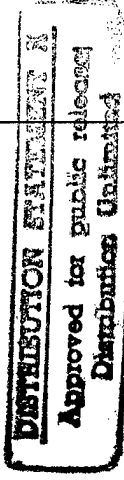


AEROCLASS TECHNOLOGIES YR - 93 Pterodactyl Final Briefing

C1C Paul Copioli
C1C Sean Gookin
C1C Scott Hufford



DTIC QUALITY INSPECTED 4
PLEASE RETURN TO:

BMD TECHNICAL INFORMATION CENTER
BALLISTIC MISSILE DEFENSE ORGANIZATION
7100 DEFENSE PENTAGON
WASHINGTON D.C. 20301-7100

19980309 021

46329

Accession Number: 6329

Title: Aeroclass Technologies, YR-93 Pterodactyl Final Briefing

Personal Author: Copioli, P.; Gookin, S.; Hufford, S.

Comments on Document: From BMDO/DE, Washington, DC

Abstract: The Pterodactyl Mission is designed to provide localized missile defense by loitering over territory, detecting missile launches, attacking the missile with talons, reposition when required, and provide long endurance coverage.

Descriptors, Keywords: Pterodactyl Yr93 aeroclass technology design concept analysis rationale loiter detection surveillance reconnaissance reposition endurance talon canister mission profile

Pages: 56

Cataloged Date: Jan 06, 1998

Copyrighted or Not: NO

Document Type: HC

Number of Copies In Library: 000001

Record ID: 46032

INTRODUCTION

I. Problem Statement / Mission
Description

II. Design Drivers

III. Concept Description

IV. Alternate Designs

V. Design Analysis and Rationale

VI. Conclusion

Pterodactyl Mission

Provide Localized Missile Defense

- ▶ **Loiter Over Territory**
- ▶ **Detect Missile Launch**
- ▶ **Attack Missile with Talons**
- ▶ **Reposition When Required**
- ▶ **Provide Long Endurance Coverage**

The Talon

The Canister

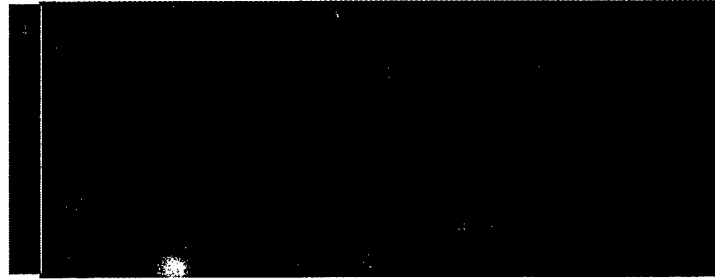


Weight 29 lbs

50 watts

10 inches

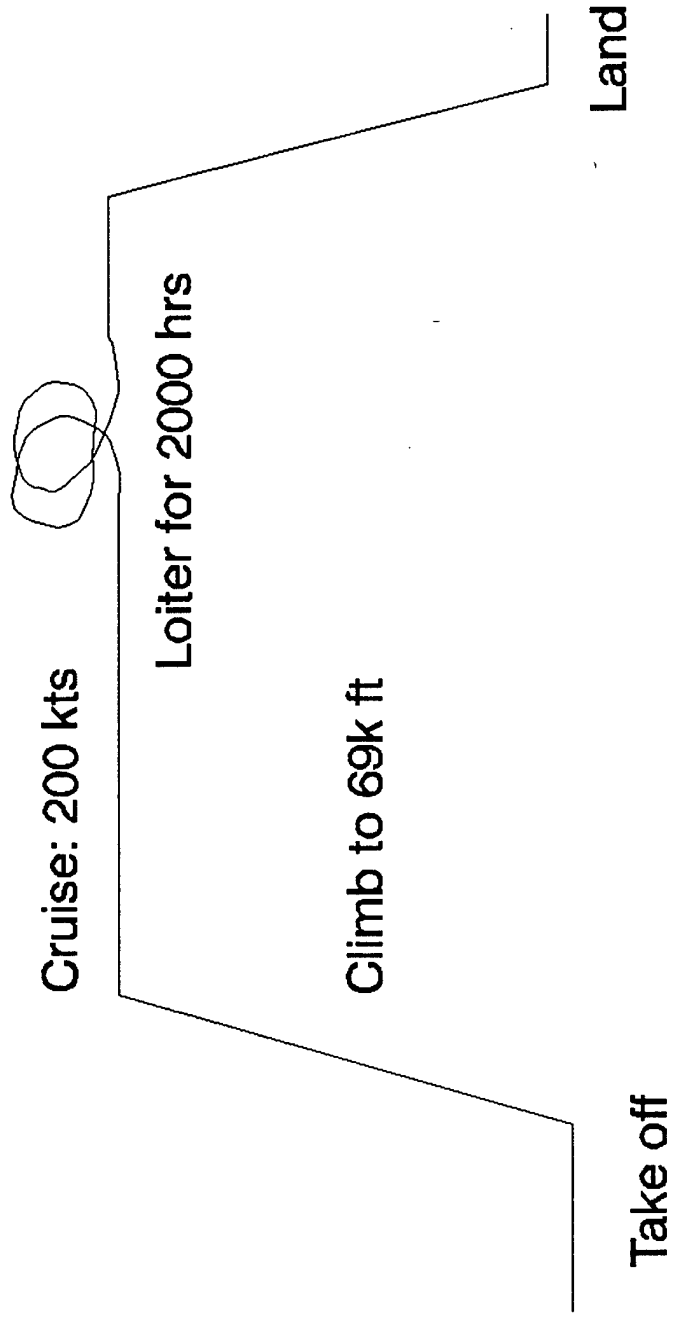
Parachute



RFP Mission Requirements

- ✓ Mission Endurance 2000 hours
- ✓ Mission Range 4000 miles
- ✓ Payload 200 pounds
- ✓ Max Cruise Speed 200 knots
- ✓ Energy Source solar/electric
- ✓ Stability S.M .1 to -.3

RFP Mission Profile



II. Design Drivers

Design Drivers

Most Restrictive Constraints

1. 2,000 Hour Endurance
2. Maximum Altitude of 80,000 feet
 - a. Increased Survivability
 - b. Increased Potential Energy
3. Highest Cruise Speed as Possible
 - a. Try for 200 knots
4. Minimize Power Required
 - a. Reduced Fuel Cell Weight
 - b. Reduced Cost

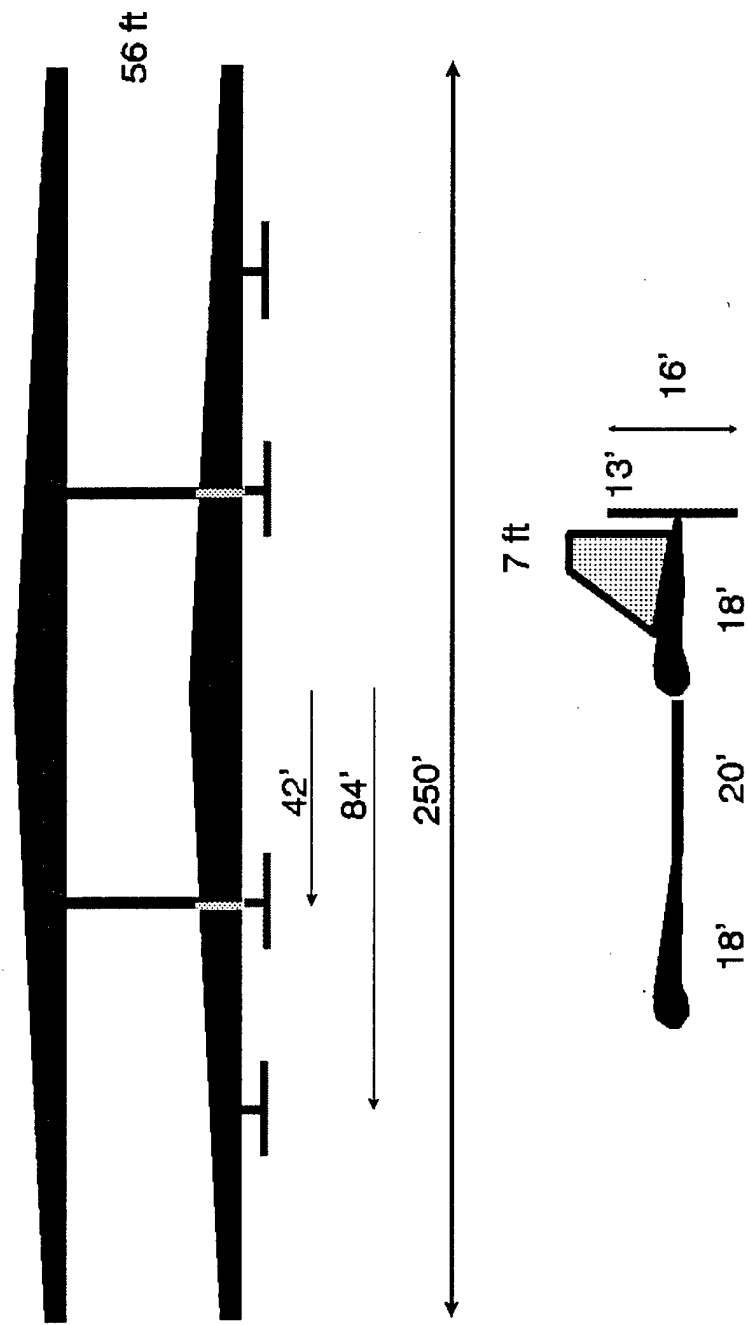
Pterodactyl Concept Description

1. Overall Description
2. Subsystem Description
3. RFP Compliance

1. Overall Description

- I. Dimensions**
- II. Parameters**
- III. Mission Description**
- IV. Area Coverage**
- V. Balsa Wood Glider**
- VI. Key Mission Elements**
- VII. Performance**
- VIII. Constraint Diagram**

Pterodactyl Dimensions

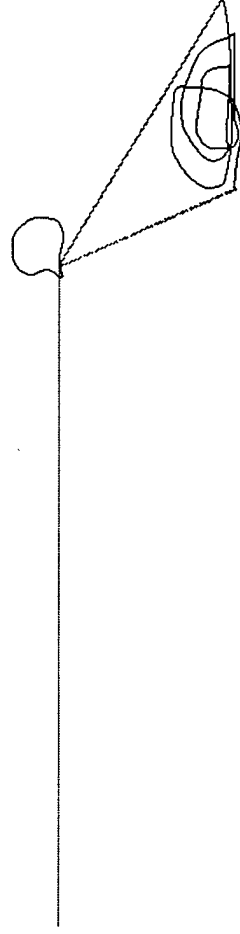


Descriptive Parameters

Planform

Parameter	Wings	Vertical Tails
Span	250 ft	13 ft
Root Chord	18 ft	13 ft
Tip Chord	4.2 ft	7 ft
Area	2775 sq ft each	130 sq ft each
Aspect Ratio	22.5 each	N/A
Sweep	4.7 degrees	26.6 degrees
Airfoil	LDL101b	NACA 0009

