Part 1: Profile of an Ideal Trip
Review the data on an “ideal trip” for each persona, calculate speed (3), wheel rotations (4) and rear wheel RPM (5).

<table>
<thead>
<tr>
<th>Persona</th>
<th>Distance (km)</th>
<th>Time (min)</th>
<th>Speed (k/h)</th>
<th>Rear Wheel Total Rev.</th>
<th>Rear Wheel RPM</th>
<th>Ideal Pedal RPM</th>
<th>Min Comfort Mech Adv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourist</td>
<td>10</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>0.40</td>
</tr>
<tr>
<td>Shopper</td>
<td>8</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td>55</td>
<td>0.25</td>
</tr>
<tr>
<td>Commuter</td>
<td>12</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Hint: Wheel diameter is 660mm (.66 meters); \( \pi \approx 3.14159 \)

Part 2: Analyze the Drive Train Options
Calculate speed ratio (12), pedal RPM for an ideal trip (13-15) and mechanical advantage (16) for each drive train option.

**Speed Ratio - Equation 1**

\[
\text{Speed Ratio} = \frac{\omega_{\text{out}}}{\omega_{\text{in}}} = \left( \frac{N_{\text{chainring}}}{N_{\text{cassette}}} \right)
\]

**Mechanical Advantage - Equation 2**

\[
M.A. = \frac{F_{\text{out}}}{F_{\text{in}}} = \left( \frac{L_{\text{crank}}}{R_{\text{wheel}}} \right) \left( \frac{N_{\text{cassette}}}{N_{\text{chainring}}} \right)
\]

**Hint #1:** Pedal RPM is the rear wheel RPM divided by the speed ratio.

**Hint #2:** This is a good use for a spreadsheet!

<table>
<thead>
<tr>
<th>Option</th>
<th>Manufacturer Brand</th>
<th>Chainring teeth</th>
<th>Cassette teeth</th>
<th>Crank Length mm</th>
<th>Speed Ratio Equ 1</th>
<th>Tourist Pedal RPM</th>
<th>Commuter Pedal RPM</th>
<th>Shopper Pedal RPM</th>
<th>Mech Advantage Equ 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shimano Traveler</td>
<td>30</td>
<td>28</td>
<td>170</td>
<td>(12)</td>
<td>(13)</td>
<td>(14)</td>
<td>(15)</td>
<td>(16)</td>
</tr>
<tr>
<td>2</td>
<td>Campagnolo Trieste</td>
<td>48</td>
<td>34</td>
<td>170</td>
<td>(12)</td>
<td>(13)</td>
<td>(14)</td>
<td>(15)</td>
<td>(16)</td>
</tr>
<tr>
<td>3</td>
<td>SRAM Cardinal</td>
<td>52</td>
<td>24</td>
<td>160</td>
<td>(12)</td>
<td>(13)</td>
<td>(14)</td>
<td>(15)</td>
<td>(16)</td>
</tr>
<tr>
<td>4</td>
<td>Shimano Blue</td>
<td>52</td>
<td>32</td>
<td>170</td>
<td>(12)</td>
<td>(13)</td>
<td>(14)</td>
<td>(15)</td>
<td>(16)</td>
</tr>
<tr>
<td>5</td>
<td>Bontrager Rolhoff</td>
<td>44</td>
<td>-15%</td>
<td>170</td>
<td>(12)</td>
<td>(13)</td>
<td>(14)</td>
<td>(15)</td>
<td>(16)</td>
</tr>
</tbody>
</table>
Part 3: Putting It All Together

Decide on your design persona (17), then recall the ideal pedal RPM (18)(6) and minimum comfort mechanical advantage (19)(7) for this persona. Review your data from Part II, then select a manufacturer and brand (20) that is best for your design persona. Record the ideal trip RPM (21) for this drive train choice (Part II, 13-15) and calculate the difference (22) from the Ideal RPM (21-18). Finally, record the mechanical advantage (23) for this drive train choice (Part II, 16) and calculate the difference (24) from the design persona minimum comfort mechanical advantage (24-19).

<table>
<thead>
<tr>
<th>Design Persona</th>
<th>Your Drive Train Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>What persona are you designing for?</td>
<td>Ideal Pedal RPM</td>
</tr>
<tr>
<td>(17)</td>
<td>(18)</td>
</tr>
</tbody>
</table>

Part 4: Making it Real

Designers often sketch or draw a representation of the customer of their design. This is a way for your brain to integrate thoughts that are often hard to express in words.

Try it! Draw a picture (right) of the type of customer you think should be the target of this design – Tourist, Shopper or Commuter. Add notes on the persona that you think are important and should be considered as part of the final design.
Part 5: Enrolling Your Team
Empathy Maps (right and next page) can be used to bring team members together around a vision of the design customer. Matt will need to enroll his team on the drive train decision and will use an empathy map.

What problem is your persona trying to solve with B-cycle?

Why is that important to your persona?

What PAIN are they trying to avoid by using a B-cycle?

What GAIN are they trying to achieve with B-cycle?

Based on this, are there any design characteristics that are critical to make B-cycle the best solution for your design persona?

Now, try working with an Empathy Map to capture your ideas. On the following page is a full-size Empathy Map. Write or sketch your thoughts – who are you solving for? What problem are they trying to solve? What PAIN are they avoiding or GAIN they are achieving? and what are the potential solutions that most interest you as a designer? Now imagine how Matt might use this to talk about his design decision with the broader product development team at Trek.

©2013 Stanford University School of Engineering and Epicenter directed by the Stanford Technology Ventures Program. This case was prepared by Mark Schar and Ruben Pierre-Antoine as part of Professor Sheri Sheppard’s Designing Education Lab. Cases are developed solely as the basis for class discussion and are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

This work is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported License
Empathy Map
Getting inside the mind of your customer

1. Who are you solving for? (Persona)

2. What problem are they trying to solve?

... and why is that important to them?

3. What PAIN are they trying to avoid? Aspirin

... and why is that important to them?

3. What GAIN are they trying to achieve? Vitamins

... and why is that important to them?

4. Based on this ... what potential solutions are interesting to you as the engineering designer?