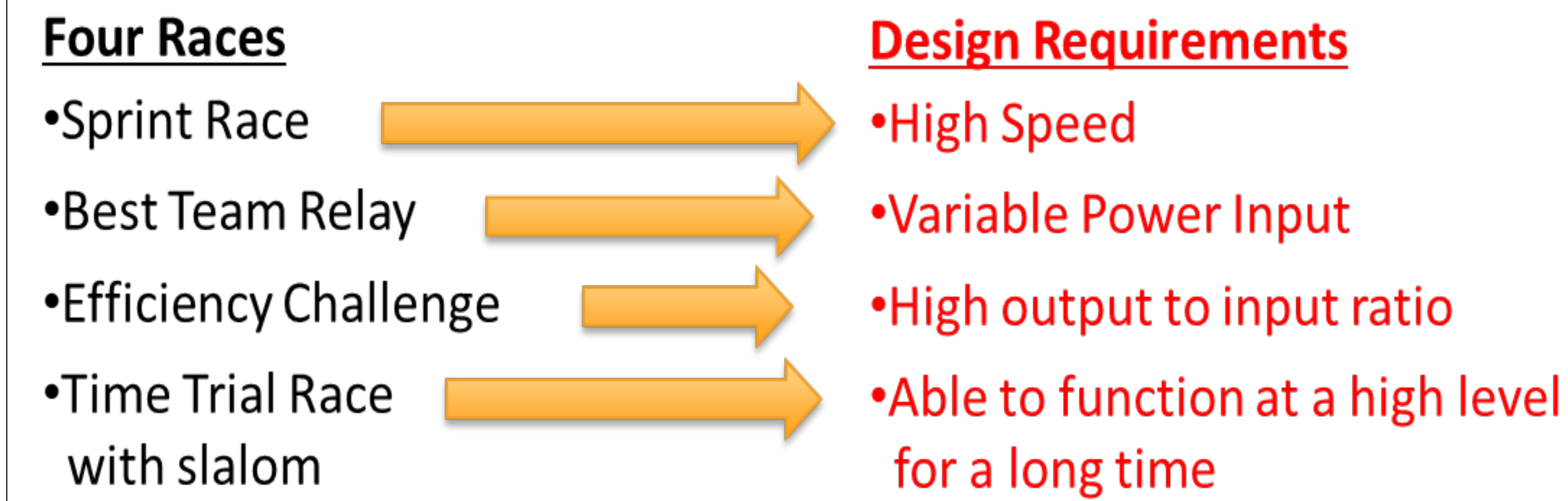# Chainless Challenge

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◆ Problem Definition and Review

The purpose of this project is to design and build a human powered vehicle without the use of mechanical power transfer. The solution must be both competitive and manufacturable. The vehicle must offer the same values as a normal bicycle; easy to use, low cost, low weight, simplicity of maintenance. This poses a challenge because fluid power is not efficient at low input speed. The competition consists of several races that translate into different design requirements. See figure at right.

Four Races
- Sprint Race
- Best Team Relay
- Efficiency Challenge
- Time Trial Race with slalom

Design Requirements
- High Speed
- Variable Power Input
- High output to input ratio
- Able to function at a high level for a long time

◆ Alternative and Our Solution

Designed according to Parker Chainless Challenge Specifications, our hydraulic tricycle, the *HydraTryke*, is a commercial prototype. Our design predominately focuses on optimization for the four races in the challenge. It implements a dual gear hydraulic pump and hydraulic motor as the main means of transmitting power. Besides being able to shift hydraulically, there is an 8-speed electronically controlled internal gear hub. The tricycle can be shifted both hydraulically and mechanically through the use of an IQAN interface. Gears can be selected automatically through the use of an integrated heart rate sensor, the vehicle's speed, or the user directly. We arrived at this solution by first laying out the hydraulic circuit, then modeling the circuit in AMESim, and finally running an optimization in AMESim to get the proper component sizes.

