Beneficial Designs
research/design/education

Designing beyond the norm to meet the needs of all people.

Peter Axelson
Beneficial Designs, Inc.
Minden, NV
Beneficial Design
Designing Beyond the Norm to Meet the Needs of All People

Research
Design
Education

Stanford University
28 January 2016
Peter Axelson
Beneficial Designs’ Mission Statement

Beneficial Designs works towards universal access through research, design, and education. We believe all individuals should have access to the physical, intellectual, and spiritual aspects of life.
Beneficial Designs’ Mission Statement

We seek to enhance the quality of life for people of all abilities, and work to achieve this aim by developing and marketing technology for daily living, vocational, and leisure activities.
Bill Blythe,
Technical Assistant
Seanna Kringen, Research Associate
Nathan Tolbert, Sidewalk Assessment Coordinator
Stephen Pieters, Wheelchair Test Lab Leader
Jaime McGuire, Marketing and Project Manager
Stephanie Schnorbus, Office Manager
Allison Ansel,
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Sharon Vazquez, Office Assistant

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Jo Anne Snarr, Bookkeeper
Ria Axelson,
Office Assistant
Design of Consumer Products

Product Development
Assessment of Products
Universal Design of Products
Product Development

Mainstream Products
Opportunity for Universal Design
Adaptive Products
Personal Technologies
Activity Specific Technologies
Establishing Balance

Physical
Intellectual
Spiritual
Sociological Dimension

Dependence
Independence
Interdependence
Personal Technologies
Activity-Specific Technologies
Environmental Technologies
Activity-Specific Technologies
Arroya Sit Ski
Mono Ski
Dynamic Seating Spring Assist
Cross Country Ski
Pax Back

Available from BES Rehab Ltd
Clutch, Brake and Gas on Hand Control
Dynamic Seating
Hand Bike

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Hand Bike
Contoured Seating
Seat Cushion Testing
SKELI Used on Foam

2” HR45 Foam Cushion
ASLI Prototype
ISO Part 2 Shape
Pressure Measurements Symmetric
### Pressure Measurements

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 27 | 5.5 | 7.8 | 98 | 63 | 38 | 42 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 8.6 | 23 | 46 | 53 | 63 | 60 | 136 | 68 | 67 | 115 | 69 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 70 | 56 | 85 | 67 | 70 | 122 | 110 | 128 | 120 | 181 | 85 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 62 | 117 | 91 | 63 | 45 | 88 | 101 | 137 | 171 | 135 | 120 | 3.9 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 22 | 39 | 103 | 78 | 59 | 93 | 112 | 122 | 178 | 200 | 72 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 16 | 34 | 75 | 72 | 60 | 56 | 96 | 96 | 145 | 151 | 47 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 4.7 | 62 | 55 | 66 | 49 | 53 | 81 | 78 | 141 | 96 | 52 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 14 | 39 | 46 | 70 | 47 | 48 | 79 | 71 | 122 | 167 | 25 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 64 | 72 | 36 | 38 | 79 | 75 | 11 | 77 | 2.4 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 27 | 31 | 3.1 | 22 | 39 | 37 | 64 | 23 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 32 | 35 | 3.9 | 0 | 0 | 9.4 | 37 | 50 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 0 | 0 | 0 | 0 | 16 | 27 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 13 | 0 | 0 | 0 | 0 | 5.5 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 5.5 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Pelvic Obliquity

- mmHg (millimeters of mercury)
Pressure Measurements

15 Posterior Pelvic Tilt
Pelvis Movement During Extensor Thrust Activity

Force at Thigh and Backrest During Extension

Pelvis Moves Up, Out and Rotates
Variations of Belt Angle

Downward Pull Limits Upward Movement

Allows Posterior Pelvic Rotation

Limits Full Anterior ROM
HipGrip Concept
HipGrip Ph1 - Prototype 2
What Is the HipGrip?

