# “I Hate This Chair!”

## Translating Common Power Wheelchair Challenges into Practice Solutions

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# Disclosure

Emma Smith has no affiliations, financial or otherwise, to disclose. Brenlee Mogul-Rotman and Tricia Garven are employees of Permobil Inc.

# Overview

- Introductions
- Drive Configuration
- Seating and Positioning
- Drive Controls
  - Proportional v. Non-Proportional
- Programming Parameters
  - Clinical Relevance
- Case Study Stations (4)
- Discussion and wrap-up

Getting to know you…

http://etc.ch/7anN

# Drive Configuration

And how it impacts your clients..

# Selecting the most appropriate wheelchair base

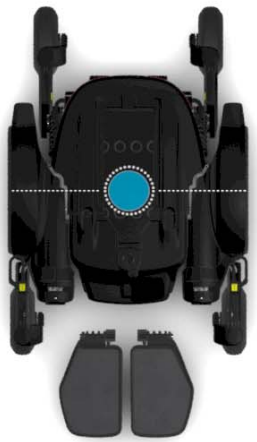
1. **Understanding Consumer's Needs**
   - Goals and Lifestyle
   - Environment and Transportation
   - Medical Issues
2. **Objectively Compare and Contrast Features of Power Wheelchair Bases**
   - Real life information
   - Realistic expectation

# Rear-Wheel Drive (RWD) – general perceptions

- Good tracking for higher speeds
- Most sensitive to changes in weight distribution
- *Typically* has good suspension
- Obstacle climbing – needs to be straight on
- Front swiveling casters
  - LE positioning/stand pivot transfers
- Largest Turning Radius

# Mid-Wheel Drive (MWD) – general perceptions

- Good stability for power seating
- Intuitive Driving
  - Drive wheel usually directly below user
- 6 wheels on the ground can limit smoothness of ride
- Obstacle climbing – needs to be straight on
  - Potential to “high center” in certain situations
- Front swiveling casters
  - LE positioning/stand pivot transfers
- Smallest overall turning radius
  - Smallest overall turning radius



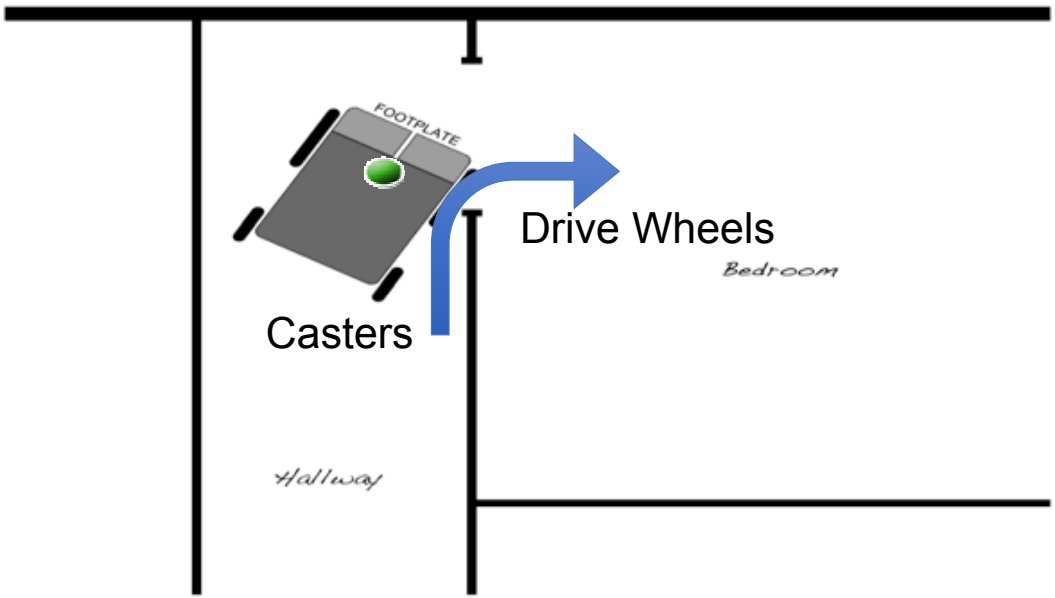
# Front-Wheel Drive (fwd) – general perceptions

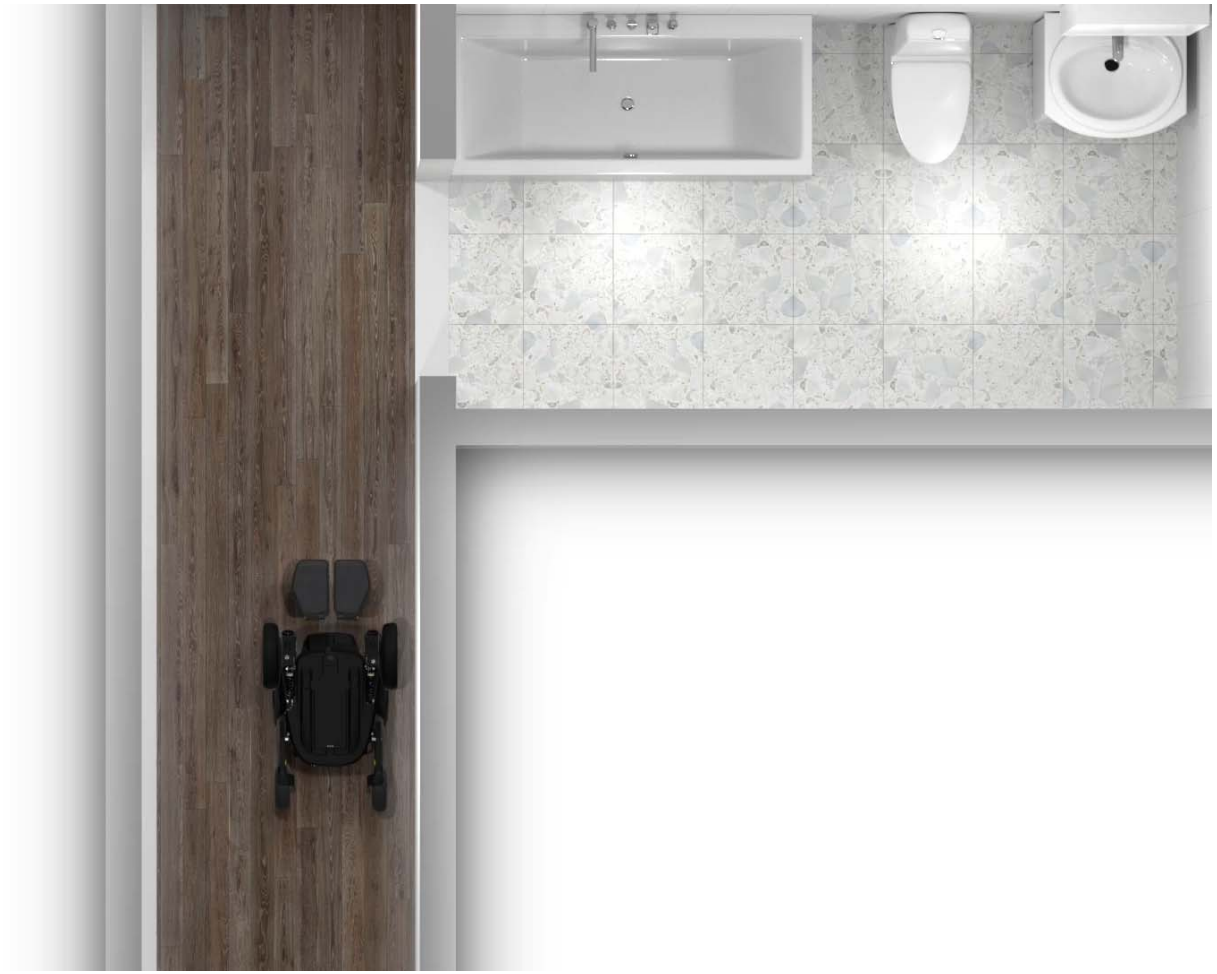
- Good stability for power seating
- Intuitive driving
  - Some people may need to learn technique
- Superior obstacle climbing from any direction
  - Handles well across all terrains
- Perception of poor tracking at high speeds
  - Not an issue with today's tracking technology
- Accommodates tight hamstrings
  - While maintaining low seat to floor height
- Smallest front turning aspect
  - "Hugging" the corner

# FWD: Specific skills training

- Turn toward the obstacle/problem
- Pull all the way in before starting the turn
- Hug the corner
- Obstacle climbing . . . Commit!
- Navigating declines . . .
- Slower without abrupt stopping