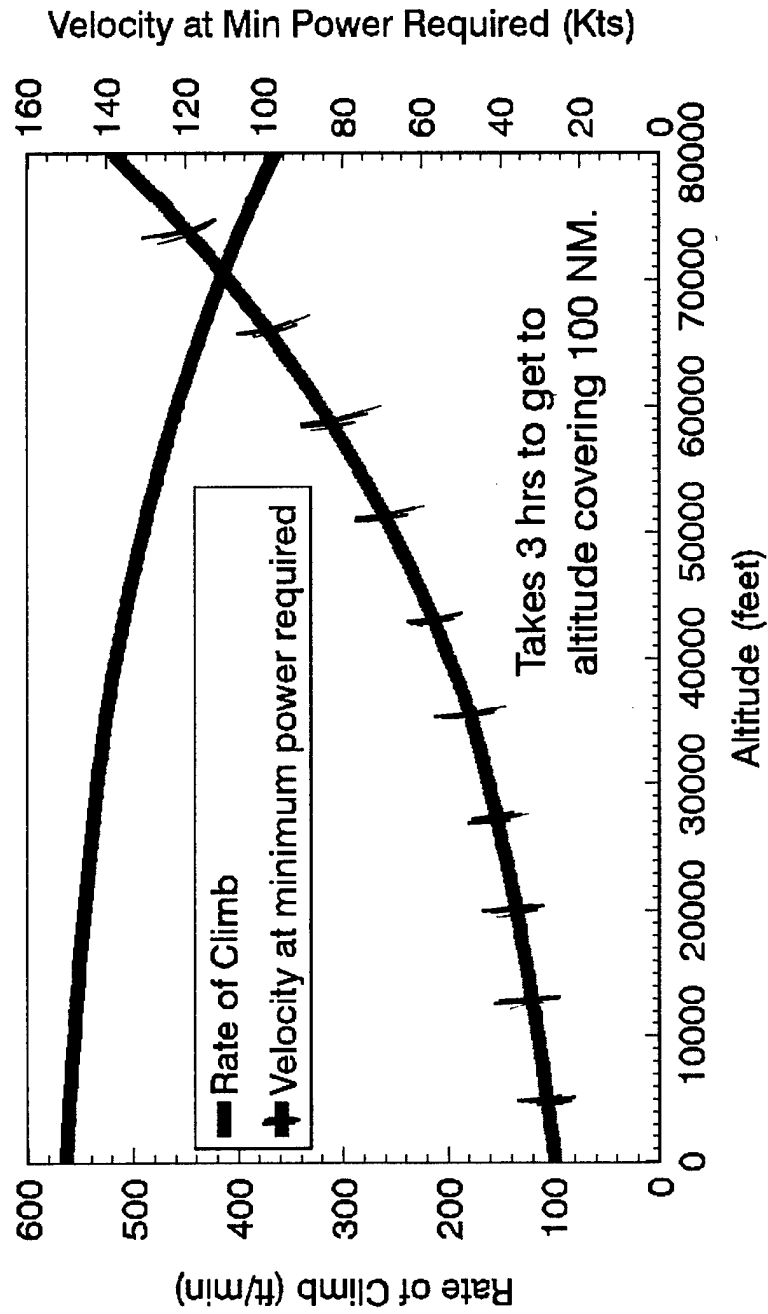
Pterodactyl Mission Profile



- Initial climb 3 hrs covering 100 NM
- Cruise at 80K ft for 9 hours covering 1300 NM. $V = 136$ kts
- Night time glide for 3 hours to 50,000 ft.
- Night time loiter at 50K ft for 9 hours. $V = 40$ kts
- Day time climb for 8 hours.
- Daytime loiter at 80K ft for 4 hours. $V = 82$ kts.

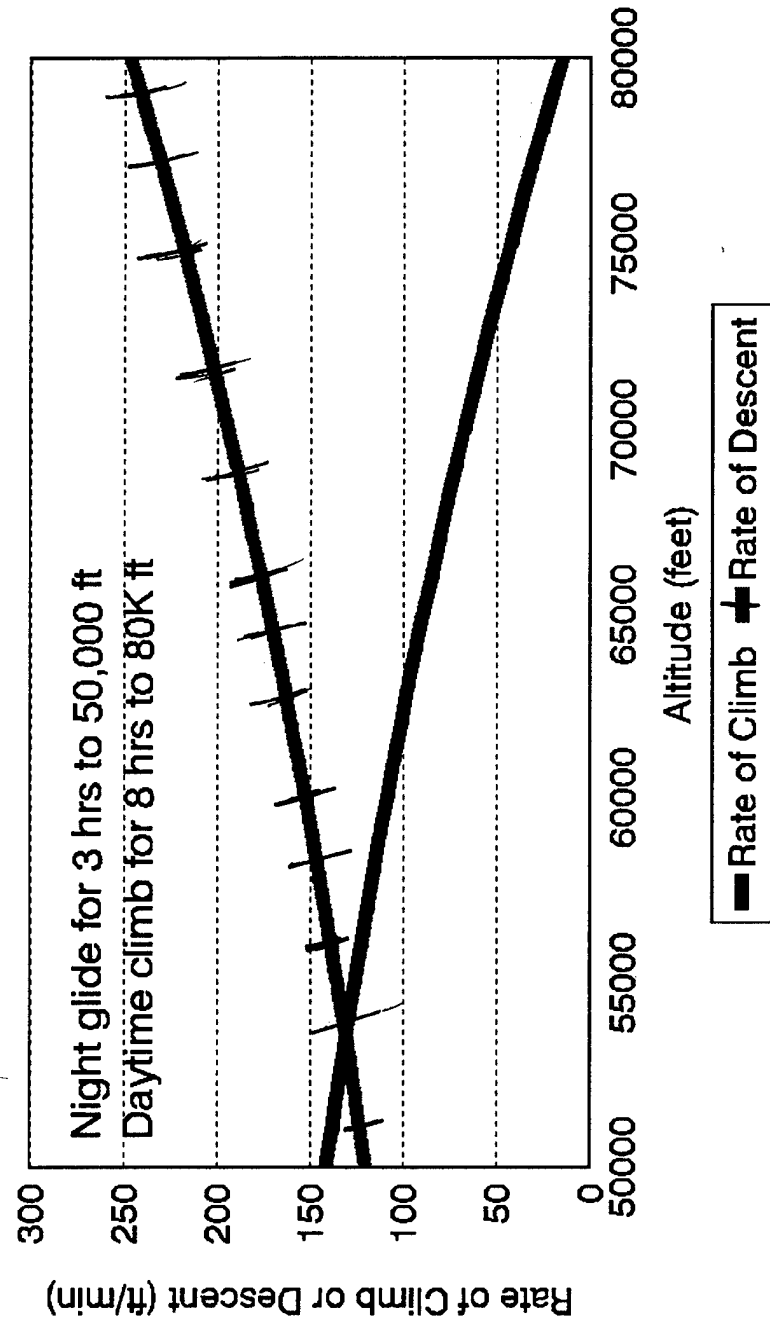
Pterodactyl's Altitude Profile

Initial Dash to Target



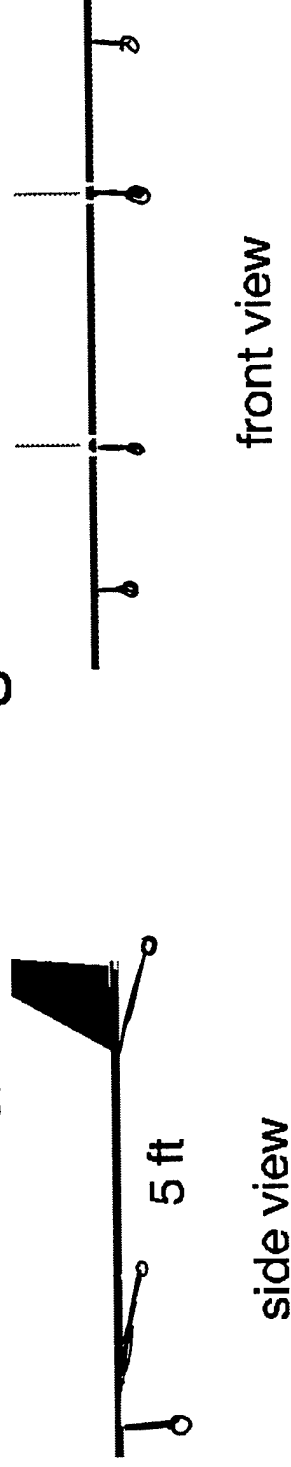
Rates of Climb and Descent vs Altitude

Pterodactyl's Climb/Glide Cycle



Key Mission Elements

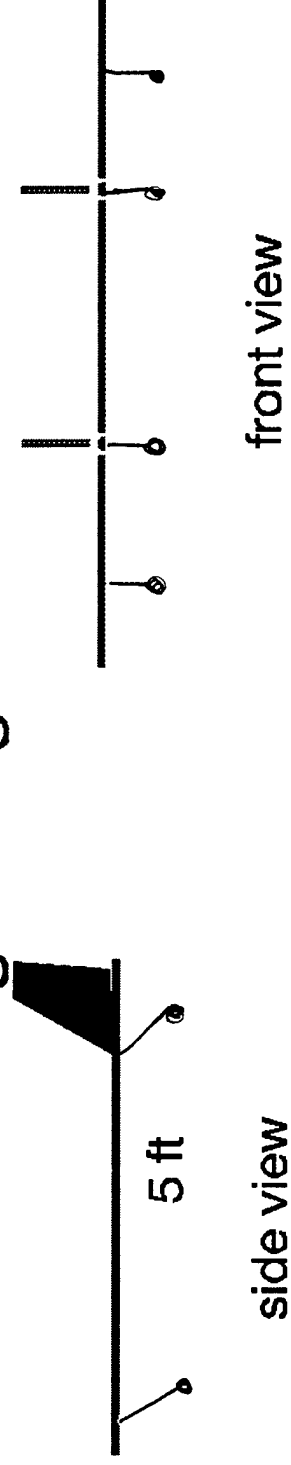
Take off Configuration



1. Two struts per wing at fuselage intersection.
2. Two struts per wing at outside engine location.
3. All 8 struts release after take off.
4. 8 landing gear struts are retracted during take off.