- Dynamic Pelvic Support
- Provides Pelvic Stability
- Allows Controlled Anterior Tilt ROM
HipGrip
Test
Fixture
Functional Forward Reach
Functional Reach Downward
HipGrip

Available from Bodypoint
FlexRim – Combining the discrete compliant fasteners into one
The best profiles were fully developed and tested.
FlexRim Ergonomic Pushrim
Frictional improvements

Preliminary tests show over a 2x increased frictional coefficient
Impact absorption
Applied a 120 lb repetitive load in one place until failure.

Pushrim cracked after 444,072 cycles.
Baseline study – FlexRim
Subjects are tested over a wide variety of usage environments.
FlexRim

Design
The FlexRim consists of a dynamic high friction rubber surface that spans between the aluminum pushrim and the wheel. The shape of the rubber is ergonomically designed to conform to your hand when gripped, making it the most comfortable pushrim you will ever use.

Impact Testing
Impact loading of the FlexRim was studied for a wide range of impact intensities. The FlexRim was found to consistently reduce impact loading by 10%.

Overuse Injuries
Shoulder and wrist problems are very common among wheelchair users. Impact loading is one of the contributing factors. Your hands and arms absorb impact shock when you first hit the pushrim, illustrated in the graph below.

- Reducing impact is one strategy recommended to help protect you from developing overuse injuries.

Population Testing
In lab testing, wheelchair users pushed with both a standard pushrim and the FlexRim on a research treadmill. Grip muscle activity, oxygen demand, and power generated were all measured during propulsion and compared across pushrims.

- Users required 12% less grip force to push with the FlexRim.
- Overall grip exertion was reduced by 15%.
- On average users required 2% less oxygen to push with the FlexRim than with a standard pushrim.
- Users generated 19% more power when using the FlexRim.

The ergonomic benefits of the FlexRim have been published in numerous scientific journals, and in a PhD dissertation at Stanford University.

Advanced Ergonomics

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GripRim
Adaptive Canoe Seating
Methods - Endurance

MedGraphics VO2000 portable metabolic system
Lateral Balance Test
Water Egress Testing
Wave Ski
Environmental Technologies

Things that do not move
Small Watercraft Launch Access
# High Float Boat Launch Pier

**San Francisco Bay Area Water Trail Program**

## Amenities & Allowed Uses:
- Boat launch
- Drinking water
- Canoe access
- Fishing pier
- Hand launch
- Kayaking
- Motorboating
- Parking
- Restrooms

## Water Conditions / Exposure:

### Fetch:

![Fetch Diagram]

### Current:

![Current Diagram]

### Wave Height:

< 1 ft

## Access Route

<table>
<thead>
<tr>
<th>Parking to Launch Environment</th>
<th>Edge of Environment to Transfer Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>+ 200 ft</td>
</tr>
<tr>
<td><strong>Elev Loss</strong></td>
<td>2 ft</td>
</tr>
<tr>
<td><strong>Grade</strong></td>
<td>Typical</td>
</tr>
<tr>
<td><strong>Cross Slope</strong></td>
<td>Typical</td>
</tr>
<tr>
<td><strong>Tread Width</strong></td>
<td>&gt; 10 ft</td>
</tr>
<tr>
<td><strong>Surface</strong></td>
<td>Asphalt/Concrete</td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td>Paved</td>
</tr>
<tr>
<td><strong>Amount</strong></td>
<td>100%</td>
</tr>
</tbody>
</table>

## Transfer Area

<table>
<thead>
<tr>
<th>Launch Type</th>
<th>Concrete Boat Launch / High Float Dock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clear Space</strong></td>
<td>Unlimited</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>Unlimited</td>
</tr>
<tr>
<td><strong>Width</strong></td>
<td>~ 50 ft / 96 in</td>
</tr>
<tr>
<td><strong>Grade</strong></td>
<td>14%</td>
</tr>
<tr>
<td><strong>Cross Slope</strong></td>
<td>0%</td>
</tr>
<tr>
<td><strong>Surface</strong></td>
<td>Concrete / Composite</td>
</tr>
</tbody>
</table>

## WARNING:

Conditions may have changed since December 2012 when this facility was assessed. Temporary obstacles are not reported.