# Fwd – end of hallway

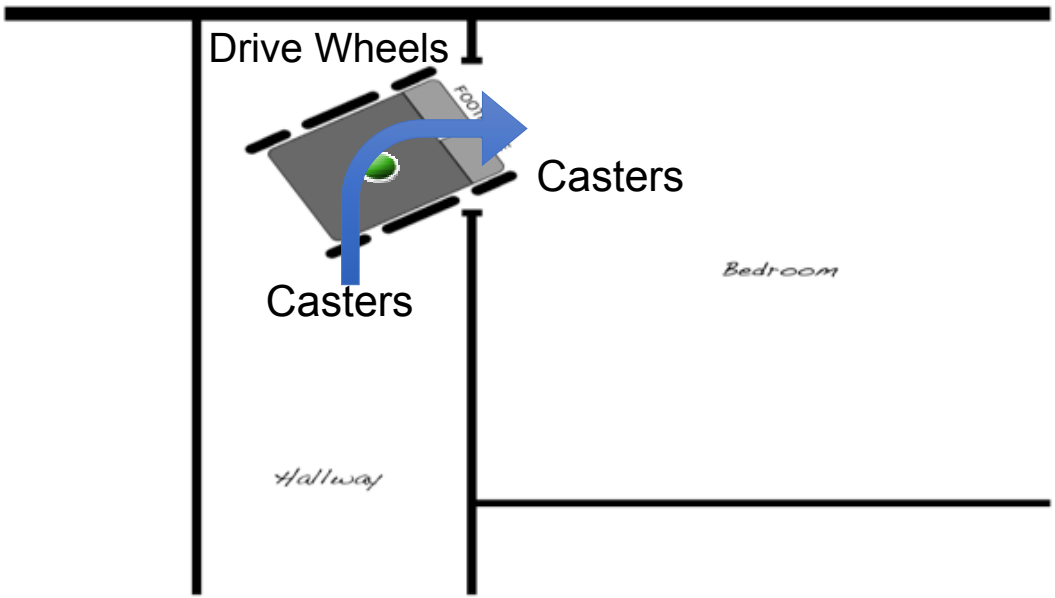


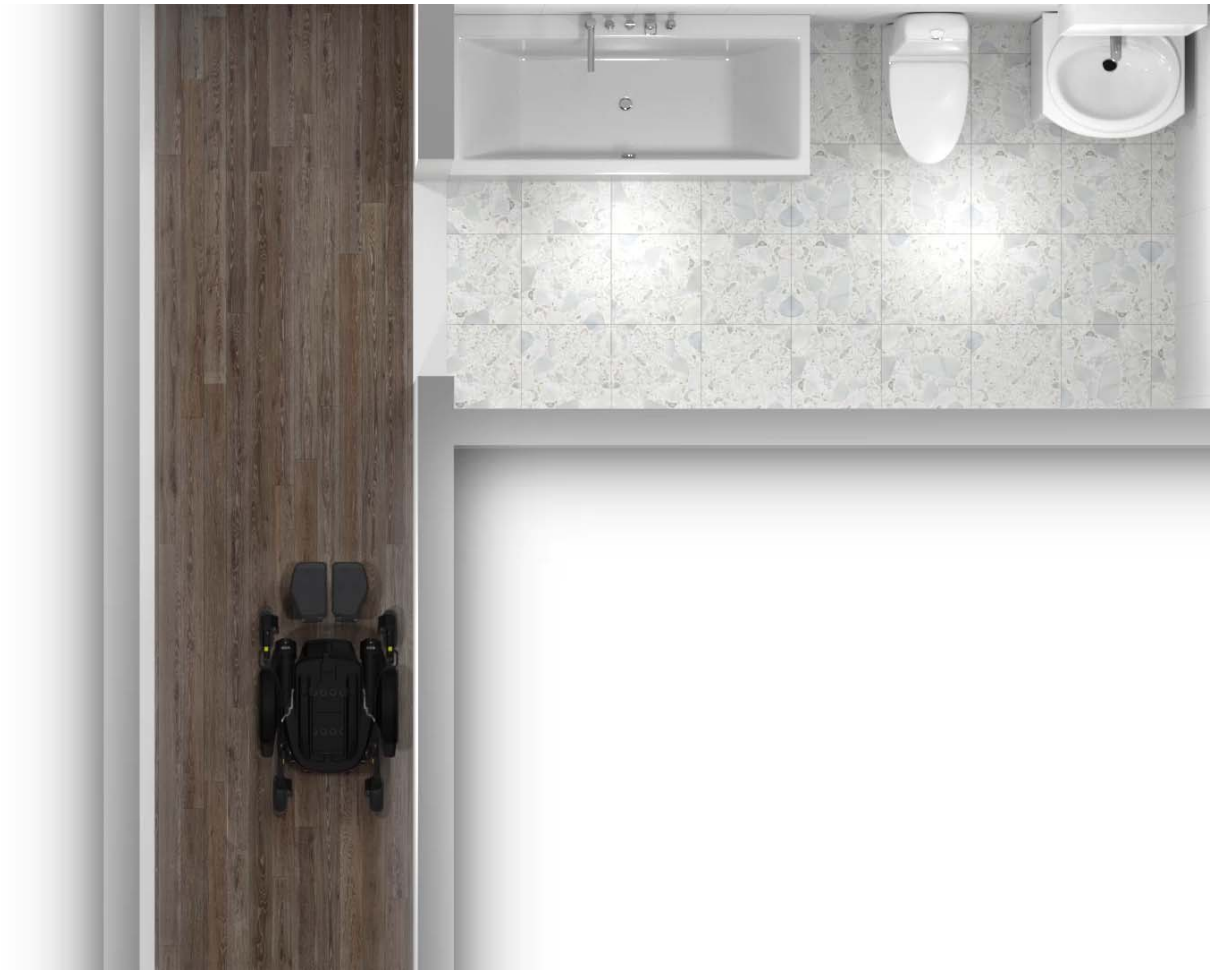


# MWD: Specific skills

- Keep feet in as close as possible – avoid front caster interference
- Line up drive wheel with corner for turning around obstacles
- Obstacle climbing . . . Line up front casters – straight on
- Navigating uneven terrain:
  - High centering is a risk with any MWD chair

