AHS
International

# ecocopter

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# Introduction

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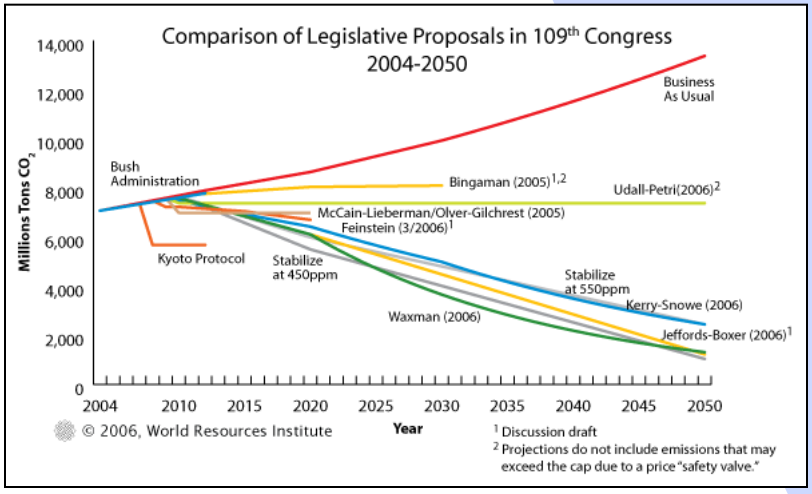
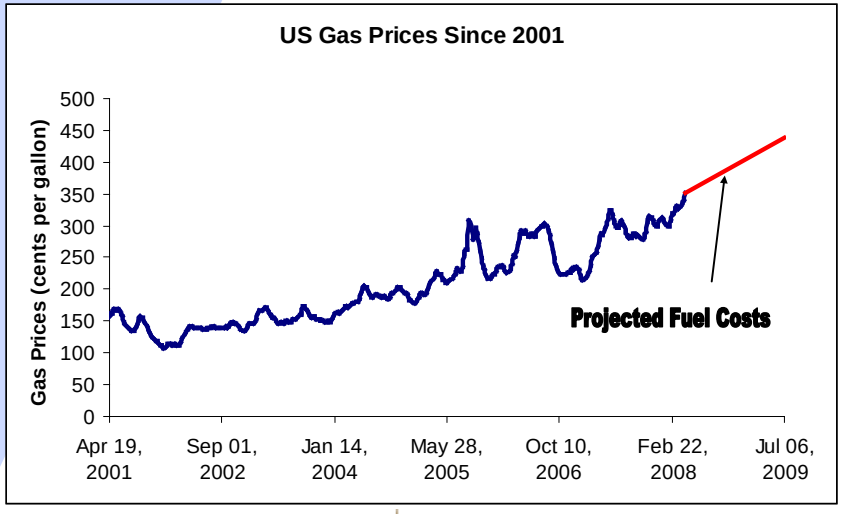
In today's market for vehicles there is a high demand for high efficiency, low emission vehicles and the helicopter market is no different.

