# Clinical Tool for Prosthetics

**PROJECT BRIEF**

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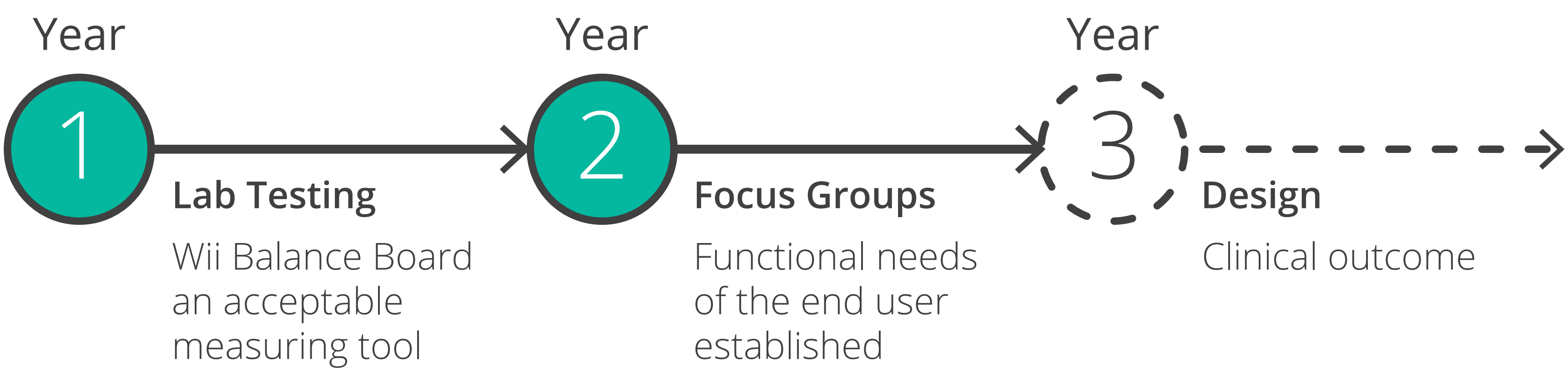
# Introduction

## PROJECT BACKGROUND

This project started two years ago when a small team of researchers at the BCIT Technology Centre identified a need to quantify and document patient progress for Prosthetics and Orthotics. They initiated a three year project titled *Exploration and validation of the use of the Wii Fit and other gaming technology as a quantitative clinical tool in the Prosthetics and Orthotics field.* This project is funded by the BCIT Institute Research Fund awarded by an internal committee to foster a research environment.

The partner's project is progressing into its final year which will centre on a design outcome based on research from the previous two years. The team approached Emily Carr University via the Health Design Lab and subsequently made the project available for a thesis project.



## PROJECT SUMMARY

The study of prosthetics and orthotics (P&O) are integral to ensuring patients in need to experience a good quality of life that includes self-sustainable mobility. This project will focus on the methods that clinicians in these fields use to diagnose patients and improve the usability of their prosthetics and orthotics. Traditionally, doctors and clinicians have used visual observation, manual measuring or in some cases video-based laboratory-grade “force platforms” in their analysis of a patient’s gait. Many of these approaches are either not detailed enough, or not being used due to complications and expensive cumbersome technology.

This project seeks to give prosthetists and orthoticists easy to use tools to improve amputee clinical care. The use of readily available and inexpensive gaming technology that will allow the collection of clinical measurements should address cost issues. Initial research has shown that tools designed with ease of use as a primary objective can lead to an increase in their uptake. Making use of these techniques and delivering a user interface that clinicians will want to use will likely result in a product that could provide patients with better care than in the past.

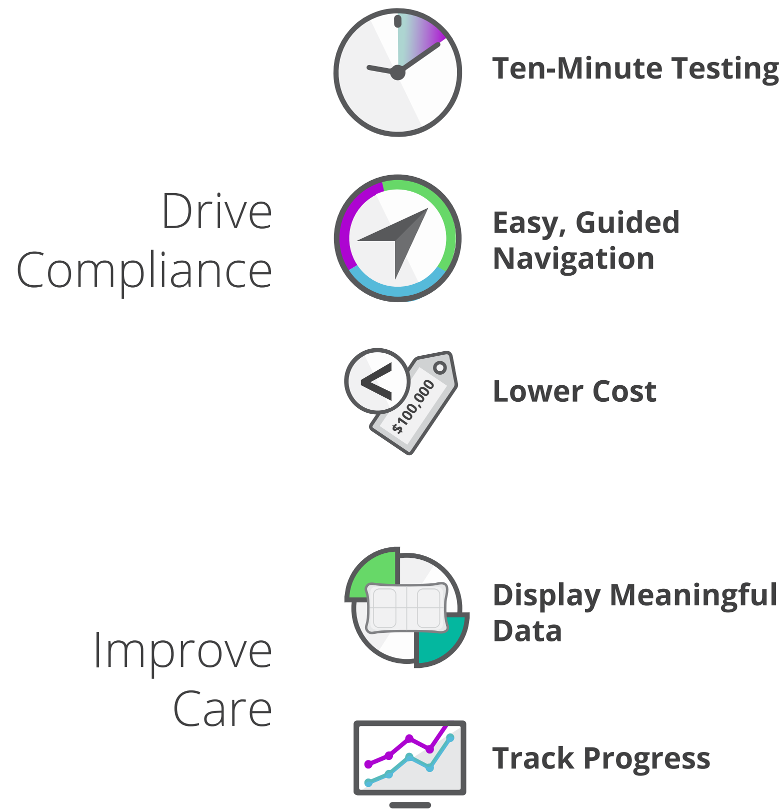
The team was looking at the Wii Balance Board because it showed promise as a starting point for a cheaper alternative to some of the solutions out there now. A paper released in 2010 by the University of Melbourne revealed that the Wii Balance Board was close to as sensitive as a laboratory grade Force platform

## OBJECTIVES

In order to increase the usage of a gait analysis, the system's usability needs to be improved. This will be accomplished through many set objectives that will be subject to modification. The overarching objective will be fulfilled by designing a graphical user interface that displays data in a way that is that is meaningful to prosthetists for clinical purposes. This will include dual force plate visualization and a graphical presentation of diagnostic data.

A successful outcome should address the clinician requests uncovered in the focus groups and co-creation sessions. The outcome should seek increased user compliance by reducing workload, learning curve, and the amount of time spent on data collection. BCIT's focus groups have found that 10 minutes would be the ideal maximum time period allocated to an assessment session.

In essence, clinicians need to improve adoption and as a means to improve care. A system that is a pleasure to use can go a long way to supporting us.. By creating a tool tailored to the needs of P&O clinicians, I believe usage of gait analysis system can be increased. This in turn will help to empower clinicians to deliver improved P&O patient care.

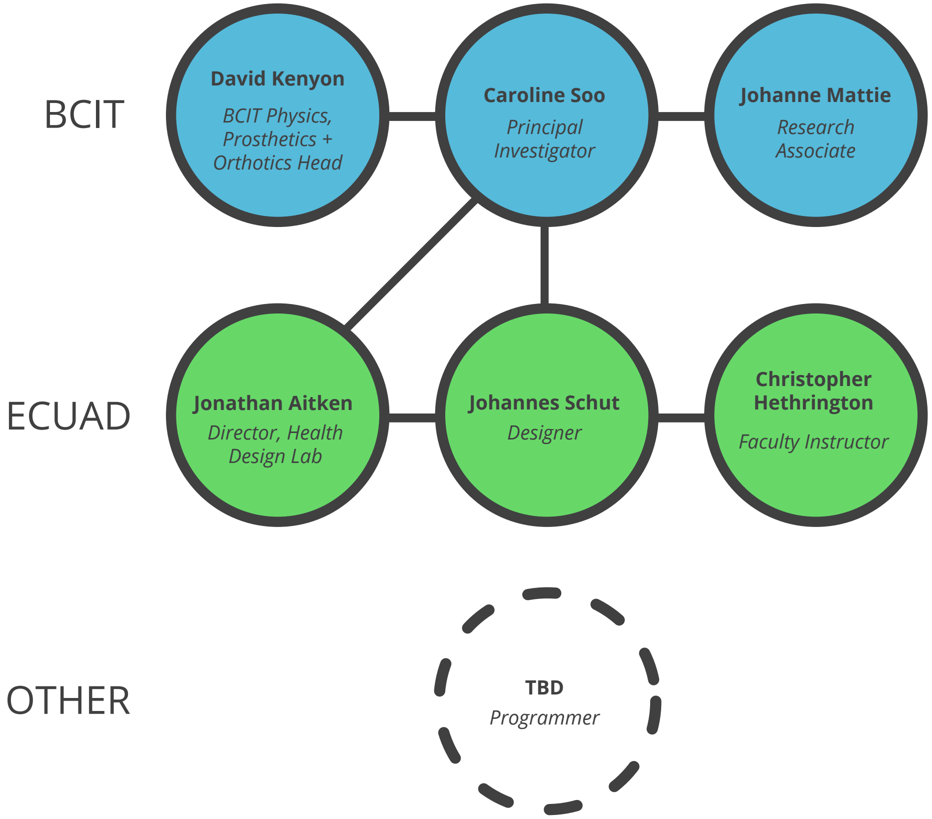


## TEAM

Our project team consists of our partners at BCIT along with myself as the designer, Christopher Hethrington & Katherine Gillieson as my Faculty Instructors and Jonathan Aitken, Director of the Health Design Lab who facilitated the partnership.

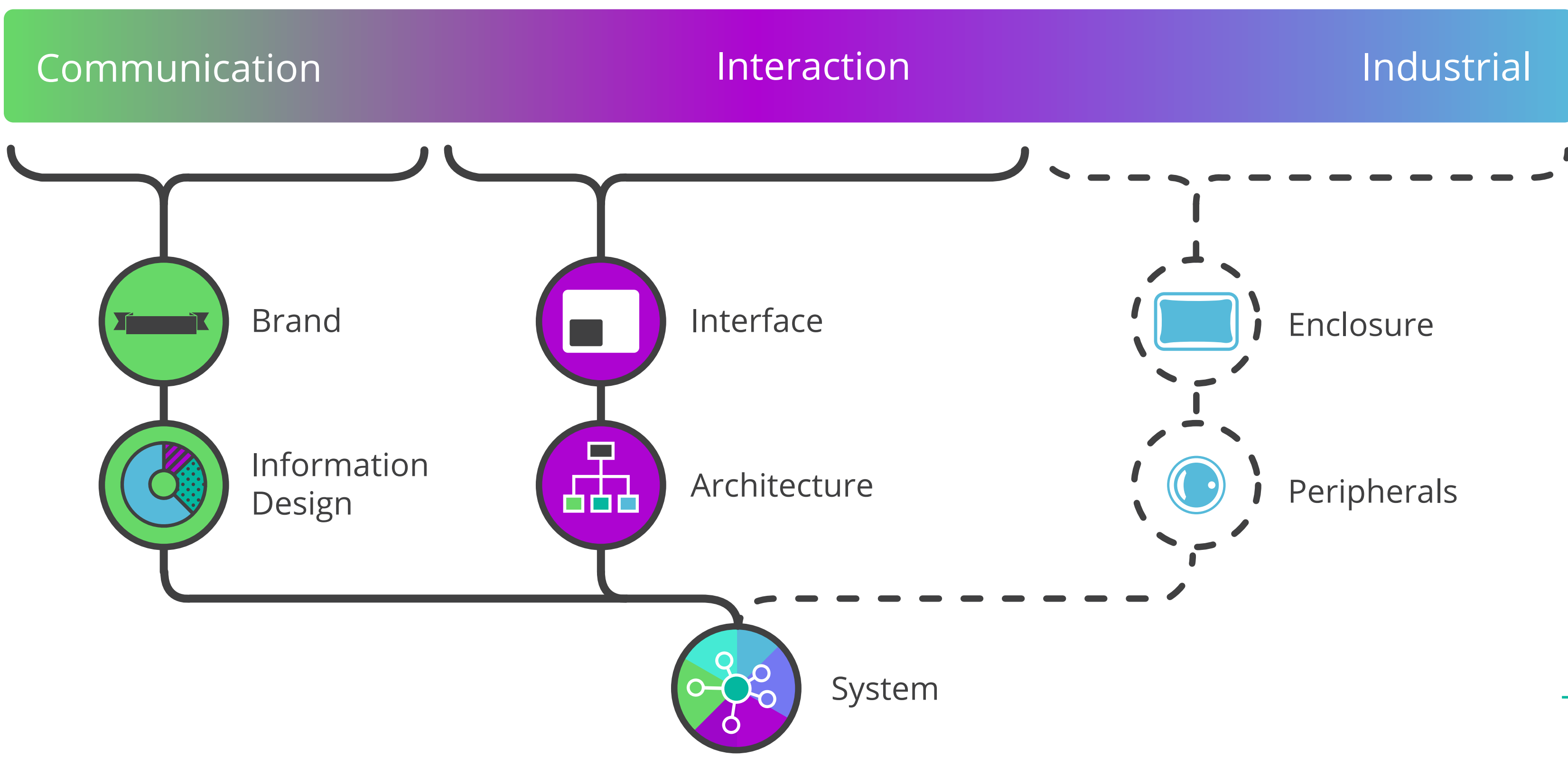
The BCIT group is Caroline Soo, Principal Investigator of this project and Research Coordinator for Prosthetics and Orthotics at BCIT., David Kenyon, BCIT Physics, Prosthetics & Orthotics Head, and Johanne Mattie, Research Associate for the Technology & Product Evaluation Group at the BCIT Technology Centre.