# MWD – end of hallway

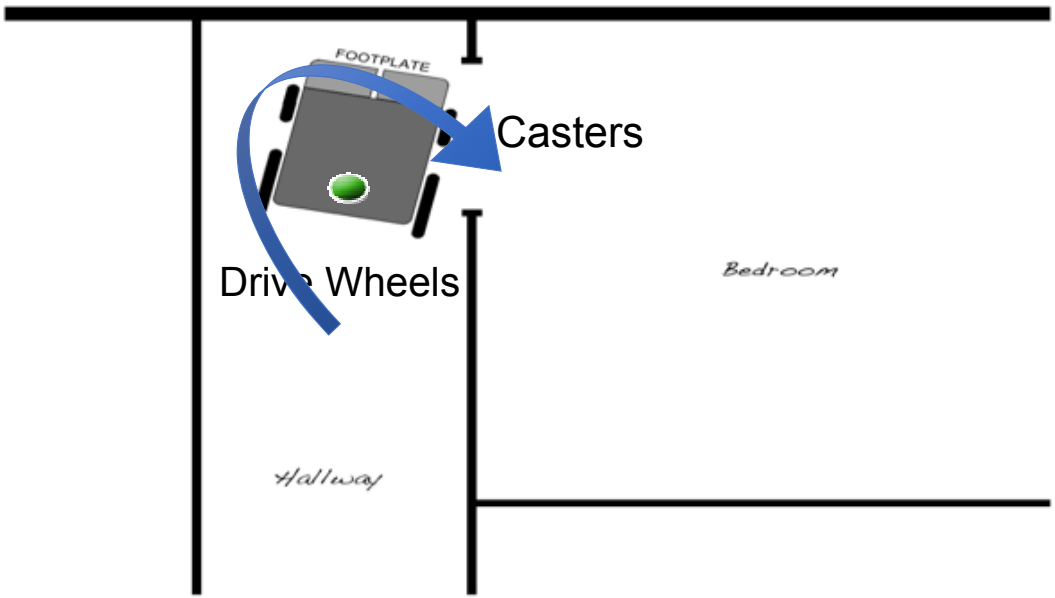




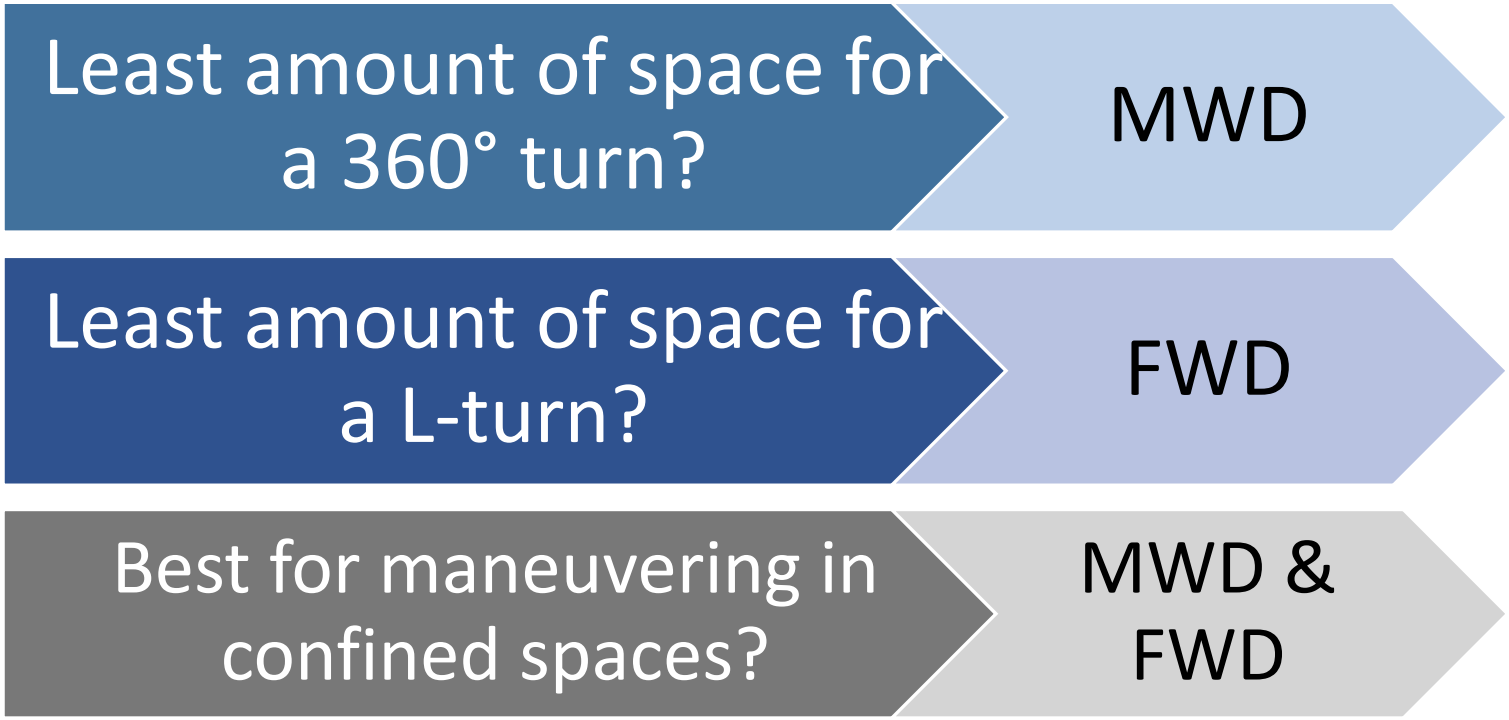
# RWD: Specific skills

- Keep feet in as close as possible – avoid front caster interference
- Wider turns are necessary around corners
- Obstacle climbing . . . Line up front casters – straight on
- Be careful with weight distribution/stability when navigating inclines and rough terrain

# RWD – end of hallway



# Power Base: What does the research say?




(Koontz et al, 2010)

# Design Features that Impact Maneuverability

- *"Mid-wheel-drive PWCs required the least space for the 360°- turn in place compared with front-wheel-drive and rear-wheel-drive PWCs (P<.01) but performed equally as well as front-wheel-drive models on all other turning tasks."*

- *"Even though the front-wheel-drive models were longer and likely had larger swing angles in the rear compared with mid-wheel drive and rear-wheel-drive configurations, users maneuvered these chairs in the least amount of space around the L-turn."*

- Koontz et al, Design Features that Impact the Maneuverability of Wheelchairs and Scooters. Arch Phys Med Rehabil Vol 91, May 2010

# Design Features that Impact Maneuverability

- *"Our PWC findings combined suggest that front-wheel-drive and mid-wheel-drive wheelchairs are better than rear-wheel-drive wheelchairs for maneuvering in confined spaces. Maneuverability of front-wheel-drive PWCs may be more intuitive and easier to learn for users who are new to powered mobility or have impaired proprioception because turns can be initiated closer to the bend."*

- *"The handling of front-wheel-drive PWCs may be more intuitive for some users because the center of rotation is toward the front of wheelchair, enabling the user to initiate a turn at the bend versus having to judge when to begin initiating a turn in order to accommodate a wider front-end swing angle."*

- Koontz et al, Design Features that Impact the Maneuverability of Wheelchairs and Scooters. Arch Phys Med Rehabil Vol 91, May 2010

# Information about the study


- *Note: From the Human Engineering Research Laboratories, Veterans Affairs Pittsburgh HealthCare System (Koontz, Brindle, Kankipati, Cooper), Departments of Bio-engineering (Koontz, Brindle, Cooper), Rehabilitation Science and Technology (Koontz, Kankipati, Cooper), University of Pittsburgh, Pittsburgh, PA; Department of Design and Environmental Analysis, Cornell University, Ithaca, NY (Feathers).*



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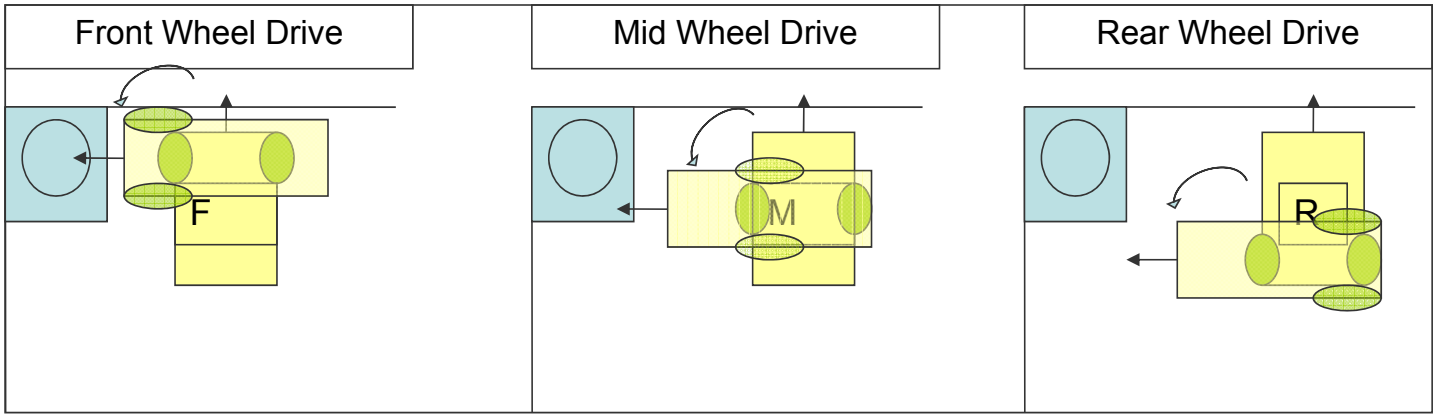
- *No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or on any organization with which the authors are associated.*



- *Reprint requests to Alicia M. Koontz, PhD, Human Engineering Research Laboratories (15 1R1-H), VA Pittsburgh Health Care System, 7180 Highland Dr, 151R1-H, Pittsburgh, PA 15206, e-mail: akoontz@pitt.edu.*

# Importance of front turning aspect




- Imagine a small bathroom, access required to sink right next to wall. The only configuration able to get the user correctly to the sink is front wheel drive. Other configurations might work better in alternative situations.

# Smooth ride

- The fewer the wheels . . . The smoother the ride!
- **FWD/RWD fare better than MWD in this area.**
- Size Matters!
- **Larger Wheel**
  - Better obstacle climbing
  - Better negotiation of
  - soft/uneven terrain

# Pushing, pulling, or following

- RWD/MWD:
- Drive wheel is *pushing* casters.
    - Force is forward and **downward**
    - Plowing effect/Drive wheel loses traction
- FWD:
- Drive wheel is *pulling* casters.
    - Force is forward and **upward**
    - Reduced tendency to lose traction

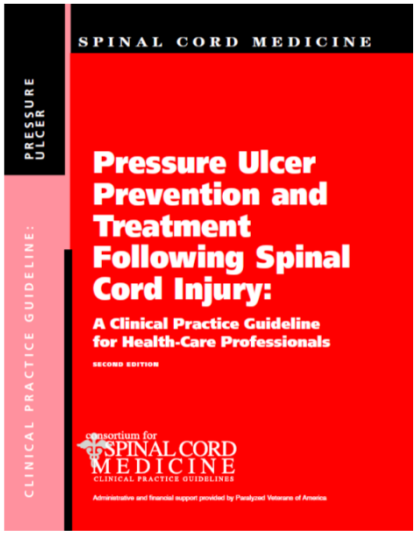
# Seating and Positioning

Why it matters to the client experience

# What about the Power Seat Functions?

# Seating: Movement Matters

- How Often?
  - Every 15-30 minutes
- How Long?
  - 1-3 minutes
- What Angles are Necessary?
  - More is better (at least 45 tilt)
- In what order?
  - Tilt before recline - reduces shear




