)}$$

Bt solving this equation, **$C_{D,0}$ = 0.022.**

Takeoff performance (by Kosuke)

The takeoff distance (S_{LO}, ft) can be determined by using a formula,

$$S_{LO} = \frac{1.44W^2}{g\rho_\infty S C_{L,\max}\{T - [D + \mu_r(W - L)]_{0.7V_{LO}}\}} \qquad \text{(EQN 2.1)}$$

Where,

- g — Acceleration of Gravity (32.2ft/s^2)
- $C_{L,max}$ — Maximum coefficient of lift (refer equation)
- μr — Rolling friction coefficient (paved runway =0.2)

The takeoff speed, V_{LO}, is determined to be $1.2V_{stall}$, since Katana 100 stalls at 69.2ft/s,

V_{LO} = 1.2 (69.2) ft/s = 83.04 ft/s (with no head wind) (EQN 2.2a)

Or, V_{LO} = 1.2(69.2) – (head wind in ft/s) (EQN 2.2b)

= 68.37 ft/s (10mph head wind), 53.70 ft/s (20mph head wind)

As result, $0.7V_{LO}$, the value used to determine the average thrust, drag and lift during the takeoff become,

$$V_{avg} = 0.7V_{LO} \qquad \text{(EQN 2.3)}$$
$$= (0.7)(83.04) \text{ ft/s} = 58.13 \text{ ft/s}$$
also, $= 47.86$ ft/s, and 37.59 ft/s for 10mph, 20mph head wind

To find $C_{L,max}$, taking the stall speed as reference. The airspeed can be determined from the formula below,

$$V_{stall} = \sqrt{\frac{2W}{\rho_\infty S C_{L,\max}}} \qquad \text{(EQN 2.4)}$$

by using this formula, the $C_{L,max}$ for 1,095lbf, 1,375lbf and 1,653lbf are to be 1.5392, 1.9328 and 2.3235 respectively.

From this condition, the average values of T, D and L for 1,095, 1,375 and 1,653lbf are,

T =	4940.95lbf,	4940.95lbf,	4940.95lbf	(refer EQN1.2c)
D =	42.74lbf,	59.58lbf,	80.07lbf	(refer EQN1.2b)
L =	772.6lbf,	970.2lbf,	1166lbf	(refer EQN1.3b)

Also, the average values of T, D and L for 0, 10 and 20mph head wind are,

T =	4940.95lbf,	4068.09lbf	3195.22lbf	(refer EQN1.2c)
D =	59.58lbf,	40.39lbf,	20.92lbf	(refer EQN1.2b)
L =	970.2lbf,	657.69lbf,	405.73lbf	(refer EQN1.3b)

1. Takeoff distance at different weight configurations (Sea level, no wind)
   a. **781ft,** at empty weight (1,095lbf)
   b. **987ft,** at medium weight (1,374lbf)
   c. **1,196ft,** at maximum gross take-off weight (1,653lbf)

2. Takeoff distance at different wind configurations (Sea level, medium weight)
   a. **987ft,** with 0mph head wind
   b. **827ft,** with 10mph head wind
   c. **666ft,** with 20mph head wind

Hodograph (by Monal)

The hodograph take vertical speed (or R/C) against horizontal speed. Both horizontal and vertical components of the velocity will be determined from the procedure described here.

1. Use the equation 1.1 to determine the P_A
2. Drag force can be derived from equation 1.2a,b and c for desired speed.
3. Use equation 1.5, so the P_R will be determined
4. By using equation 3.1 shown below, the vertical component (V_v) of the air speed can be found.

