OVERVIEW

- Who Are We??
- Establishing the Need
- Project Origins
- Partnership: Handicapés en Avant
- Hand-Powered Need & Design
- Electric-Powered Need & Design
Mission

- To provide appropriate, sustainable mobility devices for persons with disabilities living in the developing world.
Establishing the Need

- Estimates are that there are more than 20 million people in developing countries in need of a good wheelchair.

- Donated wheelchairs are usually not appropriate for conditions in developing countries. Most imported wheelchairs are based on American and European designs from the mid-20th century for indoor home and institutional use. These designs were not intended for outdoor use on unpaved terrain. They break easily, but are not easily repaired because spare parts and repair equipment are not usually locally available.
Establishing the Need

• The life of the disabled
  – Slow and difficult mobility
  – Limited household contributions
  – Shoes on hands
  – Calluses on knees and feet
Burkina Faso is located in West Africa, between the Sahara to the North and the tropics to the South. It is a land-locked country that covers an area slightly larger than the state of Colorado.

Its name means: “Country of Integrity”.
The capital city is Ouagadougou, one of the fastest-growing cities in Africa. It is the site of the annual African Film Festival and recently hosted the African World Cup.

SIM Burkina Faso headquarters is in Ouaga, and it serves the five SIM missions in Mahadaga, Djibo, Fada-Ngourma, Piela, and Tenkodogo.
Handicapés en Avant

- A comprehensive ministry to disadvantaged peoples in Mahadaga, Burkina Faso

- Supported by SIM Missions

- Led by visionary French missionary, Françoise Pedeau
Handicapés en Avant

- Part of God’s response to the prayer “Your Kingdom come, Your will be done”
- Evidence of God’s love for the people of Mahadaga
- A place where the lame do walk, the blind read, the deaf learn
- Handicapés en Avant: People With Disabilities Moving Forward
Handicapés en Avant

• Ministries
  – Library
  – School for the hearing impaired
  – Employment for local artists, craftspeople
Handicapés en Avant

- Ministries
  - Agricultural project for employment and training
  - Physical therapy
Ministries

– Personal transportation technologies for the disabled
• Words of the apostle Paul: I Timothy 1: 12
• Dokimoi Ergatai: partnered with Handicapés en Avant
  – Support and further the ministry of providing personal transportation technologies
  – Improving tricycle design and manufacturing processes, designing new solutions
Typical wheelchairs are not able to be made locally and do not perform well off-road and for long distance travel.

Hand-powered Tricycles:

• Locally made
• Locally maintained
• Provide freedom in travel
• Enable contribution to the community
• Lift the owner up off the ground
Design Origin

- Developed by Handicapped International for Manufacture In Burkina Faso
- The square tube design used in Mahadaga is a simplified version of the Handicapped International design.
Design Issues

• Wheel Flop
Design Issues

- Chain Tensioning
- Steering Assembly
Design Issues

• Crank Orientation
Original Project Objectives

- Reduce side to side motion of the front wheel during power transmission.
- Prevent the chain from falling off the drive sprockets during power transmission.
- Reorient drive crank handles for more efficient power input.
- Simplify the existing tricycle manufacturing process.
- Specify frame dimensions suitable for child users.
Design Philosophy

- Simple, appropriate solutions that are cost effective relative to locally available resources.
- Sustainable solutions that maximize the use of locally available materials and value the expertise of local craftsmen.
- Solutions that promote technology transfer in order to maximize ownership and minimize dependency.
Burkina Faso Quick Facts

Health
• Infant Mortality – 97 deaths per 1000 live births.
• Life Expectancy – 47 years.
• Physicians – One per 27,000

Literacy
• Total Adult Literacy: 13%

Economy
• Subsistence Agriculture Predominates
• Other Economic Activity: Food Processing, Textiles, Mining, Light Manufacturing.
• Annual Per Capita Income -- $360
Typical Terrain
Tools & Materials
Design Solution (2001)
Design Comparison
Hand Crank Position
Existing Axle
Axle Grinding Fixture
Crank Mounting Procedure/Fixture
Child Size Tricycle
Project Outcomes

- The use of a derailleur proved to be problematic for several reasons:
  - Increased cost
  - Derailleur pulley material failures
  - Incompatibility with existing chain type
  - Alignment problems due increased complexity of the drive-train and insufficient manufacturing documentation.
Project Outcomes
Project Status

• Fabricators have reverted back to using the original front end design due to manufacturing and performance difficulties associated with the derailleur tensioning system. The only modification they have retained is the use of the bicycle frame components for the steering system.
Project Outcomes

• Redesigning the tricycle steering system around a bicycle frame significantly simplified the manufacturing process…..