PVA PU Clinical Practice Guidelines 2014
www.pva.org

# Power Tilt: GOOD

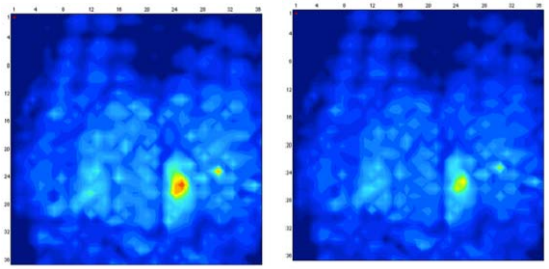
# Power Tilt: Benefits

- Seat to Back Angle Remains Consistent
  - Access to devices doesn’t change
- Pressure Redistribution
- Postural Stability
- Improved Sitting Tolerance
- Position of Rest

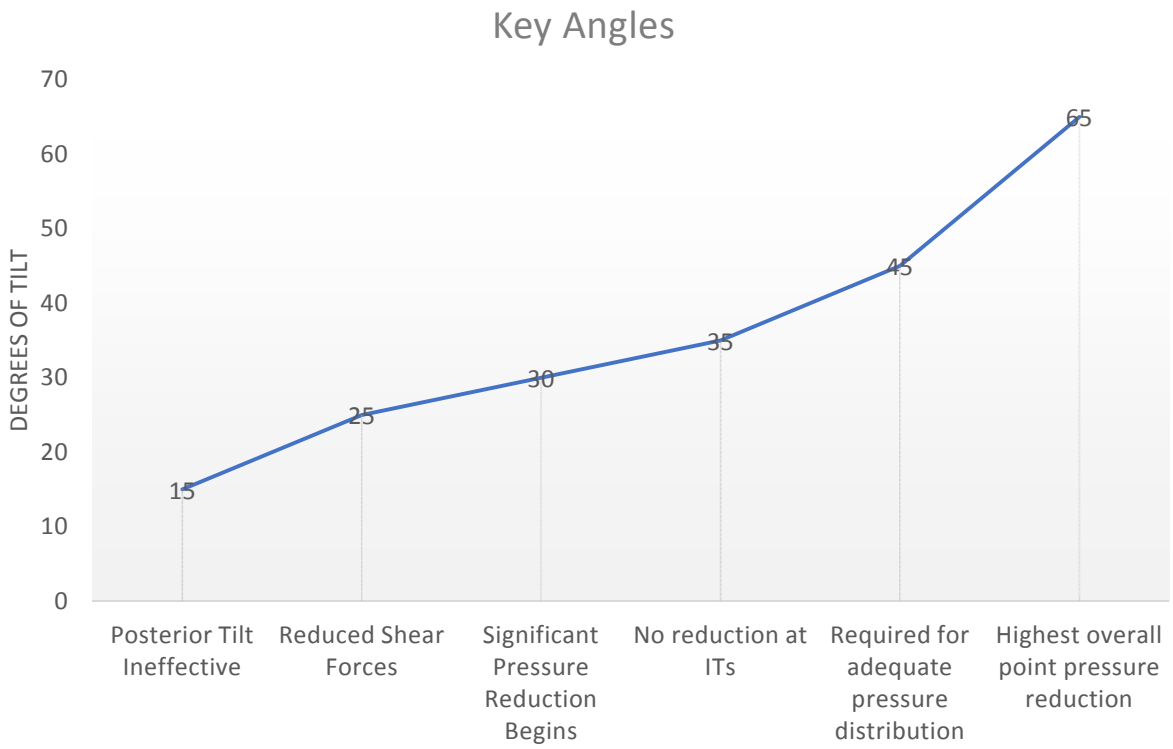
# Power Tilt: Research

- More tilt is better for pressure relief
  - inverse relationship between tilt angle and pressure at the sitting surface.
  - Significant pressure reduction starts at 30°
  - Maximum tilt = maximum pressure reduction (Sonenblum & Sprigle, 2011)

Pressure Imaging
Upright vs. 30 deg.
tilt



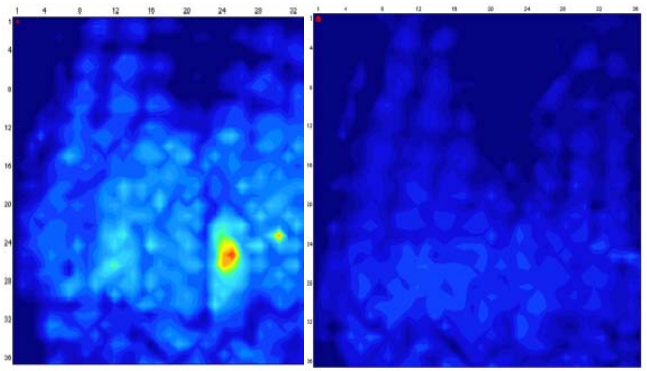
# Power Tilt: Research



# Power Recline: Good

# Power Recline: Benefits

- Greater pressure reduction with recline as opposed to tilt
  - Reduction of seat load during full recline: 61%
  - Reduction of seat load in full tilt: 46%



Pressure Mapping
Recline:
Upright vs. 150° recline

# Power Recline: Risks

- When used without tilt, thought to increase the risk of shear
- Potential loss of positioning
- Decreased access to switches/input devices/headrests

# Power Tilt & Recline: Better

# Power Tilt & Recline: Benefits

- Superior Pressure Relief
  - *with* shear reduction
- Respiration
- Tone Management
- Improved Sitting Tolerance
- Medical Management
- Position of Rest

# Power Tilt & Recline: Better Together

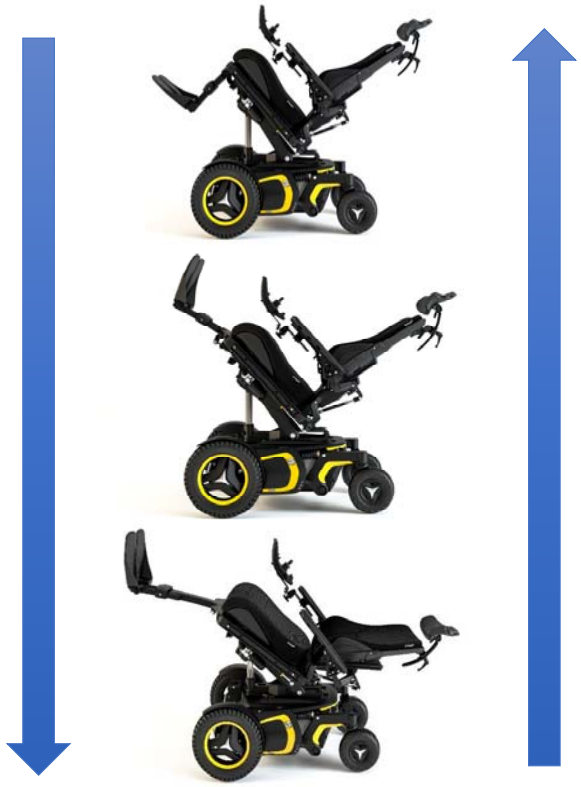
- Why would someone need tilt & recline compared to a tilt only system?
  - Maximum Pressure Redistribution
  - Improved Sitting Tolerance
  - Comfort/Position of Rest
  - Functional Activities
    - Toileting/lower body clothing mgmt.
  - Respiration (respiratory care)
  - Tone Management
  - Medical Management (orthostatic hypotension)

# Power Tilt & Recline: Research

- Jan et al., 2013 studied tissue reperfusion
  - Significant skin reperfusion could be achieved by:
    - ≥ 35° tilt *or*
    - ≥ 15° tilt & 120° recline
  - Significant muscle reperfusion achieved by:
    - ≥ 25° tilt and 120° recline
    - *Unable to be achieved with 35° tilt alone*

# Power Tilt & Recline: Research

- The individual is recommended to initially move to a fully tilted position to stabilize the pelvis, and then follow with activation the recline system so as to minimize loss of postural stability (Kreutz,1997)

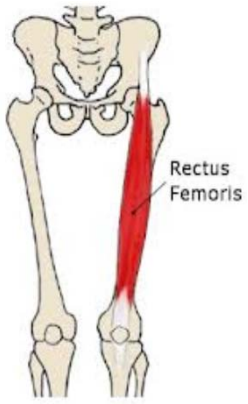


# Power Elevating Legrests (ELRs): Good

- Reduces LE edema
  - Combined with tilt & recline
- Accommodates contractures
- Supports LE casts & splints
- Improves circulation
- Pain management

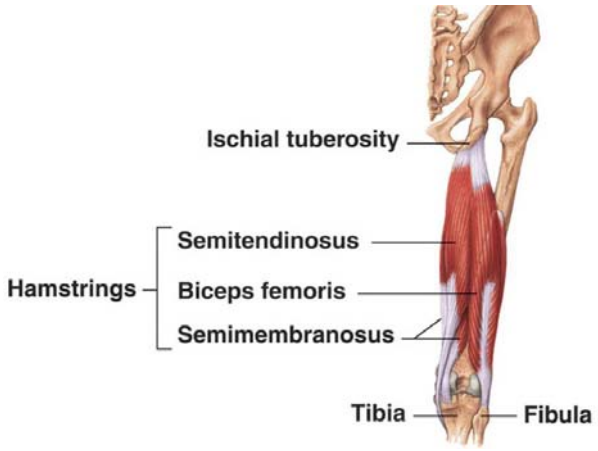
# Power Recline & Legs: Better Together

- RECLINE alone (or with TILT)
  - Stretch of Rectus Femoris
  - Anterior Tilt of Pelvis
  - Sliding - Shearing
- RECLINE with ELRs
  - Provides relief of Rectus Femoris
  - Controls Shearing/Sliding/Ant. Tilt