Key Mission Elements

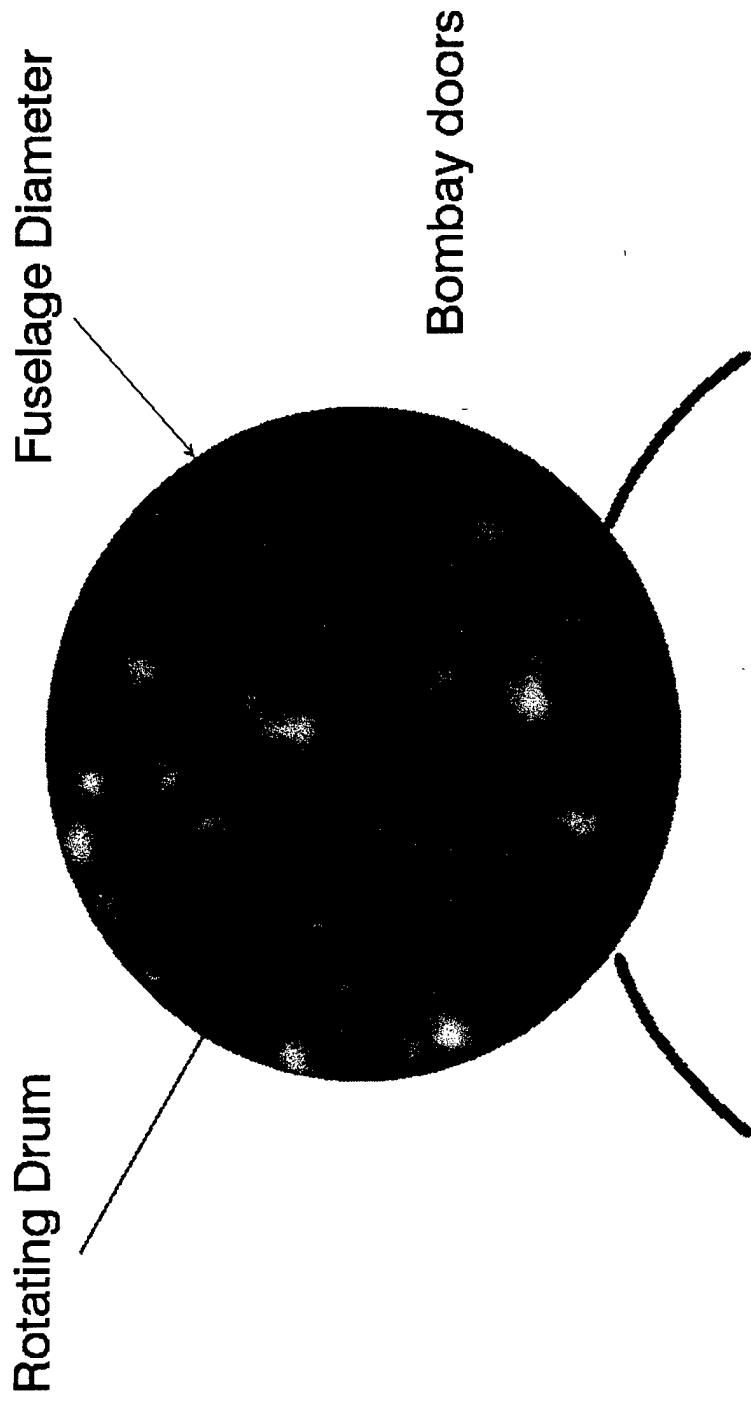
Landing Configuration



1. 8 landing struts are spring loaded and released before landing.
2. Only good for 1 landing.

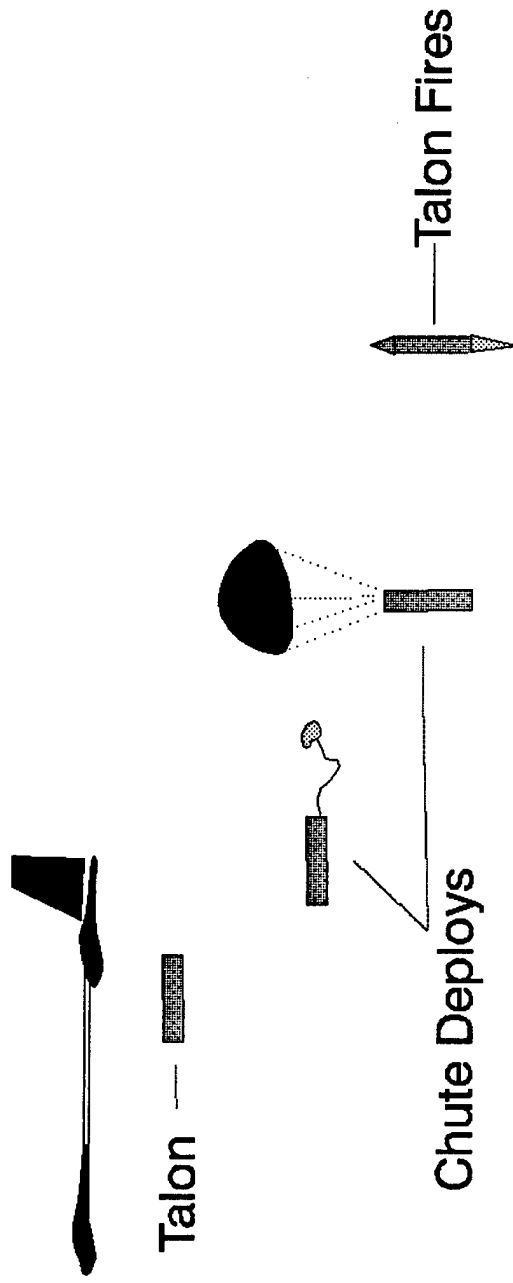
Key Mission Elements

Talon Placement



Key Mission Elements

Talon Deployment



Pterodactyl Performance

Parameter	Value
Top Cruise Speed	136 kts
Approach Speed	16 kts
CI Max	1.6
Max Ceiling	80,000 ft
Sustained Turn	1.1 g
Velocity for Min Pwr Req	40 or 82 kts

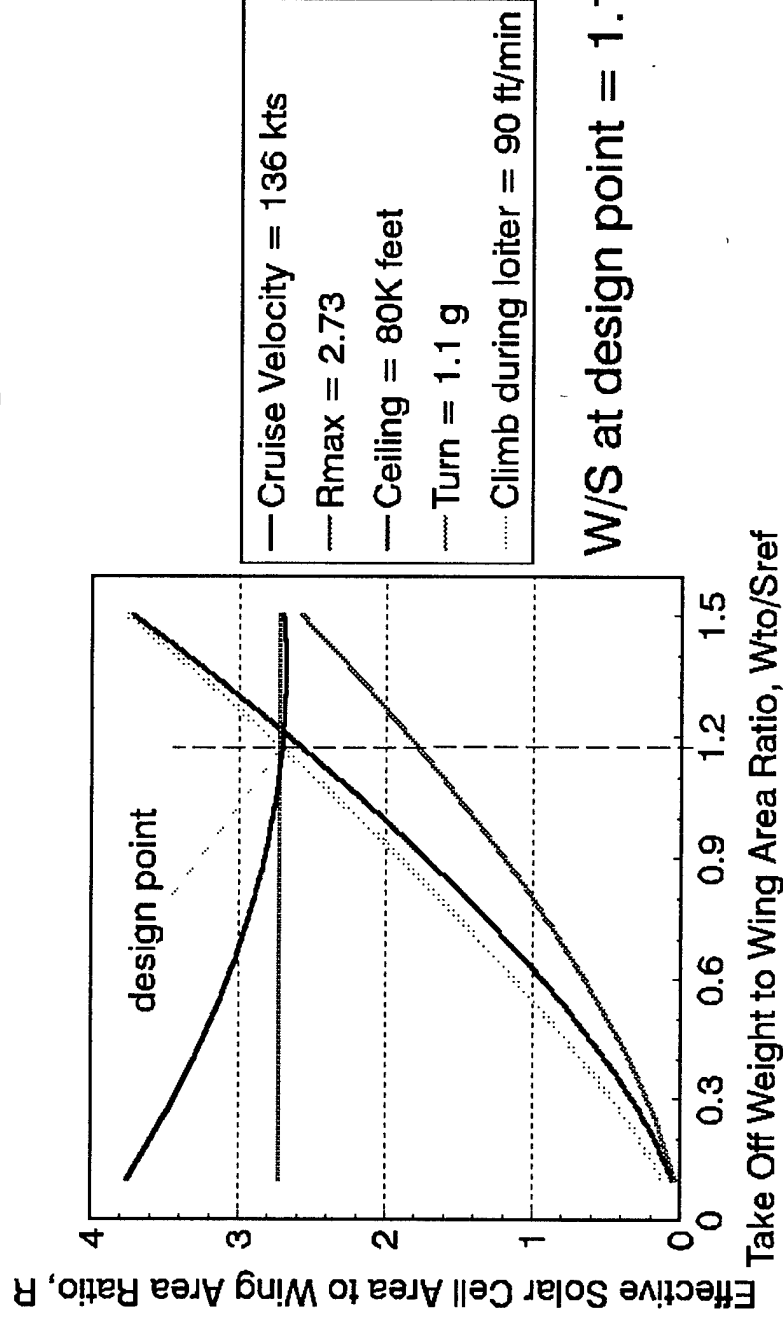
Velocity for Minimum Power Required

for both Loiter Altitudes

- | | |
|-----------------------------------|------|
| 1. Night time loiter at 50,000 ft | - 40 |
| 2. Day time loiter at 80,000 ft | - 82 |

Pterodactyl Constraint Diagram

AEROCLASS Technologies



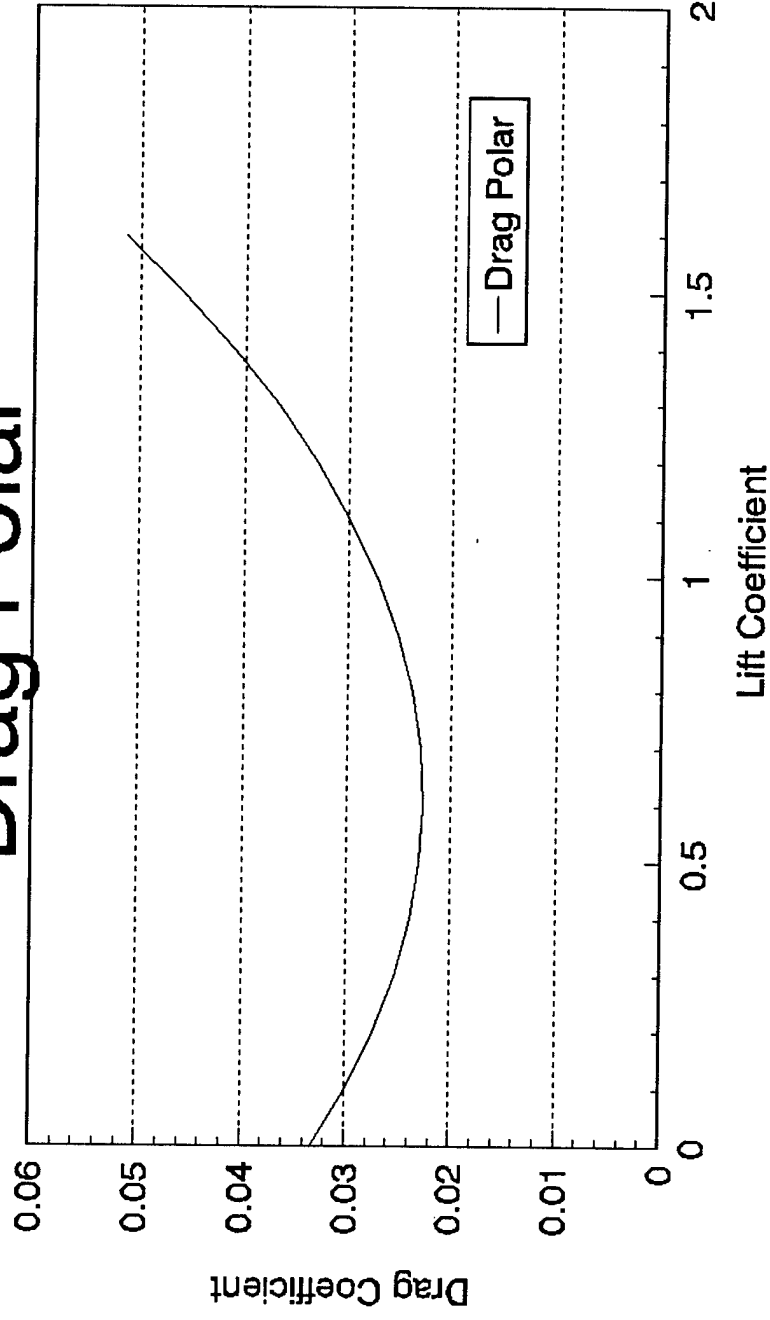
W/S at design point = 1.17

2. Subsystem Description

- I. Aerodynamic Description
- II. Stability Description
- III. Propulsion System Description
- IV. Structures Description
- V. Weights and CG



