2008 North American Handmade Bicycle Show

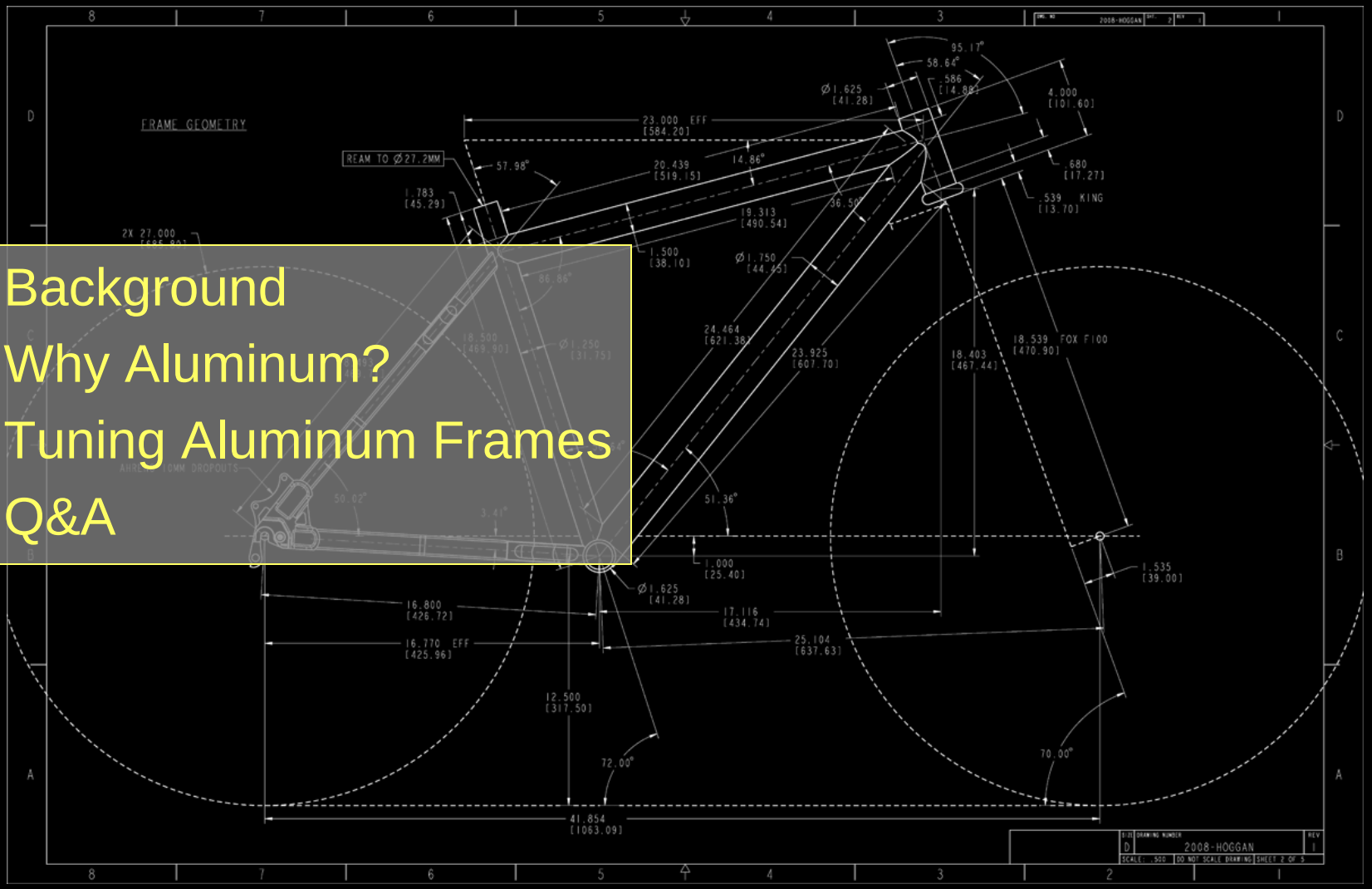
Aluminum Frame Design Considerations

by Mike Ahrens

February 8, 2008

ahrens BICYCLES

Seminar Topics

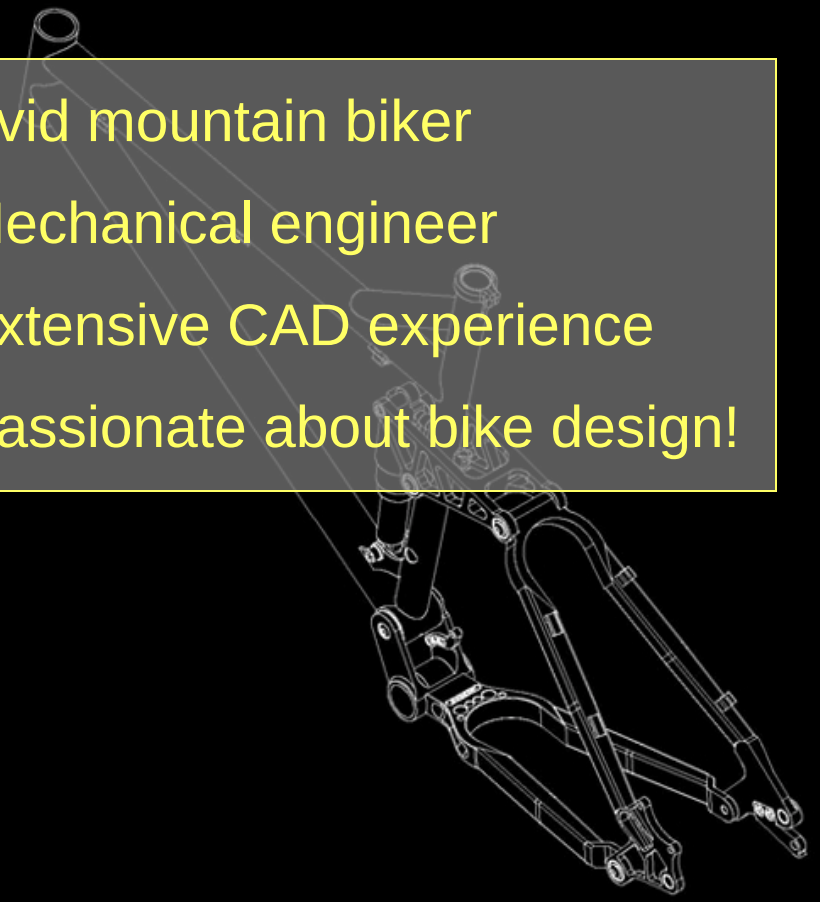


- Background
- Why Aluminum?