Signage created by Beneficial Designs Inc. using data collected by a certified trail assessment coordinator.

The State Coastal Conservancy is leading the implementation of the San Francisco Bay Area Water Trail (Water Trail) in close collaboration with the Association of Bay Area Governments (ABAG), the San Francisco Bay Conservation and Development Commission, and the Department of Boating and Waterways. The Water Trail is a growing network of access sites (or “trailheads”) that will help people using non-motorized, small boats or other beachable sail craft, such as kayaks, canoes, dragon boats, stand-up paddle and windsurf boards, to safely enjoy single and multiple-day trips around San Francisco Bay.

http://ccceagov/2010/07/30/san-francisco-bay-area-water-trail/
Universal Trail Assessment Process (UTAP)
Key UTAP Information

Length

Width

Cross slope

Grade

Surface

Features & Facilities
UTAP – Implementation Status

Over 1200 people trained to lead UTAP assessments
Over 155 trainers to teach UTAP workshops
High Efficiency Trail Assessment Process
HETAP-Rollawheel
Developed Outdoor Recreation Assessment Process
Outdoor Constructed Features

Bench
Camp Shelter
Cooking Surface/Grill
Fire Ring, Wood Stove/Fireplace
Outdoor Rinsing Shower
Parking Area
Picnic Table
Pit Toilet

Tent Pad/Platform
Toilet Building
Trash/Recycling Receptacle
Utility/Sewage Connection
Viewing Area at Overlooks
Viewing Scope
Water Spout
Adjustable Height Cooking Grill
Water Pump with Closed Fist Operation
Water Pump Actuation Force
Water Pump Height Measurement
Picnic Table Clearance Space
Specify the Approach Type

Verify that a Clear Space is positioned for Forward Approach to Tables

Using the appropriate profile, verify that the minimum clear space is provided below the table surface at each wheelchair space provided

The Length of the Parallel Approach Clear Space must be centered on the Fixture

Measure the Vertical Distance from the Ground Surface to the top of the Knee Clearance
Trail Access Information

..........in a Food Facts Label Format

**Tahoe Meadows Interpretive Trail**

- **Length**: 1.5 mi (2.3 km)
- **Hiking**: 
- **Dogs On Leash**: 
- **Grade**: 
  - Typical Grade 2.3%
  - 7% of the trail is 3% to 10%
  - 307 ft (100 m) in 7%
  - 304 ft (92 m) in 0% to 10%
- **X-Slope**: 
  - Typical Cross Slope 2.0%
  - 36% of the trail is 0% to 5%
  - 304 ft (92 m) in 0% to 10%
- **Tread Width**: 
  - Typical Tread Width 7.5 ft (2.3 m)
  - Minimum Clearance Width 42 in (107 cm)
- **Surface Type**: 
  - Aggregate / Gravel
  - 82% is Firm or better
  - 14% is Soft or worn
- **Obstructions**: 
  - Rock 2 inches high
  - Entrance 1 inch deep
  - Root 2 inches high

---

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## Trails with desired access features