Aerodynamic Description Drag Polar



$$C_D = 0.03325 + 0.029C_L^2 - 0.035C_L$$

Stability Description

Stability Derivative Summary

Stability Derivative	Natural Value	Required Value	Using SAS
Longitudinal			
Cm_{α}	0.014	from -0.5 to -0.1	-0.3
Cm_q	-5.15	within range	not needed
Lat-Directional			
Cl_p	-1.2	slightly high	not needed
Cl_{β}	-0.06	within range	not needed
Cn_{β}	0.001	within range	not needed
Cn_r	-0.2	within range	not needed

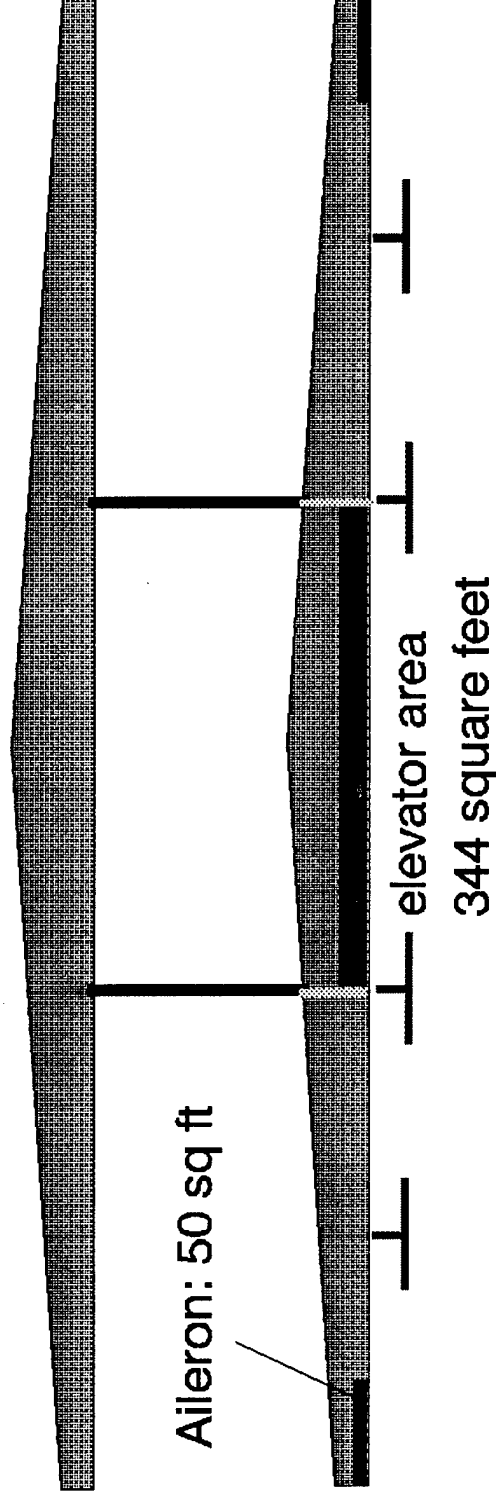
Stability Description

Results on Modes

Mode	Natural Frequency	Damping Ratio	Meet Mil-Spec
Short Period	0.01	1.21	no
-- with SAS	0.042	0.29	yes
Phugoid	0.34	0.32	yes
Spiral	Time to 2X amp = 414 sec		yes
Dutch Roll	0.009	2.59	yes

Stability Description

Control Placement

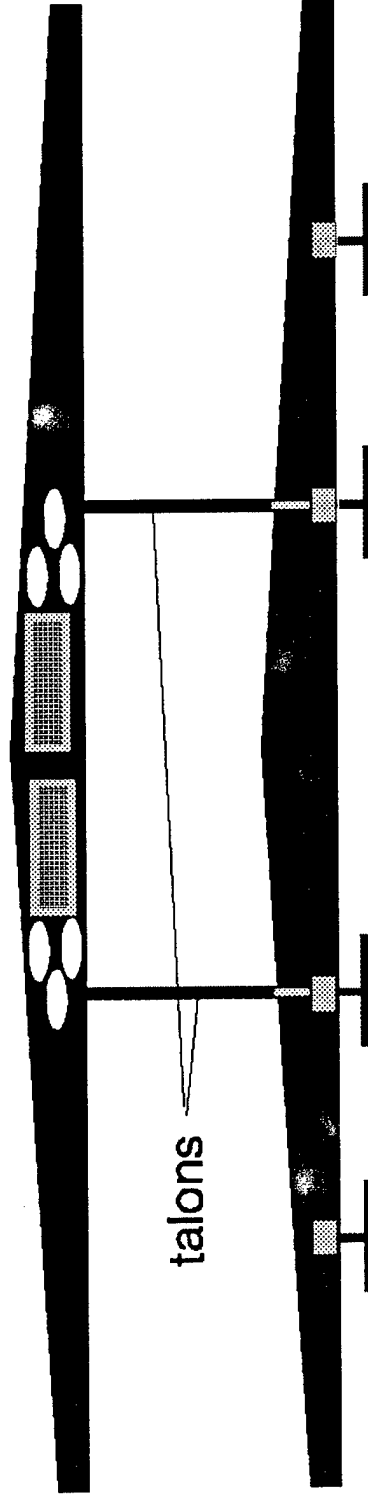


Trimmed flight :

0 degrees AOA: deflection equals -2.5 degrees

6 degrees AOA: deflection equals 2.5 degrees

Stability Description Systems Placement



-  = motors and gears
-  = fuel cells
-  = storage tanks

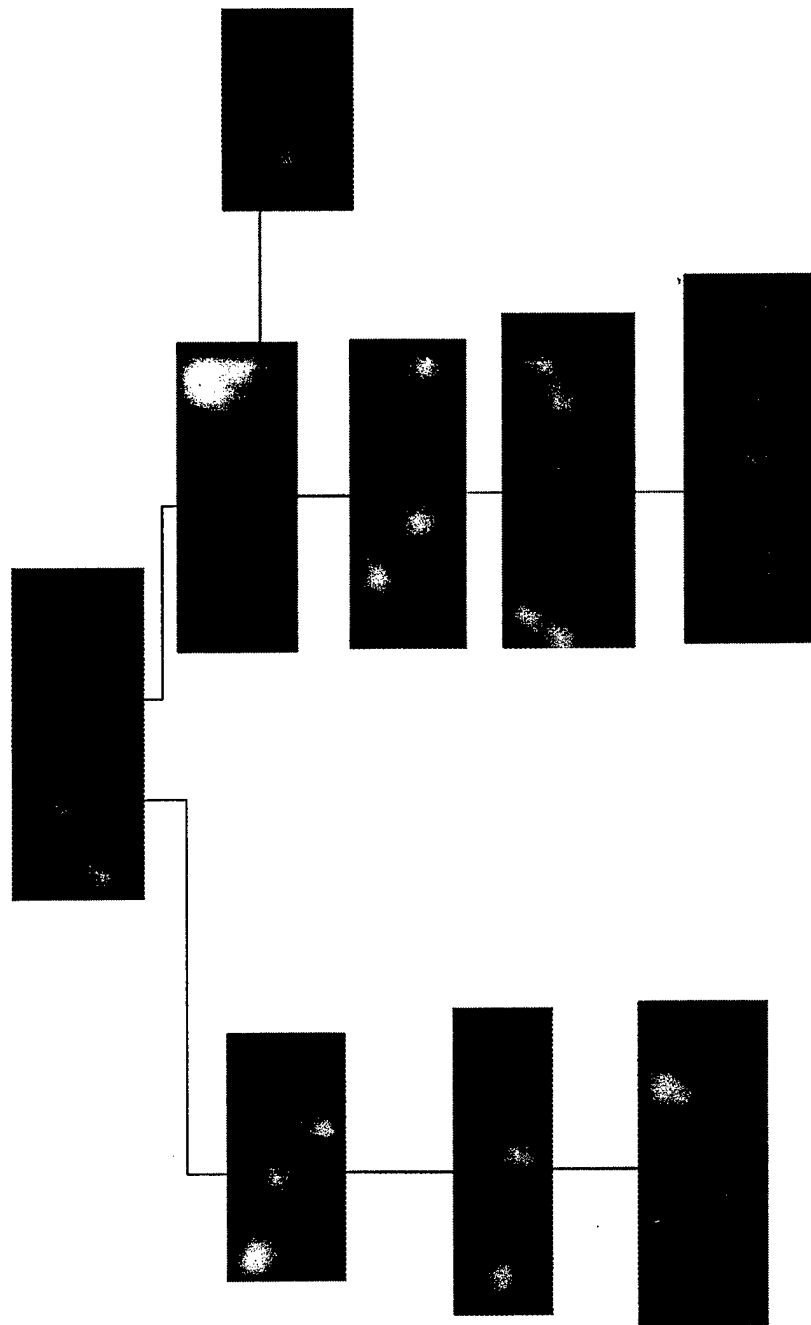
Propulsion System Description

System Summary

1. Power Source
 - a. Solar Cells
 - i. CIS-Se (c)ii
 - ii. Effective Area = 7576 sq ft
 - iii. Actual Area = 11,587 sq feet
 - b. Fuel Cells
 - i. 4.0 KW H₂O₂
2. Motors
 - a. 4 General Electric 6.0 horsepower motors
 - b. 1900 RPM
3. Propellers
 - a. 4, 16 foot diameter propellers
 - b. 475 RPM (400 ft/sec tip speed)
4. Gear box with gear ratio of 4:1

