



16.810 Critical Design Review Crossover Bicycle

Team 3

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Introduction and Initial Design

❖ Cross Over Bicycle designed for mass consumer market

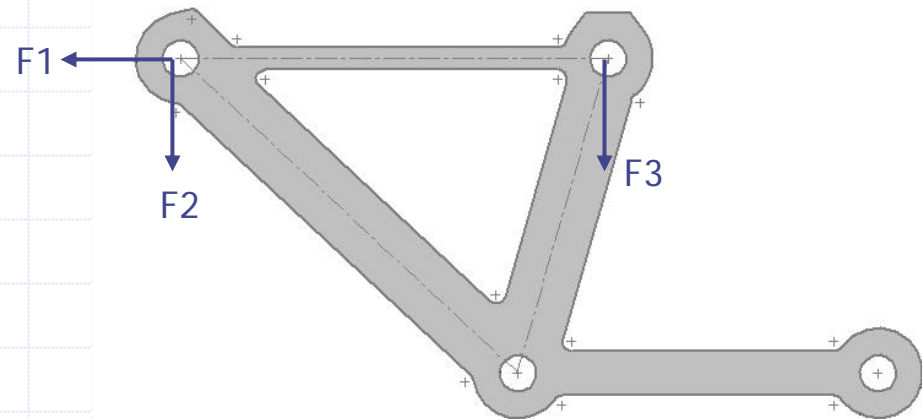
- Constrain Mass
- Optimize Cost
- Accept Performance

❖ Loading Cases

- $F1 = 50$ lbs
- $F2 = 75$ lbs
- $F3 = 75$ lbs

❖ Requirements

- $\Delta 1 < 0.060$ mm
- $\Delta 2 < 0.009$ mm
- Natural Frequency > 505 Hz
- Mass $< .27$ lbs
- Cost $< \$5.20$ per part
- Cutting Quality = 4



**Initial CAD Design from
Hand Sketch**

Version 1: Manufactured and Tested

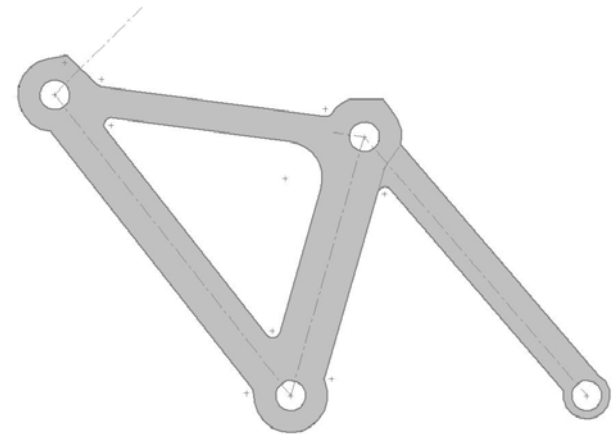
❖ Manufactured part slightly different from original design

- Bar between bottom holes moved because it was not being stressed
- Design freedom used on the “fork” hole: moved diagonally upward
- Individual bar widths modified to redistribute mass

❖ FEM and Test Results

Parameter	Constraint	FEM Version 1	Test Version 1
Cost	< \$5.2	\$5.22	\$5.22
delta 1 (mm)	< 0.060	0.052	0.156
delta 2 (mm)	< 0.009	0.0034	0.051
Unrestrained Natural Frequency (Hz)	> 505	476	486
Mass (lbs)	< 0.27	0.246	0.25

- All displacements were met with FEM
- Displacements were ~1/5 and 4/5 less than constraints
- Test Delta 1 is factor of 3 greater than FEM
- Test Delta 2 is factor of 15 greater than FEM



**Manufactured Version 1
CAD Design**

Version 2: Manufactured and Tested

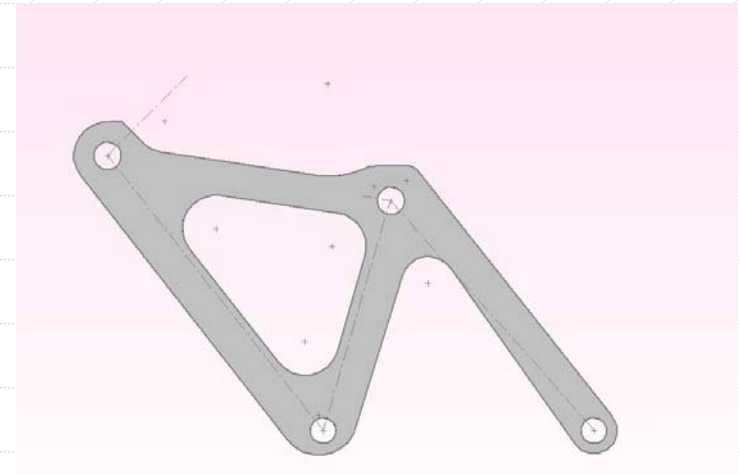
❖ Goal to minimize cost while staying exactly at mass limit

- Fillet Radii increased to decrease cutting time
- Straight paths joining holes
- Altered thickness of bars

❖ FEM and Test Results

Parameter	Constraint	FEM Version 2	Test Version 2
Cost	< \$5.2	\$5.05	\$5.05
delta 1 (mm)	< 0.060	0.045	0.0685
delta 2 (mm)	< 0.009	0.0055	0.0598
Unrestrained Natural Frequency (Hz)	> 505	487	506
Mass (lbs)	< 0.27	0.27	0.279

- All displacements were met with FEM
- Displacements were ~1/4 less than constraints
- Test Delta 1 is factor of 1.5 greater than FEM
- Test Delta 2 is factor of 10.9 greater than FEM



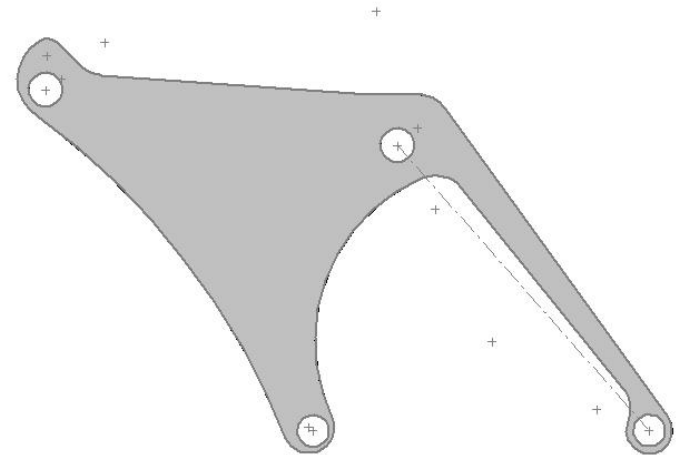
**Manufactured Version 2
CAD Design**

Alternative “Boomerang” design

- ❖ Goal to eliminate hole in middle to drastically cut cost
- ❖ Optimized mass distribution through iterations to improve performance.
- ❖ FEM and Test Results

Parameter	Constraint	FEM Version 1	Test Version 1
Cost	< \$5.2	\$4.05	\$4.05
delta 1 (mm)	< 0.060	0.0692	0.090
delta 2 (mm)	< 0.009	0.0064	0.022
Unrestrained Natural Frequency (Hz)	> 505	544	563
Mass (lbs)	< 0.27	0.27	0.272

- All except delta 1 were FEM compliant
- Delta 1 is factor of 1.3 greater than FEM
- Delta 2 is factor of 3.43 greater than FEM



New Boomerang CAD Design