Buckeye Bullet
The Story of 3 Electric Land Speed Record Cars

ODOT Planning Conference – Transportation Technology Session
Columbus, OH
July 15th 2014

David Cooke
Venturi Buckeye Bullet Racing Team
Team Leader

THE OHIO STATE UNIVERSITY
The History of OSU EV Racing

- Ohio State Motorsports
- The Bullet Team
- Landspeed Racing
- Buckeye Bullet 1
- Buckeye Bullet 2
- Buckeye Bullet 2.5
- Buckeye Bullet 3
The Buckeye Bullet Team

Student Team

- 11 Team Members
- Mechanical, Electrical, Aerospace, Welding, and, Materials Engineering
- Design, Communications, Business
- 3 Graduate Students
- High School Interns
- Over 100 Students involved over program life

Team Alumni

- 16 Masters and 1 PhD
- Over 100 Students involved over program life
- Superior Job Placement Around the World

OSU Advisors

- Dr. Giorgio Rizzoni – Faculty Advisor
- Don Butler – Staff Advisor
Similar Records of Interest

“White Lightning”

- World’s Fastest Electric Vehicle (FIA)
- Ni-Mh Battery Powered
- October, 1999
- 245.524 MPH - FIA

“The Turbinator”

- Ultimate Wheel Driven Record Holder
- Turboshaft Engine Driven 4 Wheel Drive
- October, 2001
- 458.440 MPH - FIA

“Burkland Family Streamliner”

- World’s Fastest Piston Engine Vehicle
- September, 2008
- 415.896 MPH - FIA

“Thrust SSC”

- Ultimate Landspeed Record
- Jet Turbine Engine
- October 1997
- 763.035 MPH - FIA

“The Turbinator”

- Ultimate Wheel Driven Record Holder
- Turboshaft Engine Driven 4 Wheel Drive
- October, 2001
- 458.440 MPH - FIA
**History of EV Racing**

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**“The Jeantaude”**
- Lead Acid Battery
- Credited with the first Land Speed Record
- 1899
- 57.6 MPH

**“The La Jamais Contente”**
- Lead Acid Battery
- First Vehicle Over 100 KPH
- 1899
- 100 KPH

**“The Lead Wedge”**
- Lead Acid Battery
- 1968
- 138 MPH

**“The Silver Eagle”**
- Lead Acid Battery
- 1972
- 146.4 MPH

**“The Lightning Rod”**
- Lead Acid Batteries
- 1997
- 213.084 MPH

**“The White Lightning”**
- NiMH Batteries
- 1999
- 245.52 MPH
The racing conditions at Bonneville make it one of the most popular areas in the world for speed.

BNI hosts a spectacular week of racing each year in August, the highlight event of the “LSR” season.

“Speed Week” consists of six days of racing. Entrants come from all over the world to participate in the week long event.
Land Speed Racing

**US Land Speed Records**

- 4:00 hours
- US Records are certified by the SCTA-BNI
- 7 mile course
- Timed over 3, 4, and 5th mile
- Average of 2 runs in the *same direction*
- Up to 4 hours to service vehicle

**International Records**

- 1:00 hour
- International Records are certified by the FIA
- Any length course may be used
- Timed over middle mile and kilometer
- Average 2 runs in *opposite directions*
- Must be completed within 1 hour
Buckeye Bullet 1 - 2004

✓ First E-car to break 300 MPH Barrier ~ 308 MPH
✓ Peak Timed Mile ~ 321.737 MPH
✓ U.S. Land Speed Record ~ 314.958 MPH
✓ BNI International Record ~ 271.737 MPH
Buckeye Bullet 2 - 2009

September 25, 2009
303.025 mph (flying kilometer)
302.877 mph (flying mile)

Hydrogen Fuel Cell Electric Land Speed Streamliner
First Fuel cell-powered car over 300 mph
Fastest FIA Record for any Electric Car
www.buckeyebullet.com
Accomplishments; 1993 - 2010

Smokin’Buckeye
1993 – 2001
Most Winning Formula Lightning Vehicle
3 ABB National Championships

Buckeye Bullet 1
2001 – 2004
World’s Fastest NiMH Battery Vehicle – 315 MPH

Buckeye Bullet 2
2006 – 2009
World’s Fastest Hydrogen Fuel Cell Vehicle – 303 MPH
FIA World Record

Buckeye Bullet 2.5
2010
World’s Fastest Li-Ion Battery Vehicle – 308 MPH
FIA World Record
Wheel-driven vehicle records  
FIA – CATEGORY A – records over 1 mile