The partner plans to hire a programmer to produce a working application towards the end of the design phase.



## PROJECT SCOPE

For this project to be successful expertise across the design disciplines will need to be realized due to the many desired components of the project. The ideal solution will incorporate all of these components into a comprehensive system. My contribution to this project will include the communication and interaction categorizations as demonstrated in the graphic below. I will also identify the possible contributions industrial design can make and present those possibilities for future consideration.



## THESIS QUESTION

Prosthetic and orthotics clinicians have the ability to provide better care for their patients through the use of analysis systems. Unnoticed problems with prosthetic devices that have not been addressed can hinder a patient's mobility and upholding therapy activities as well as quality of life. If there is discomfort the patients may avoid weight-bearing through the prosthesis. (Maguire) The capacity to capture the data required for more detailed analysis is clearly available now. However, with tight schedules as a primary limiting factor, clinicians' demands for intuitive and rapid solutions are not being fulfilled.

Information surrounding the professional and personal lives of clinicians will aid in contributing to the final outcome. This will all seek to answer the question: how can design increase usage of gait analysis to improve patient care?

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# Research

## INTRODUCTION

The Technology and Product Evaluation Group (TPEG) is an applied research group at British Columbia Institute of Technology's Technology Centre. The group evaluates of several different specializations including healthcare and works with both with industry clients and on grant-funded initiatives.

The project was started because a need to quantify and document patient progress was identified in the Prosthetics and Orthotics field by David Kenyon, Johanne Mattie and in their previous work with Prosthetists in the local community. Caroline Soo joined the project soon after as the Principal Investigator and successfully obtained a grant from the BCIT Institute Research Fund. The first two years of the study proved that a Wii Balance Board would be a suitable measuring device. Emily Carr has been approached to assist them in creating a graphical user interface that operates the system.

After meeting Caroline Soo, the coordinator of the project and the other team members, I gathered an understanding of the existing problem space. Existing solutions have been unsuccessful because they are unintuitive and expensive.

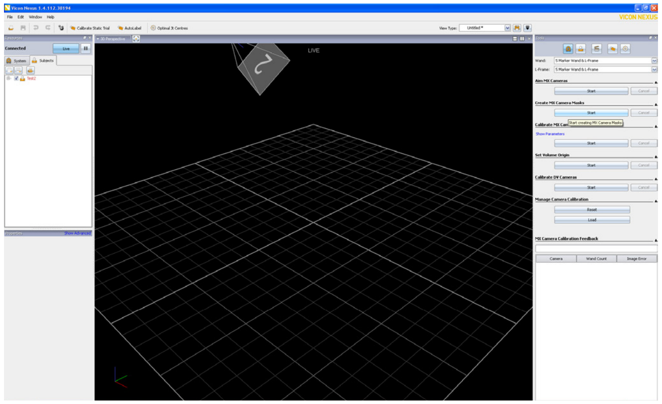
The team had put on focus groups that helped narrow down the feature set prosthetists were looking for in a new system. The team knew most of the things they wanted the solution to incorporate but did not have a clear idea what that would look like once put together. My challenge is to dig deeper into what the needs of the user is in order to develop a fully tailored solution.

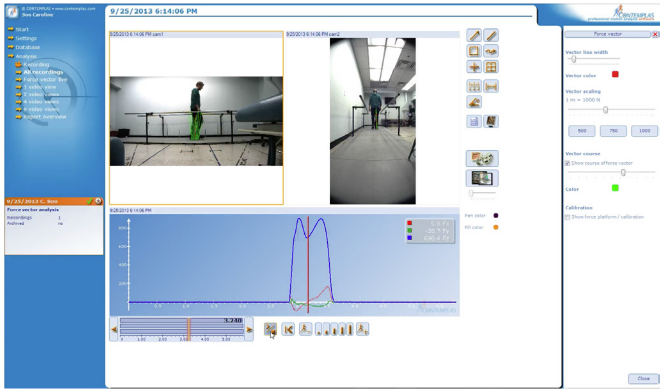
## EXISTING SOLUTIONS

Looking into existing systems for gait analysis revealed that a great variety of products are available to clinicians. As previously stated they are both prohibitively expensive and unintuitive. I had the opportunity to experience some of the systems first hand at BCIT's Technology Centre and Prosthetics and orthotics program.

The Technology Centre employed an advanced motion capture system using infrared cameras to pick up markers attached to key points around joints, combined with a force platform. The software at the heart of this system is VICON Nexus a "Life Science software suite"(Vicon) offering motion capture analysis for gait analysis, rehabilitation, sports performance, animal science, and balance & motor control. The software seems overly complex and it is no surprise that one would not use this in a clinical setting. It seems stronger suited to research tasks.

At the prosthetics and orthotics program at BCIT housed a simpler camera-based setup. Motion Analysis Resource Systems' TEMPLO was being used. While software bills itself as the "most intuitive video analysis software available", I found the software to have many messy interface elements impeding use. The software is aimed towards many different uses such as posture, gait, industry, bike, science, high speed, sport, shoe fitting and more. Upon being introduced to the system, I was surprised to see that it required an extensive configuration process was required before we could use it, an annoyance also previously noted by the focus groups.



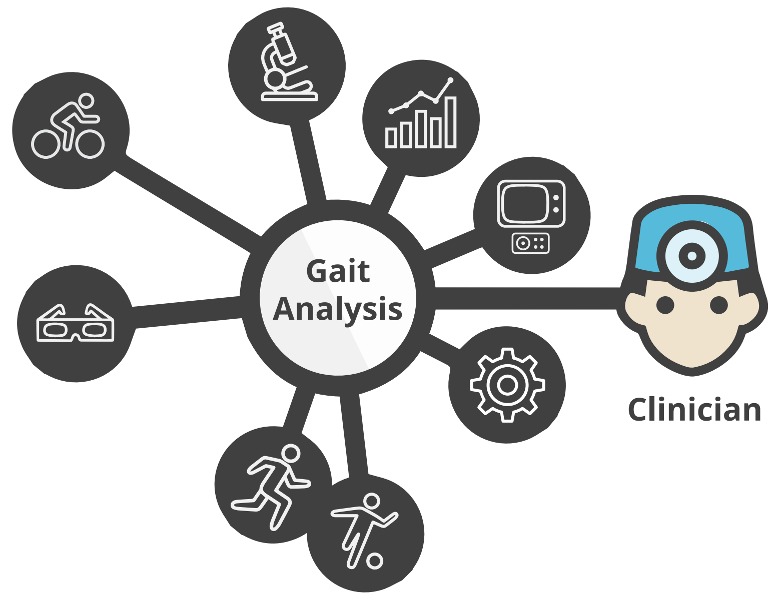


If is my belief that a lack of focus is hampering efforts by these companies to excel in any one specific field. Existing software seeks to be modular and adaptable to a wide variety of disciplines including research and testing, causing them to lack a user experience that allows them to be suitable in a clinical environment.

According to Prosthetist John T. Brinkmann, while “Gait assessment and analysis is integral to the provision of prosthetic and orthotic care” the “Data collection tools are underused” because “consistent measurement can be difficult.”(Brinkmann). He argues that gait analysis is very similar to an MRI test because “both provide a very high level of detailed information to support a diagnosis or intervention, and both are time-consuming and expensive to perform”. (Brinkmann) Our challenge in this respect will be to design an economical system. Since the sensors used to gait analysis are only a fraction of the cost of an MRI system, we believe this problem of a symptom of the current system design. Reducing time and cost should be an attainable goal.

Inter-rater reliability can be poor because therapists rely mainly on subjective observation of gait to evaluate the effectiveness of the patient’s rehabilitation progress (Besser et al) This leads to a lack of quantitative data. The design of the interface for this project will attempt to mitigate these issues.

Another hurdle is inputting normative data to compare against. Once optimal normative values are determined, the information becomes invaluable to maintaining care.(Besser et al)




“It [currently] may not even be feasible to perform a video analysis during every clinical encounter due to the cost and time required.” (Brinkmann)

## TECHNOLOGY IN HEALTHCARE

A great concern among healthcare professionals is the perceived divide between providers and patients when using a traditional PC-based systems which have been popular with early Electronic Medical Records (EMRs). EMR's carry a risk of not being implemented well, requiring too much support, as well as some perceived risks of loss of data. BCIT's E-health accelerator works in bringing about technological change for healthcare by providing an environment test and identify strengths and weaknesses to improve the quality of these types of technologies. One of the findings of the accelerator was that the computer screen gets between the doctor and the patient but this was not as much of a problem with mobile devices. (Mattie)

The lack of adoption and compliance of record keeping technologies in the healthcare sector is leading to 80 percent of patient data being unstructured—meaning it's not being organized in a predefined manner. Furthermore, 90 percent of data being discarded by healthcare providers. (Hinssen)

Organizations such as the Mayo Clinic and the Ottawa Hospital developed an app to bring their EMRs to mobile devices because Physicians felt like they were interacting with computers more than they were interacting with patients. The Mayo Clinic's transition from PC-based to mobile based EMR was a huge success. "It really brings us back to the time when health care was a personal interaction between the physician and the patient"(A Medical Leader).

It has become to me clear that in for this project the solution should leverage a mobile platform based rather than desktop based to address the user's concerns.


"Not only has iPad increased efficiency from a provider perspective —
it's increased engagement between the provider and patient." (Visocky)

— DALE POTTER, THE OTTAWA HOSPITAL

## GAMIFICATION

Gamification is a tool for motivation. Non competitive games can be defined as "structured experiences with rules and goals that are fun to play".(Werbach) Techniques to incorporate these qualities into everything around us are increasingly gaining momentum. It has been particularly useful in personal activity monitoring

I also looked at how sensor data has been used for consumers. Nike Plus is a great example of how sensor data can be used for increasing awareness on many levels related to running. Nike Fuel Band expanded sensor data use from just running to looking at overall personal activity. Jawbone Up takes another step and adds sleep tracking goals. Basis Science goes further yet again and integrates a heart rate monitor as well as a personal activity tracker. The interesting thing about this one is that it has a prominent focus on goals.

Providing a goal system would great way to drive both clinician and patient compliance and improve involvement in treatment. But may be outside of the scope project. The team was intrigued with the idea as it hadn't been brought up before.

The triggers that drive behavior are outlined in BJ Fogg's Behavior Model the facilitator, signal, and spark. The facilitator would be the trigger that increases the user's level of ability to combine with a high motivation. In the case of the personal activity software, they are functioning more as a spark to increase motivation while your ability to be active was already established. Our solution will seek to facilitate easy testing for which the motivation is already quite high.