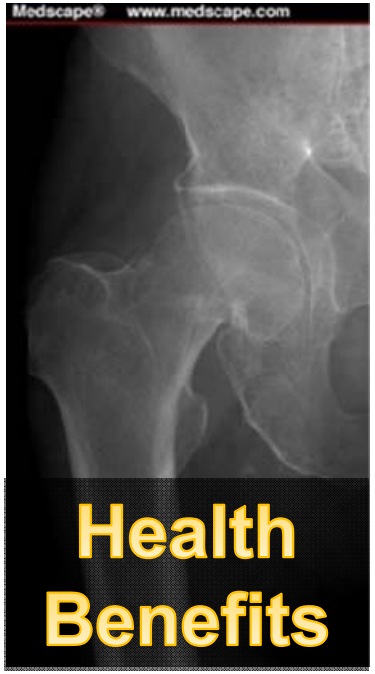

www.somastruct.com

- ELRs alone (with Tilt or alone)
  - Stretch of Hamstrings
  - Posterior Tilt of Pelvis
  - Sliding - Shearing
- ELRs with RECLINE
  - Provides relief of Hamstrings
  - Controls Shearing/Sliding/Post. Tilt




www.rci.rutgers.edu

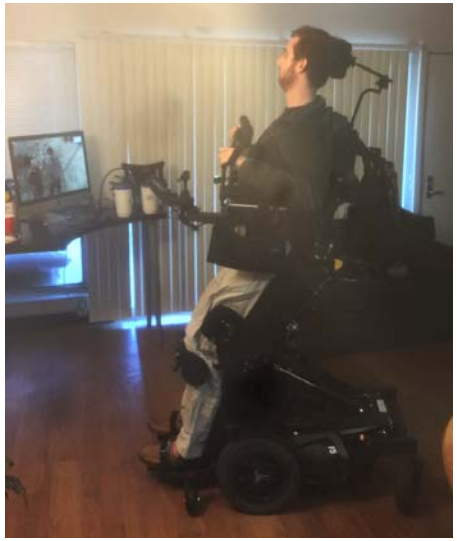
# Power Standing: Best





# Power Stand Benefits

- Standing to achieve pressure redistribution may be seen as more socially acceptable than tilting or reclining back and therefore may be more likely to be utilized in the community
- The physical space needed for a wheelchair to assume a standing position as compared to tilting/ reclining is less, thus can be performed in smaller areas where accessibility is an issue
- Function while managing pressure



# Power Stand: Physiological Benefits

- Bone Mineral Density
  - Dynamic Weight Bearing – Shorter, More

# Power Stand: Physiological Benefits

- Bone Mineral Density
- GI/Respiratory/Circulatory
  - Higher Frequency of Standing – Greater

# Power Stand: Physiological Benefits

- Bone Mineral Density
- GI/Respiratory/Circulatory
- Bowel/Bladder
  - Reducing UTI/Kidney Stones/Constipatic

# Power Stand: Physiological Benefits

- Bone Mineral Density
- GI/Respiratory/Circulatory
- Bowel/Bladder
- Spasticity
  - Immediate and Significant Effect - Benef

# Power Stand: Physiological Benefits

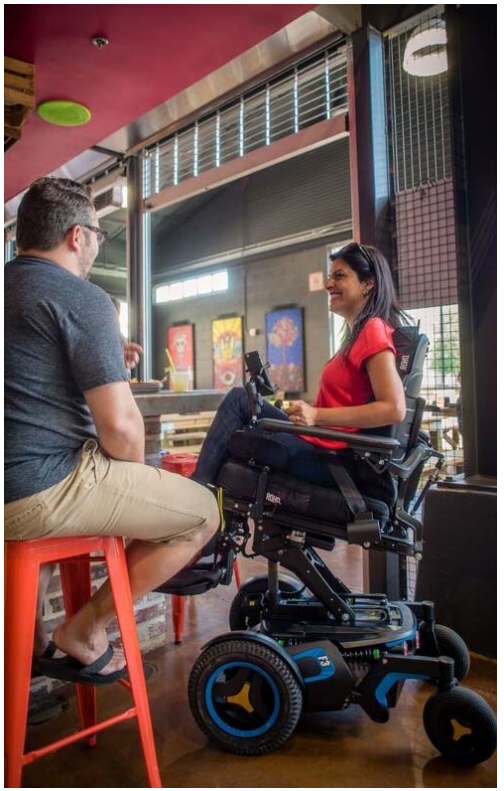
- Bone Mineral Density
- GI/Respiratory/Circulatory
- Bowel/Bladder
- Spasticity
- Pressure Management
  - Reduced Frequency when Using Stande
  - Best Pressure Redistribution Overall

# Power Stand: For Function

- Perform functional activities in standing position
- Reduce amount of caregiver assistance required
- Improved compliance with standing program
- Provide energy conservation
- Improves productivity at work or school

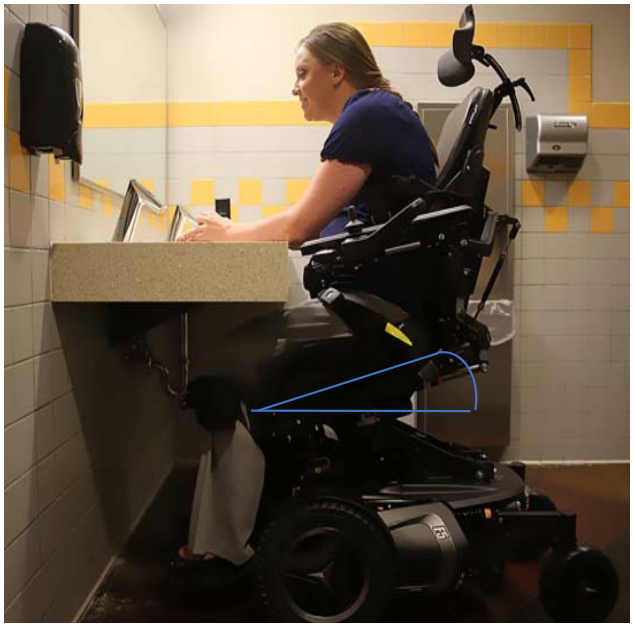
# Power Seat Elevation: Good

- Improves Independence
  - Sit to stand & Lateral transfers
- Improves functional reach/access
- Reduces cervical pain/stress
- Improves visual attention
- Psychosocial benefits

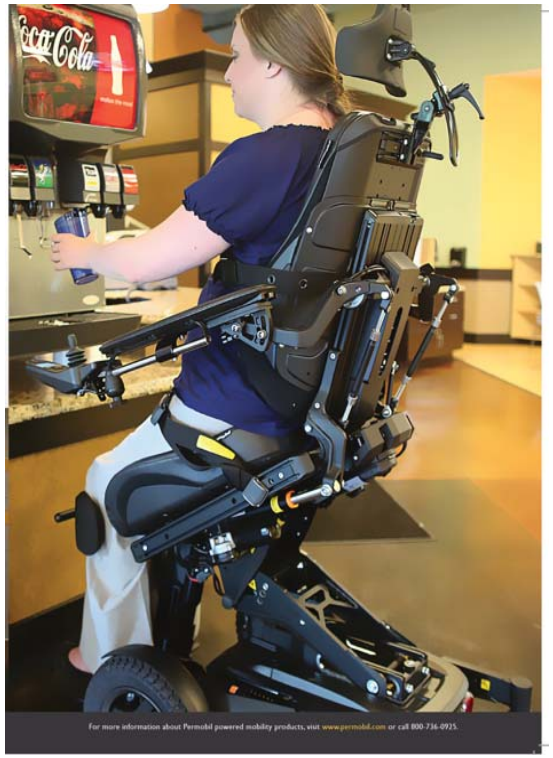


# Active Reach/Anterior Tilt: Better

- Functional Access and Reach
- Ready Position
- Tone Management
- Postural Support/Balance



# Active Reach/Anterior Tilt: Functional Access & Reach




# Anterior Tilt: Assists with Transfers



- Mitigates risk of skin shearing and other injuries during transfers
- Functional compensation for limited hip flexion
- Sit to Stand Transfers
- “Nose over Toes”
- Lateral Transfers

Comfortable, socially forward user position.

Use of secondary supports.