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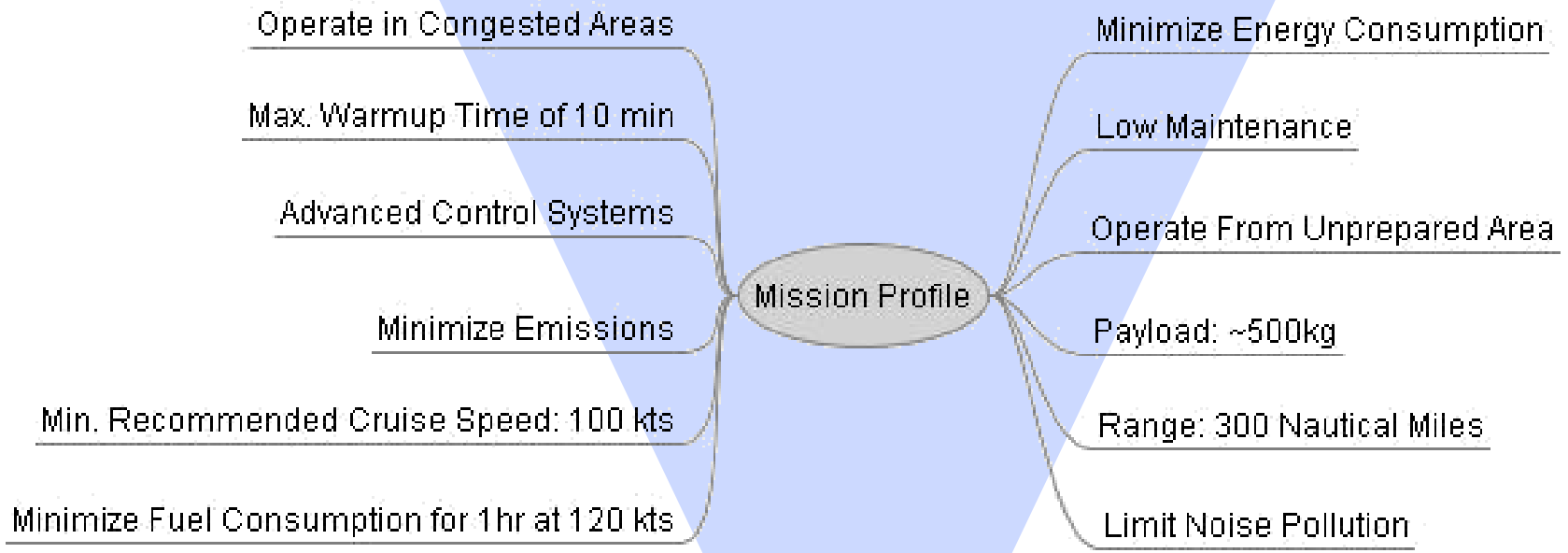
# Requirement Analysis





# Quality Function Deployment

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| Quality Function Deployment | Customer Importance | HOWs (Title) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Figure of Merit | Gross Weight | Disk Loading | Tip Speed | Rotor Radius | Solidity | # of Blades | Taper | Pitch Ranges | Rotor Inertia | Shaft Tilt | # of Engines | # of Main Rotors | Volume | SFC | PowerAvailable | Blade Twist |
| How Much | | 0.8 | 3200 lbs | 4.5 psf | 675 ft/s | 14.5 ft | 0.054 | 4 | 2:1 | | 20 AI | | 1 | 1 | 54.5 cubic ft | .3 lb/hr | 375 HP | -12deg linear |
| Organizational Difficulty | | 3 | 3 | 2 | 3 | 4 | 4 | 2 | 1 | 2 | 3 | 4 | 5 | 5 | 3 | 2 | 2 | 1 |
| Weighted Importance | | 136.0 | 239.0 | 125.0 | 164.0 | 114.0 | 53.0 | 237.0 | 38.0 | 8.0 | 125.0 | 25.0 | 200.0 | 261.0 | 128.0 | 297.0 | 127.0 | 112.0 |
| Relative Importance | | | | | | | | | | | | | | | | | | |
| Absolute Difficulty | | 45.3 | 79.7 | 62.5 | 65.6 | 28.5 | 13.3 | 118.5 | 38.0 | 4.0 | 41.7 | 6.3 | 40.0 | 52.2 | 42.7 | 148.5 | 63.5 | 112.0 |
| Relative Difficulty | | | | | | | | | | | | | | | | | | |

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# Overall Metric

- Need a way to rate different aircraft configurations by the requirements of the RFP
- Used an overall metric, combining four sub-metrics based on the results of the QFD
- Sub-metrics used target values to provide an rating for each section
- Sub-metrics
  - Efficiency Rating (EfR)
  - Mission Rating (MiR)
  - Emission Rating (EmR)
  - Cost Rating (CR)

| | Overall Metric |
|---|---|
| Ecocopter | 0.785 |
| MD 500E | 0.700 |
| MD 520 | 0.677 |
| EC 120 | 0.671 |
| Bell 206L4 | 0.658 |
| EC 130 | 0.641 |
| Bell 407 | 0.609 |