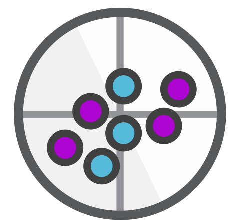
## INFORMATION DESIGN

The types of data displayed in gait analysis fall under three distinct categories: ground reaction forces, centre of pressure and numerical data. Ground reaction force analysis graphs which usually take the form of line graphs showing force over time. Centre of pressure is displayed as plots on a quadrant grid, which indicate the relative position of the two coordinates that make up the plot. Finally, the measurements also include a variety of numbers that include step length and speed. (Brinkmann)

Since our prototype will likely involve two Wii balance boards, the ground reaction force and centre of pressure information display will be doubled. The large quantity of data produced by the measurements necessitates the data is sufficiently distilled in each display to avoid information overload. When initiated by graphics, this is known as “map shock” or “visual shock” in which users describe a sense of being lost an not knowing where to start.(Visocky) The primary challenge will be ensuring the information is sufficiently hierarchical in order to avoid compromising comprehension.

In addition to hierarchical tools to avoid information overload is ensuring absolute legibility. The Principal of Least Effort states that data users will gravitate to the most accessible data.(Visocky) We will ensure the most important data will be easy to get to by being quick to read.

Ground Reaction Force



Centre of Pressure


Other (Numeric)

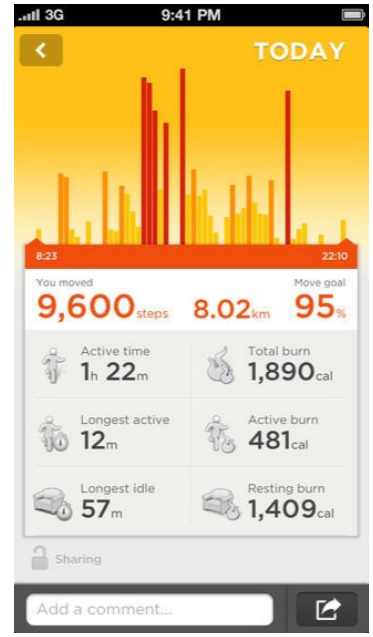
“The goal of any information design task is to communicate a specific message to the end user in a way that is clear, accessible, and easy to understand.” (Visocky)

## PERSONAL FITNESS MONITORS

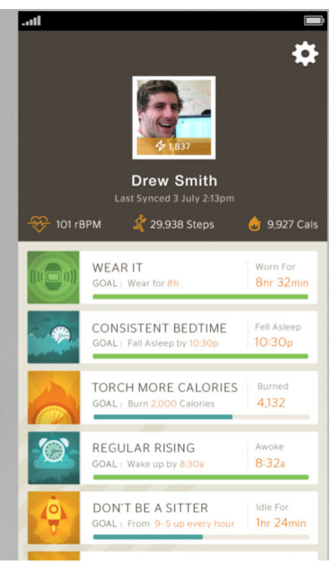
Personal fitness monitors such as Nike Plus, Fuel Band, Jawbone Up and Basis Science are great examples of how sensor data can be used to drive positive change. So far this sensor data has been used for consumers to promote increased activity levels and more consistent sleep patterns. The goals set through the application seek to motivate personal activity through the improvement of actual data entered into the systems. Reflection upon the data can assist the user in identifying new solutions to personal activity. Basis Science has a prominent focus on goals and badges and does a great job gamifying the experience.

These devices shed lights on how providing a patient side goal system would great way to drive patient compliance with their treatment. This may be outside of the scope project but is important to consider for future updates. This idea was not brought up before in any of the focus groups.

In the same way, the bigger picture of overall patient data could be aggregated in a way to motivate the provider to increase their overall level of care.

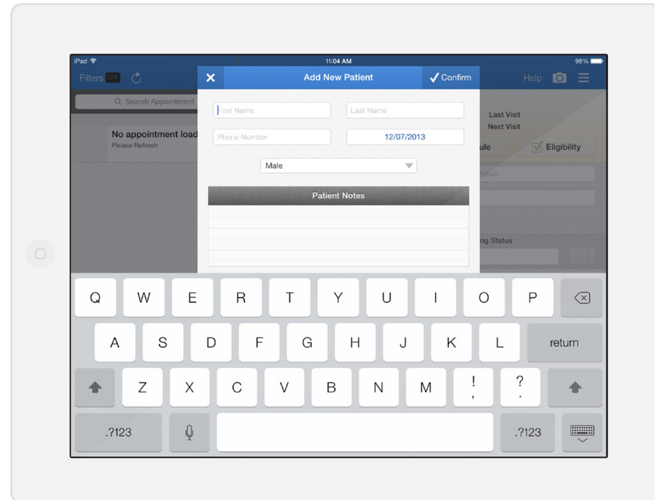


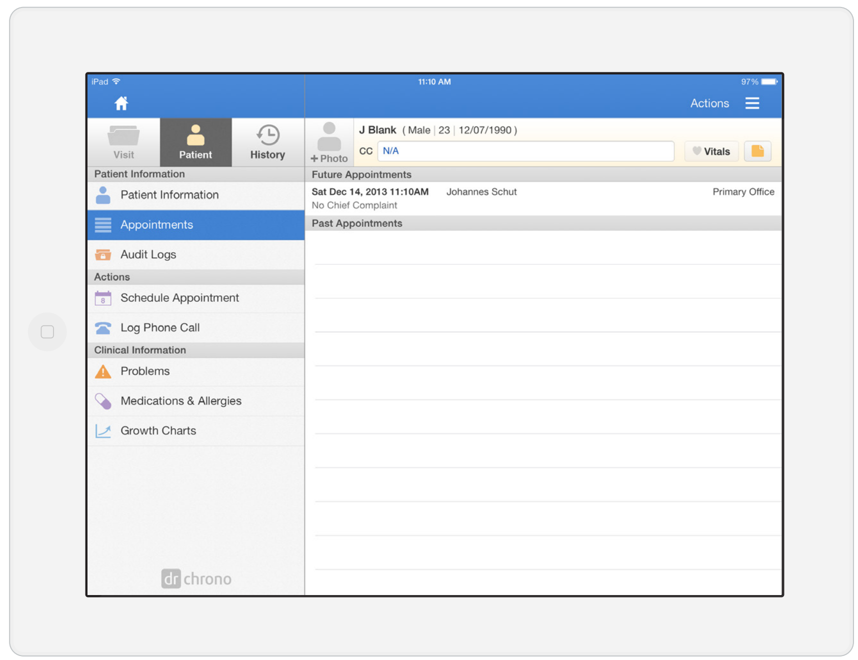


## DRCHRONO EHR

DrChrono is the first native complete EHR (Electronic Health Record) software solution for the iPad. It has a multitude of features from patient and appointment management to billing and note taking. It shows us how medical software can implement features that  to a vast range of  tasks required for healthcare providers. However, the software has a steep learning curve and many interface elements are not where one would expect based on past experience using iOS devices.

Interestingly, there is a companion application for patients available that allows the patient to check in and view information relevant to the appointment. This type of interconnectivity could have positive use scenarios for this project as well.



## KOUBACHI

Koubachi is a plant management application and is not directly related to the medical field in any way however some of the concepts it relys on are translatable.

The sensor measures soil moisture, temperature, and light intensity and compares them to norms. The application then provides feedback to the user based on compliance to those norms. It is an interesting example of how instructional cues can be integrated into a sensor based application. This actually forms a major component of the application's overall function and act as a facilitator trigger. This attempts to bring about behavior change to help user to take better care of their plants.

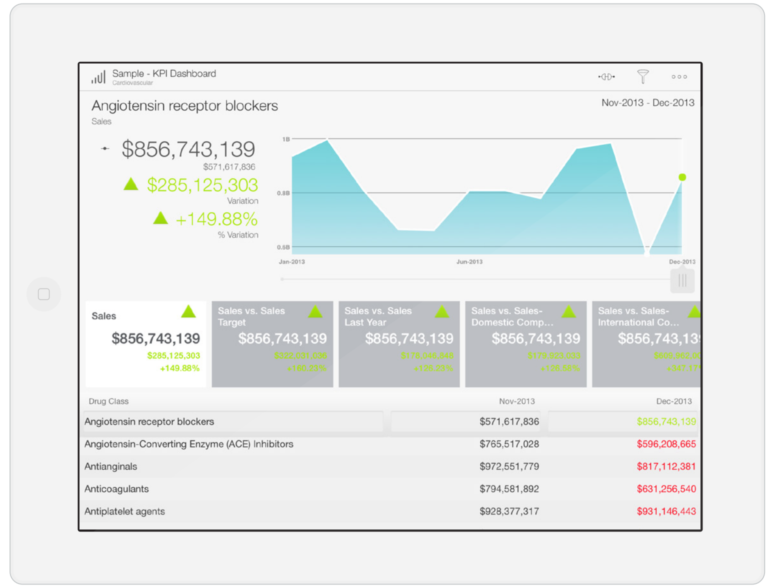
The functionality of this preprogrammed information gives us a sense of how we could facilitate better patient care.

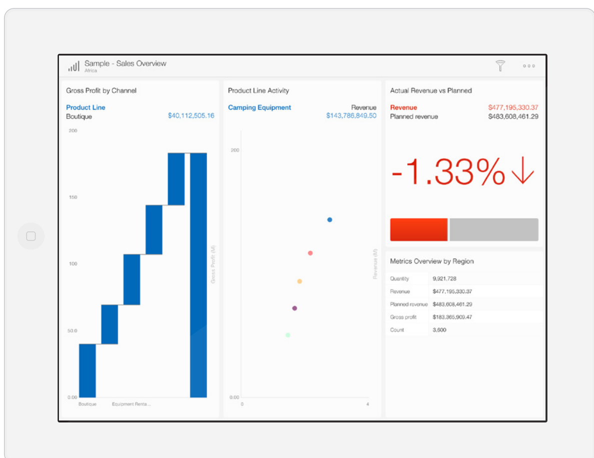
## ROAMBI ANALYTICS

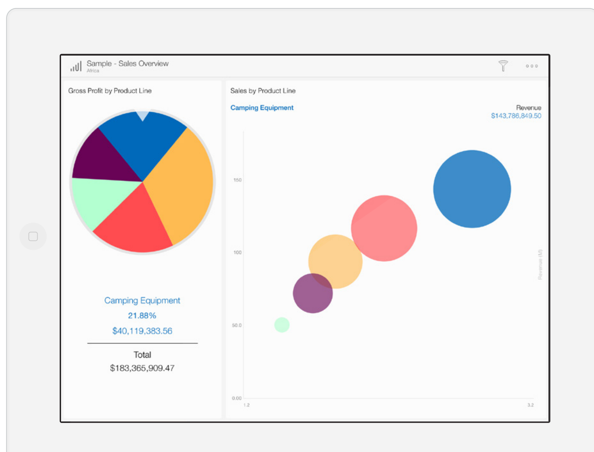
Roambi analytics is a client application where users download and interact with visualizations that have been published It displays data interactively in many different views. Each one can have unique combination of interactive navigation, visualization, and analytic features designed to engage and guide you through your data.

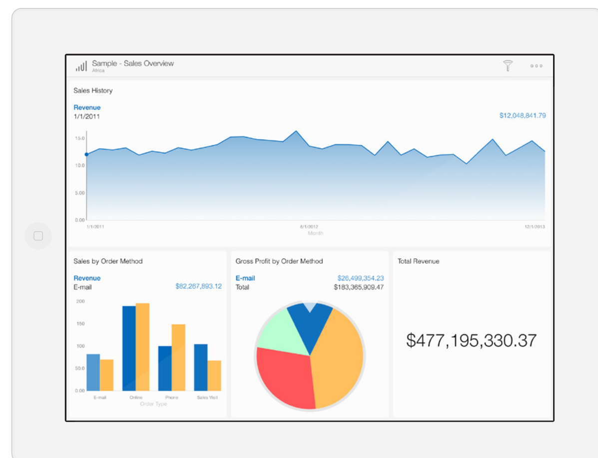
Roambi shows how an touchscreen interface can be used to enhance information graphic visualizations. Tapping on each graph element will provide a tooltip that explains what the data is referring to. Sliding across a line or area graph will provide a reading of the value that can be more accurate while still delivering an overall clean presentation.