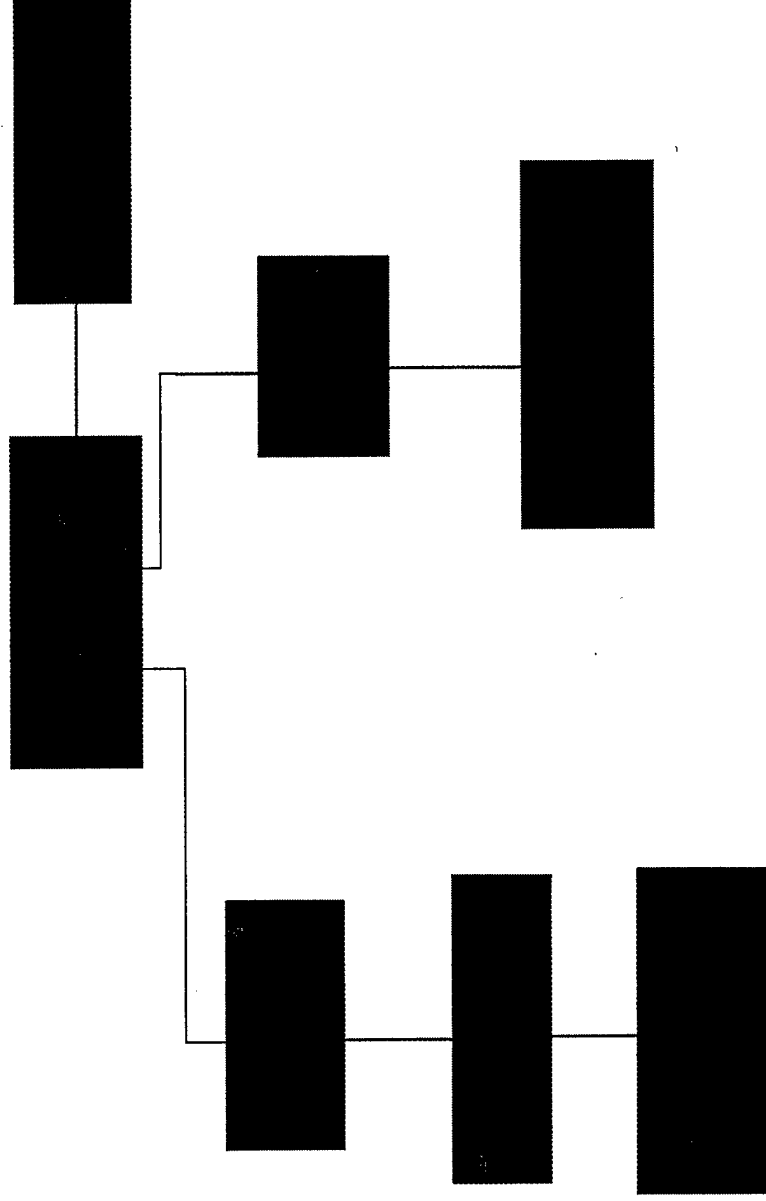
Propulsion Description

Day Operation



Propulsion Description

Night Operation



Propulsion Description

Final System Efficiencies

Component	Efficiency	Energy Density
Solar Cells	15%	2000 Watts/kg
Fuel Cells	53%	352 W-hrs/kg
Motor	90%	N/A
Gear	95%	N/A
Propeller	86%	N/A
Cf	0.374	N/A

Structures Description

Composition

- I. Wings
 - A. Skin
 - 1. MYLAR skin
 - 2. solar cells
 - 3. TEDLAR covering
 - B. Ribs
 - 1. graphite/epoxy composite shell
 - 2. foam core
 - C. Tubular Spar
 - 1. +-45 degree graphite/epoxy thin tube
- II. Fuselage and Vertical Tails
 - A. Standard airframe structures

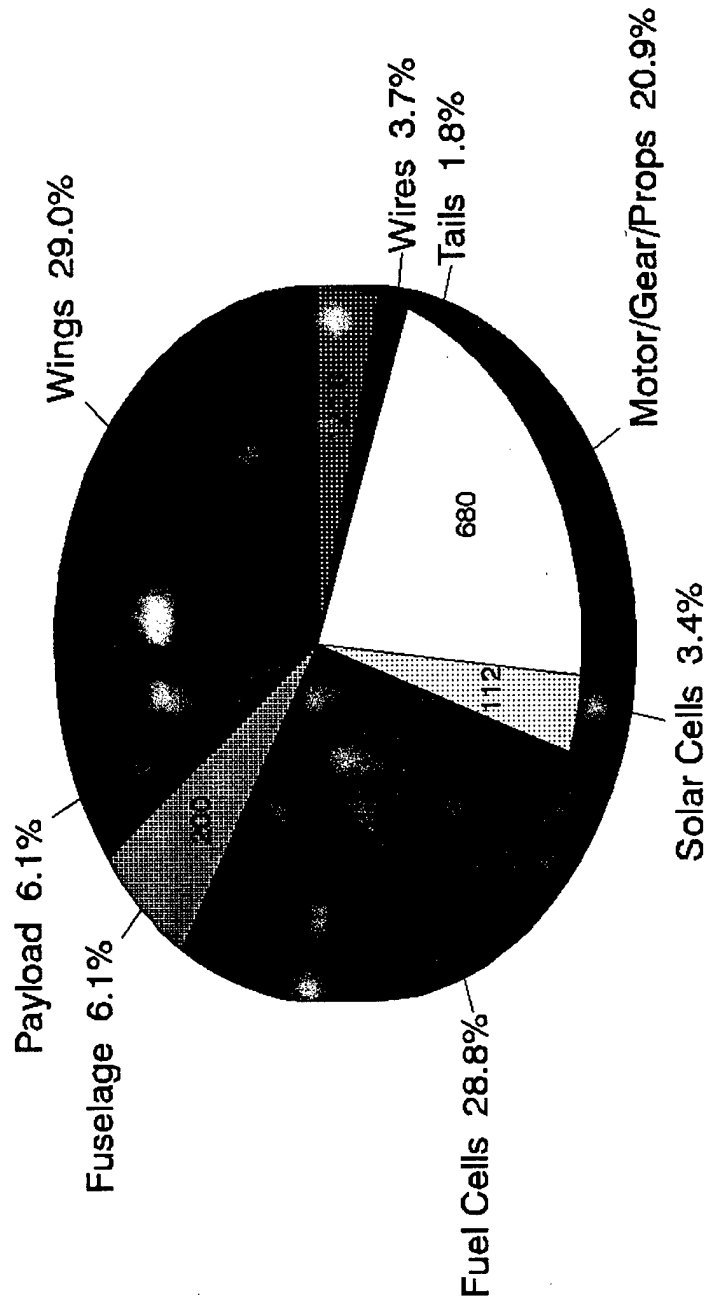
Structures Description

Finite Element Results

- Actual Results
 - Top skin fails in compression
 - Wing tip deflection = 22 feet
 - Safety factor of 3.5
- Realistic Analysis
 - Top skin is flexible in compression
 - Span loading was not taken into account

Pterodactyl Final Weight Breakdown

Total Weight = 3255 lbs



RFP Compliance Table

Pterodactyl Performance Report

Parameter	Required	Pterodactyl
Max Cruise Speed	200 kts	136 kts
Mission Endurance	2000 hrs	infinite
Mission Range	4000 NM	infinite
Payload	200 pounds	200 pounds
Absolute Ceiling	70,000 ft	80,000 ft
Power Source	Solar	Solar and Fuel Cells
Static Margin	.1 to -.3	-0.02

IV. Alternate Designs

Peregrine

- I. Reference Area = 3600 sq ft
- II. Wing/Canard Configuration
 - a. Wing Area = 3600 sq ft
 - b. Canard Area = 1800 sq ft
 - c. Canard 10 ft above wing
- III. 2 propellers with 2 motors per propeller
- IV. No vertical stabilizers

Alternative Designs

Night Owl

- Reference Area = 2550 sq ft
- Wing and Canard Configuration
 - Wing Area = 2550 sq ft
 - Canard Area = 400 sq ft
- Two 15 Foot Diameter Propellers
- One Motor per Propeller
- No Vertical Stabilizers

V. Configuration and Design Justification

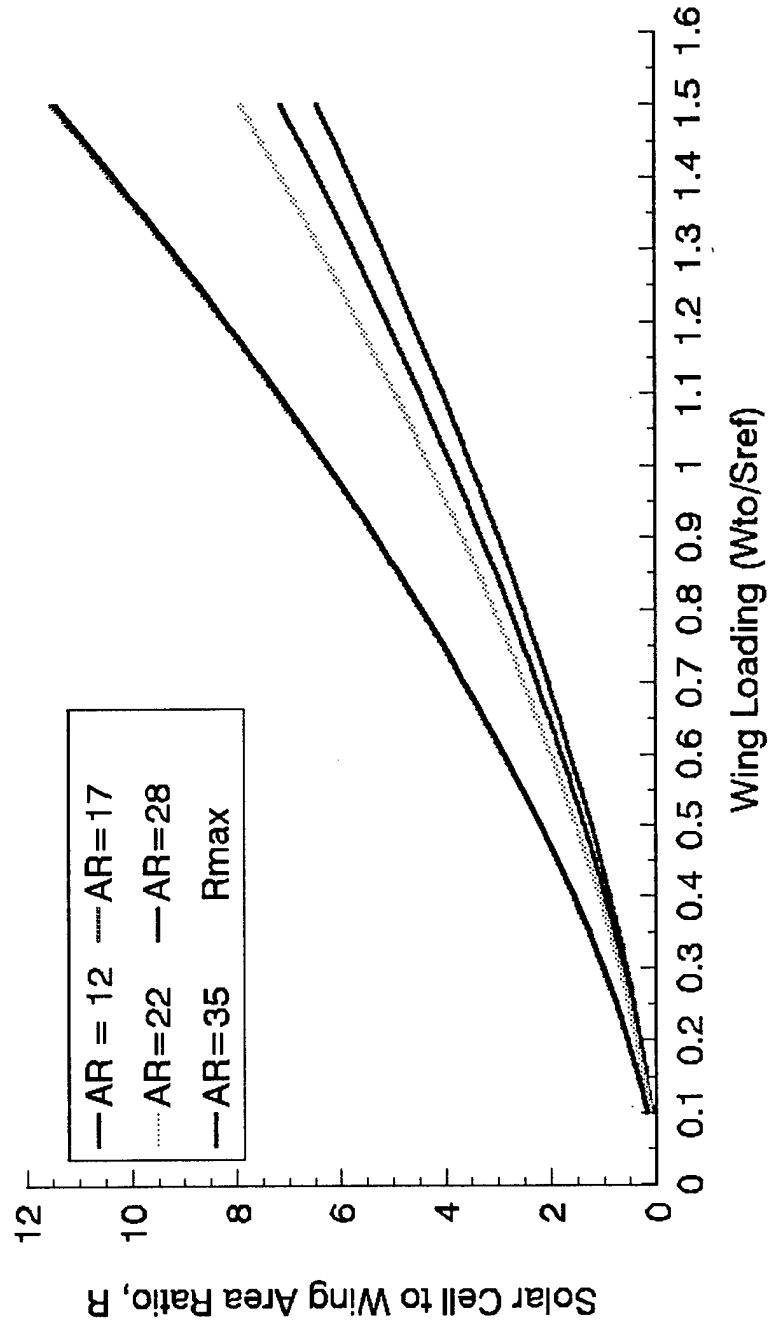
1. Aerodynamic Analysis
2. Stability and Control
3. Propulsion
4. Weight Breakdown
5. RFP Compliance