# Vehicle Sizing and Performance

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- Baseline Vehicle Configuration
  - Focused on high efficiency and low emissions
    - Single main rotor helicopter
    - Fenestron anit-torque system
    - Skid landing gear
- Methodology
  - CIRADS ($R_f$ method)
  - Design Matrix

| Fuselage Dimensions | |
|---|---|
| Length | 8.7 m |
| Height | 2.74 m |
| Width | 2 m |

| Weights | |
|---|---|
| Gross Weight | 1615 kg |
| Empty Weight | 858 kg |
| Fuel Weight | 158 kg |
| Payload | 757 kg |

| Main Rotor | |
|---|---|
| Radius | 4.42 m |
| Number of Blades | 4 |
| Solidity | 0.05 |
| Tip speed | 206 m/s |
| Tip Taper Ratio | 5:3 |
| Shaft Tilt | 0° |
| Disk Loading | 217 N/m$^2$ |
| Twist Rates | -8° linear |

| Performance | |
|---|---|
| Recommended Cruise | 114 kts |
| Max Airspeed | 159 kts |
| Endurance Airspeed | 71 kts |
| Max ROC | 630 m/min |
| Range with 20min reserve | 411 Nmi |
| Endurance with 20min reserve | 4.5 hr |

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# Vehicle Sizing and Performance

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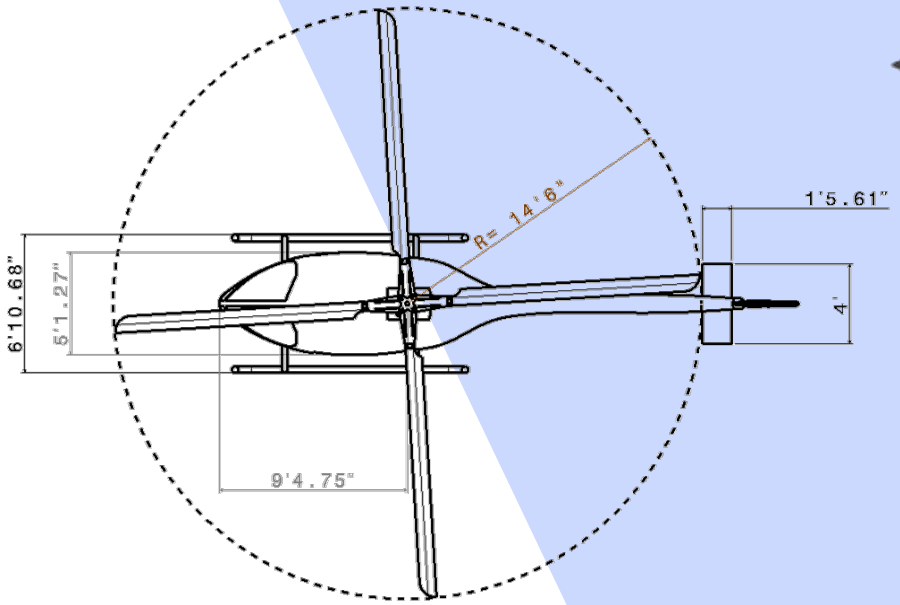