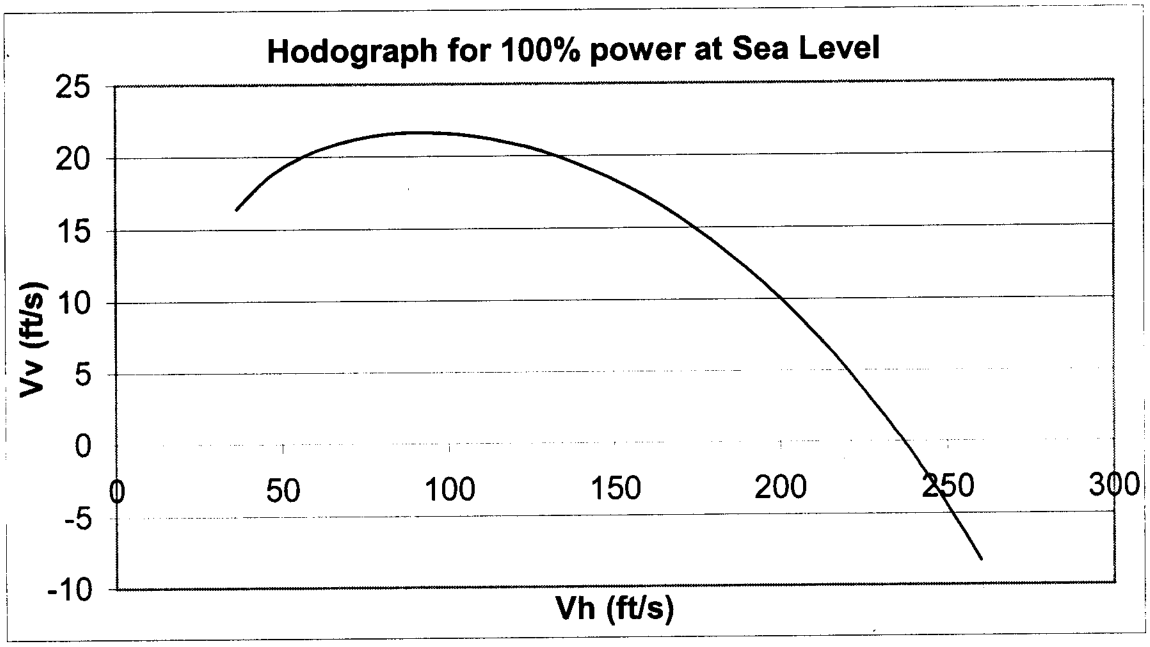
$$(R/C) = \frac{P_A - P_R}{W} \qquad \text{(EQN 3.1)}$$

5. Using the equation below, the climb angle of the airplane at the air speed will be found

$$\theta = \sin^{-1}\left(\frac{R/C}{V_\infty}\right) \qquad \text{(EQN 3.2)}$$

6. To find the horizontal component (V_h), utilize the angle found from the equation 3.2.

$$V_h = V_\infty \cos\theta \qquad \text{(EQN 3.3)}$$



Maximum Endurance and Maximum Range (by Kosuke)

According to the brochure, cruise condition is set at 7,500ft with 75% power setting. Katana 100 uses 6.1gph of fuel at cruise, and 1 gallon of the fuel weigh 5.64 lbf, thus the airplane consumes 34.40lbf of fuel per hour while the power available is 27,990lbf-ft/s (EQN1.1). The consistent unit (c) is,

$$c = 34.04\text{lbf} / [27990(\text{lbf-ft/s})*3600(\text{sec})] = 3.4139\times10^{-7}(1/\text{ft}) \qquad \text{(EQN 4.1)}$$

By using Breguet's formulas, the maximum endurance and the range can be found from the two equations below. These equations are fairly accurate and have errors of 10~20%

$$E = \frac{\eta}{c}\left(\frac{C_L^{3/2}}{C_D}\right)_{\max}\sqrt{2\rho_\infty S}\left(\frac{1}{\sqrt{W_1}}-\frac{1}{\sqrt{W_0}}\right) \qquad \text{(EQN 4.2)}$$

$$R = \frac{\eta}{c}\left(\frac{C_L}{C_D}\right)_{\max}\ln\frac{W_0}{W_1} \qquad \text{(EQN 4.3)}$$

Where,

Where,	E	Endurance (sec.);	R	Range (ft)
	ρ_∞	Density (slugs/ft^3);	S	Wing area (125 ft^2)
	η	Propeller Efficiency (0.85);	W_0	Weight at T=0
	W_1	Weight after all usable fuel is consumed		

In order to find the $(C_L/C_D)_{max}$ and $(C_L^{3/2}/C_D)_{max}$, these equations are used.

$$\left(\frac{C_L}{C_D}\right)_{\max} = \frac{(C_{D,0}\pi eAR)^{1/2}}{2C_{D,0}} = 16.4283 \qquad \text{(EQN 4.4)}$$

$$\left(\frac{C_L^{3/2}}{C_D}\right)_{\max} = \frac{(3C_{D,0}\pi eAR)^{3/4}}{4C_{D,0}} = 15.9194 \qquad \text{(EQN 4.5)}$$

Using the equation 4.2 and 4.3,

1. Maximum Endurance = **23,522 sec.** = **6.53 hours**
2. Maximum Range = **2,816,749ft** = **533miles**

Absolute and Service Ceilings (by Kosuke)

The service ceiling is defined as an altitude where $(R/C)_{max}$ = 100fpm. According to the catalog information, the service ceiling of Katana 100 is **17,600ft**.