- Tuning Aluminum Frames
- Q&A

ahrens BICYCLES

Mike’s Background

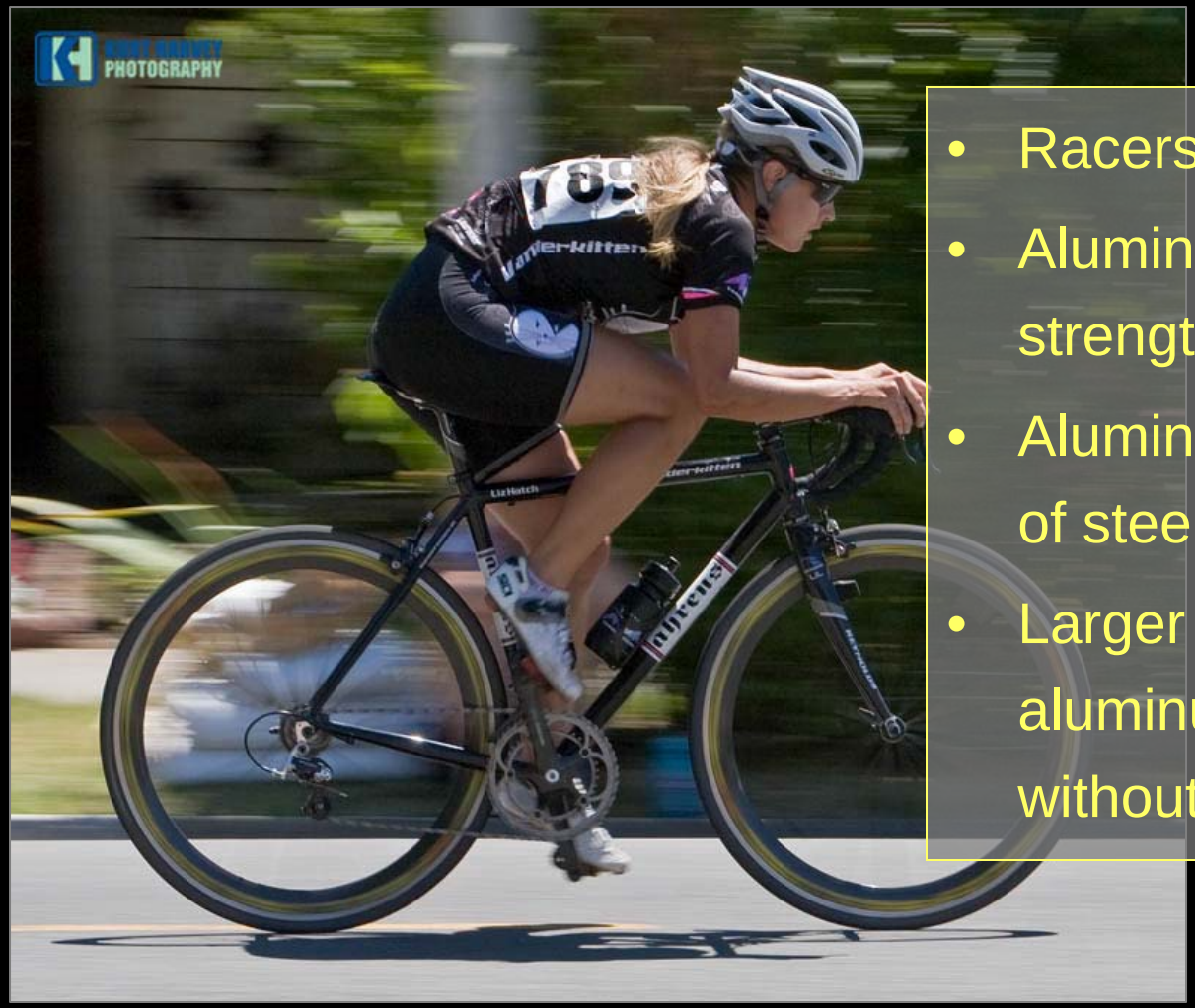
- Avid mountain biker
- Mechanical engineer
- Extensive CAD experience
- Passionate about bike design!



Rider: Mike Ahrens/Ahrens Bicycles

ahrens BICYCLES

Why Aluminum?