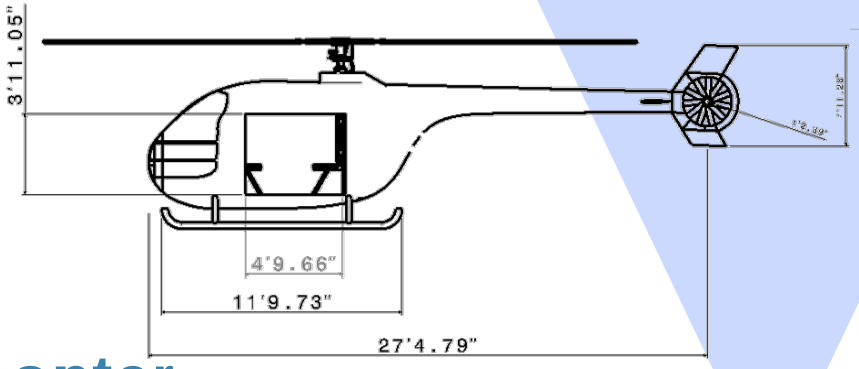


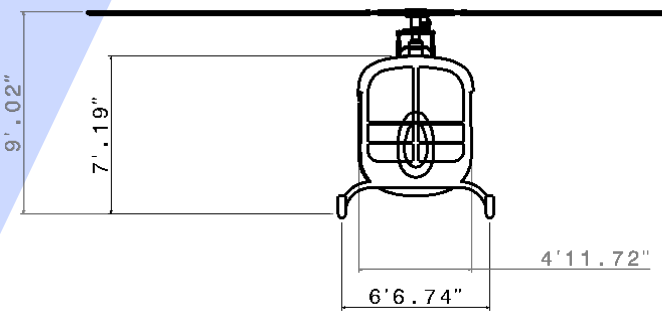


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# Key Design Features

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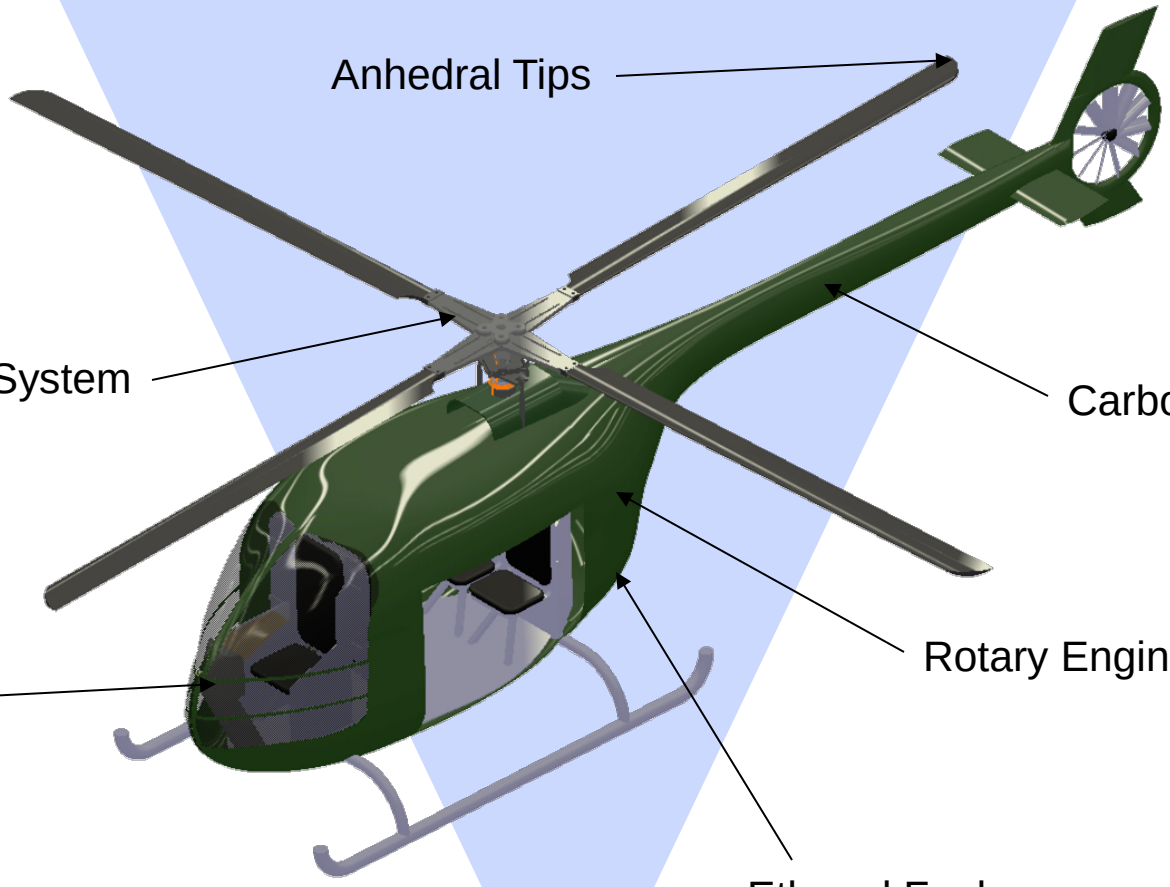