The absolute ceiling is an altitude where the $(R/C)_{max}$ = 0fpm, so

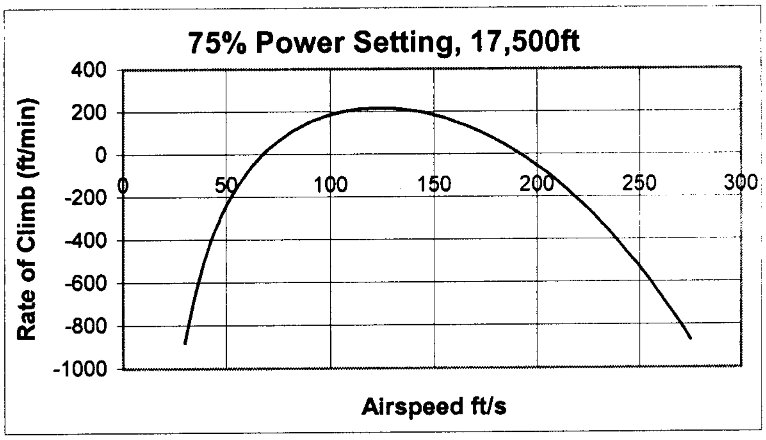
$$(R/C) = \frac{P_A - P_R}{W} = 0 \qquad \text{(EQN 5.1a)}$$

Where, P_A = Power available (lbf-ft/s)
P_R = Power required (lbf-ft/s)
W = weight of the airplane (1,653 lbf)

The performance at the service ceiling can be used to determine the absolute ceiling of the airplane. Using equation 5.1a the difference between P_A and P_R is,

$$P_A - P_R = (100\text{ft/min})(1\text{min}/60\text{sec.})(1{,}653\text{lbf}) = 2{,}755 \text{ lbf-ft/s} \qquad \text{(EQN 5.1b)}$$

The mathematical model at 17,500ft has the rate of climb of more than 200fpm (shown in right). In order to interpolate the value, a new P_A value must to be selected. The curve of the graph may move vertically as the P_A changes, but the related air speed remains the same. In this case, the V_∞, which gives the best R/C, is at 124ft/s. By using equation 1.4 and 1.7, the C_L is equal to 1.2481, and the drag is 169.22lbf. The P_R can be determined by referring to equation 1.2c,



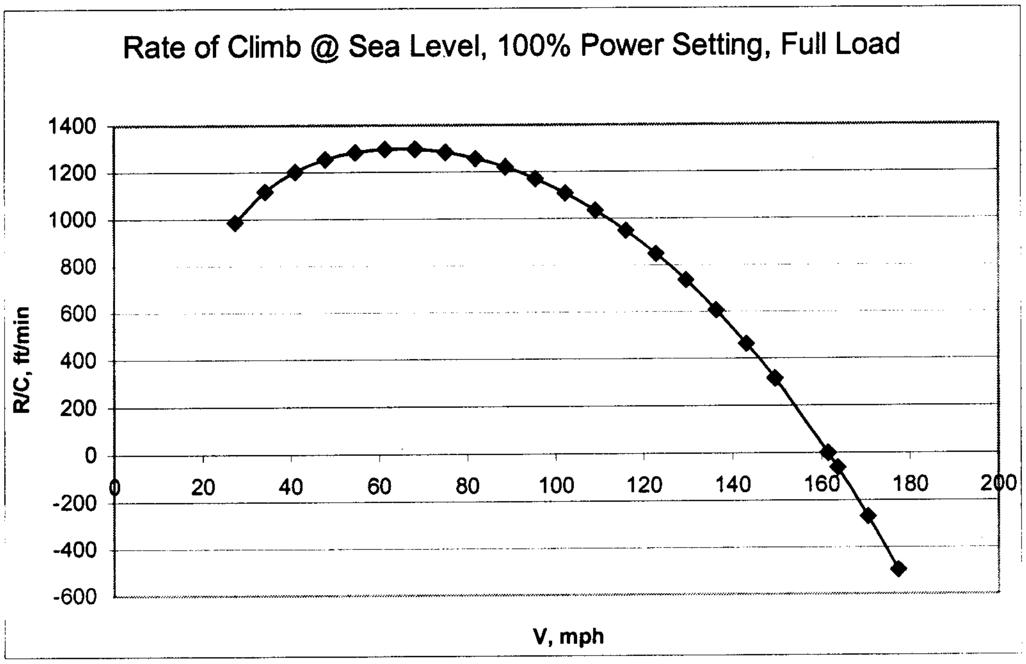
$$P_R = DV_\infty = (169.22\text{lbf})(124\text{ft/s}) = 13543 \text{ lbf-ft/s}$$
$$P_A = P_R + 2{,}755\text{lbf-ft/s} = 13{,}543 + 2{,}755 = 16{,}928 \text{ lbf-ft/s}$$

