



# Land Wind Racer

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# Objective

Design and construct a 100% wind powered vehicle capable of winning the CCHCC Celebration of Wind race.



# CCHEC Celebration of Wind Race

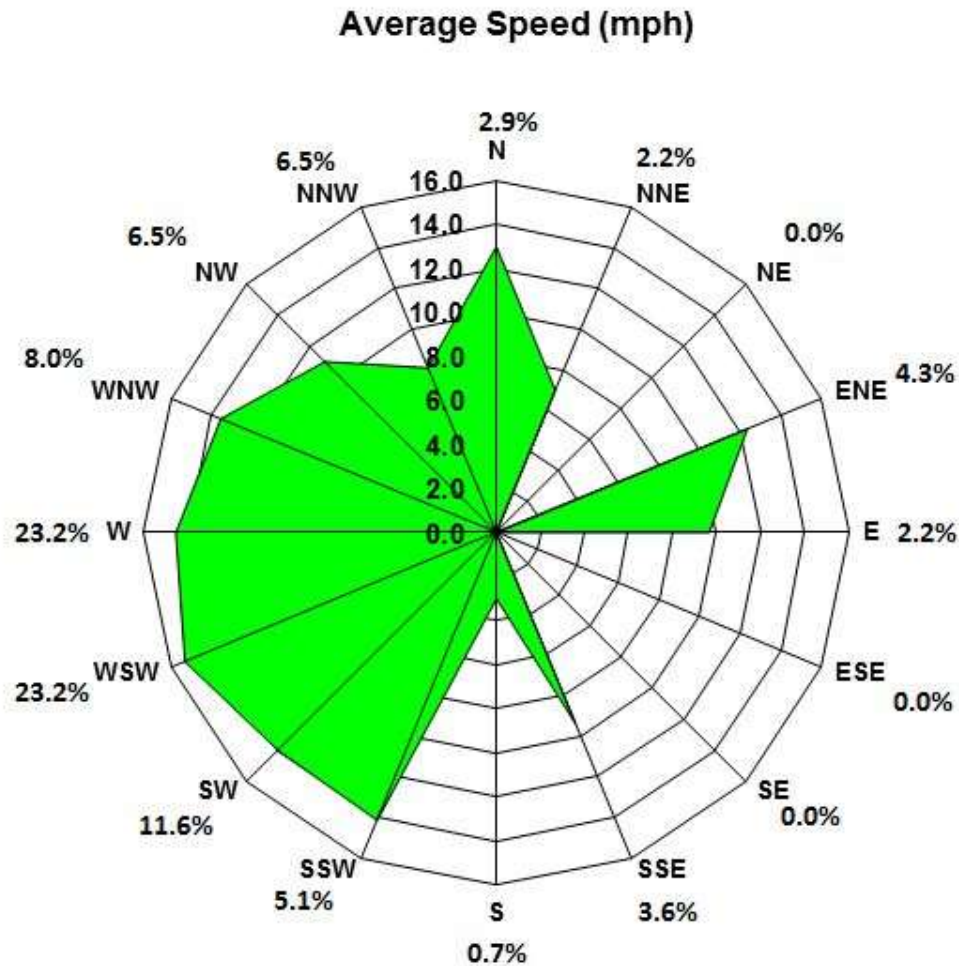


- May 4, 2013 in Rawlins, WY
- Course Length: 650 yd
- Road Surface: Asphalt
- West to East

# Competition Rules ([cchec.org](http://cchec.org))

- All vehicles must be wind powered
- Vehicles must have a minimum of 3 wheels
- Minimum wheel diameter: 5 inches
- Braking and directional controls
- No commercially made vehicles
- Carry one or more people
- Height limited to 13 feet, 6 inches

# CCHEC Celebration of Wind Race



Wind Rose (Month of April, 2008-2012). Source: [www.wunderground.com](http://www.wunderground.com)

# Project Specifications

Category	Specification(s)
<b>Propulsion</b>	<ul style="list-style-type: none"><li>• Direct tailwind to direct crosswind operation.</li><li>• Operational to a wind speed of 40 mph.</li></ul>
<b>Safety</b>	<ul style="list-style-type: none"><li>• Minimize rolling, tipping and driver ejection.</li><li>• Inhibit driver contact with road surface.</li></ul>
<b>Transportation Size</b>	<ul style="list-style-type: none"><li>• Fit in the bed of a pickup (3' x 4' x 12')</li><li>• 120 lbs (vehicle only, no operator).</li></ul>
<b>Pre-race Assembly</b>	<ul style="list-style-type: none"><li>• Assembled in 20 minutes with basic tools.</li></ul>
<b>Road Conditions</b>	<ul style="list-style-type: none"><li>• Asphalt or groomed dirt roads.</li></ul>
<b>Operator Requirements</b>	<ul style="list-style-type: none"><li>• Height range: 5'2" – 6'4"</li><li>• Operator weight limit: 250 lbs.</li></ul>
<b>Steering &amp; Braking</b>	<ul style="list-style-type: none"><li>• Turning radius of 20 feet.</li><li>• lock up wheels on dry asphalt.</li></ul>

# Design Alternatives

## **Elimination Criteria**

- Crosswind Capable?
- Tailwind Capable?
- Within Race Rules?
- Cost Effective?
- Manufacturable?