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# Rotor System

- Hingeless Rotor System
  - Use of material flexing to compensate for dissymmetry of life, flapping, and lead/lag

- Starflex (Eurocopter AS series)
- Spheriflex (Eurocopter EC series)

## Pros

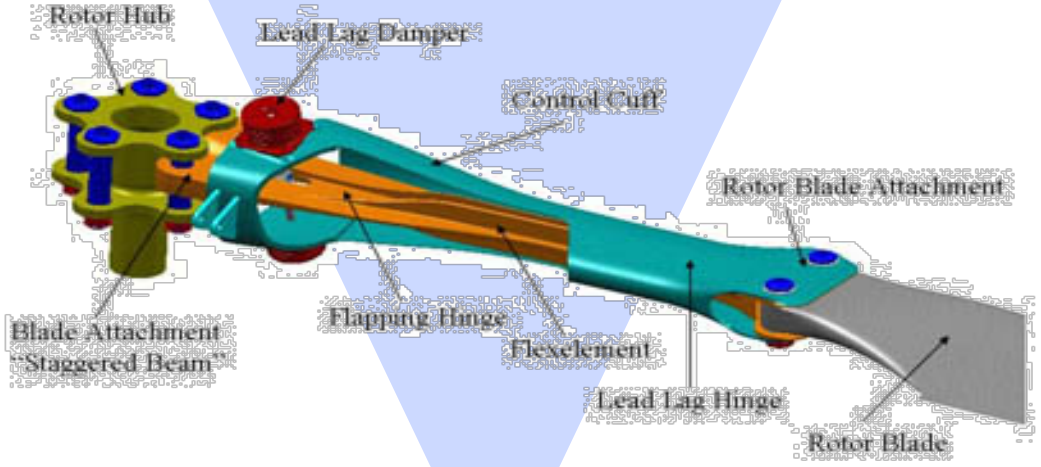
- Fewer Parts
- Simplicity
- Reduction in hub vibrations

## Cons

- Cost (composite material and manufacturing)

# Rotor System

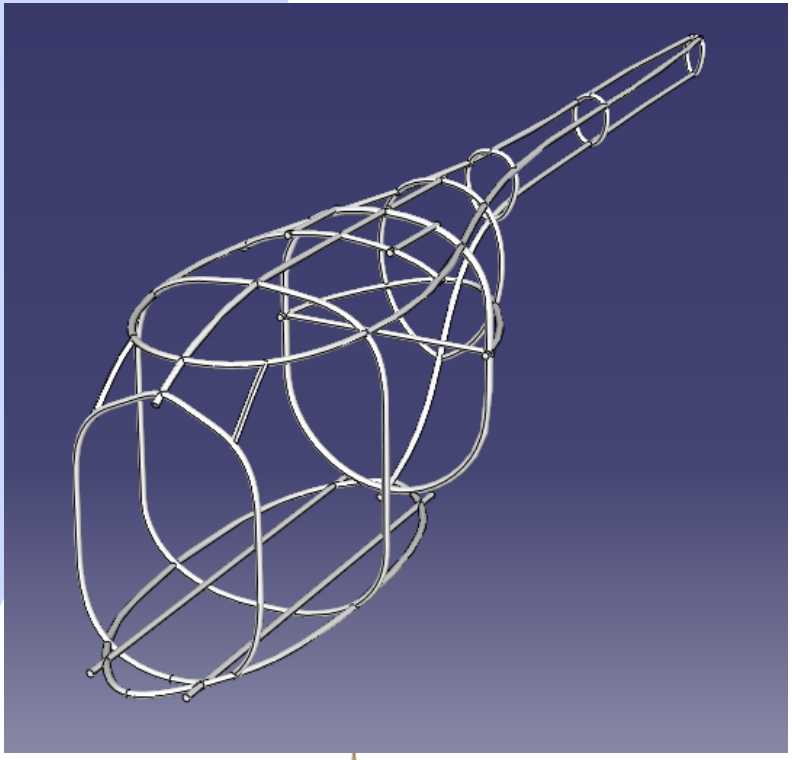
- Advanced Technology Rotor (ATR)
  - Hingeless and bearingless system
  - Feathering accomplished by beam twisting
  - Developed by Eurocopter
  - Modified for the Ecocopter's four blade rotor system