This application is a great example of effective data presentation which is relevant to the design outcome.



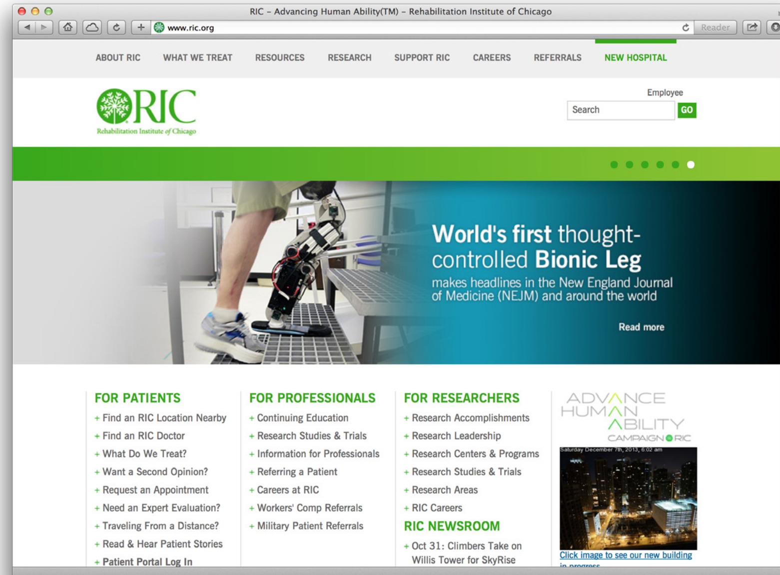



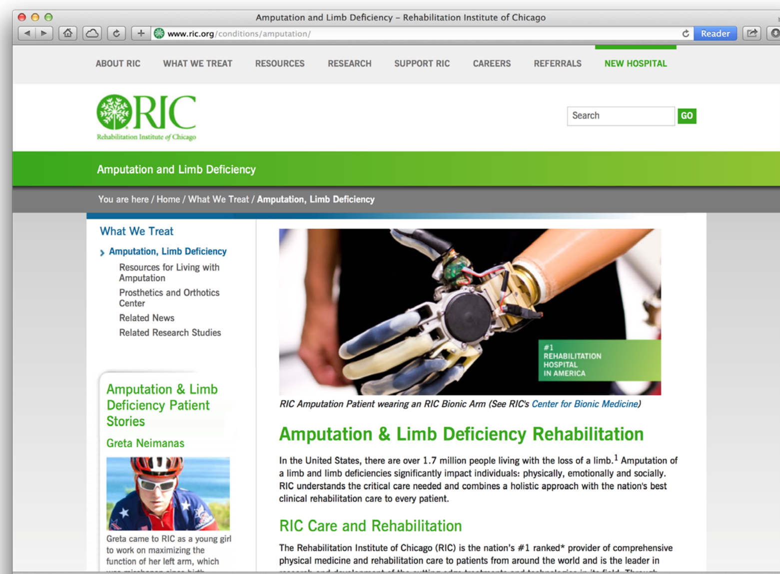



## REHABILITATION WEBSITES

There aren't many revolutionary items in the way prosthetic and amputee information is displayed online. Key information include functional aspects of practice, imagery is focused on showing optimism stemming from prosthetic devices and procedures, colours are kept simple, success stories are provided.



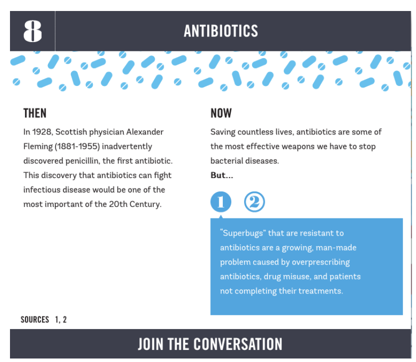


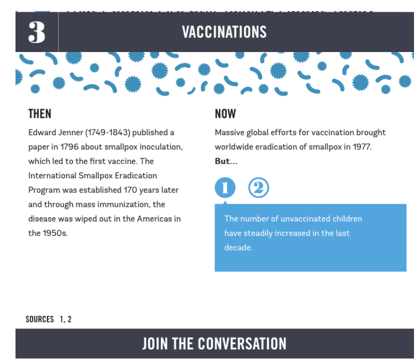


## HEALTHCARE INFOGRAPHICS

The 11 Controversial Health Innovations infographic by Good.is features many health innovations that have saved lives, reduced illness, and prevented severe outbreaks yet have become sources of controversy and debate today.

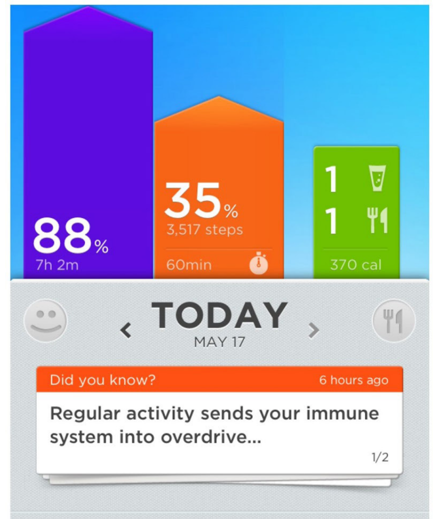
The illustrations used are great ways of making the issues seem more friendly and approachable. Approachable is a benefit I would like to see in the design solution. Therefore the style will form a basis for some of the flat illustrations I will be integrating to the application.

## SENSOR DATA VISUALIZATION

Both the Nike Fuel Band and Jawbone Up collect a good amount of data about your fitness, and presents it in a clear way designed to help you draw conclusions and change your habits. The use of colour in the Up software allows a variety different tasks to stay perceptible despite many streams of information. This is especially useful when reviewing multiple days at a time (bottom left). The Nike application takes a different approach with colour and uses it primarily as a motivational instrument, with red indicating insufficient activity and green that goals have been reached. It can be argued that the Nike software is easier to read due to additional spacing between elements.






# Ideation

# FOCUS GROUP DATA

The partner created a table outlining the key insights and requests provided by the participants. Moving forward, the insights gained from this data would be distilled down to help structure our basic requirements.

| Requirement Number | Design Module | Requirement Type | Requirement | Rationale | Source | Acceptance Criteria (concept) |
|---|---|---|---|---|---|---|
| 7 | Overall | Function | must recognize the trade-off of obtaining more information with burdening the client with instrumentation | Increase user compliance | EPFG | |
| 8 | Overall | Function | Must use the most intuitive technology available | Increase user compliance | EPFG | |
| 9 | Overall | Function | Intended for permanent setup (combine with other instruments - Gaitrite) | easier to conduct assessments if the measurement system is always set up; the longer you must prepare to collect data, the less likely you are to bother | EPFG/PTFG | Focus group suggestion & Team consensus |
| 10 | Overall | Function | Must involve clinician education / learning curve / what to do with info / volume of info | Increase user compliance | PTFG | Focus group suggestion & Team consensus |
| 11 | Overall | Function | Function and navigation must be intuitive | Increase user compliance | PTFG | Focus group suggestion & Team consensus |
| 12 | Overall | Function | Must put space concerns ahead of cost | Increase user compliance | PTFG | Focus group suggestion & Team consensus |
| 13 | Overall | Function | Must be durable wear and tear issues - | can we leave it out and have people walk over it all the time? | PTFG | Durability study? |
| 14 | Overall | Other | Cost limit | | | |
| 15 | Overall | Performance | Why reinvent the wheel when the gait rite mat exists? | Existing technology how does it differ? See Appendix B | PFG | Improve on existing technology |
| 16 | Software | Aesthetics | Graphs: Clear, visually appealing simple | Satisfies clinician request | PFG | JS - Co-creation session |
| 17 | Software | Aesthetics / Function | Must show ground reaction force | Satisfies clinician request | PFG | Focus group suggestion & Team consensus |
| 18 | Software | Function | Determine the calibration procedure over time | Electrical signals fluctuate over time | PFG | Measurement |
| 19 | Software | Function | Displays data in real time | Immediate feedback | PFG | Data must be real time |
| 20 | Software | Function | Graphs to represent information | Comparison | PFG | Use units of existing literature |
| 21 | Software | Function | Repeatable measurement | Must have sensitivity and specificity | PFG | Measurement |
| 22 | Software | Function | Less than 10 minutes | Ease of use and max time a clinician would spend on assessment | PFG | Measurement |
| 23 | Software | Function | Select certain test to run, do not run test all the time | Ease of use and max time a clinician would spend on assessment | PFG | Focus group suggestion & Team consensus |
| 24 | Software | Function | Universal outcome measurements | Must have sensitivity and specificity | PFG | Literature search for each outcome's landmark paper |
| 25 | Software | Function | 1 WBB to measure balance | Satisfies outcome requirement | PFG | Focus group suggestion & Team consensus |
| 26 | Software | Function | 2 WBB to measure individual feet (foot alignment or walking | Satisfies outcome requirement | PFG | Focus group suggestion & Team consensus |
| 27 | Software | Function | Perform test without revealing results (so patient don't know it is a measurement - game as a distraction | Measures data without changing the behavior of patients | PFG | Focus group suggestion & Team consensus |
| 28 | Software | Function | Need to understand why we are performing certain tests, "if want to know about X do test B,C,D etc" | Clinicians want to know why they are perform the task what is allure of performing tests? | PFG / PTFG | Literature search for each outcome's landmark paper purpose of each test? |
| 30 | Software | Function | Data comparison to normal | To see progress and setbacks | PFG | Focus group suggestion & Team consensus |
| 31 | Software | Function | Remote Application | Future potential for growth | PFG / PTFG | Focus group suggestion & Team consensus |
| 32 | Software | Function | Video need the ability to view patients at slower speeds and even frame by frame. | Satisfies clinician request | EPFG / PTFG | Focus group suggestion & Team consensus |
| 33 | Software | Function | Video must have frontal and sagittal view | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 34 | Software | Function | Video of walking trials to be viewed by patient and clinicians | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 35 | Software | Function | Must have four passes on the electronic walkway where each pass has at least two complete gait cycles before calculating statistics | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 36 | Software | Function | Must have simple cue to the person: "Walk like you do in school," "Walk like you are in the mall," or "Walk as fast as you safely can." | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 37 | Software | Function | Collect at different speeds: some gait discrepancies become more obvious if I ask a patient to walk faster | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 38 | Software | Function | Data collected must compare to self over time | Establishes baseline for patient / To see progress and setbacks | PFG / EPFG | Focus group suggestion & Team consensus |
| 39 | Software | Function | Data promote comparison to "normal" data (as an option not a default setting) | Some clinicians want control on whether to show data compared to non-pathological gait | EPFG | Focus group suggestion & Team consensus |
| 40 | Software | Function | stopwatch and video camera combo | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 41 | Software | Function | Tape measure function | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 42 | Software | Function | Test data at 3 times in outpatient stay: baseline, mid-term and upon discharge (relative - naming?) | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 43 | Software | Function | Games must have different level of challenge - some patients have very low function | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 44 | Software | Function | Must have a list to pick which tests to do directly. | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 45 | Software | Function | Selective what to show in patient outputs | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 46 | Software | Function | Wii character to look like an amputee. | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 47 | Software | Function | Game level of difficulty changes with score | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 48 | Software | Function | Customizing games to patient needs | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 49 | Software | Function | Disguising games - linking it to specific outcome measures (in the game we would be getting the info for our outcome measures) | Measures data without changing the behavior of patients | PTFG | Focus group suggestion & Team consensus |
| 50 | Software | Function | Combine measurement and exercise blended into one tool | Increase user compliance & Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 51 | Software | Function | Must have ability to print out of results (with different diagnoses) | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 52 | Software | Function | Each side colour coded | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 53 | Software | Function | digital device - no pen and paper | Increase user compliance | PTFG | Development using Tablet input? |
| 54 | Software | Function | Temporospatial: Walking velocity | Satisfies clinician request | PFG / EPFG | Focus group suggestion & Team consensus |
| 55 | Software | Function | Temporospatial: Stride length | Satisfies clinician request | PFG / EPFG | Focus group suggestion & Team consensus |
| 56 | Software | Function | Temporospatial: Walking cadence | Satisfies clinician request | PFG / EPFG | Focus group suggestion & Team consensus |
| 57 | Software | Function | Temporospatial: Step length | Satisfies clinician request | PFG / EPFG / PTFG | Focus group suggestion & Team consensus |
| 58 | Software | Function | Temporospatial: percent of the gait cycle spent in swing, stance, and single- and double-limb support (used to fine tune) | Satisfies clinician request | EPFG / PTFG | Focus group suggestion & Team consensus |
| 59 | Software | Function | Temporospatial: time on the heel, time on the toe | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 60 | Software | Function | Temporospatial: roll over is normal or how un-normal it is | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 61 | Software | Function | Temporospatial: gait step-to-step variability and symmetry | Satisfies clinician request | EPFG | Focus group suggestion & Team consensus |
| 62 | Software | Function | Temporospatial: how much weight is being placed on each leg during the gaitcycle. | Satisfies clinician request | EPFG / PTFG | Focus group suggestion & Team consensus |
| 63 | Software | Function | Outcome Measurements: Functional Ambulation Profile (FAP) | Satisfies clinician request | EPFG / PTFG | Focus group suggestion & Team consensus |
| 64 | Software | Function | Outcome Measurements: Ltest | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 65 | Software | Function | Outcome Measurements: 4 square test | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 66 | Software | Function | Outcome Measurements: socket comfort scale = 80% for discharge | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 67 | Software | Function | Outcome Measurements: ABC (same as) balance confidence??, = 8/10 for discharge | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 68 | Software | Function | Outcome Measurements: a subjective questionnaire (activity index, can't recall the name offhand) | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 69 | Software | Function | Outcome Measurements: BERG balance | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 70 | Software | Function | Outcome Measurements: TUG, | Satisfies clinician request | PFG / PTFG | Focus group suggestion & Team consensus |
| 71 | Software | Function | Outcome Measurements: 4 min walk test, 6 min walk test, 10 min walk test | Satisfies clinician request | PFG / PTFG | Focus group suggestion & Team consensus |
| 72 | Software | Function | Energy Consumption: COM Displacements (Vert and Lat) | Satisfies clinician request | PFG | Focus group suggestion & Team consensus |
| 73 | Software | Function | OGA: Gait deviations with built in solutions (Componentry/Alignment/Therapy) | Satisfies clinician request | PFG | Focus group suggestion & Team consensus |
| 74 | Software | Function | Balance: Ability Weight shift (AP and ML) | Satisfies clinician request | PFG | Focus group suggestion & Team consensus |
| 75 | Software | Function | Balance: Standing balance score (establishe outcomes BERG)** | Satisfies clinician request | PFG | Focus group suggestion & Team consensus |
| 76 | Software | Function | Balance: postural sway | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 77 | Software | Function | Balance: step-to-step variability in step time and step length | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 79 | Software | Function | Balance: Are they becoming more equal in their weight distribution? | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 80 | Software | Function | Balance: Endurance - How long they are able to do it for? Does this time increase? | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 81 | Software | Function | Posture: View posture in different planes | Satisfies clinician request | PTFG | Focus group suggestion & Team consensus |
| 82 | Software | Function | Include basic vitals that can be retrieved from external sources (e.g. Opie) in future | Satisfies clinician request | PFG | Focus group suggestion & Team consensus |