# Drive Controls

Getting it right with a good assessment

# How do people drive?

- Hand
- Finger
- Chin
- Lip
- Head
- Breath
- Foot

# What do people drive with?

- Joystick

# What do people drive with?

- Joystick
- Mini/compact joystick

# What do people drive with?

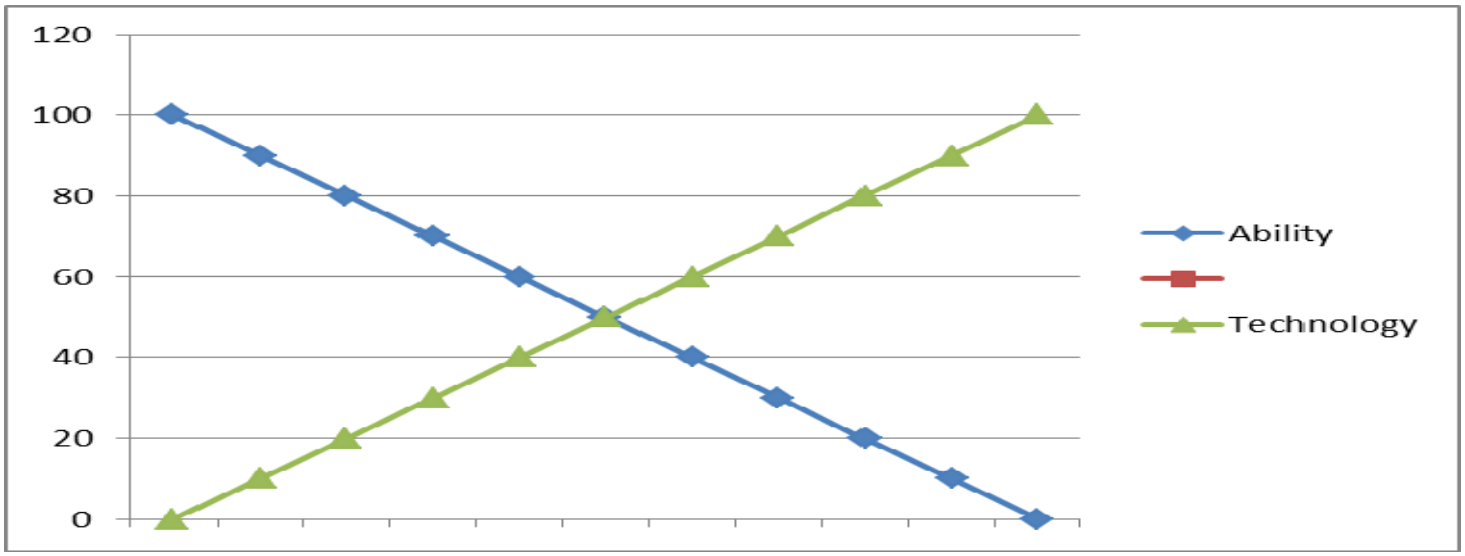
- Joystick
- Mini/small joystick
- Head array

# What do people drive with?

- Joystick
- Mini/small joystick
- Head array
- Sip n puff

# Relationship: Ability and Technology

- Ability and Technology have inverse relationship
- Decreased ability requires increased technology.



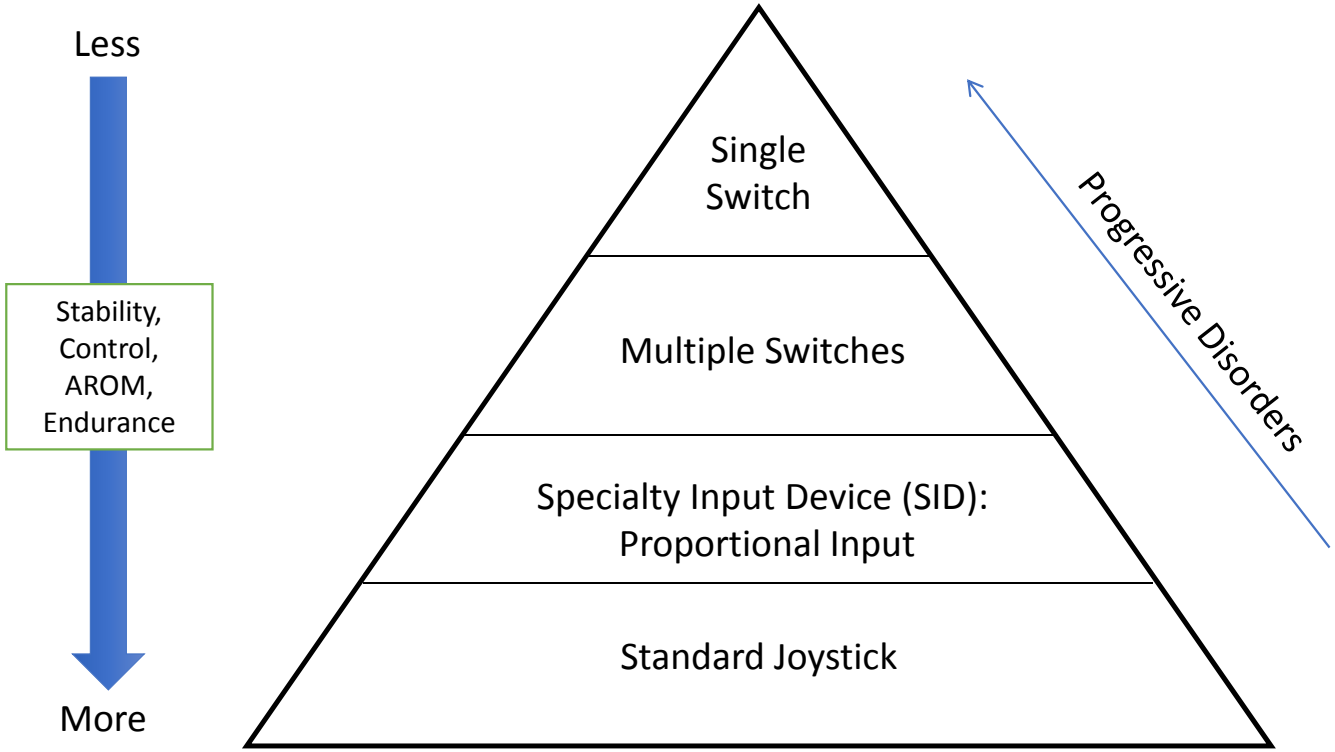
# Choosing a Driver Control (input device)

| Goal Assessment | Consideration |
|---|---|
| **Stability & Consistency** | What is the most consistent control site? Are positioning components optimized? |
| **Location** | Do different positions elicit more/less stability and control? (Midline mount, alignment of joystick higher or lower, etc.) |
| **Motor Control** | With this control site, is the person using fine or gross motor movements? |
| **ROM** | How much movement is required to effectively operate the input? What about during use of power seating? |
| **Endurance and Fatigue** | Does the driver have enough endurance for the chosen input device? |
| **Interface** | Custom handle, goal post, tennis ball, etc. |

# Mechanism of control

- Proportional controls
  - Infinite control of speed (0=max mph) and 360 degrees of direction
  - Continuous and fluid response while moving further from neutral
- Non-Proportional controls (digital, switch, pneumatic)
  - Either ON or OFF
  - Up to 8 discrete directions
  - Can be programmed for single or multiple speeds

# Hierarchy of Drive Controls



# Proportional Joysticks


Permobil PJSM


Color Joystick


LED Joystick

# Proportional Joysticks

Heavy Duty

Compact Advanced

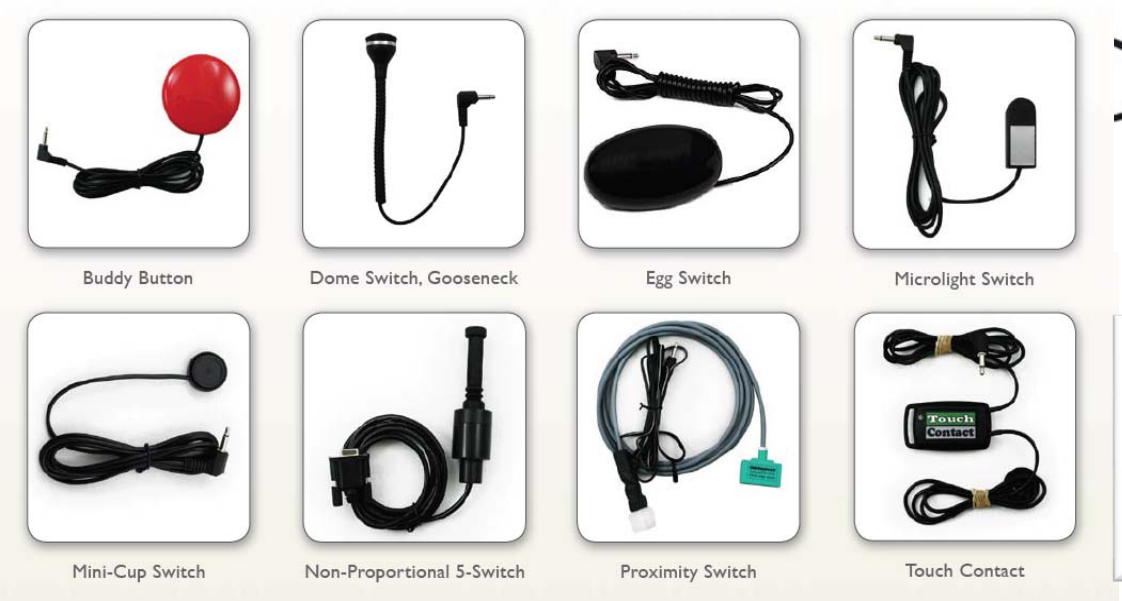
# Alternative Drive Controls

Specialty Input Devices (SIDs)