# Structural Analysis



- Structural members to support helicopter frame
  - Maneuvering loads
    - Main rotor: +3.5g, -1.0g
    - Tail rotor
  - Crash loads
    - Frame floor impact: 4.5g
- Designed in CATIA
- Analyzed in ABAQUS



# Freedom Rotapower 530

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| | |
|---|---|
| Type | Rotary |
| Fuels | Multi-fuel Capable |
| Power | 300 HP |
| Weight | 140 lb |
| Power Density | .47 lb/HP |
| SFC | .4 lb/HP-hr |
| Emissions | SULEV |

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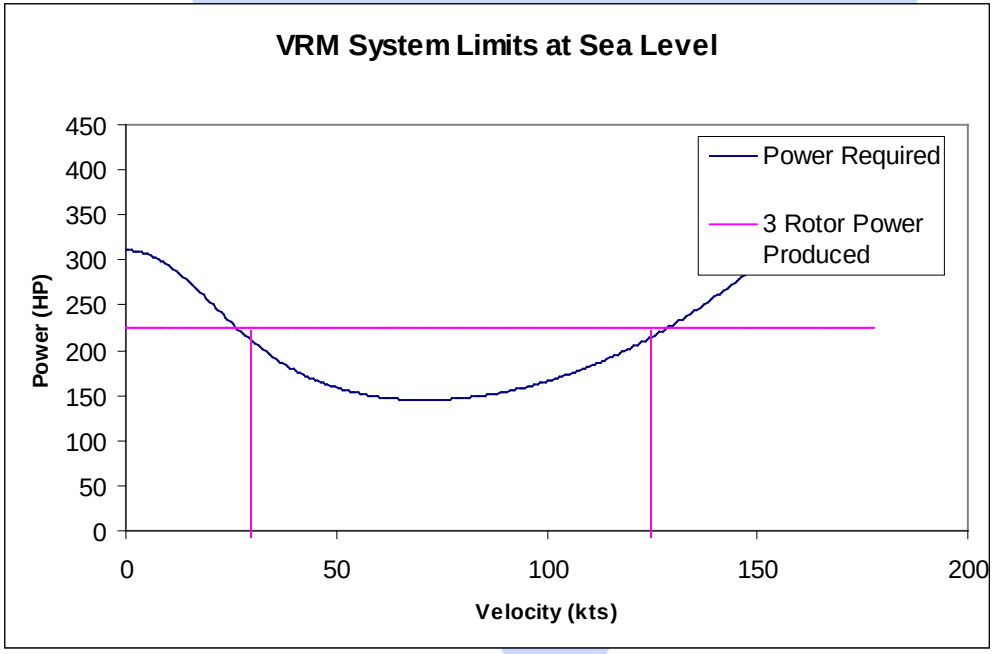
# Engine Configuration

- VRM System
  - Engine computer shuts off fuel injectors and spark plugs to inactive rotors
  - Solenoid detaches inactive rotors from camshaft
- VRM Conditions