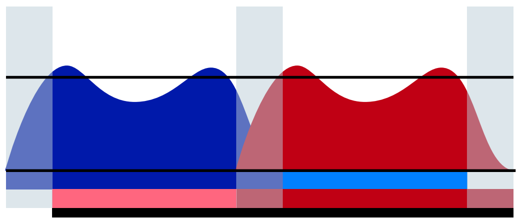
= time permitting

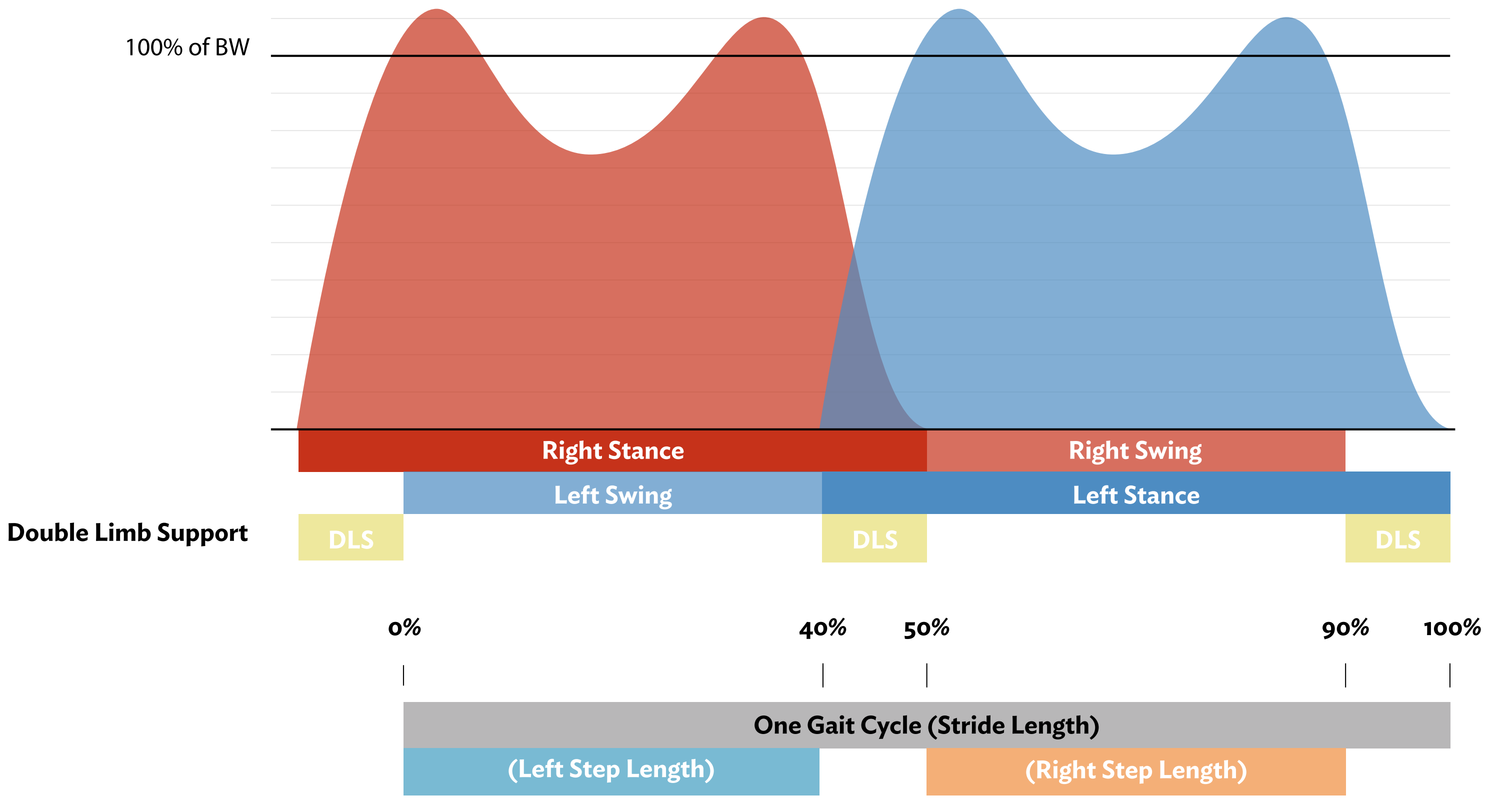
### DISTILLED FOCUS GROUP FEATURES

- Option to display tests for relevant to specific conditions or amputee type / Explanation of why test is relevant. / Guide
- Ground reaction force display
- Balance Measurement
- Individual Foot Measurement
- Non-revealing results option (overlay?)
- Data comparison to normal
- Touchscreen interface
- Laptop based interface
- Frontal view camera
- Saggital view camera
- Slow motion
- Replay
- Compare to self over time (overlay)
- Compare to “normal” data (overlay)
- Balance Games
- Print out results (share?)
- Mobile app
- Graphs
- Testing timeframe (test length)
- Selective outputs (overlays)
- Color Coding (left right) (What else?)
- Force measurement units: % of body weight (or other?)
- Temporospatial Measurements: Automated
  - Walking Velocity
  - Gait Step-to-step Variability
  - Weight placed on each leg during gait cycle
  - Steps per minute
  - Percent of cycle in each phase: swing, stance.
- Temporospatial Measurements: Manual
  - Stride Length (Estimate)
  - Step Length (Estimate)
  - Time on heel / time on toe
  - Roll over. Normal / Abnormal
- Single Board Balance Measurements
  - Posture (visual)
  - Endurance
  - Weight distribution
  - Postural sway
  - Ability weight shift (AP & ML)
  - Step-to-step variability

## VISUALIZING GAIT

Gait has many elements that can be visualized The ground reaction force is equal in magnitude and opposite in direction to the force that the body exerts on the supporting surface through the foot.

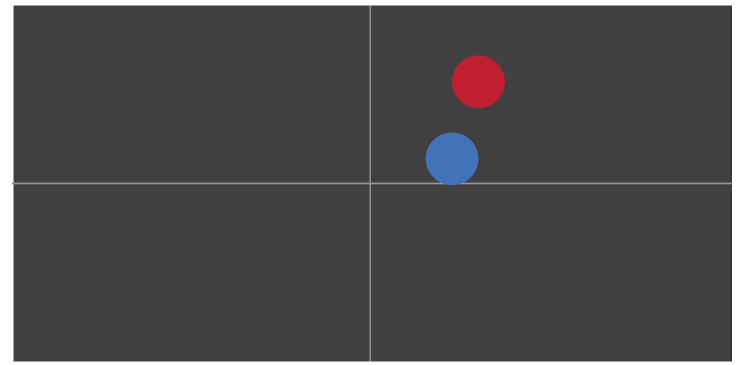


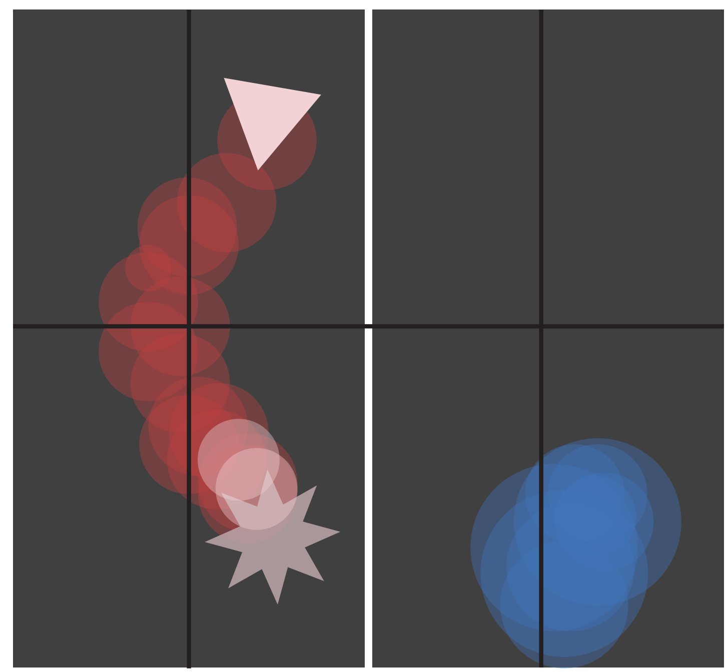


## VISUALIZING CENTRE OF PRESSURE

Center of pressure is the term given to the point of application of the ground reaction force vector. The center of pressure is not a static outcome measure. For instance, during human walking, the center of pressure is near the heel at the time of heelstrike and moves anteriorly throughout the step, being located near the toes at toe-off. Therefore, analysis of the center of pressure will need to take into account the dynamic nature of the signal.

My initial experimentation with centre of pressure focused on using shapes to indicate heel-strike and toe off along with different shape sizes to indicate force level.