1. Aerodynamic Analysis

- a. Aspect Ratio Comparisons
 - b. Zero lift Drag
- c. Power Required vs Velocity

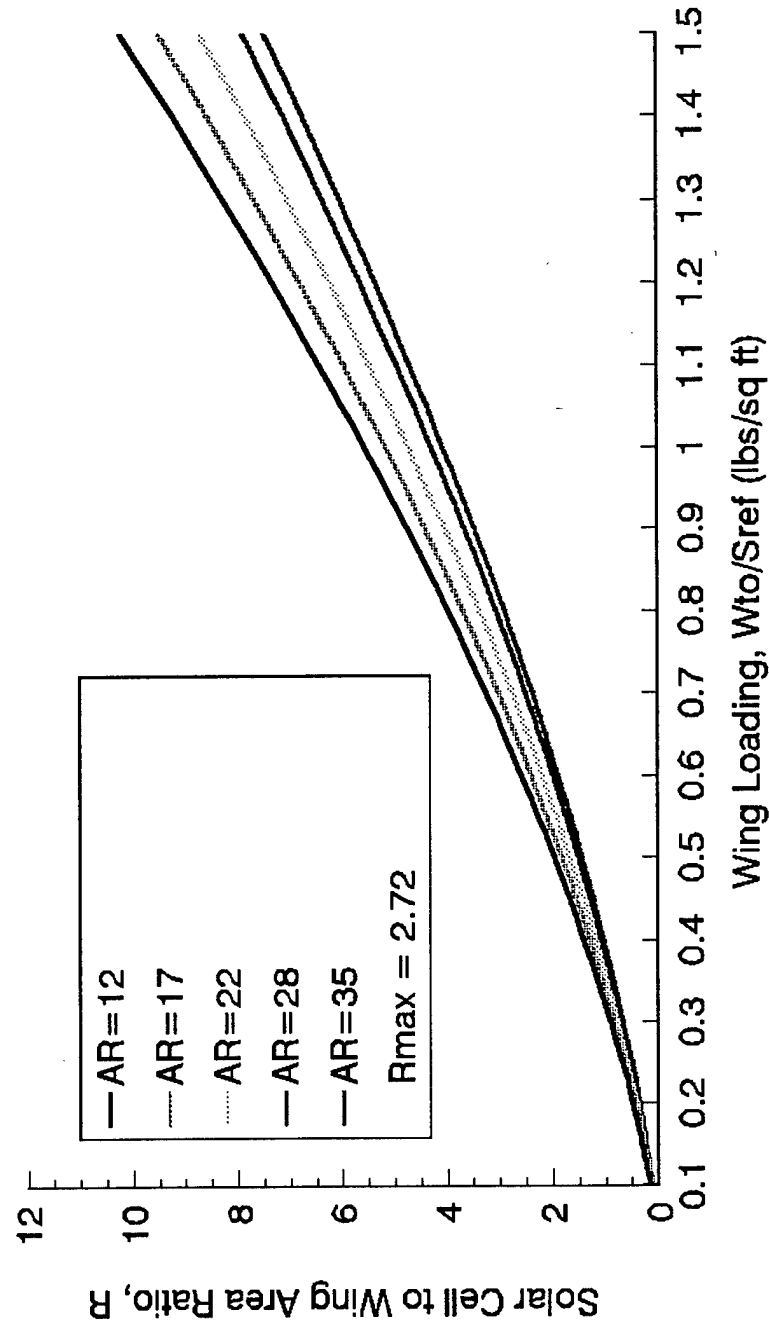
Pterodactyl Aspect Ratio Sensitivity

Constant Wing Area, $S=2775$ sq ft



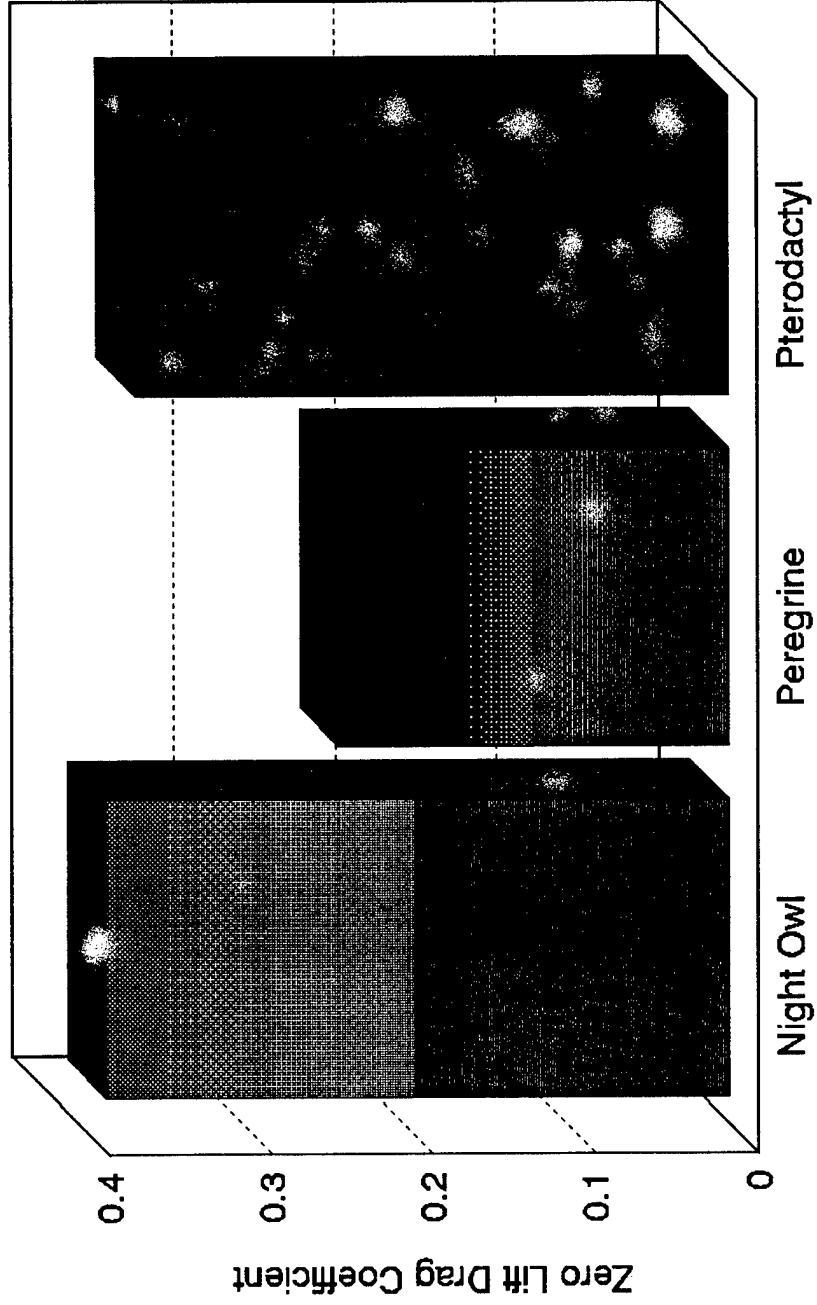
Pterodactyl Aspect Ratio Sensitivity

Constant Wing Span, $b=250$ ft



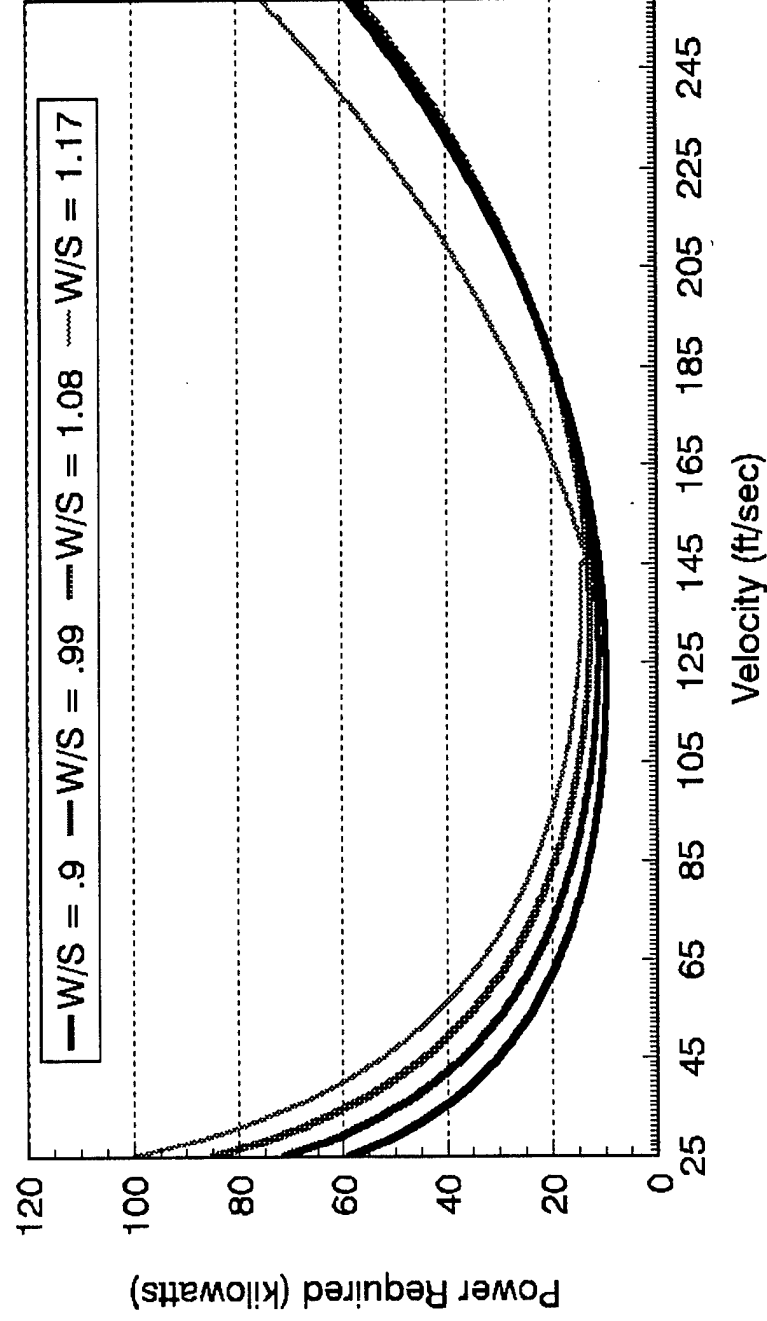
Wing and Canard Zero Lift Drag

Comparing All Three Aircraft



Power Required vs Velocity

Pterodactyl at 80,000 feet

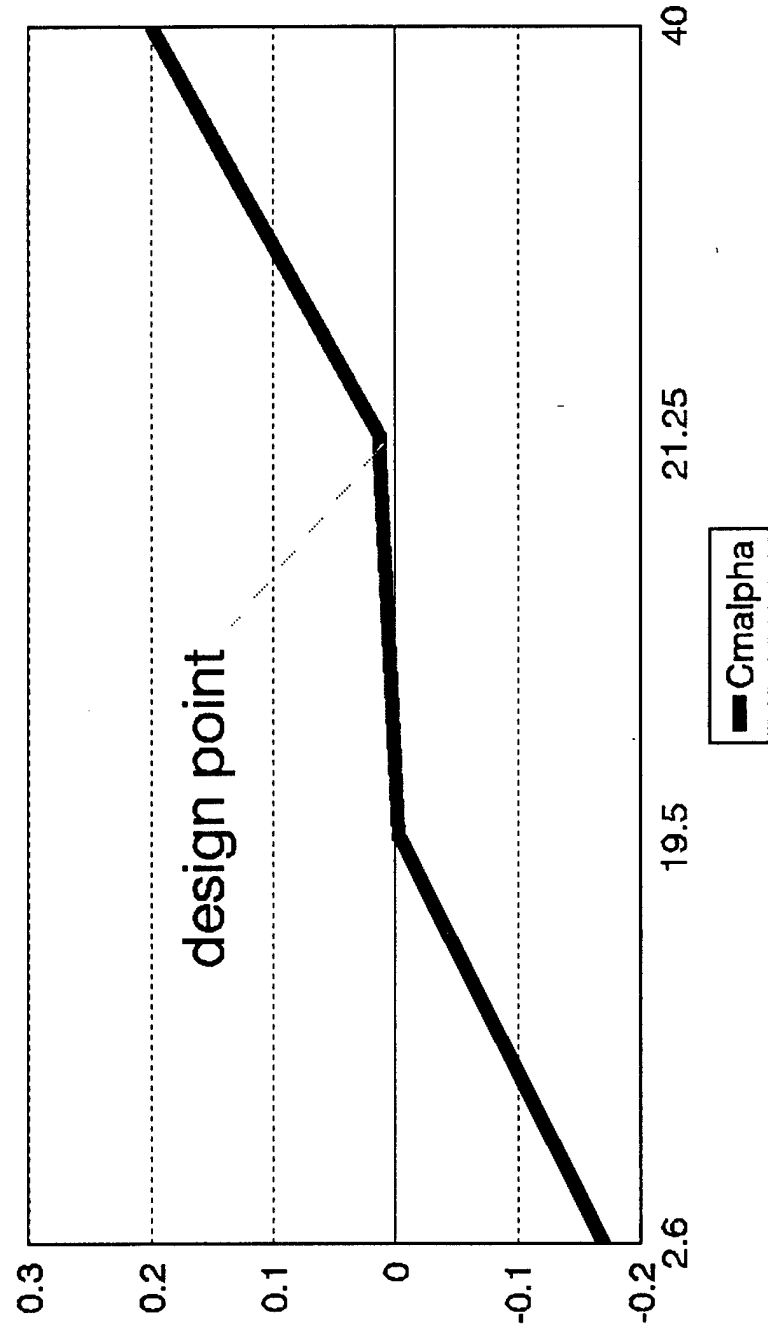


2. Stability Analysis

- a. Longitudinal Sensitivity
- b. Lateral-Directional Sensitivity

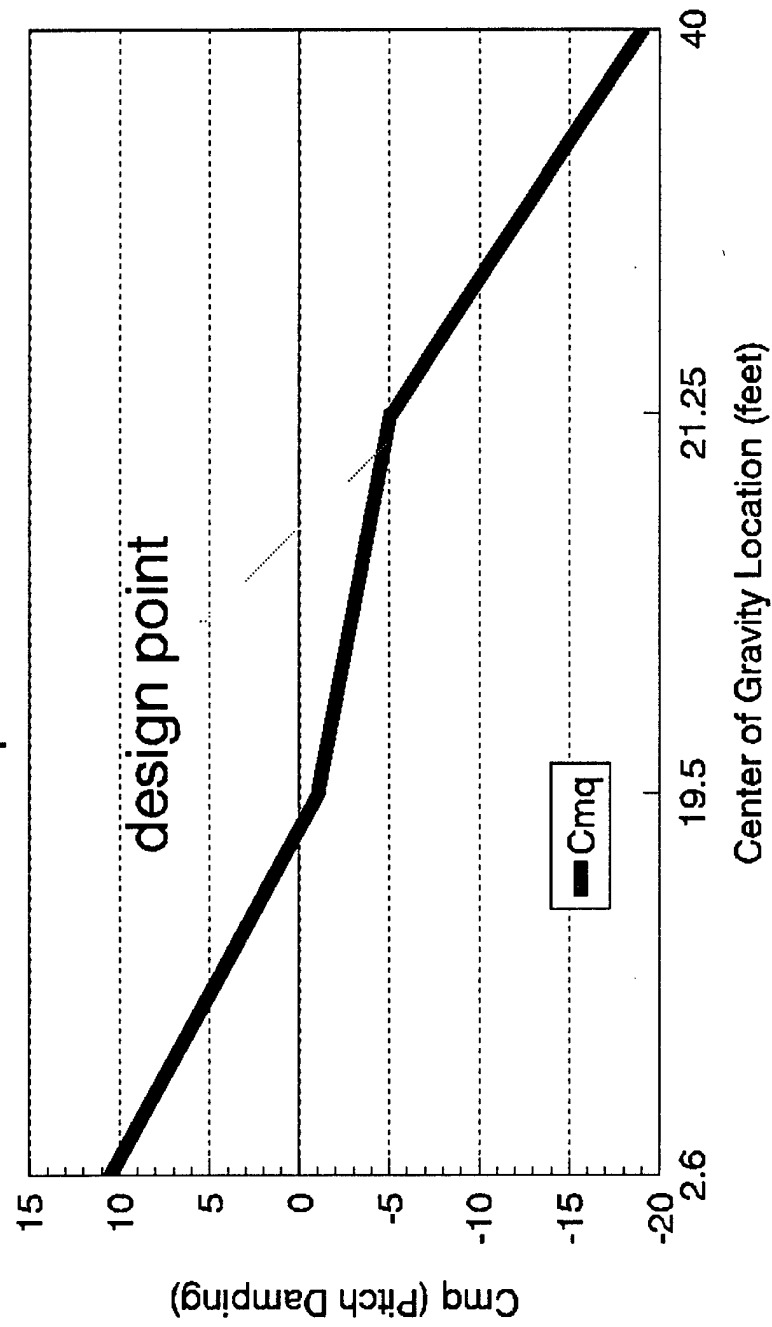
Stability Analysis

C_{m_α} Sensitivity