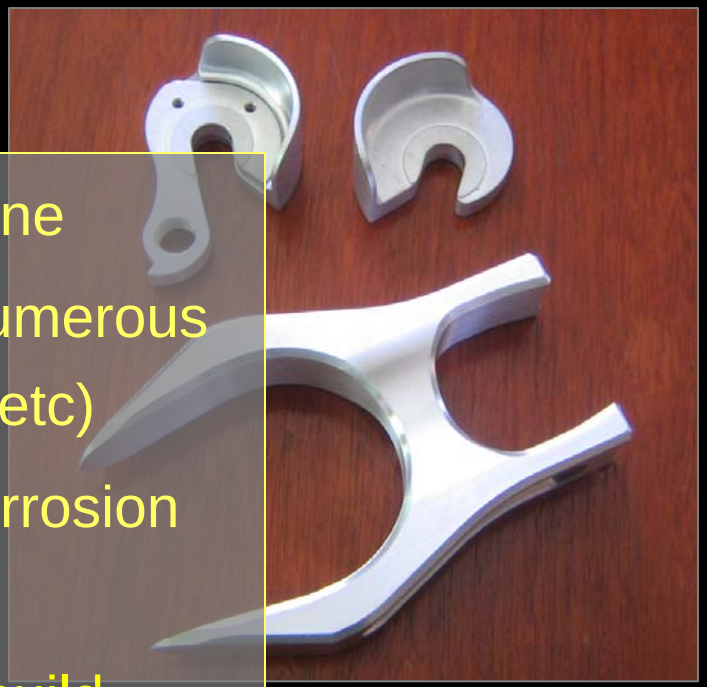


- Racers demand performance
- Aluminum has an excellent strength-to-weight ratio
- Aluminum's density is 1/3 that of steel (0.098 lb/in^3)
- Larger diameter, taperwall aluminum tubes can be used without weight penalty