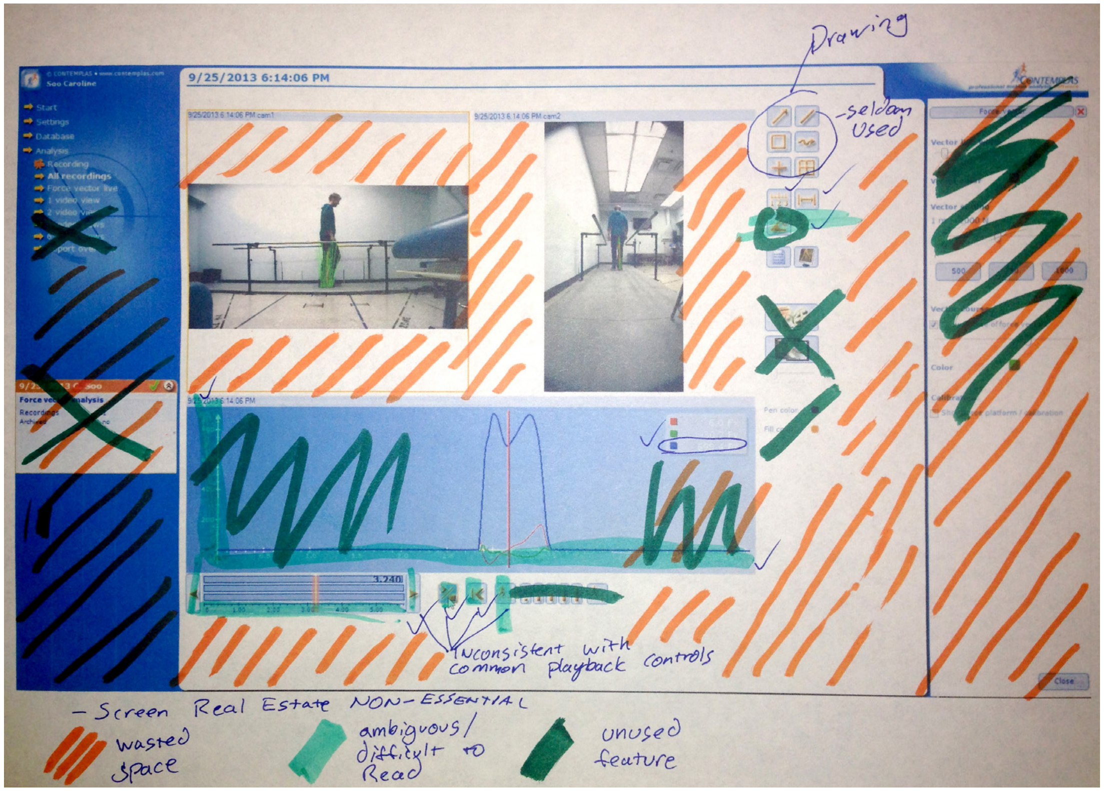




# Design Development

# FEATURE IDENTIFICATION

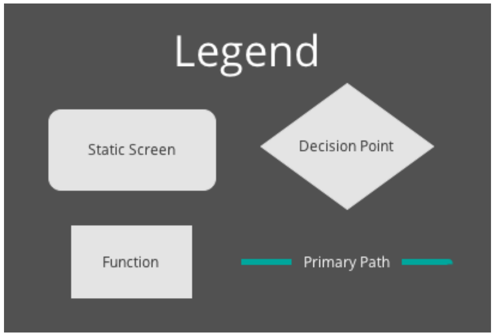
Working with the partner on a printout of the interface of TEMPLO as a working platform I was able to quickly rule out features that were deemed non essential. Ruling out features helped establish a feature set that would be more focused on the specific needs of the user. This study also revealed icons that were ambiguous or non-standard. Finally, the amount of "wasted space" provided a compelling case that this PC application would have no problem migrating to a smaller screen.

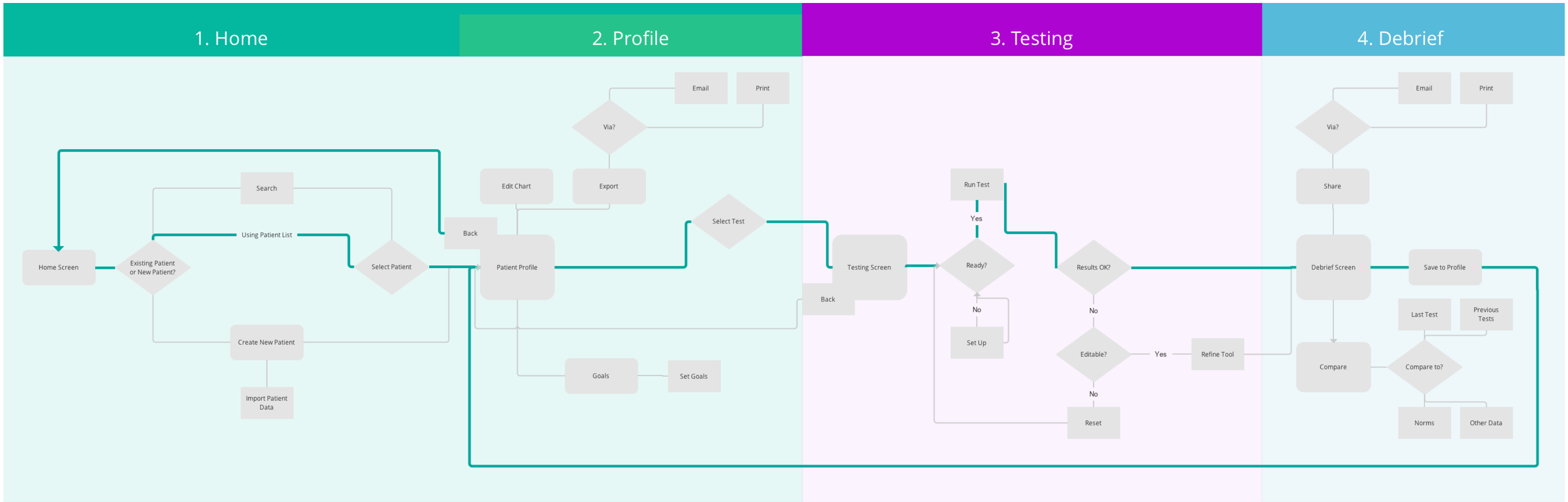


## USER FLOW

Putting together the user flow is super helpful in visualizing the relationship between interfaces. Specific sequences of actions lead customers through your app as they try to accomplish their tasks. Drawing out every state of a flow is time-consuming but effective in mapping out the goals of the application and revealed details that weren't immediately obvious.

The user flow helped identify that the application would benefit from having three or four distinct groupings of actions being performed. This formed a rationale for differentiating the groups with visual cues — in this case colour — as a way to quickly, at a glance, orient the user.



## COLOUR

Based on my user flow I have chosen to use colour to differentiate groupings. I experimented with various colours in our master swatches and went from saturated blues and greens, and purples to monochrome greys. Pale yellows and browns were too mellow and lacked the energy needed to communicate, whereas, the bright greens and blues worked well to catch the viewer's attention. The final result was to take the highly saturated colours and warm them up a bit. In the end, the chosen colours play off of traditional medical industry colours but with enhanced warmth and playful differences. Although these specific colours changed slightly throughout the many iterations, the basic structure remained constant.

**R**103 **G**216 **B**104

**R**4 **G**183 **B**159

**R**86 **G**186 **B**218

**R**173 **G**4 **B**209

## TYPE

SCREEN

Open Sans

PRINT

Whitney

IOS

## CO-CREATION & USER TESTING

The complexity of the project necessitates a large degree of exploration in data visualization, user interface design. Since it is a human-centred design project that focuses on a very specific user, co-creation exercises are very suitable. While the focus groups were a great start, they somewhat narrowly focused on overall desired functions rather than how users would interact with said functions. Co-creation was originally scheduled for late November but complications synchronizing ethics forms between BCIT and Emily Carr has necessitated rescheduling for January.

I have taken a different direction with the co-creation session and looked at work flow and usability constraints. The co-creation included storyboarding the work day & clinical process, ranking importance or frequency of use for the desired functions to establish a hierarchy. A mind mapping exercise ascertained familiarity with technology. Iconography was evaluated with the participants asked to link icons with a variety of application components.

Finally, user testing was completed with an updated online mockup presented in Adobe Fireworks Touch Application Prototyping on iPads.

### Clinical Tool for Prosthetics

**CO-CREATION AND USER TESTING**

#### Activity 1

**STORYBOARDING + PROBLEM POINTS** **15-20MIN**

This activity will seek to gain insight about the daily lives of Clinicians. Start from when you wake up. What is a day in the life of your profession? We seek to uncover points of frustration and possibie solutions. What are the highs and lows? Participants will be supplied with a sticker sheet with which to identify problems and solutions that can occur throughout their day.

#### Activity 1B

**MOODBOARD** **5MIN**

Use images and words, along with your own artwork to create a moodboard that visuilized emotions and thoughts around the clinical / rehabilitation environment. Illustrate relationships between Clinicians and Patients.

#### Activity 2

**FEATURE SPECTRUM** **15-20MIN**

Focus groups have revealed many requested features. Tell us which are the most compelling by pasting them in order of importance and frequency of use.

#### Activity 2B

**ICON ID** **10MIN**

Participants will be supplied with a sheet of icons to apply to their feature set spectrum.

Use blank stickers if you think of a reminder that we might have missed.

#### Activity 3 (time permitting)

**MIND MAPPING ACTIVITY** **10MIN**

Mind map your thoughts on the current state of gait analysis, and how it can be improved. How can patients be more involved? Any remaining stickers from the previous activities can be used.

#### User Testing **10-20MIN**

Participants will have the opportunity to experience and critique an interactive prototype.

## Feature Spectrum

Focus groups have revealed many requested features. Tell us which are the most compelling by pasting them in order of necessity and frequency of use. Did we miss something? Write it in.

necessary

not essential

seldom used

frequently used

## Storyboard a Typical Work Day

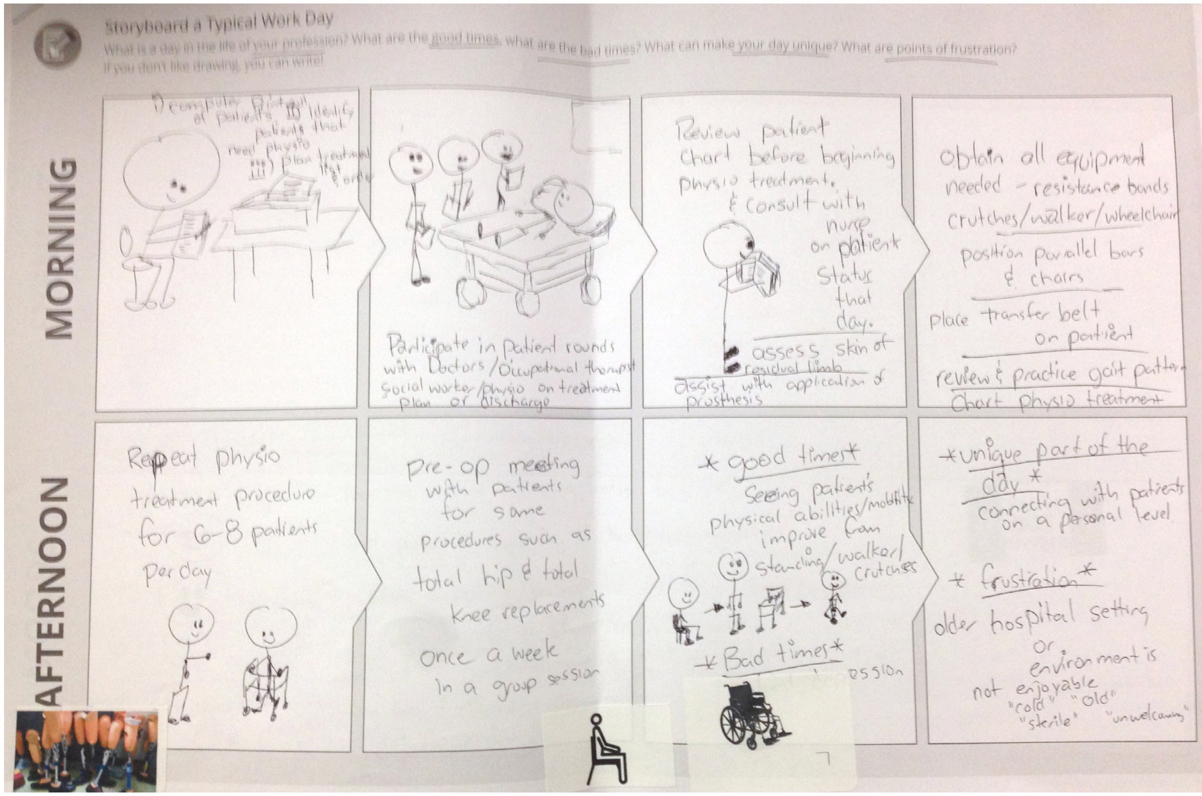
What is a day in the life of your profession? What are the good times, what are the bad times? What can make your day unique? What are points of frustration?
If you don't like drawing, you can write!