# Mechanical & Electrical Turbine



Source: [engineeringontheedge.com](http://engineeringontheedge.com)

# Solid Airfoil Sail



Source: [designophy.com](http://designophy.com)

# Spinnaker Sail



Source: en.academic.ru

# Crosswind Sail

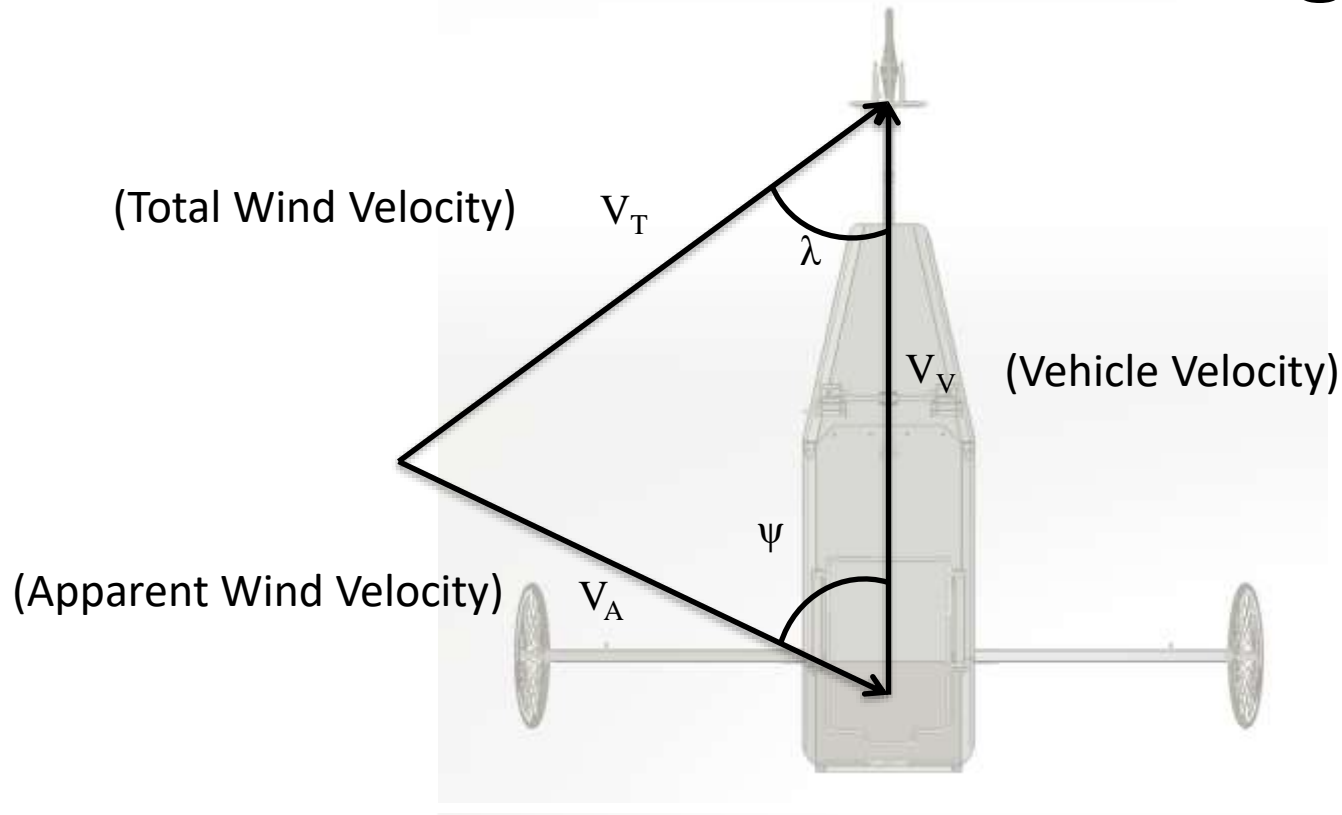


Source: [seabreeze.com.au](http://seabreeze.com.au)