Racer: Liz Hatch/Vanderkitten

ahrens BICYCLES

Why Aluminum – cont



- Aluminum is easy to machine
- Aluminum is available in numerous formats (bar stock, tubing, etc)
- Aluminum has excellent corrosion resistance
- Aluminum can be used to build lightweight bicycle frames with highly-tuned stiffness characteristics

ahrens BICYCLES

Common Bicycle Alloys

- 6061 and 7005 aluminum are the most common grades for bicycle applications
- Both grades require heat treatment after welding to achieve proper mechanical strength
- This seminar will focus on **7005** alloy

ahrens
BICYCLES

7005 Alloy

- Zinc is the major alloying element
- 7005 has good fracture toughness, easy formability and good corrosion resistance
- After welding, 7005 can be polished, painted or powdercoated
- Powdercoat temperatures must be closely monitored as to not over-age frames after heat treating

ahrens BICYCLES

7005 Alloy – cont

- Stress Corrosion Cracking (SCC) is a known failure mode with 7000-series alloys containing copper (such as 7075)
- However, 7005 materials used for bicycle frames ***do not*** contain copper and are much less susceptible to SCC
- The key to minimizing SCC is to minimize the chance of cracks from starting in the first place
- Good manufacturing practice includes close-tolerance mitering, using correct filler rod and prompt frame alignment

Racer: Christine Vardaros/Vanderkitten

ahrens BICYCLES

7005 Heat Treating

- 7005 tubing comes pre-heat treated; thus no solution heat treatment is required (only artificial aging after welding)
- Residual stress remains in the frame after the welding process; it's important to relieve the majority of these stresses through a controlled heat treating process
- Proper heat treating creates precipitates within the grain structure at desired locations; ultimately improving hardness

Racer: Mandy Lozano/Vanderkitten

ahrens BICYCLES

7005 Heat Treating – cont

- Precipitates serve to strengthen the material by minimizing the movement of dislocations between adjacent grain boundaries
- Artificial aging process for 7005 frames:
  - 6 hours @ 200°F
  - 4 hours @ 320°F