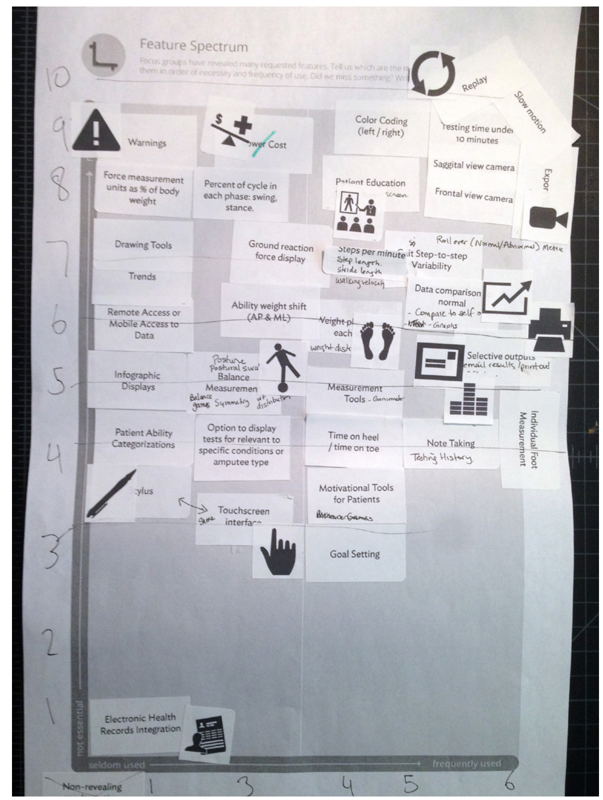
MORNING

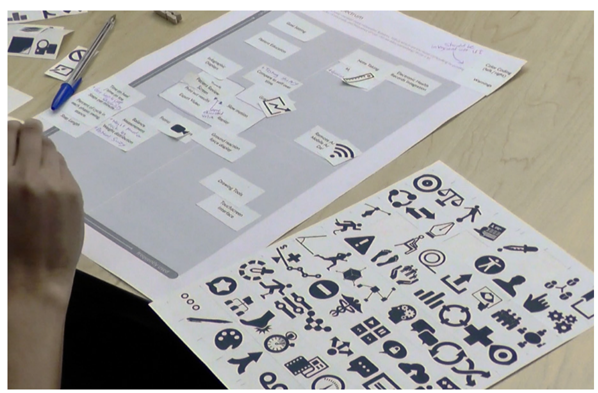
AFTERNOON

Mind map your thoughts on the current state of gait analysis

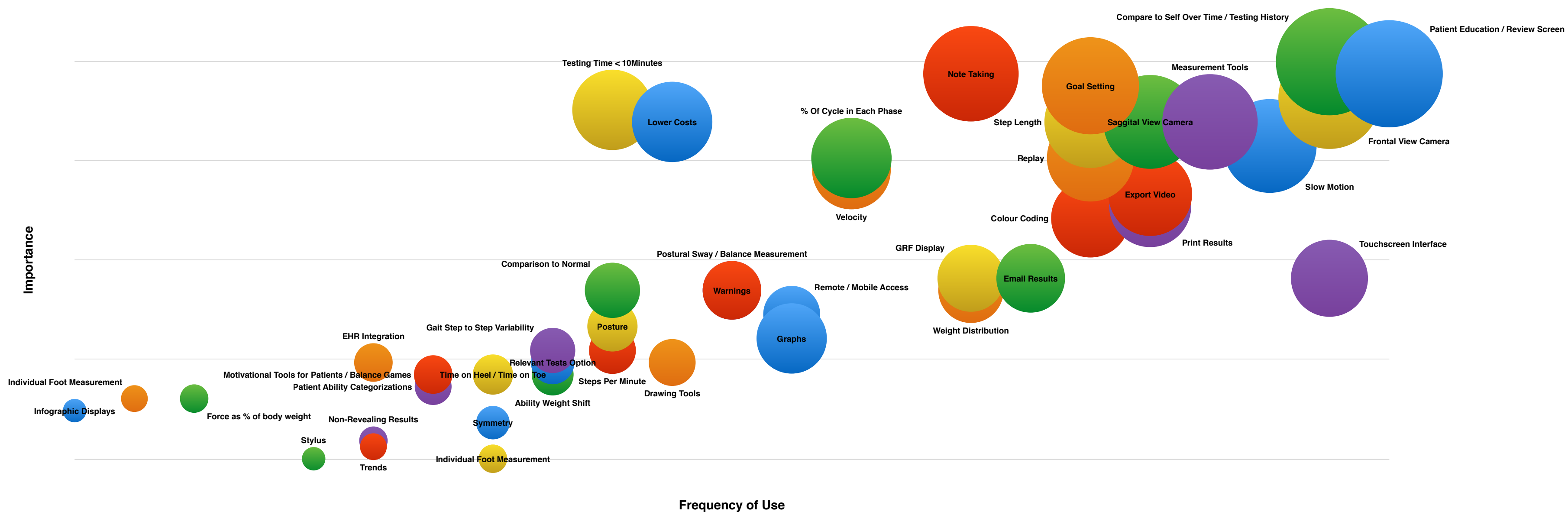
Gait Analysis


Storyboard a Typical Work Day
What is a day in the life of your profession? What are the good times, what are the bad times? What can make your day unique? What are points of frustration?
If you don't like drawing, you can write!
MORNING
AFTERNOON
Participate in patient rounds with Doctors / Occupational therapist social worker / physio on treatment plan or discharge
Review patient chart before beginning physio treatment. & consult with nurse on patient status that day.
assess skin of residual limb
assist with application of prosthesis
obtain all equipment needed - resistance bands crutches / walker / wheelchair
position parallel bars & chairs
place transfer belt on patient
review & practice gait pattern
chart physio treatment
Repeat physio treatment procedure for 6-8 patients per day
Pre-op meeting with patients for same procedures such as total hip & total knee replacements
Once a week in a group session
* good times * Seeing patient's physical abilities / mobility improve from standing / walker / crutches
* Bad times *
* unique part of the day * connecting with patients on a personal level
* frustration * older hospital setting or environment is not enjoyable "cold" "old" "sterile" "unwelcoming"


Feature Spectrum
Warnings
Cost
Color Coding (left / right)
Replay
Slow motion
Testing time under 10 minutes
Force measurement units as % of body weight
Percent of cycle in each phase: swing, stance.
Patient Education
Saggital view camera
Frontal view camera
Drawing Tools
Ground reaction force display
Steps per minute
Step-to-step Variability
Trends
Remote Access or Mobile Access to Data
Ability weight shift (AP & ML)
Data comparison normal
Infographic Displays
Balance Measurement
Measurement Tools
Selective outputs
Patient Ability Categorizations
Option to display tests for relevant to specific conditions or amputee type
Time on heel / time on toe
Note Taking
Individual Foot Measurement
Touchscreen interface
Motivational Tools for Patients
Goal Setting
Electronic Health Records Integration
seldom used
frequently used
not essential
Non-revealing



## CO-CREATION FINDINGS




- Patient Education and Goal Setting were consistently rated the most important feature, despite Goal Setting not having been mentioned at all in previous focus groups.
- Comparing to Self Over Time, Note Taking, Sharing are among other highly rated features.
- Colour coding is important to prosthetic clinicians.
- Remote or mobile access to data would be useful to clinicians.

## USER TESTING FINDINGS

- Colour coded sections are helpful. Similar treatments could be colour coded.
- “Right is red” in traditional colour coded gait analysis.
- Establishing a visual language for specific actions is helpful, such as the triangles and stars used in the centre of pressure demonstation. It would be great to establish visual standards.
- Note taking was noticeably absent.
- Tablet platform was a huge improvement over PC-based systems.
- Visual language of symmetry arc was good, but requires more numbers.
- Clinicians would like to see more drawings of footprints to be used as a visual linkage.

# Proposed Design

## STRATEGY

Based on the user flow I've identified that the application would benefit from having three distinct groupings of actions being performed. The application structure will centre around the four areas of Patient Management and Goal Setting, Testing and Information Review. Based on Co-Creation findings, these three modules are still suitable to be used minor tweaks and feature additions brought forward.

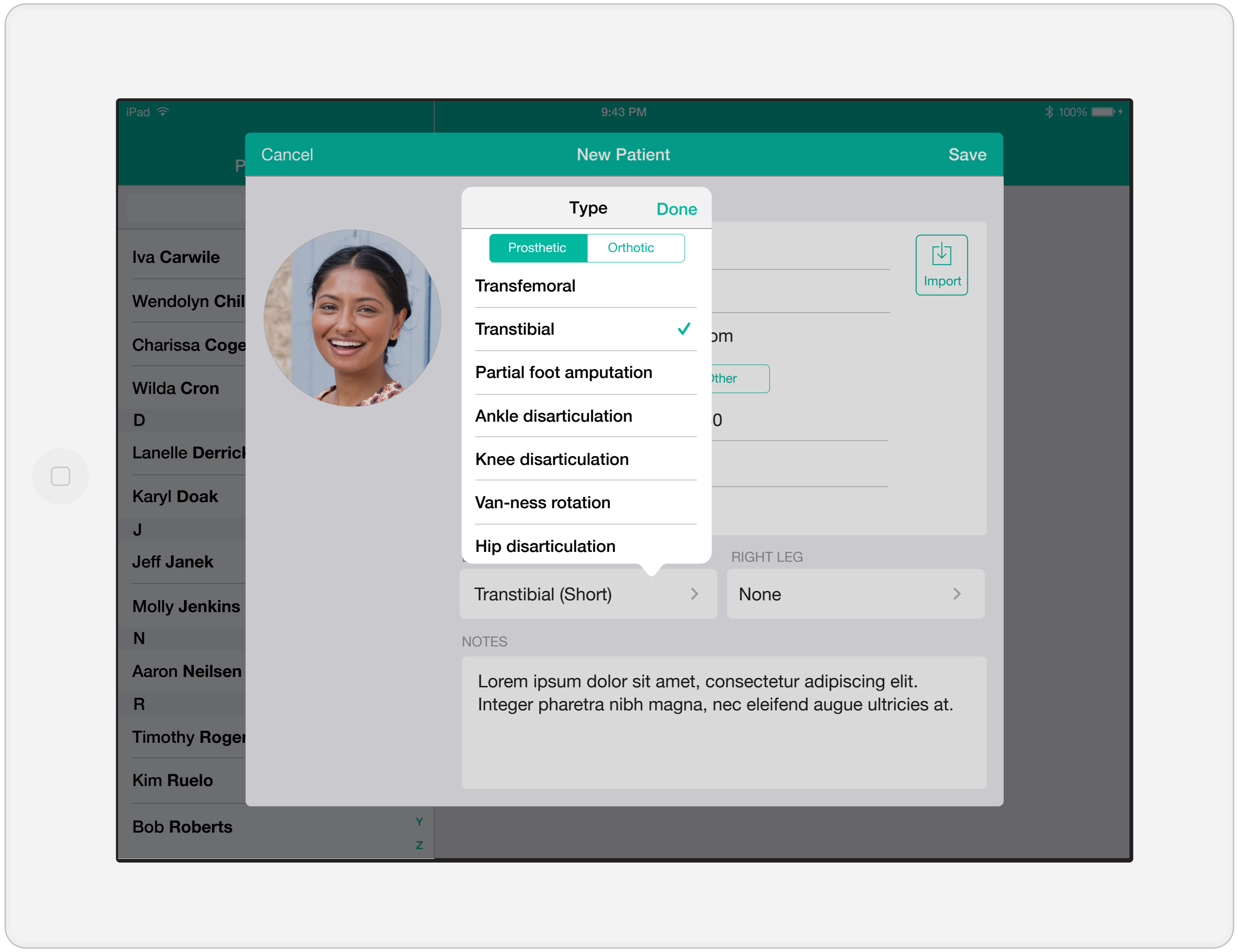
Patient Management and Goal Setting

Testing

Information Review

## PATIENT MANAGEMENT

Speedy patient creation with predefined inputs.