# Dual Sails



# Mathematical Modeling

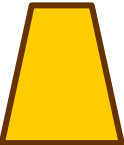




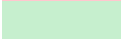
$$V_A = \sqrt{V_T^2 + V_V^2 - 2 \cdot V_T \cdot V_V \cdot \cos(\lambda)}$$

$$F = \frac{1}{2} \cdot \frac{\rho}{g_c} \cdot A \cdot C \cdot V_A^2$$

# Mathematical Modeling

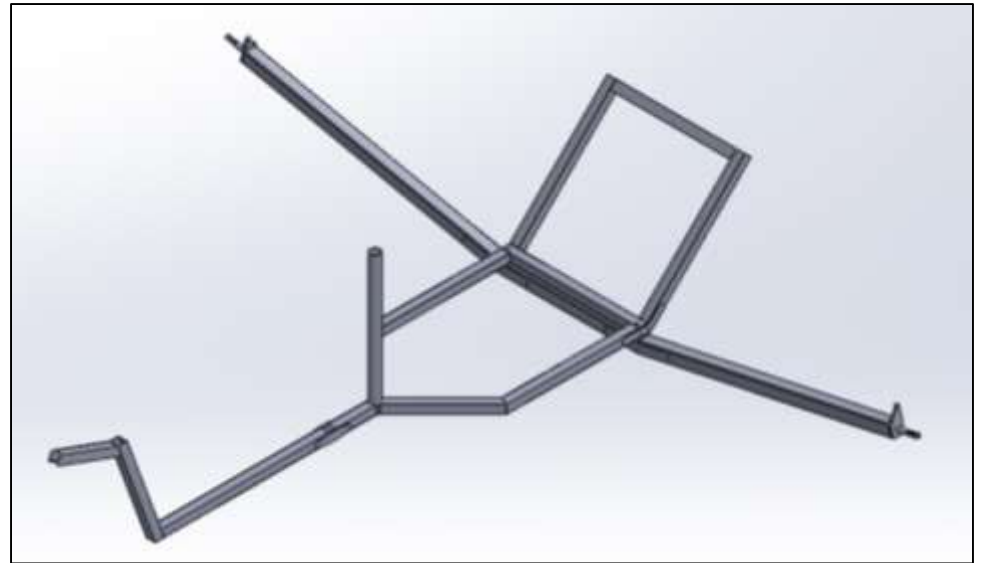
Stability profile for a variety of frame geometries

				Wind Speed = 40 mph True Wind Angle = 90 Degrees CG Location = 9 Feet From Front Axle							
				Vehicle Speed (mph)							
				10	20	30	40	50	60	70	
	Rear Axle is 10 ft Wide	Front Axle Width (ft)	0	646	374	34	-395	-917	-1540	-2260	
			2	740	478	151	-263	-765	-1365	-2059	
			4	826	572	255	-146	-633	-1215	-1888	
			6	900	651	342	-50	-526	-1094	-1751	
			8	958	713	408	22	-447	-1007	-1655	
Square Platform			10	998	754	451	67	-400	-957	-1602	
	Front Axle is 10 ft Wide	Rear Axle Width (ft)	8	719	474	170	-217	-686	-1246	-1893	
			6	429	181	-129	-520	-997	-1564	-2222	
			4	137	-118	-434	-836	-1323	-1904	-2577	
			2	-151	-413	-740	-1154	-1657	-2257	-2951	
			0	-427	-700	-1039	-1468	-1990	-2613	-3334	

Will Overturn   
Will Not Overturn 

# Vehicle Design

- Frame Geometry
  - 10.5' Overall Length
  - 10' Track
  - 12° camber
- Material
  - Frame: A513
  - Mast: 6061 T6



# Vehicle Design

- Propulsion
  - Dual sail configuration



# Vehicle Design

- Cam cleats for quick release



# Vehicle Design

- Guy-wire system



# Vehicle Design

- Foot Operated Steering and Braking
- Adjustable Head Tube Angle



# Vehicle Design

- Aluminum Floor Plate



# Vehicle Design

- Adjustable Seat Position



# Compliance Testing

- Preliminary Testing
- Top Speed Test
- Turning Radius Test
- Propulsion Disengagement & Braking Test

# Compliance Testing Modifications

- Ground Clearance



# Compliance Testing Modifications

- Front Wheel Dynamic Stability Issues



Old Design: Dual Cables



New Design: Single Tie Rod

# Compliance Testing Modifications

- Driver Position Adjustments



# Compliance Testing Modifications

- Rigging Adjustments



# Compliance Testing Modifications

- Seat Reconstruction



# Cost Analysis

Engineering	\$ 33,200
Construction	\$ 7,300
Materials	\$ 900
Total	\$41,400

# Conclusion

- Results of Design
  - Fun and easy to drive
  - In compliance with race rules
  - Meets all specifications except weight requirement
- Recommendations for Future Projects
  - Reduce vehicle weight
  - Consider driver seating

# Special Thanks

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# ZEPHYR RACING



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