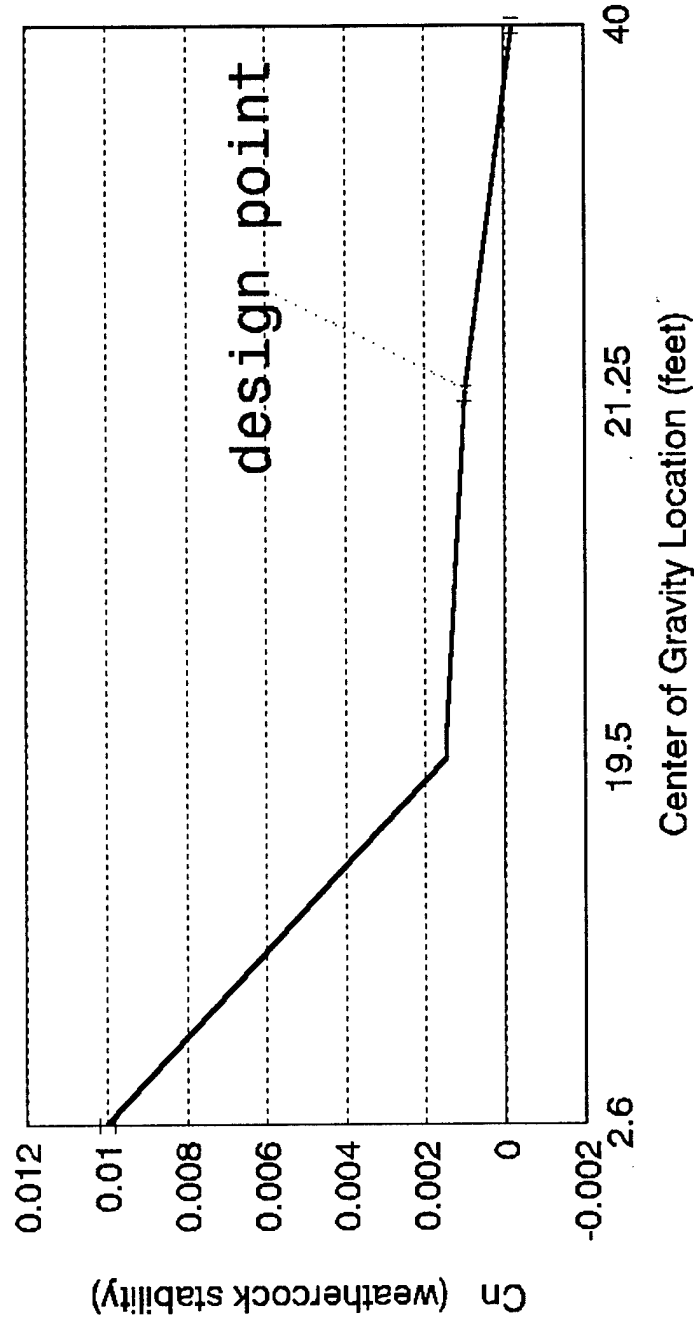
Stability Analysis

C_{m_q} Sensitivity



Stability Analysis

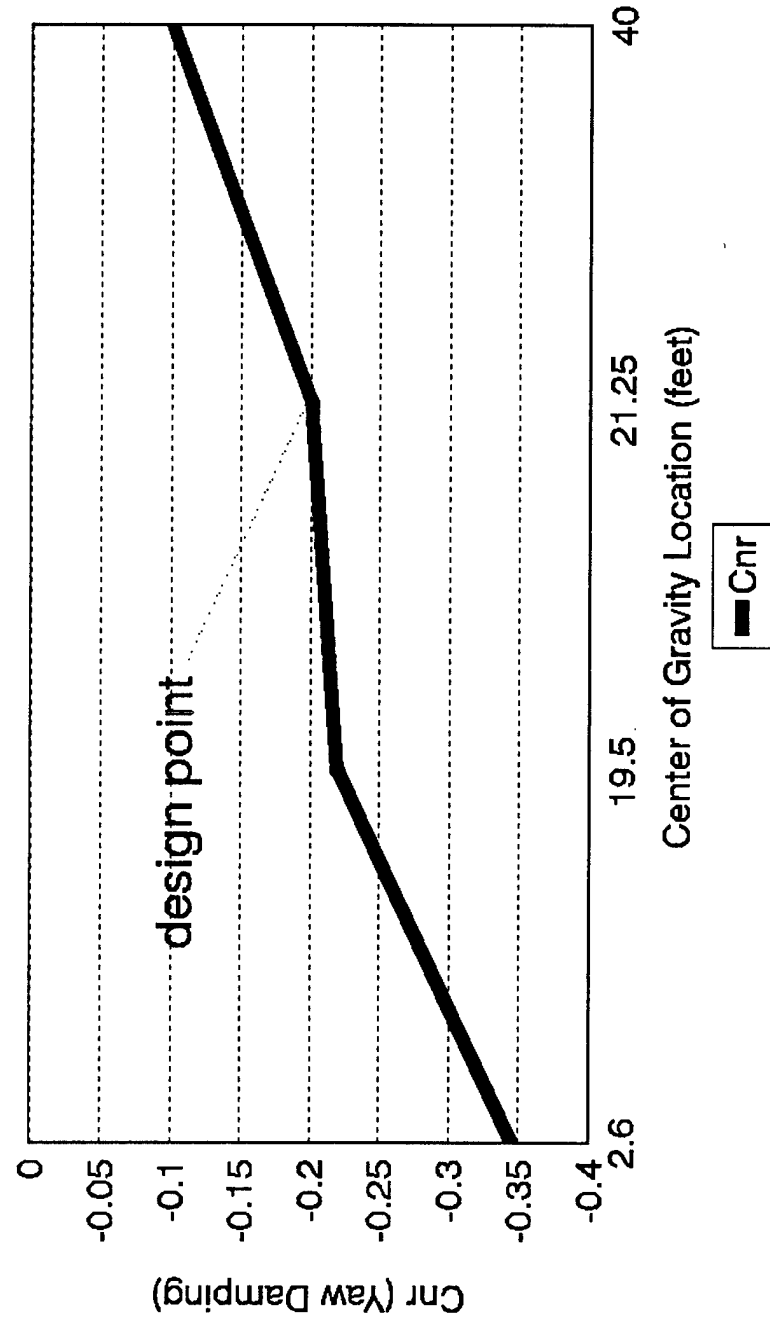
Cn Sensitivity



++ Cn

Stability Analysis

Cnr Sensitivity



FLIGHT SIMULATOR TIME

3. Propulsion Analysis

- a Fuel Cell and Battery Comparisons
 - b. Solar Cells Considered
 - c. Solar Cell Comparison

Propulsion Analysis

Fuel Cell / Battery Comparisons

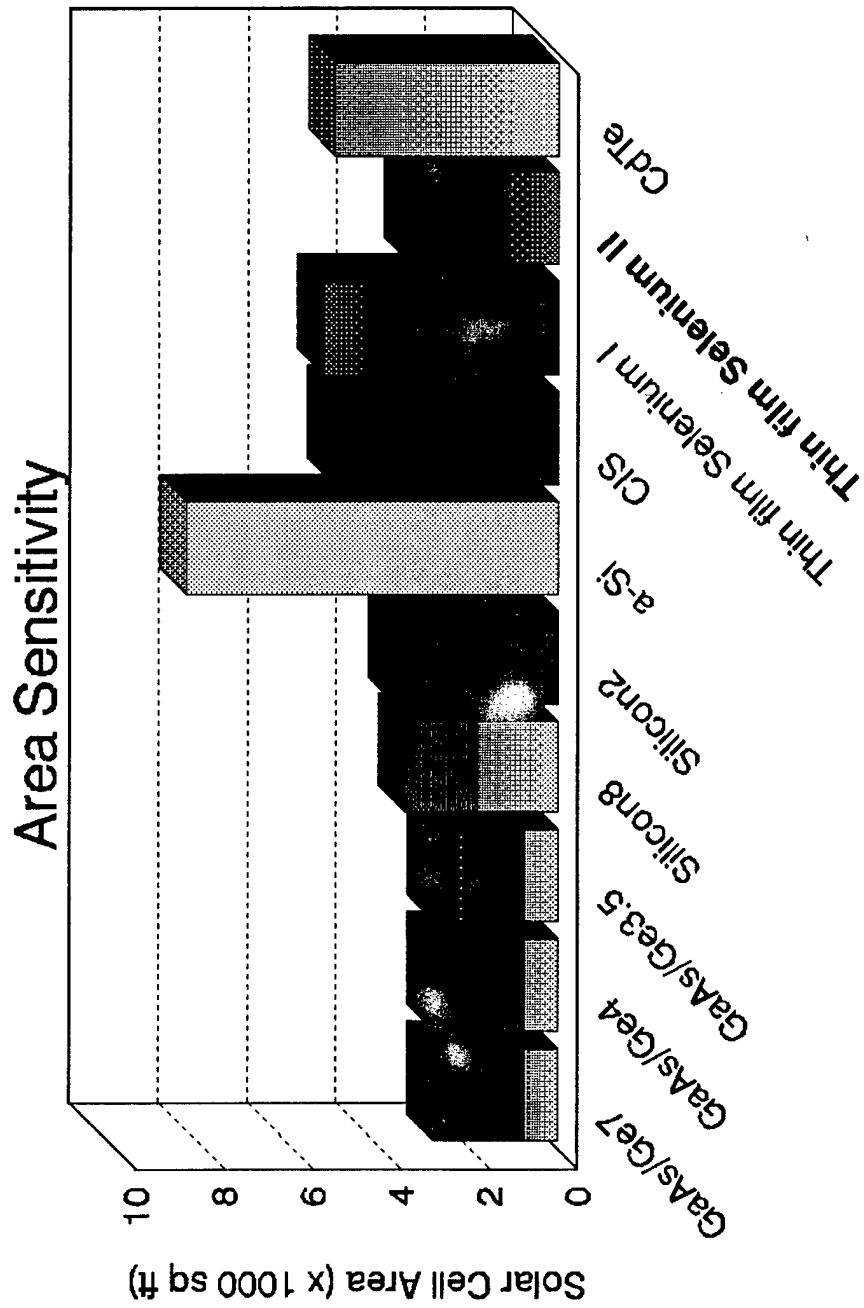
CELL	Specific Energy (W - hrs/kg)	Technological Maturity	WEIGHT
NiCd	30	Mature	7195.887
Lead Acid	35	Mature	6167.903
NiMH	54	Experimental	3997.715
Zn/AgO	90	Mature	2398.629
NaS	100	Mature	2158.766
Li/LiCo2	132	Experimental	1635.429
Li-FeS2	180	Experimental	1199.314
Li- Solid Polymer	160	Experimental	1349.229