◆ Hydraulic Modes

The fluid circuit must be able to perform four essential functions. These four functions or modes are described below.

| Pedal Mode | Charging Mode | Boost Mode | Regeneration Mode |
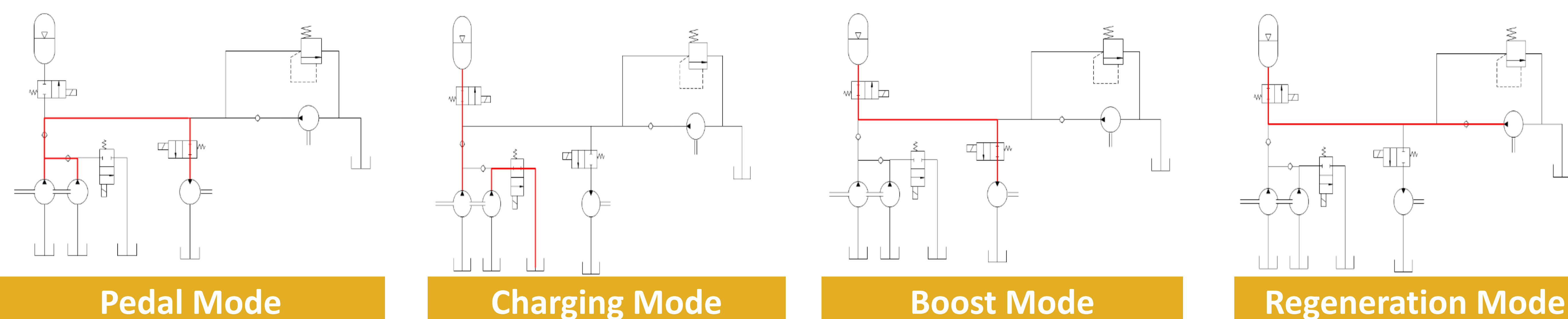
The first function is pedaling, which enables the rider to manually power the bike. The next function requires the rider to charge the accumulator before each race. After charging the accumulator the boost function may be used to propel the vehicle forward. Lastly, a regeneration function will allow the rider to brake the vehicle and store some of the energy by recharging the accumulator.

◆ Impact, Sustainability, Economics

While the technology does not currently exist for an economical solution to a human powered hydraulic vehicle, due to inefficiencies at low input speeds, research in this area is currently being conducted. Hydraulic hybrids are more environmentally sustainable then electric hybrids which rely heavily on batteries and precious metals. Hydraulic hybrid vehicle will become more common place in the future and the technology will continue to improve.