  Unfortunately

• The use of a bicycle frame increased tricycle cost by about 16%
Simplified Chain Tensioning Device

- Single wooden roller
- Inner tube rubber for the tensioning device
- Bolt on design
- Constructed using a hand drill and simple drilling jigs.
Redesign to Eliminate Bike Frame

- Provide a new design for the tricycle front end that provides the manufacturing simplicity afforded by the use of a bicycle frame without the associated cost.
- Eliminate or reduce the need for the existing front-end diagonal support brace.
Redesign to Eliminate Bike Frame
Future Work

• Continue the development process for the front-end design: prototyping, cost analysis, manufacturing, reliability, documentation etc.

• Research & develop appropriate maintenance procedures suitable for tricycle users in Mahadaga, Burkina Faso. Develop appropriate picture based documentation to teach tricycle riders new maintenance techniques.

• Research, recommend or develop appropriate, cost effective methods/materials that will improve the performance of existing tricycle tires.

• Conduct an ergonomic study/evaluation of the existing hand powered tricycle designs.

• Develop a set of tricycle frame manufacturing fixtures
Phase II: Frame Redesign

- Decrease manufacturing time, reduce part count and minimize use of welded joints.
- Reduce cost and weight
- Provide documentation tailored to local fabricators
Frame Design Comparison
Joint Fabrication Comparison
Bending Tools
Extérieur Roué Soutien (Outside Wheel Support)
Outcomes: Frame Redesign

- Number of welds decreased from 173 to 78
- Number of frame members decreased from 18 to 10
- Frame fabrication time reduced from three days to two
- 35% reduction in tricycle frame cost
- 38% reduction in tricycle frame weight
Outcomes: Frame Redesign

- Repeatable results were difficult to obtain with original bending equipment.
- Original bending equipment was large and difficult to ship overseas.
Future Work

- Evaluate the manufacturability of the tricycle frame designed in 2005 using the hand pump hydraulic tubing bender. Develop and provide appropriate manufacturing fixtures and documentation for use by local fabricators in Burkina.
- Evaluate the performance of the bent tube tricycle frame design.
- Complete reliability and destructive testing trials for the bent tube design.
- Implement the existing design in Burkina Faso and obtain client feedback.
Electric Tricycle Project:

Appropriate Mobility
Purpose

• Add electric power train and controls to the current hand-powered tricycle

• Simple, inexpensive, appropriate electric wheelchair

• Bring increased mobility to disabled persons in Burkina Faso
Background

- Hand-powered tricycles: not useful for the more severely disabled
- Electric wheelchairs… not appropriate
- Yempabou - first intended user
- Physical disadvantage: Cerebral Palsy
Block Diagram
Motor & Control

Currie Scooter Motor
- 24V Brushed Type
- 600 W
- 2600 RPM

24V PWM Type Control
- 0-5V Input
- 40 A Output
- Environmentally Sealed

Complete kit $109.95
Chain Drive

- 26:1 gear reduction achieved via jackshaft
- Gear motor is avoided for cost reduction
Drive Train

• Chain Drive
  – Pros
    • Reliable torque transmission
    • Locally available parts, construction methods can be used
    • Inexpensive motor & control package
  – Cons
    • Multiple speed reductions
    • Drive components must be precisely aligned
    • Chain and bearing maintenance
Drive Train Manufacturing Fixtures
User Inputs-Throttle

- OEM twist throttle not adaptable to our client’s disability.
- Solid state hall-effect sensor not able to be maintained or repaired locally
User Inputs-Throttle

• Single axis joystick controls throttle and brake
• Low cost sliding potentiometer replaces $35.00 solid state twist throttle control
User Inputs

• Steering
  – One handed tiller type steering bar
• Accessible power interrupt and forward/reverse switch

• Battery voltage gage to prevent battery damage from over discharge

...User Input
## Cost

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<th>Total Cost</th>
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<td>Currie DC motor</td>
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<td>Motor controller</td>
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<td>Switches and controls</td>
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<td>Bicycle and moped parts</td>
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<td>Batteries</td>
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<tr>
<td>Battery Charger</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$ 465</strong></td>
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Implementation

• All materials (excluding electronics) purchased in markets in Ouagadougou, Burkina Faso
• All construction completed in Mahadaga
• Local craftsperson currently being trained in manufacture and maintenance
Project Outcomes

- Yempabou has adapted quickly to his new tricycle, controls requiring minimal dexterity prove to be a good match.
- His ability to operate the electric tricycle has improved steadily.
- Repeated failures necessitated the redesign of the joystick control.
- Drive train component alignment has proved difficult for local fabricators. The result has been poor performance of the chain drive.
Simplified Control Design
Simplified Drive Train

- Single chain
- 4:1 Planetary speed reducer eliminates “jack shaft”
Future Work

• Testing: component optimization, reliability, life expectancy, cost reduction
• Adaptive Controls
• Simplified Wiring System
• Simplified Drive Train
• Improved Manufacturing Fixtures
• Feasibility of remote charging stations