# Alternative Drive Control-Joysticks

- Requires OMNI display module
- Change in throw
- Change in force
- Change in size
- Change in mounting location

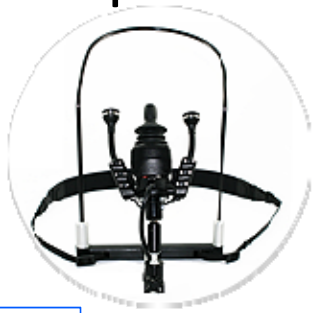
# Switch Options




ASL Ultra Light

Tinkerton EMG

# Alternative Proportional Drive

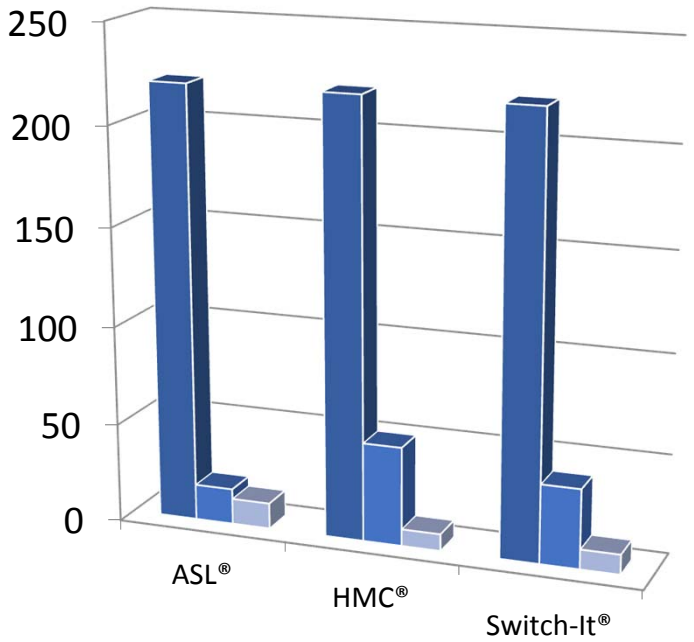


Compact joystick

Compact joystick LITE


Mini Joystick

# Joystick Force




**Joystick Force**: How much strength is required to move the joystick.

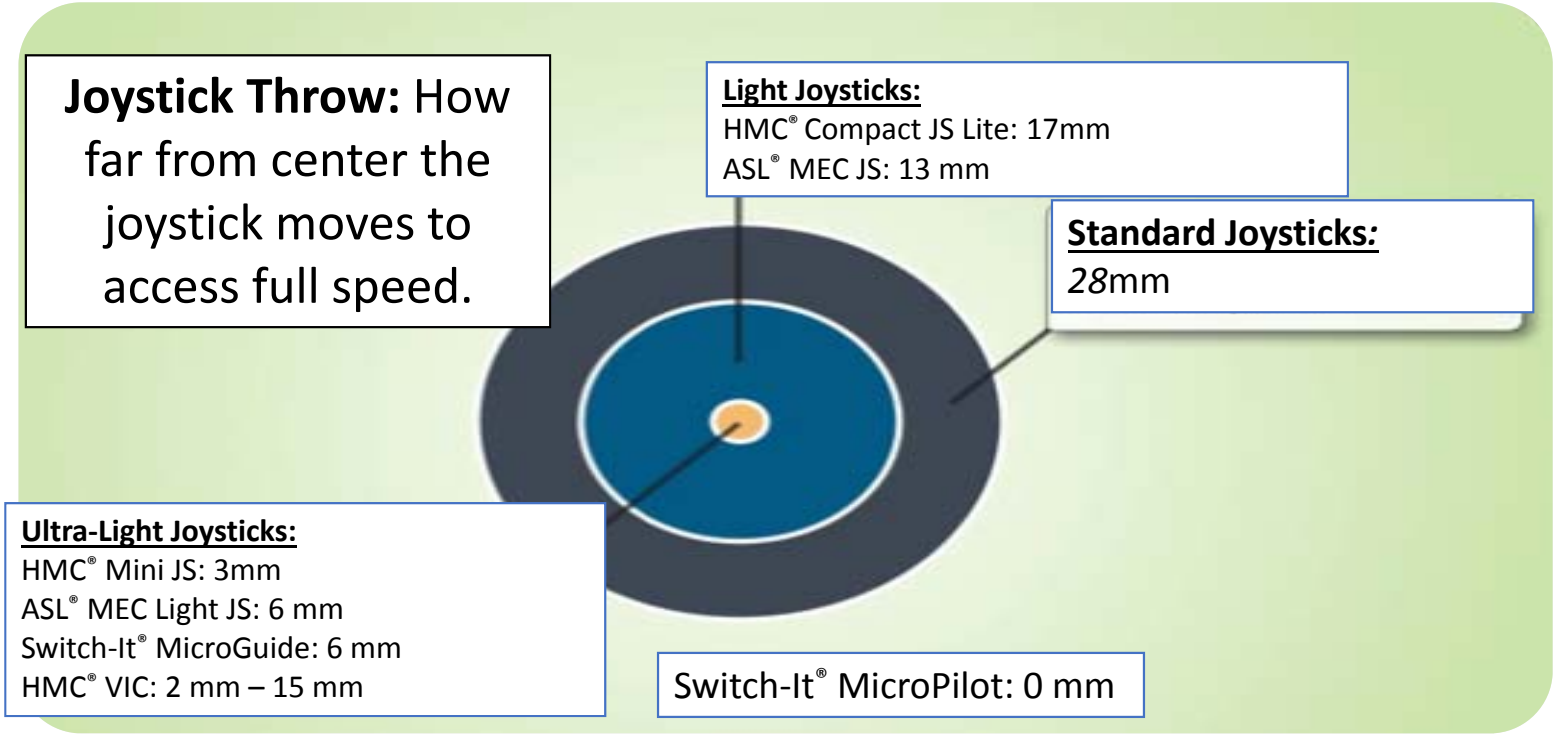
# Additional Proportional Input Devices


Switch-It TD2

Switch-It Micro Guide

Switch-It Micro Pilot

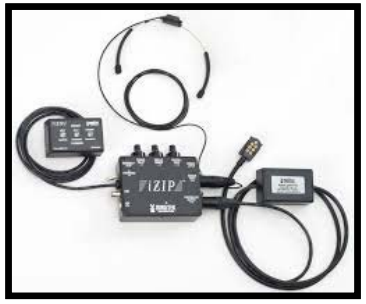
# Joystick Throw



# Proportional SIDs

Video Game Controller





Magiteck Drive


ASL Micro-Mini

# Non-Proportional (Digital) SIDs

- Either ON or OFF
- Up to 8 discrete directions
- Can be programmed for single or multiple speeds.