From EQN1.1,
$$P_A = (P_E)\eta(\rho_{alt}/\rho_{sea\ level}) = (P_E)(0.85)(0.0013781/0.0023769)$$
$$P_E = 33{,}054\text{lbf-ft/s} = 60 \text{ hp (equivalent power output at sea level)}$$

Recalculating the rate of climbs by every 500ft with P_E = 60hp, the **absolute ceiling is about 19,500ft**

Climbing Performance (by Monal, Kosuke)

1. Rate of Climb (Monal)



In order to a create rate of climb graph, C_L, C_D, D, T_R, P_R, P_A must be calculated for airspeed. The equations used are,

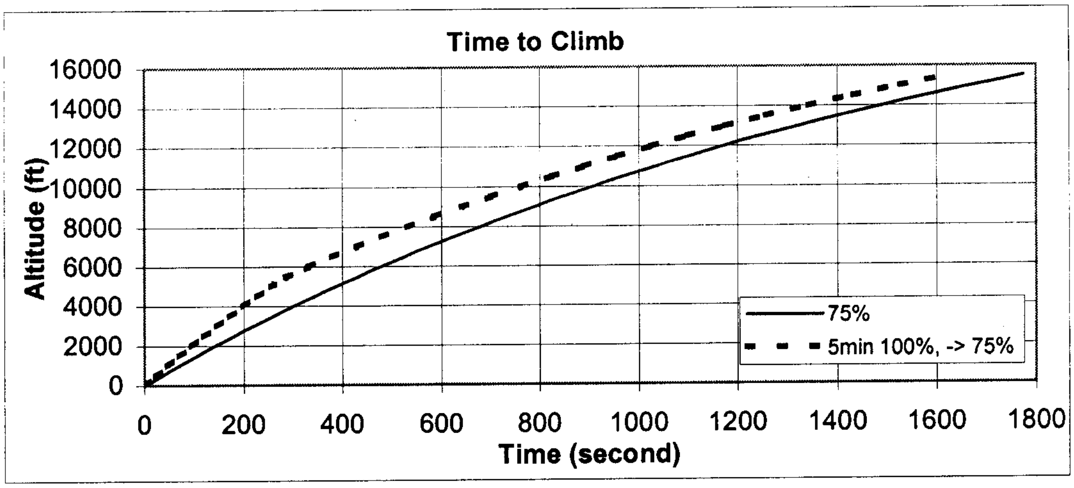
- Equation 1.4 to determine C_L
- Equation 1.3b and 1.7 for C_D and drag force (D)
- Equation 1.5 for the thrust required (T_R)
- Equation 1.2 for the power required (P_R)
- Equation 1.1 for the power available (P_A)
- Equation 5.1 to determine the Rate of Climb

By using the equations above, rate of climb charts for any desired altitude can be derived.

2. Time to Climb (Kosuke)

   Katana 100 has a Rotax 912S engine, which allows 100% power for 5 minutes, and/or 75% continuous power. Equation 5.1a is used to calculate the time to climb for every 500ft. As the result,

   a. To 5,000ft **386 seconds / 255 seconds** (w/ 5 min. 100% operation)
   b. To 10,000ft **907 seconds / 760 seconds** (w/ 5 min. 100% operation)
   c. To 15,000ft **1,673 seconds / 1,527 seconds** (w/ 5 min. 100% operation)



Maximum level flight speed (by Monal)

From observing the rate of climb chart shown in the previous section, the maximum level flight occurs at where the x-axis and the graph curve intersects. By drowning the charts for sea level, 5,000ft and 10,000ft, the values for each case are determined.