<table>
<thead>
<tr>
<th>Trail</th>
<th>Park</th>
<th>Nearest Level(s)</th>
<th>Length</th>
<th>Uses</th>
<th>Typical Grade</th>
<th>Surface Firmness</th>
<th>Trail Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trail 10</td>
<td>McCormick's Creek State Park</td>
<td>IN</td>
<td>0.7 miles (1.1 km)</td>
<td>Hiking</td>
<td>3.3%</td>
<td>Firm</td>
<td>Trail 10 begins near the stairs on Trail 8. The trail follows McCormick's Creek downstream to the Old Statehouse Quarry and Trail 2. Depending on the season and water levels, the trail borders the creek, crosses the creek numerous times, or is completely in the creekbed.</td>
</tr>
<tr>
<td>Trail 9</td>
<td>McCormick's Creek State Park</td>
<td>IN</td>
<td>0.7 miles (1.1 km)</td>
<td>Hiking</td>
<td>2.3%</td>
<td>Paved</td>
<td>Trail 9 connects the campground to the swimming pool and Nature Center. Pine Bluff Shelter and picnic/playground area can be reached from the trail.</td>
</tr>
<tr>
<td>Trail 8</td>
<td>McCormick’s Creek State Park</td>
<td>IN</td>
<td>0.2 miles (0.3 km)</td>
<td>Hiking</td>
<td>2.2%</td>
<td>Firm</td>
<td>Trail 8 is a connector trail from the Campsite 8 connector to Trail 7.</td>
</tr>
<tr>
<td>Trail 6</td>
<td>Spring Mill State Park</td>
<td>IN</td>
<td>0.4 miles (0.7 km)</td>
<td>Hiking</td>
<td>2.3%</td>
<td>Paved</td>
<td>Trail 6 is a paved loop trail near the Virgil B. &quot;Bass&quot; Oesteman Memorial.</td>
</tr>
<tr>
<td>Trail 7</td>
<td>Spring Mill State Park</td>
<td>IN</td>
<td>0.9 miles (1.5 km)</td>
<td>Hiking</td>
<td>3.3%</td>
<td>Firm</td>
<td>Trail 7 loops around the Oak Ridge Picnic Area and connects with Trail 7 spur that leads to Trail 4.</td>
</tr>
<tr>
<td>Trail 7 Spur to Trail 4</td>
<td>Spring Mill State Park</td>
<td>IN</td>
<td>0.4 miles (0.6 km)</td>
<td>Hiking</td>
<td>3.9%</td>
<td>Firm</td>
<td>Trail 7 Spur connects Trail 7 from the Oak Ridge Picnic Area to Trail 4.</td>
</tr>
<tr>
<td>Trail 10 Spur to Campsite 8</td>
<td>Turkey Run State Park</td>
<td>IN</td>
<td>0.1 miles (0.2 km)</td>
<td>Hiking</td>
<td>6.9%</td>
<td>Firm</td>
<td>The spur to Campsite 8 begins at the junction of Trail 10. The short trail ends at Campsite 8. There is an observation dock and bench.</td>
</tr>
<tr>
<td>Trail 11</td>
<td>Turkey Run State Park</td>
<td>IN</td>
<td>0.2 miles (0.3 km)</td>
<td>Hiking</td>
<td>3.1%</td>
<td>Firm</td>
<td>Trail 11 starts from the Service Road beside the Turkey Run 2m. A short hike about Turkey Run Hollow to the Lester Memorial and Log Church.</td>
</tr>
<tr>
<td>Trail 7 Spur to Campground</td>
<td>Turkey Run State Park</td>
<td>IN</td>
<td>0.1 miles (0.2 km)</td>
<td>Hiking</td>
<td>3.3%</td>
<td>Firm</td>
<td>Connector trail between the Campground and Trail 7.</td>
</tr>
</tbody>
</table>
Develop standards for trail and sidewalk design

Architectural Barriers Act Outdoor Recreation Access Guidelines
Public Rights of Way Access Guidelines
ADA Recreation Trail

Grade

- up to 30% of length > 8.33%
- 5% for any distance
- 8.33% for 200 feet
- 10% for 30 feet
- 12.5% for 10 feet
- 14% for 5 feet in drains if cross slope < 5%
ADA Recreation Trail