Racer: Liz Hatch/Vanderkitten

ahrens BICYCLES

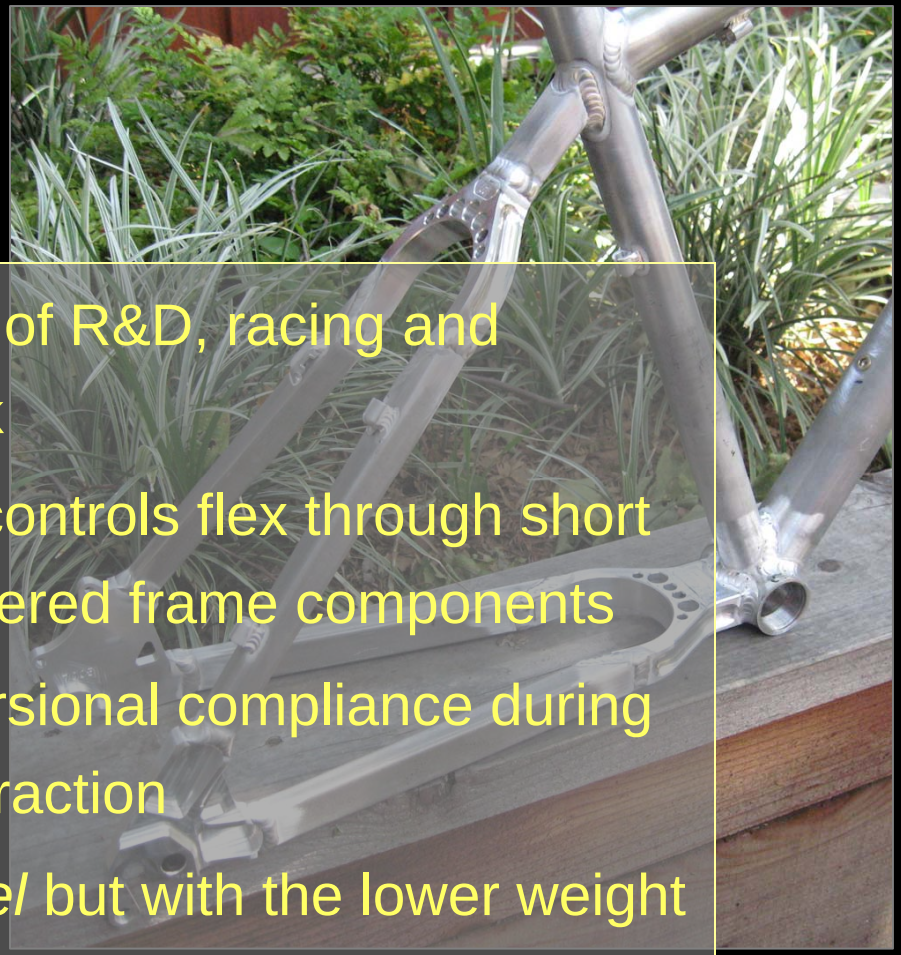
Tuning Aluminum Frames

- Open communication is the key to understanding the rider's needs, their riding style and pros/cons of their current setup
- Frame designer develops a comprehensive solution that encourages proper fit in all riding scenarios
- Frame designer provides custom frame design utilizing appropriate geometry and tubing profiles for the application

Racer: Christine Vardaros/Vanderkitten

ahrens BICYCLES

Signature Rear Triangle



- Developed over 7 years of R&D, racing and extensive rider feedback
- Wishbone rear triangle controls flex through short tube lengths and engineered frame components
- This design improves torsional compliance during descents for increased traction
- Similar to the *feel of steel* but with the lower weight of aluminum

ahrens BICYCLES

Practical Design Approach

- Lower Yoke has been designed to resist bottom bracket twisting under load for increased powertrain efficiency
- Forward motion is achieved with less effort from the rider, minimizing rider fatigue
- Lower/Upper Yoke designs enhance torsional compliance on hardtail frames
- Excellent rear tire & crank arm clearance is achieved with this approach

ahrens BICYCLES

Modularity

- Our library of 7005 frame components are modular in nature
- Modularity makes it easy to develop custom frames around popular wheel sizes

  (26” • 650B • 29” • 700C)
- Other frame builders can incorporate these components into their frames