H2 O2 Fuel Cell	142.5	Mature	1514.923
H2 O2 Fuel Cell	352	Developing	596.3442

Propulsion Analysis

Solar Cells Considered

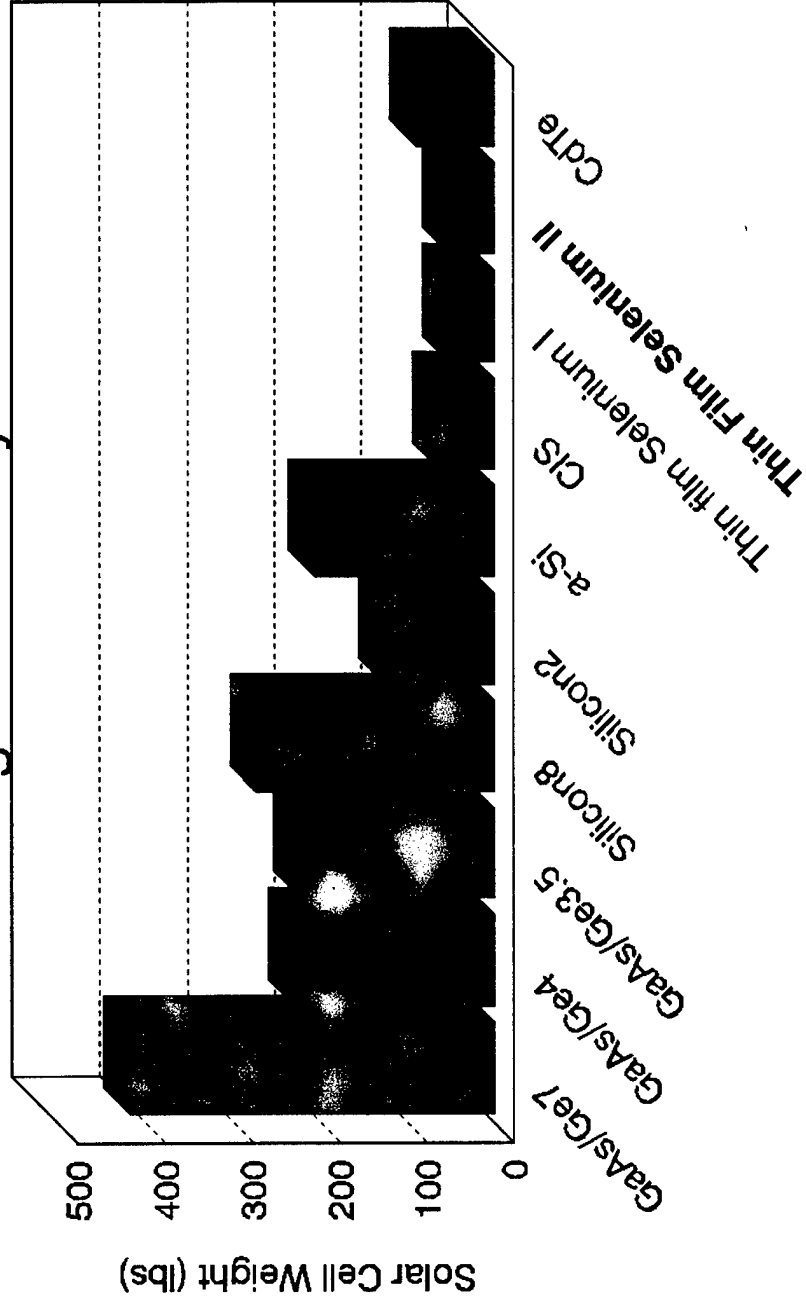
	Solar Cell	Efficiency
1	GaAs/Ge7	0.180
2	GaAs/Ge4	0.180
3	GaAs/Ge3.5	0.180
4	Silicon8	0.145
5	Silicon2	0.137
6	a-Si	0.060
7	CIS	0.099
8	Thin film Selenium I	0.095
9	Thin film Selenium II	0.150
10	CdTe	0.100
	Future Cell (req. to go 200kts)	0.54

Propulsion Analysis



Propulsion Analysis

Weight Sensitivity



CONCLUSION

- Meets all RFP Requirements Except:
 - Max Cruise Speed
- Propulsion
 - Uses Solar Power and Fuel Cells
 - Uses 3 hours of night time glide to decrease fuel cell weight
- Solar Cell Cost is Much too High to even Consider Use