1. Sea level **235ft/s (161mph)**
2. 5,000ft **234ft/s (160mph)**
3. 10,000ft **231ft/s (157mph)**

V-n Diagram (by Monal)

For general aviation, the limit load factors are 6 at positive, and –3 at negative side for aerobatic category. This means the airplane has to stand the both loading conditions. Since the C_L value for the negative side is not available, the value was assumed to be the same as for the positive side.

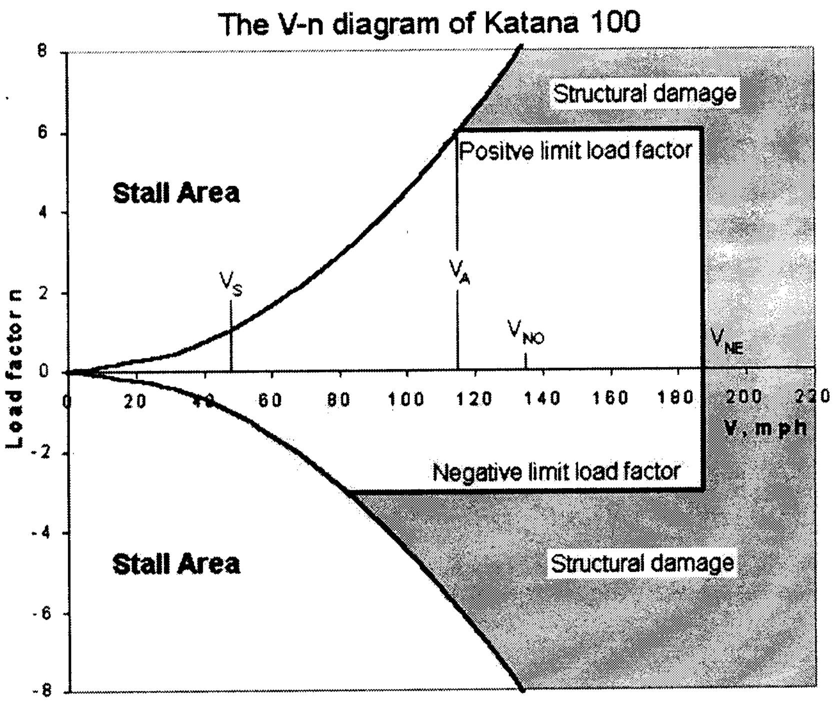
To determine the load factor (n),

$$n = \frac{L}{W} = \frac{\frac{1}{2}\rho_\infty V_\infty^2 S C_L}{W} \qquad \text{(EQN 8.1)}$$

From the specification, the wing loading is13.2 lbf/ft^2 which is weight of the aircraft over the wing area (=W/S). And for the maximum load factor for any airspeed, the C_L must be set at the maximum value, which is 2.3253, referred from equation 2.4, at the takeoff performance section. For n_{max}, the equation 8.1 becomes,

$$n_{\max} = \frac{1}{2}\rho_\infty V_\infty^2 \frac{C_{L,\max}}{W/S} \qquad \text{(EQN 8.2)}$$

By using this equation, the V-n diagram has been created as shown below. (The catalog values shown as references)



V_S = 41 KIAS
= 47 mph
= 69 ft/s

V_A = 104 KIAS
= 119 mph
= 175 ft/s

V_{NO} = 118 KIAS
= 136mph
= 200 ft/s

V_{NE} = 161KIAS
= 185mph
= 271 ft/s

Appendix: (by Kosuke)

Appendix A: References

Anderson, John D., Jr. *Introduction to Flight, Fourth Edition.* McGraw-Hill, 2000
Raymer, Daniel P. *Aircraft Design: A Conceptual Approach, Third Edition.* AIAA, 1999
Diamond Aircraft Industries http://www.diamondair.com/
Hoffmann Propeller Germany http://www.hoffmann-prop.com/
Zenith Aircraft Company http://www.zenithair.com/kit-data/zac-rtx912s.html
NASG Airfoil Database http://www.nasg.com/afdb/list-polar-e.phtml

Appendix B: Aircraft Brochure

Katana DA20-A1

All specifications are subject to change without notice. Illustrations may show optional equipment.