<table>
<thead>
<tr>
<th>Speed (MPH)</th>
<th>Speed (Km/h)</th>
<th>Vehicle</th>
<th>Team</th>
<th>Year</th>
<th>Record</th>
<th>Propulsion system</th>
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</thead>
<tbody>
<tr>
<td>458,444</td>
<td>737,794</td>
<td>Vesco Turbinator</td>
<td>Team Vesco</td>
<td>2001</td>
<td>FIA</td>
<td>1 turbine engine – 4WD</td>
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<tr>
<td>439,024</td>
<td>706,54</td>
<td>Speed Demon</td>
<td>Poteet and Main</td>
<td>2012</td>
<td>FIA</td>
<td>1 piston engine turbocharged - 2WD</td>
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<tr>
<td>415,896</td>
<td>669,319</td>
<td>Burkland's 411</td>
<td>Burkland Family</td>
<td>2008</td>
<td>FIA</td>
<td>2 piston engines Turbocharged - 4WD</td>
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<tr>
<td>414,316</td>
<td>666,776</td>
<td>Spirit of Rett</td>
<td>Charles Nearburg</td>
<td>2010</td>
<td>FIA</td>
<td>1 piston engine - 2WD</td>
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<tr>
<td>409,978</td>
<td>659,796</td>
<td>Speed-O-Motive</td>
<td>Al Teague</td>
<td>1991</td>
<td>FIA</td>
<td>4 piston engines - 2WD</td>
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<td>409,277</td>
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<td>Goldenrod</td>
<td>Summers Brothers</td>
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<td>403,100</td>
<td>648,727</td>
<td>Blue Bird</td>
<td>Donald Campbell</td>
<td>1964</td>
<td>FIA</td>
<td>1 turbine engine – 4WD</td>
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</tbody>
</table>
The Buckeye Bullet 3 - 2014

- 4 Wheel Drive
- Li-Ion Battery Power
- Advanced Lightweight Structure
- Initial Goal: 400 MPH
- Ultimate Goal: Fastest Wheel Driven Vehicle
Sub-Teams and Engineering Challenges

**Aero Team**
- Aerodynamic Design (Drag) Reduction
- Vehicle Stability
- Bodywork

**Electrical Team**
- Vehicle Modeling
- Battery Pack
- Inverters
- Control Systems
- Data Acquisition
- Wiring Harness
- Race Strategy

**Mechanical Team**
- Vehicle Packaging
- Chassis
- Cockpit
- Driveline (Motors / Transmission)
- Suspension / Steering / Driveshafts
- Tires / Wheels
- Parachutes
- Brakes
- Cooling Systems
CFD Development
Aero Studies – Rear Geometry
• 4.27% decrease in drag with a pointy rear
• Both cases have comparable stability
Bodywork Design
On Board Data

- Further model validation through on-the-track aero testing
- Testing equipment purchased
  - 32 input pressure scanner
    - Surface pressure measurements
  - Air-data probe
    - Velocity
    - Angle of attack
    - Yaw angle
    - Static pressure
    - Total pressure
  - Flow visualization paint
- VBB3 will be tested during the 2014 race season
MECHANICAL TEAM
Chassis
Driver Cell
Driveline Components

Motors

Inverter/Controllers

Gearbox
Motor Design
Motor Test Bench
Suspension Design
Brake Components

- Designed to handle an emergency stop from 450 MPH (725 KMH)

Components:
- Piston Housing
- Shaft Bearings
- Pistons
- Rotor Shaft
- Stator Casing
- Carbon Discs
- Mounting Plate
ELECTRICAL TEAM
Battery Testing
Bus Bar Thermal Testing
Blade Pack Overview

- 8 Blades Containing 2000 Cells packaged in 80 Modules
- 8 Separate Vehicle Level Systems
- Battery Management System for Each Pack, System Monitors 2000 Voltages, 8 Currents, and 500 Temperatures
- 32 Contactors as well as Half Pack Manual Service Disconnect and Redundant Fuses for Safety
Simulation

Weight = 36,297 lbs (8000 kg), 50/50 Distribution

- All Axles Traction Limited
- Front Axle Traction Limited
- Both Axles Power Limited
- Shift Points

Distance (Miles) vs. Speed (MPH)

- Mile 3 Avg. Speed: 302 MPH
- Mile 4 Avg. Speed: 346 MPH
- Mile 5 Avg. Speed: 362 MPH
- Mile 6 Speed (FIA): 410 MPH

- Entry Speed (US): 200 MPH
- Exit Speed (US): 396 MPH

- 34.1 Seconds
- 46.6 Seconds
- 50.8 Seconds
- 71.2 Seconds
- 30.6 Seconds
- 89.4 Seconds
Data Acquisition and Control

- System is Based on ETAS prototyping ECU hardware
- Supervisory ECU
- Completely Custom I/O system
- Development of XCM, XIM, and XNM Modules
- More than 3 Miles of Wire in the Race Vehicle
- More than 3000 Sensors and Signals
CHASSIS
MOTOR ASSEMBLY
BRAKES
SUSPENSION
TRANSMISSION
BATTERY PACK
BONNEVILLE 2013
LAKE BONNEVILLE
WENDOVER AIRPORT
WENDOVER AIRPORT
WENDOVER AIRPORT
ALWAYS TIME FOR O-H-I-O

2013 Bonneville Video
Contact Info:
David Cooke
Ohio State CAR
VBB3 Team Leader
cooke.76@osu.edu