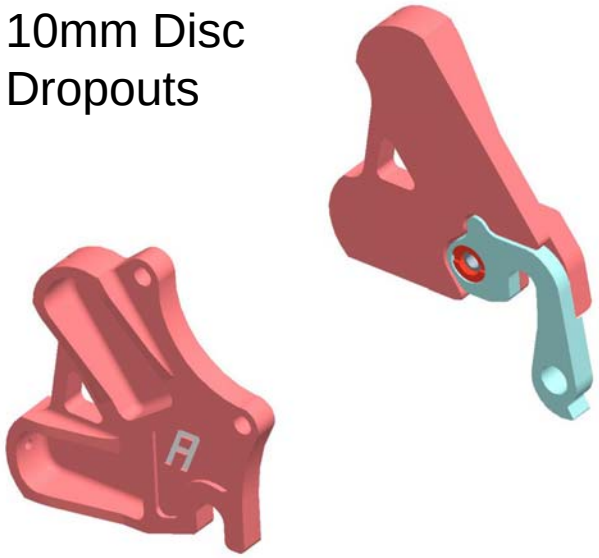
Top Image: Siren Bicycles *96er*

Bottom Image: Rock Lobster *29er*

ahrens BICYCLES

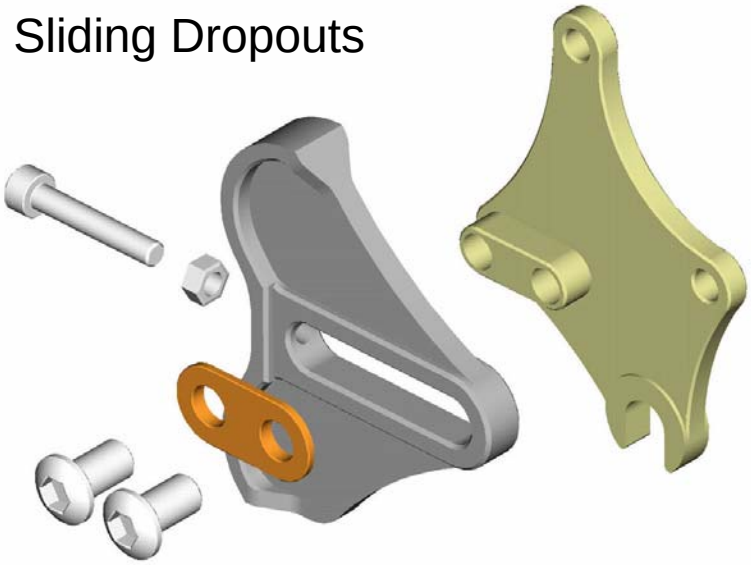
Frame Component Library

10mm Disc Dropouts

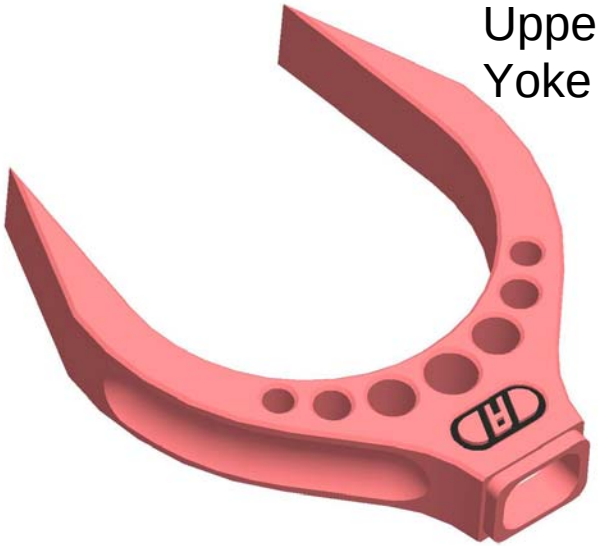


Lower Yoke

Sliding Dropouts



Upper Yoke



ahrens BICYCLES

Ease of Fabrication

- Dropout ‘hoods’ are semi-circular and easily accommodate custom frame sizing
- Welding vent holes are pre-machined into dropout designs
- Yoke holes save weight and double as tooling holes for use with Anvil fixtures
- Components are precision CNC-machined and inspected to aerospace standards

ahrens BICYCLES

Summary

- Aluminum is a viable material for developing handmade, lightweight and durable bicycle frames for numerous riding styles
- Ahrens Bicycles has developed modular frame components which help tune ride quality and ease manufacturing
- Surprisingly, very few custom frame builders use this versatile material
- **Consider aluminum as the material for your next custom frame!**

Rider: Maureen Kunz/Vanderkitten

ahrens BICYCLES

Source List

Aluminum Tubing:

- Easton Sports (7005, EA6X material)
- Columbus (7005 material)

Suppliers:

- Nova Cycle Supply (6061, 7005 material)
- Fairing (6061, 7005 material)

Background Info:

- “Fabrication Instructions for 6061 and 7005 Tube Sets” article (downloaded from www.eastonbike.com)
- “Metallurgy for Cyclists” article by Scot Nicol (downloaded from www.frameforum.net)
- “The Art of Bicycles” article by Gary Klein (downloaded from www.ibike.com)
- “Stress Corrosion Cracking of Aluminum Alloys” article (downloaded from www.key-to-nonferrous.com)

ahrens BICYCLES