◆ AMEsim Model / Design
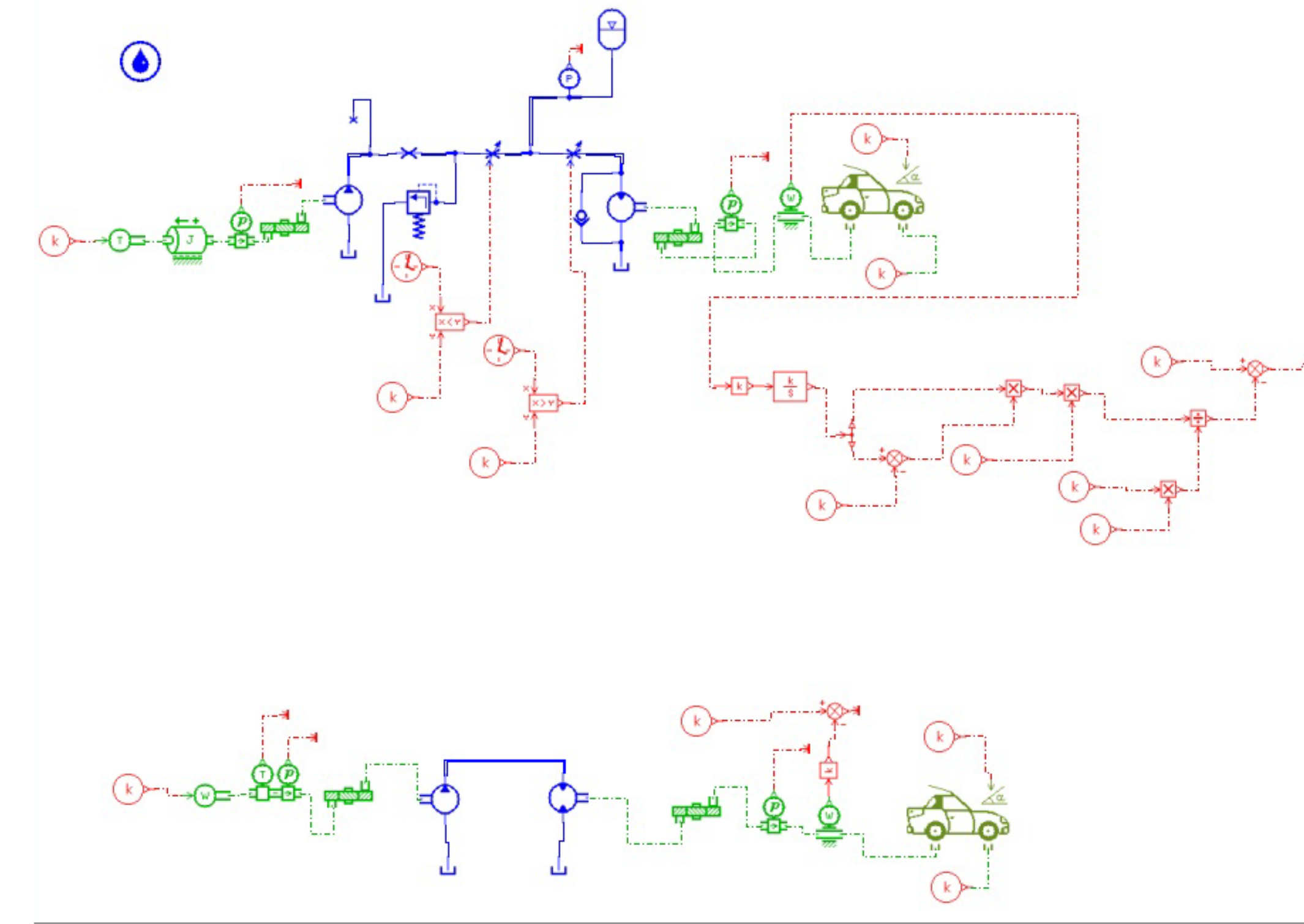
◆ Results of AMEsim Optimization

AMESim Output	
Motor	4.12 cc/rev
Accumulator Volume	3.76 L
Front Gear Ratio	10
Pump_1	2 cc/rev
Pump_2	3.6 cc/rev
Rear Gear Ratio	1.72
Pre-Charge	40 bar
Regeneration Gear Ratio	2.12
Efficiency Score	92.30%
Velocity	7.12 MPH
Torque	30.4 Nm

◆ Electronic Controls

Sensors & Valves

Automated Shifting System

Bluetooth Heart Rate Monitor

The heart rate monitor allows the user to customize their workout to fit their specific need. The sensor tells the IQAN the state of the rider so that the rider knows if their heart rate is in the target range or not. Depending on whether or not the rider's heart rate is in the target range, the IQAN can automatically shift to better meet the fitness level.

◆ Manufacturability

- Primarily comprised of commercial parts that can easily be scaled to production.
- Requires only simple tools to assemble.
- The design is very modular and the additional regeneration mode or expensive electronics are very easy to add or remove.

◆ Marketability

- Features up to 16-speeds with dual chamber pump and 8-speed gear hub.
- Automatic shifting based on heart rate means less user interaction and ease of use, as well as customized workouts
- User-friendly IQAN electronic display allows manual shifting and chamber selection.
- Professional and sleek design.
- Incredibly stable and easy get on and ride.