Sip & Puff Head Array Combo

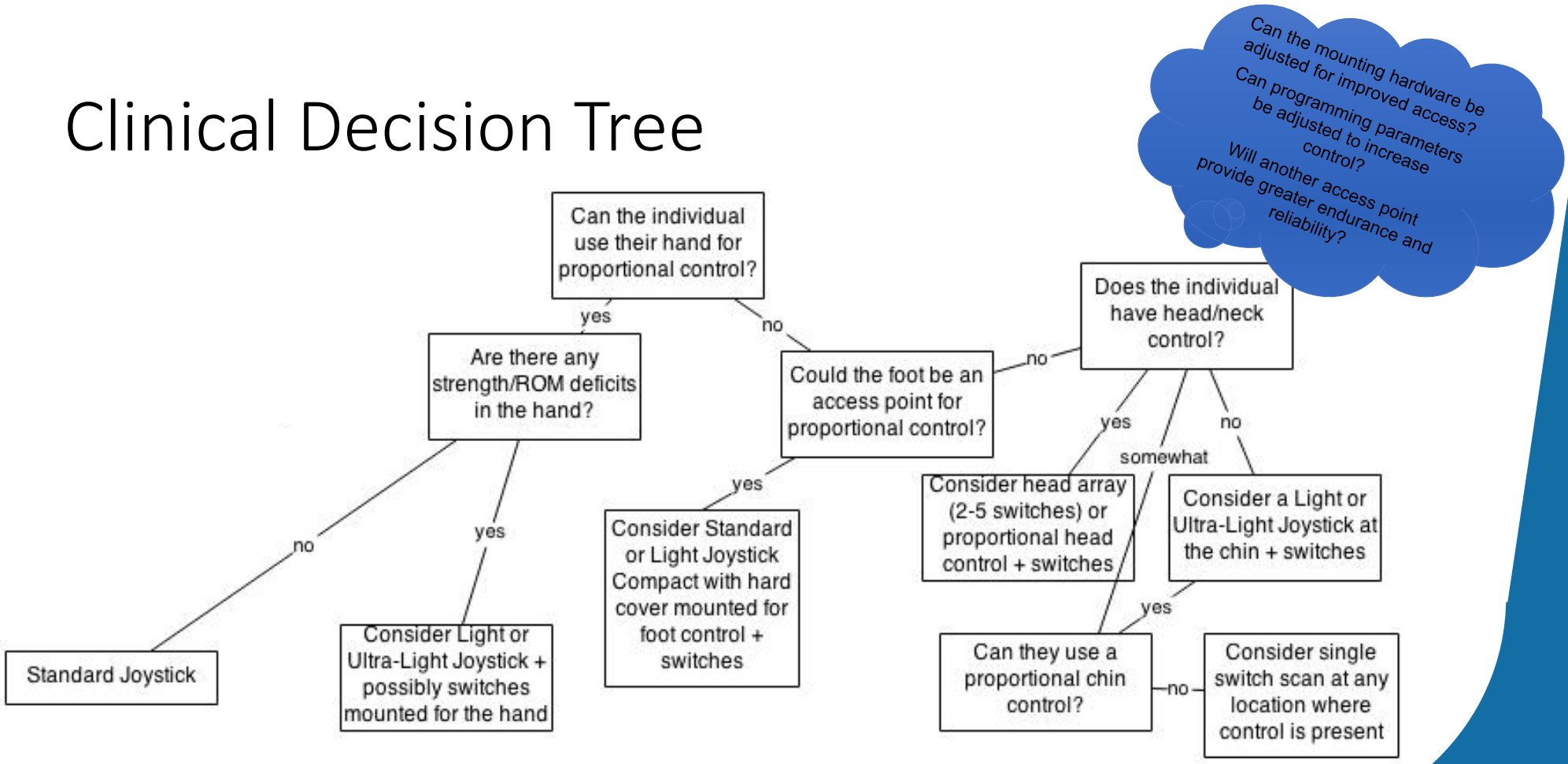
Fiber Optics Tray

Eclipse

# Total Control Head Array

- Dual Switch Enhanced Control
- Plug ‘N Play Switch Options
- Minimal Design
- 3, 4 and 5 Switch Options

# Clinical Decision Tree

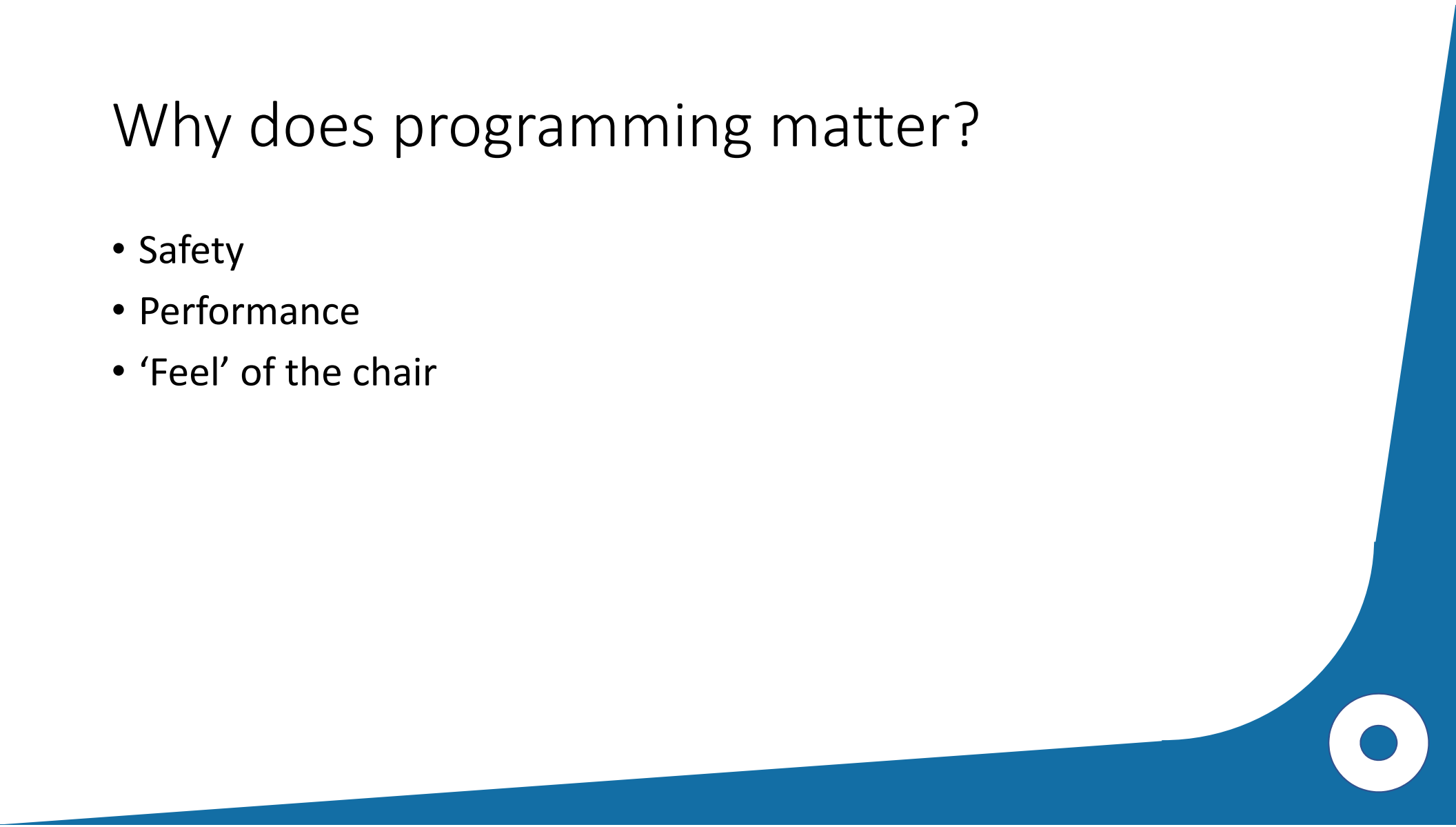


# Programming

It’s not so scary… and it makes a huge difference

# Why does programming matter?

- Safety
- Performance
- ‘Feel’ of the chair



# Programming Methods

- Hand held programmer
- On-board programming (with or without dongle)
- PC based programming (with dongle)

# Some programming terms…

- Profiles
- Modes
- Joystick
- Seating
- Motor
- Speeds

# Joystick Programming Terms

| Term | Definition |
|---|---|
| Forward Throw | Deflection required to achieve full forward speed |
| Reverse Throw | Deflection required to achieve full reverse speed |
| Left Throw | Deflection required to achieve full turning speed to the left |
| Right Throw | Deflection required to achieve full turning speed to the left |
| Deadband | How far the joystick needs to be deflected before movement starts |
| Left Right Axis | Inverts left/right axis |
| Forward Reverse Axis | Inverts forward/reverse axis |
| Swap Axis | Swaps forward/reverse with left/right axes |
| Tremor Dampening | Smooths input device commands |

# Why would I change…

- Throw
  - Limited movement in a particular direction
- Deadband
  - Promote intentional movement
  - Accidental or involuntary movements
- Axis directions
  - Accommodate for stronger or weaker movements
- Tremor Dampening
  - Accommodate for severe tremor

# Motor Programming Terms

| Term | Definition |
| --- | --- |
| Torque | Power available to the motors at low speed |
| Power | Overall power available to the motor |

# Why would I change…

- Torque
  - Accommodate difficult terrain
  - Soft surfaces like carpets
- Power
  - Increase safety for marginal drivers
  - Reduce damage from bumps

# Joystick Programming Terms

| Term | Definition |
| --- | --- |
| Forward Speed (Max and Min) | Speed moving forward |
| Reverse Speed (Max and Min) | Speed moving backwards |
| Turning Speed (Max and Min) | Speed when turning |
| Acceleration (Forward, Reverse, Turning; Max and Min) | How quickly achieves max speed |
| Deceleration (Forward, Reverse, Turning; Max and Min) | Braking rate |

# Why would I change…

- Forward or Reverse Speed
  - Increase safety
  - Provide alternative speed profiles
  - Accommodate different environments
- Turning Speed
  - Change “responsiveness” of chair
- Acceleration
  - Accommodate specific environments
  - Promote Safety
- Deceleration ** requires careful balance
  - Promote safety
  - Reaction time

# What is ESP?  (no… it's not mind-reading)

- Enhanced Steering Performance
- Accommodates terrain issues to stay straight and consistent
  - Sloped
  - Angled
  - Rough
- Similar systems called Suretrac (Sunrise), ActiveTrac (Pride), G-Trac (Invacare)

Real challenges & programming solutions

http://etc.ch/7anN

# Break

Applying theory to real-world issues…

# 4

Case studies

Stations (20 mins each)

(or 5) per group

# Wrap-Up and Discussion

# Thank You!

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