# Fuel Selection

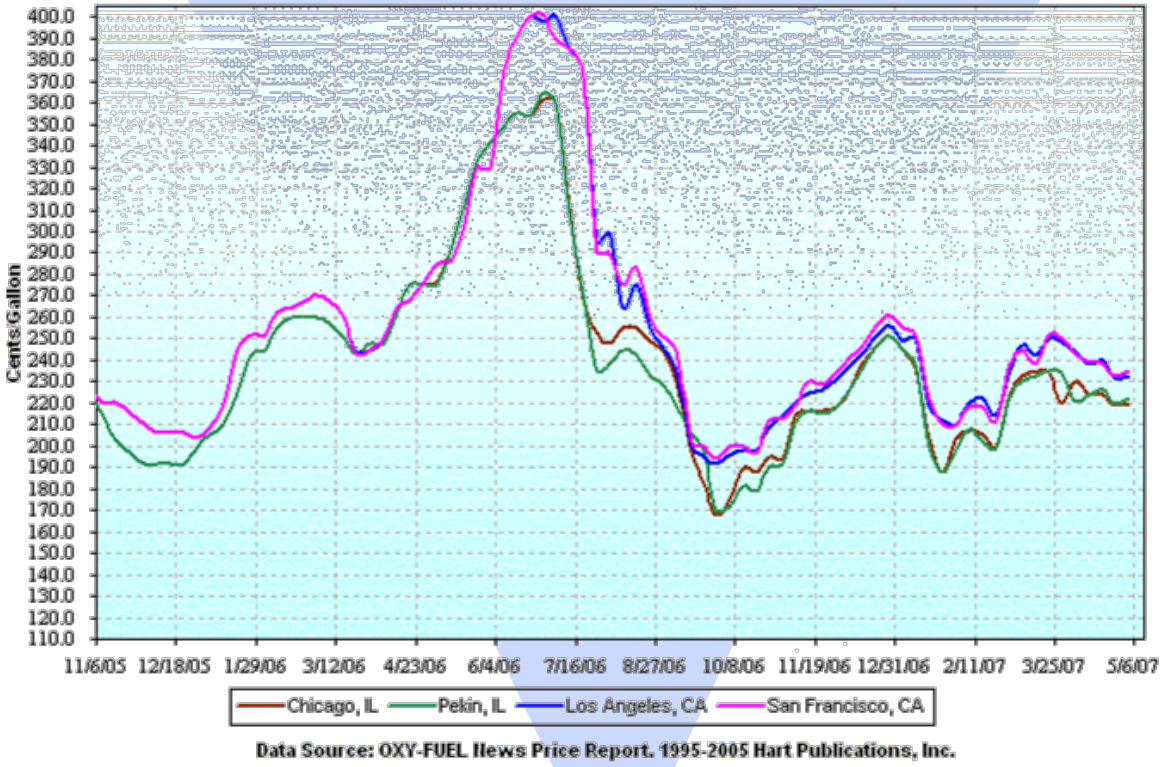
- Fuel Selected: Ethanol

| Compound | Emissions (g/hp-hr) |
|---|---|
| NOx | 0.016 |
| CO | 0.03 |
| UHC | 0.0043 |

  - 25% lower CO2 emissions compared to Gasoline
  - Renewable Resource
  - Lower Cost than Gasoline