Powerplant
Bombardier Rotax 912F3, 81 hp, four-cylinder, horizontally opposed

Specifications

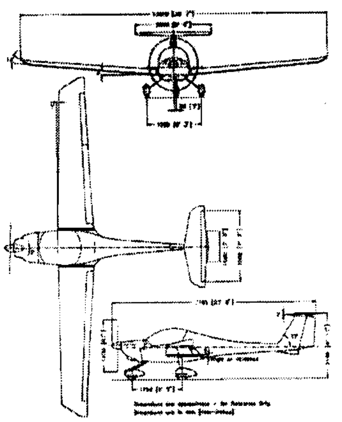
Recommended TBO	1,200 hr
Length	23 ft 6 in
Height	6 ft 11 in
Wingspan	35 ft 7 in
Wing Area	125 sq ft
Wing Loading	12.9 lb/sq ft
Power Loading	19.7 lb/hp
Seats	2
Empty weight, typical	1,095 lb
Maximum gross weight	1,609 lb
Payload w/full fuel	394 lb
Fuel capacity, std	20.1 gal (19.5 gal usable)
Oil capacity	3.2 qt

Performance

Takeoff distance, ground roll	1,120 ft
Takeoff distance over 50-ft obstacle	1,560 ft
Max demonstrated crosswind component	15 kt
Rate of climb, sea level	680 fpm
Cruise speed/fuel consumption 7,500 feet @ 75% power, best economy	117 kt/4.3 gph
Service ceiling	14,000 ft
Landing distance over 50 ft obstacle	1,490 ft
Landing distance, ground roll	748 ft

Limiting and Recommended Airspeeds

Vx (best angle of climb)	57 kias
Vy (best rate of climb)	65 kias
Va (design maneuvering)	104 kias
Vfe (max flap extended)	81 kias
Vno (max structural cruising)	118 kias
Vne (never exceed)	161 kias
Vs (stall, clean)	41 kias
Vso (stall, in landing configuration)	37 kias



AFTER SALE & CUSTOMER SUPPORT

Technical & Parts Support
Factory technicians available 7 days a week for technical and A.O.G. parts support.

Maintenance/Training
A five day course, comprised of four days of engine, propeller and airframe system w/ troubleshooting procedures, and one day of composite theory and practical repair workshop.

Field Service Support
Factory technician network available for onsite training, troubleshooting, and repairs.

Warranty
Airframe: 2 year "tip to tail" parts and labor warranty with unlimited hours. 10 year, 12,000 hr warranty on major structural components. Engine: 1 year or 200 hrs parts and labor. Parts prorated to TBO. Propeller: 1 year or 500 hours parts and labor prorated to TBO. Avionics: Manufacturer's warranty.

Repair and overhaul
Engine: overhaul and factory exchange engines available, including "firewall forward" quick engine changes (QEC). Propeller: overhaul and factory exchange propellers available.

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Sales: 1 888-359-3220

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Fax: 011 43 2622 26 780

Katana DA20-A1

The DA20-A1 Katana is a two seat aircraft designed and manufactured by Diamond Aircraft Industries of London, Canada. It is principally intended for primary flight training.

The DA20-A1 Katana features advanced composite structure, single engine, conventional configuration with low wing, T-tail, and tricycle landing gear.

The design of DA20-A1 Katana is based on the DV20 Katana, designed and manufactured by Diamond (HOAC) Aircraft of Austria. The DV20 was type certified by Austrian and German Airworthiness Authorities in 1993, and by Canadian and American Airworthiness Authorities in 1994.

The principal differences are detail design improvements and changes to facilitate production with usage of North American standard parts and materials.

Approval
The Katana is currently certified for day/night VFR operations and spinning in Canada and the United States as well as being certified by Airworthiness Authorities in the United Kingdom, Austria, Germany, Switzerland, Holland, Turkey, Portugal, France, Australia, Denmark, Czech Rep., Italy, Russia, and South Africa.

Fuselage
The fuselage is of GRP (Glass Reinforced Plastic) construction with local CRP (Carbon Reinforced Plastic) reinforcement in high stress areas.

The stressed fuselage skin is primarily made of single GRP laminate with local GRP/PVC-foam/GRP sandwich construction to increase stiffness and reduce noise. The two fuselage shells (halves) are bonded together along the joint flange in the vertical plane. Internal structure consists of the firewall, a number of transverse bulkheads, a longitudinal bulkhead in the tail tube (cone), and a main bulkhead (spar bridge) that receives the wing spar stubs. The vertical stabilizer is integrated with the fuselage.

The fixed seat shells are of GRP construction (rudder pedals are adjustable). Aft of the seats a baggage compartment is provided. Baggage is secured with a fabric net. The fuel tank is located beneath the baggage compartment. The one-piece canopy provides excellent visibility and tilts up and back to provide unrestricted cockpit access.