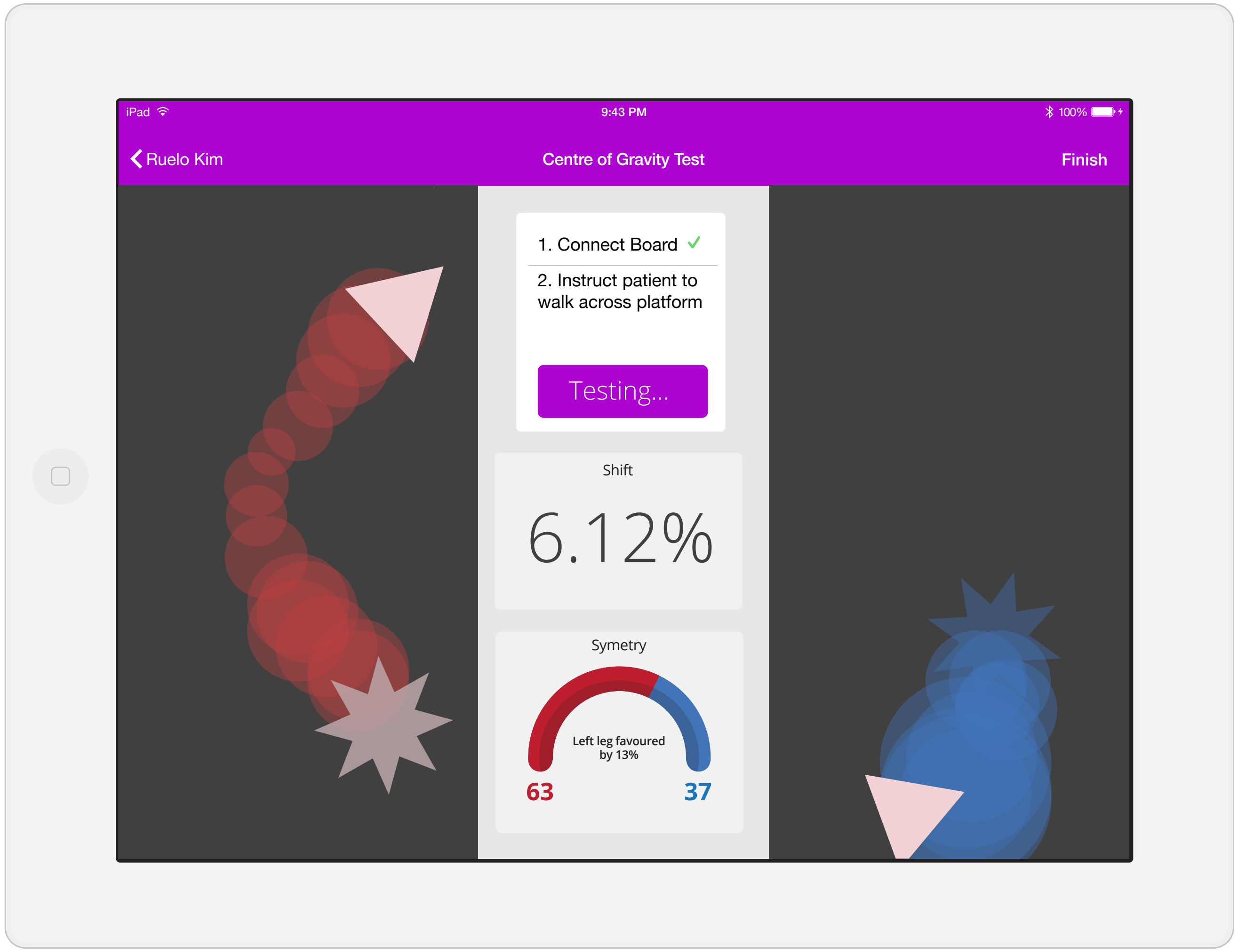



## GOAL SETTING

The Goals marker orients the patient towards taking a more empowered role in their healing. Viewing approaching goals in the header of their dashboard was intended to keep the patient focused on incremental progress and also offers possibilities in celebrating their successes in healing. Similarly, this also allows the care team to help a patient plan out their gradual improvement and enables the family to support their success. In correspondence with the timeline the dashboard forecasts discharge date that the design team hoped would keep the patient motivated to remain engaged with achieving goals and maintaining focus on healing.

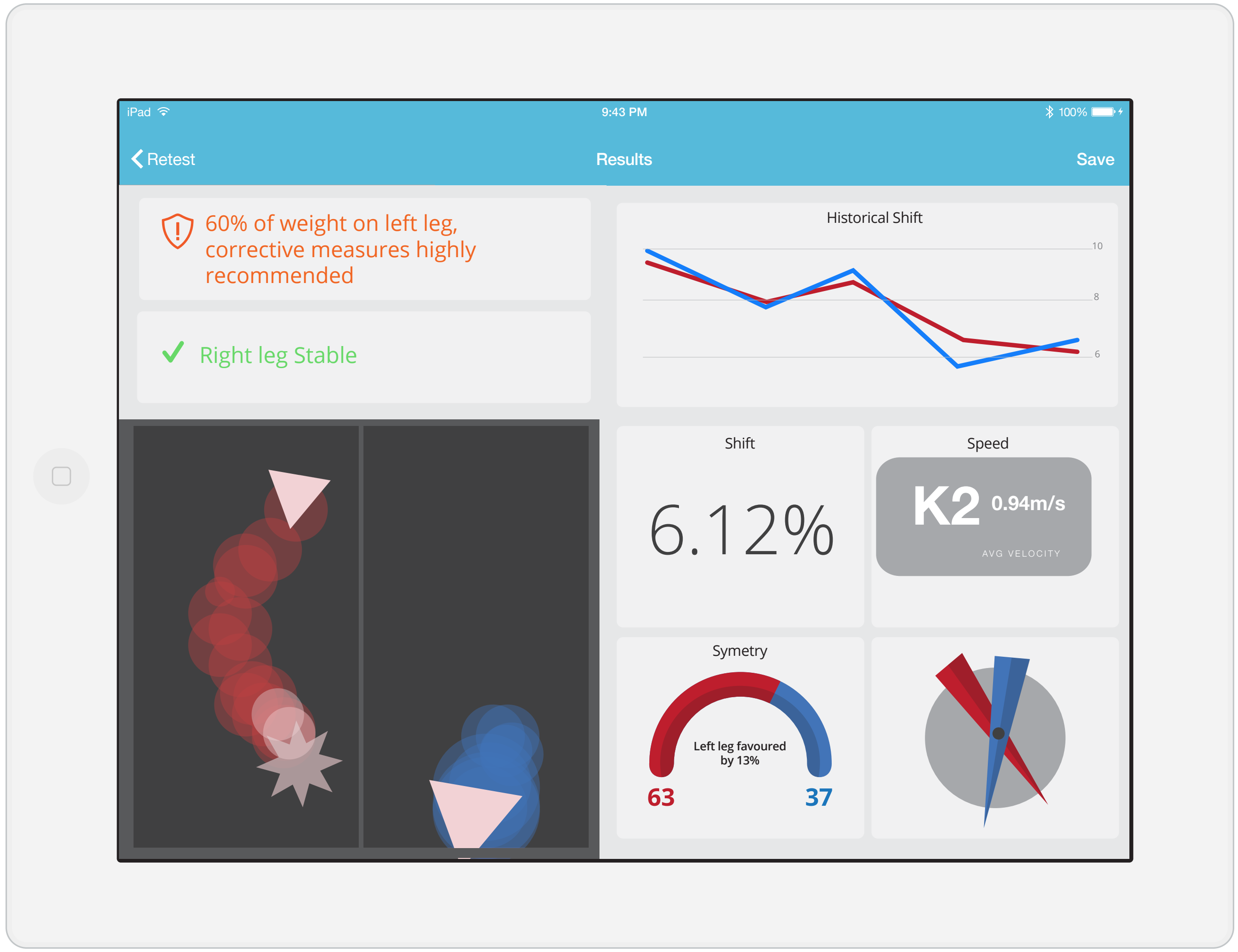
## TESTING

Testing is made easier and quicker with a central area providing instructions.



## INFORMATION REVIEW

Relevant data is accessible and can quickly be analyzed thanks to perceptible hierarchy a call outs.



## ONLINE MOCKUP

Navigate to http://lisica.co.nf/ctpo2/ for an updated online mockup presented in Adobe Fireworks Touch Application Prototyping.

Fw http://lisica.co.nf/ctpo2/

## IMPLEMENTATION

Our programmer has indicated that modern tablets will require significant hardware engineering in order to accomodate the bluetooth implementation used by the Wii Balance Board. In order to get around this in the meantime, we will be using a PC-based bridge to get the Board connected to a Tablet.

### Wii Balance Board

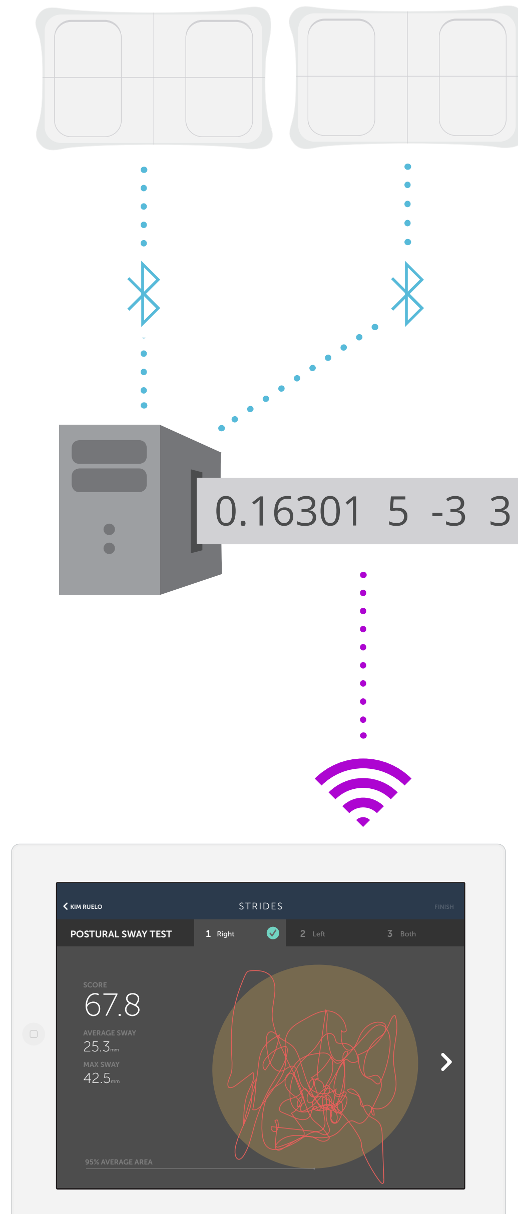
The balance board will broadcast raw data via bluetooth signals.

### PC / Server Application

Simple server application will capture bluetooth signals and make the data available via HTTP.

### Tablet

The tablet will connect to a local wifi network and receive data. The software will render visuals differently based on specific tests.



## SCHEDULE

The next steps are to continue to revise the product in order to create a final prototype and work with the programmer to turn the prototype into reality. Finally, the application of branding will ready the product for presentation.