Cross Slope
5%
10% in drains if width > 42 inches

Rest Areas
60 inches length, trail width, 5% slope

Edge Protection
3 inches minimum height when provided
ADA Outdoor Access Route

Surface
  firm and stable

Width
  36 inches
  exception 32 inches for up to 24 inches

Openings
  < 0.5 inch sphere
Rotational Penetrometer

Objective surface measurement device

Available from Beneficial Designs
Trail with firm but unstable sandy surface
Trail after Installation of surface stabilizer
Gravelpave2
Rotational Penetrometer Readings-Gravelpave 2

<table>
<thead>
<tr>
<th>Before Application</th>
<th>After Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firmness</td>
<td>Stability</td>
</tr>
<tr>
<td>0.18</td>
<td>0.77</td>
</tr>
<tr>
<td>0.17</td>
<td>0.87</td>
</tr>
<tr>
<td>0.17</td>
<td>0.77</td>
</tr>
<tr>
<td>0.18</td>
<td>0.88</td>
</tr>
<tr>
<td>0.18</td>
<td>0.79</td>
</tr>
<tr>
<td>0.18 Avg 0.82</td>
<td>0.17 Avg 0.38</td>
</tr>
</tbody>
</table>
Street Name: OLU A WEST  Segment Name: *
*N COUNTY ROAD TO MACKLAND

9/16" 0.56
Sidewalk Assessment Process
GPS receiver

Laptop prompts the user to evaluate conditions when a walkway violates the standard

1.9-megapixel webcam automatically captures sidewalk imagery

Gyro distinguishes between changes in grade and acceleration/deceleration

Sensors monitor the plane between the three wheels to measure grade and cross-slope

Detachable wheel measures areas the cart can't reach

Detachable height tool measures trip hazards

Magnet in the rear wheel tracks distance
Digital Measuring Wheel

Wireless

High accuracy
with resolution of
0.1 Inches (1 mm)
Digital Height Measuring Device

- High accuracy
- Fast measurement
- Resolution of 0.01 inches (0.1 mm)
Data Collection Software
NDOT Right of Way in Minden, NV

Tread Width
NDOT Right of Way in Minden, NV

Cross Slope
NDOT Right of Way in Minden, NV

Hazard locations
NDOT
Right of Way in Minden, NV
Tripping hazard height
Universal Design Standards for Products
Universal Design of Fitness Equipment (UDFE) Standards
Low Step-up Height Design
Universal Design of Products used by persons with Cognitive Impairments

Goal – To increase Access to Technology for People with Cognitive Impairments
Universal Design of Amusement Park Rides for Persons with Mobility and Sensory Impairments
Aircraft Boarding and Seating
Aircraft Access
Using a Boarding Chair
Requires a transfer to an aircraft boarding chair
Boarding chairs have inadequate seating and foot support
Attendant operated boarding chairs require dependence on airport attendants.
Aircraft Compatible Wheelchair
Aircraft Boarding Using a Personal Aisle Chair Removable Wheels
Aircraft Boarding
Using a wheelchair with narrow accessory wheels
Fewer Transfers
Aircraft Seating Using a Personal Aisle Chair

Feet Remain Secure
Aircraft Seating Using a Personal Aisle Chair

 Allows for More Independent Boarding
Aircraft Seating Using a Personal Aisle Chair

A Single Transfer using overhead shelf to assist transfer
Aircraft Seating Using a Personal Aisle Chair
Aircraft Seating
Using a Personal Aisle Chair

Fold and store wheelchair on board aircraft
Aircraft seating without pressure relief Cushion
Aircraft seating with pressure relief cushion from wheelchair

legs hanging shoulders forward neck extended arm not supported
Aircraft seating with pressure relief cushion and "accessories"

- foot support
- lumbar and spine support
- neck/head support
- arm support
Aircraft seating with pressure relief cushion and "accessories"

feet supported
lumbar and spine supported
neck/head support
arm supported
Seat height on Aircraft seating
Seat cushion raises the feet further.
Aircraft seating with foot support
Aircraft seating with lateral support
Loading wheelchair into aircraft
Protect input control device
Fully protect input control device