Wings
The wing section is a Wortman FX 63-137/20 HOAC laminar profile. The inner 50% of the wing span features flaps for take-off and landing. Each wing is attached to the fuselage with three bolts: two transverse at the root rib, and one longitudinal through the spar bridge and the wing spar stub.

The wing skins are of GRP/FOAM/GRP sandwich construction. The I-section spar is constructed of CRP poltruded spar caps that are joined with a GRP/FOAM sandwich construction spar web.

Several ribs provide mounting surfaces for guides of control tubes and support for control bellcranks. The flaps are actuated electrically via mechanical linkages that also provide synchronization. The ailerons are actuated via steel control tubes and aluminum bellcranks.

The left wing approximately one foot inboard of the wing tip houses individual quartz halogen landing and taxi lights.

Landing Gear
The conventional tricycle landing gear is non-retractable. The main gear struts are aluminum. The nose gear strut is steel tube sprung via an elastomeric spring pack. Steering is provided by differential braking of the main wheels and the friction damped castoring nose wheel.

Powerplant
The engine is a Rotax 912F3 with a take-off power rating of 81HP (DIN). The 912F3 is a horizontally opposed 4-cylinder, 4-stroke engine. It features liquid cooled cylinder heads, dual ignition, dry sump lubrication, dual carburetors, and a propeller drive reduction gear box (2.2727:1).

The engine features an integral 20A alternator directly driven by the crankshaft and a 40A alternator which is belt driven off the pulley that is mounted to the propeller drive flange. The DA20-A1 Katana uses the 40A alternator to power avionics, instruments and electrical accessories. The integrated 20A alternator is used exclusively to power the dual capacitance discharge, electronic ignition system.

The engine mount is of conventional welded steel tubing construction.

The hydraulically controlled, 2 blade constant speed propeller is the Hoffmann HO-V352F. The prop blades are of wood core construction, with composite skins and aluminum or polycarbonate bonded edge inserts.

The GRP firewall is clad with insulating Fibrefrax and stainless steel skin. Cowlings are fire protected by fire resistent paint.

Empennage
The rudder halves are of GRP/foam/GRP sandwich construction. The rudder is cable actuated via dual, adjustable pedals. The horizontal stabilizer and elevator are GRP/Foam/GRP sandwich construction with local CRP reinforcement. The anti-servo tab is made of CRP.

The elevator is actuated by steel control tubes. Centering and increased control forces are provided by two compression coil springs mounted concentric to the vertical push-pull tube of the elevator control system. The common spring base can be moved by an electric actuator which provides elevator trimming function.

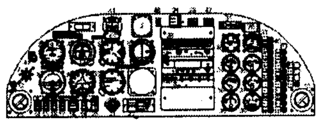
Electrical/ Avionics
Electric power (nominal 12 V) is provided by the 20 A/hr battery and the 40A alternator which features internal voltage regulation. The alternator is belt driven off the propeller shaft drive flange pulley. Electric power is supplied to the user systems via the main or avionics bus, as applicable. Circuit protection is provided by resettable panel mounted circuit breakers for each circuit.

Instrumentation and Avionics equipment is tailored to individual customer requirements. A typical equipment suite and layout are depicted in the above diagram.

Documentation
The following documentation is available:
- *Airplane Flight Manual*
- *Airplane Maintenance Manual*
- *Airplane Illustrated Parts Catalogue*
- *Miscellaneous Vendor Technical Documentation (i.e. Engine, Propeller, Avionics etc.)*

All specifications are subject to change without notice. Illustrations may show optional equipment.

Instrument Panel



1. Outside Air Temp Ind.
2. Not used
3. Air Speed Ind.
4. Artificial Horizon Ind.
5. Altimeter
6. CDI
7. Stall Warning Horn
8. Turn and Bank Ind.
9. Directional Gyro
10. Vertical Speed Ind.
11. Not used
12. Microphone Jack
13. Air Vent
14. Fuel Pump Switch
15. Strobe Light Switch
16. Landing Light Switch
17. Taxi Light Switch
18. Nav. Light Switch
19. Avionics Master
20. Master Switch
21. Ignition Switch
22. Flap Control
23. Compass Card
24. Trim Indicator
25. Annunciator Lights
26. Hobbs Meter
27. Not used
28. Radio
29. Transponder
30. Not Used
31. Intercom
32. Manifold Pressure
33. Tachometer
34. Oil Pressure Ind.
35. Oil Temp. Ind.
36. Voltmeter
37. Cylinder Head Temp. Indicator
38. Ammeter
39. Fuel Indicator
40. Circuit breakers
41. Compass
42. Canopy locking Warning Light
43. I-Panel Rheostat
44. Trim Ind. Dimmer