# Fuel Selection

- Ethanol Costs Since 2005

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# Control System Hierarchy

Standard Operating Mode

Emergency Situation

Autopilot

Waypoint Tracking

Route Planning

Automated Landing

Nearest Suitable Land Site

Pilot Assisted Control

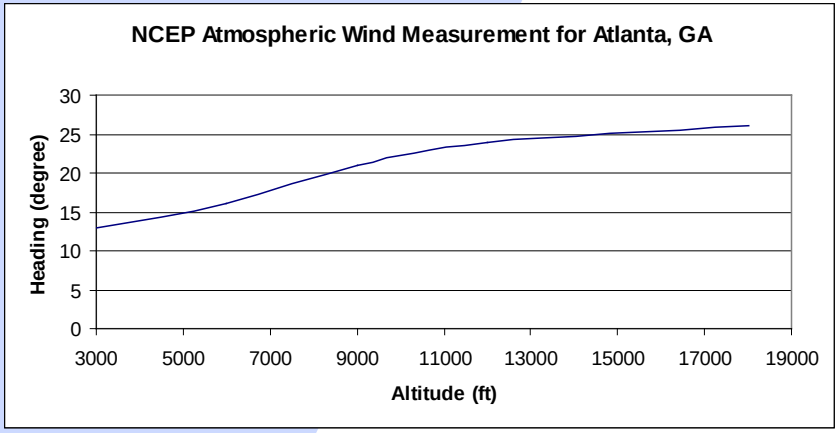
Limited Authority Control

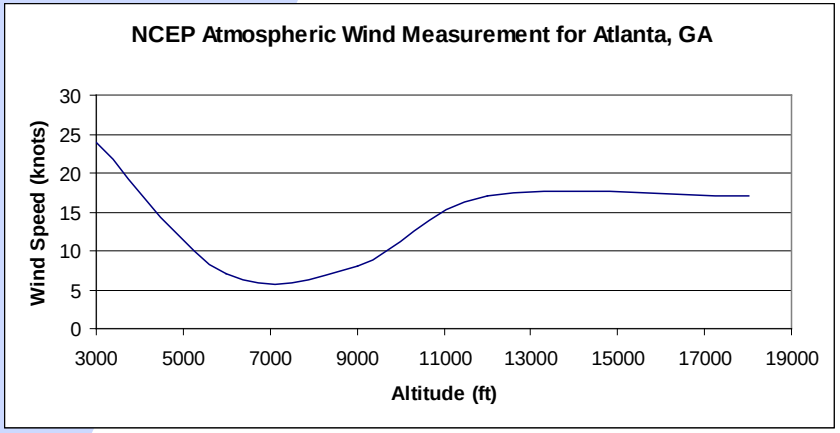
Full Autonomy

# Advanced Route Planning



- NOAA NCEP Winds Aloft forecasts report wind speed variations of approximately 5-7 knots and ~5° heading variations every 3000ft



# Advanced Route Planning

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- Atmospheric based route planning will provide a noticeable improvement to performance

| Cruise power required @ 5000ft | | |
|---|---|---|
| Condition | Power Required | % Power Reduction |
| 0 knot tailwind | 210 | 0 |
| 5 knot tailwind | 199.3 | 5.0952 |
| 10 knot tailwind | 189.8 | 9.619 |

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# Cost Analysis

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- Reviewed direct operating costs per flight hour using the Bell Cost Model using very conservative values for fuel costs

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| | | | |
|---|---|---|---|
| **DIRECT OPERATING COST** | | | |
| **FUEL AND LUBRICANTS** | | | |
| FUEL (13.7 GAL/FH @ $2.50/GAL) | $34.13 | | |
| LUBRICANTS @ 3.0% OF FUEL COST | 1.02 | | |
| **TOTAL FUEL AND LUBRICANTS** | | **$35.15** | |
| **AIRFRAME MAINTENANCE** | | | |
| LINE MAINTENANCE (0.215 MH/FH) | $10.75 | | |
| LIFE-LIMITED PARTS (REMOVE/REPLACE 0.018 MH/FH) | 0.92 | | |
| LIFE-LIMITED PARTS COST | 45.38 | | |
| OVERHAUL PARTS (REMOVE/REPLACE 0.001 MH/FH) | 0.04 | | |
| OVERHAUL PARTS (COST TO OVERHAUL) | 6.35 | | |
| UNSCHEDULED REMOVE/REPLACE LABOR (0.563 MH/FH) | 28.14 | | |
| UNSCHEDULED PARTS COST | 33.43 | | |
| **TOTAL AIRFRAME MAINTENANCE** | | **$125.01** | |
| **POWERPLANT OVERHAUL AND MAINTENANCE** | | **$54.70** | |
| **TOTAL DIRECT OPERATING COST** | | | **$214.87** |

- Published operating cost values for competitors were outdated and values based on current fuel prices were calculated

| Helicopter | Operating Cost ($2001) | Operating Cost ($2008) |
|---|---|---|
| Ecocopter | N/A | $215 |
| EC-120 | $220 | $297 |
| MD500 | $220 | $284 |

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# Conclusion

Everything you would expect from a “green” helicopter…

- Superior Engine Performance
  - High Efficiency
  - Low Emissions
  - Multi-fuel capable

- Improved Safety
  - Fenestron Anti-torque System
  - High Autorotative Index
  - Emergency Autonomous Control

… and more.