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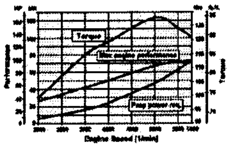
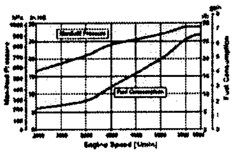
Appendix C: Engine Performance Sheet

ROTAX 912S

ROTAX **100-HP ROTAX 912S AIRCRAFT ENGINE**

ENGINE DESCRIPTION: Rotax 912 ULS	
4-cylinder, 4-stroke liquid / air cooled engine with opposed cylinders, dry sump forced lubrication with seperate oil tank, automatic adjustment by hydraulic valve tappet, dual CD carburetors, mechanical diaphragm pump, electronic dual ignition, electric starter, integrated reduction gear 1 : 2.43	
BORE / STROKE	3.31 in (84 mm) 2.40 in. (61 mm)
DISPLACEMENT	82.6 cu. in. (1352 cc)
POWER OUTPUT	Approx. 95 HP (69 kW) @ 5500 RPM 100 HP (73.5 kW) @ 5800 RPM* * with Rotax airbox and exhaust system
TORQUE MAX.	Approx. 94 ft lbs. (128 Nm) @ 5100 RPM
WEIGHT	136 lbs. (62 kg) with electric starter, carburetors, fuel pump, air filters and oil system
MAX RPM	5,800 RPM (1/min.)
CYLINDER	light alloy cylinders, NIKASIL plated
PISTON	aluminum cast; three piston rings
VALVE TRAIN	OHV, hyd. lifters, pushrods, rocker arms
CYLINDER HEAD	4 separate cylinder heads
COMPRESSION	10.5 : 1
VALVE GAP	auto adjustment by hydraulic valve
CAM SHAFT	steel, heat treated, nitrated
CRANKSHAFT	case hardened with 5 bearings
COOLING	liquid cooled cyl. heads, air cooled cyl.
LUBRICATION	dry sump with trochoid pump, camshaft driven
OIL	.08 US Gal. (3 litres); high performance auto (SAE 15W40)
FUEL	premium unleaded: 90 oct. or higher leaded or unleaded or AVGAS 100 LL
GENERATOR	13.5 V, 250 W DC @ 5500 RPM





Source: Bombardier-Rotax.
For information only.
The Rotax 912 ULS does not comply with federal safety regulations for standard aircraft. This engine is for use in experimental uncertified aircraft only and only in circumstances in which an engine failure will not compromise safety.
For more info:
www.kodiakbs.com
www.rotax-owner.com

ZENITH AIRCRAFT COMPANY, Mexico Airport, Mexico, Missouri 65265-0650 Tel: 573-581-9000 FAX: 573-581-0011
Call 573-581-9000 (Mon - Fri 8 - 5 Central) www.zenithair.com

Typical Power, Torque and Fuel Consumption For Rotax 4 Stroke Aircraft Engines

	912 UL			912 ULS			914 UL		
Power Setting (%)	65	75	100*	65	75	100*	65	75	100*
R.P.M.	4800	5000	5800	4800	5000	5800	4800	5000	5800
Power									
Kilowatts	37.7	43.5	59.6	44.6	51.0	73.5	47.8	55.1	84.5
Horsepower	50.6	58.4	81.0	59.8	68.4	100.0	64.1	73.9	115.0
Torque									
Nm	75.0	83.0	98.1	88.7	97.4	121.0	95.1	105.2	139.1
Ft.*lbs.	55.3	61.2	72.3	65.4	71.8	89.2	70.1	77.6	102.6
Fuel Consumption									
Litres / Hour	15.8	19.2	23.8	18.0	20.0	27.0	18.3	21.4	34.0
U.S. Gal. / Hour	4.2	5.1	6.3	4.8	5.3	7.1	4.8	5.7	9.0
Imp. Gal. / Hour	3.5	4.2	5.2	4.0	4.4	5.9	4.0	4.7	7.5

* Maximum take off power

Specifications and performance data shown is typical for the engines described and is general in nature.
All information is subject to change without notice.
Information shown is not to be used for flight or flight planning purposes.
Consult the appropriate engine and/or aircraft manual(s) for specific technical information

Appendix D: Propeller Performance