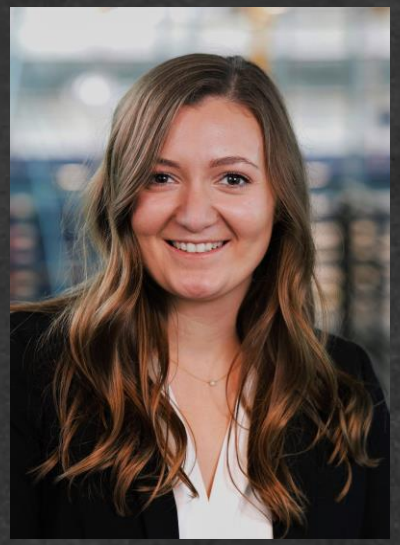
Sprinter Data

Enhance performance, maximize potential.

Team Introductions

Dylan Cedeno
Project Manager

Marc Griffiths
Design Engineer



Jordan Noyes
Quality Engineer

Handy A Pierre
Research Engineer

Edwin Ulysse
Data Engineer

Sponsor and Advisor

<u>Sponsor</u>
FAMU-FSU College of Engineering
Academic Institution

<u>Academic Advisor</u>
Jonathon Clark, Ph.D.
Associate Professor

Project Background

Jordan Noyes and Handy A Pierre

Motivation

- Every athlete wants to perform at a higher level
- There is no wholistic way to objectively measure or predict sprinter performance

Objective

The objective of this project is to create a desirable product that will objectively measure and predict a sprinter's performance

Competitors

1080 Sprint

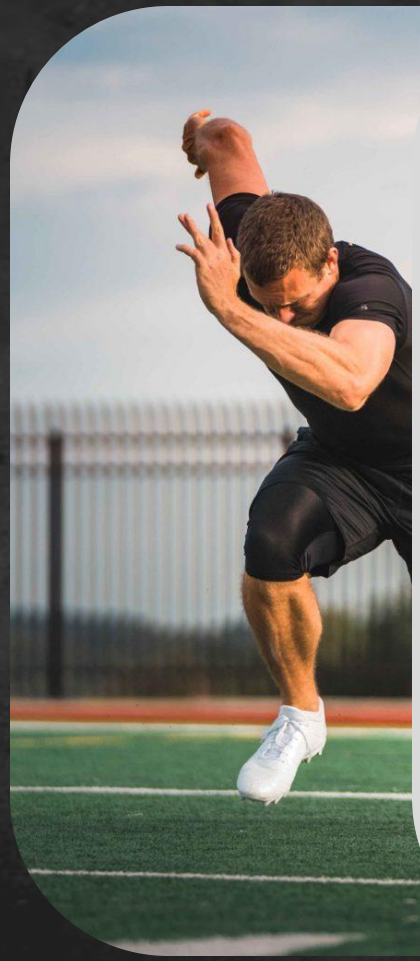
- Advantages:
  - Tension cord that offers resistance and assistance
  - Successful training tool
- Disadvantages:
  - Does not retrieve valuable measurements
  - Does not have a prediction model
  - VERY expensive

Jordan Noyes

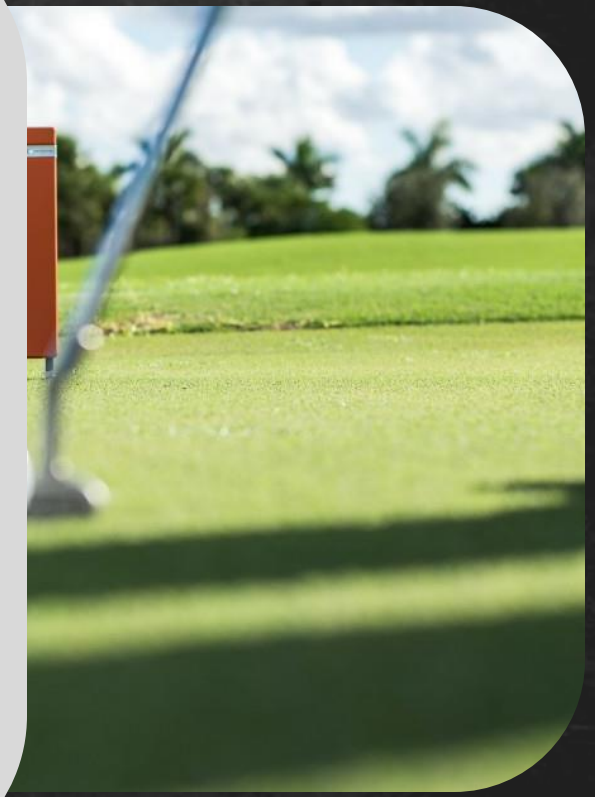
Competitors

Trackman

- Advantages:
  - Launch Monitor mechanism that tracks data
  - Successful golf tool
- Disadvantages:
  - Can only be used for golf
  - VERY expensive



Team S21



Jordan Noyes

Assumptions

- Product will be used in fair weather
- User has prior experience with sprinting
- Sprinter starts in a standard starting block
- User has access to a laptop or smartphone
- Device is used on a collegiate approved track

Customer Background

Personas

Sprinter

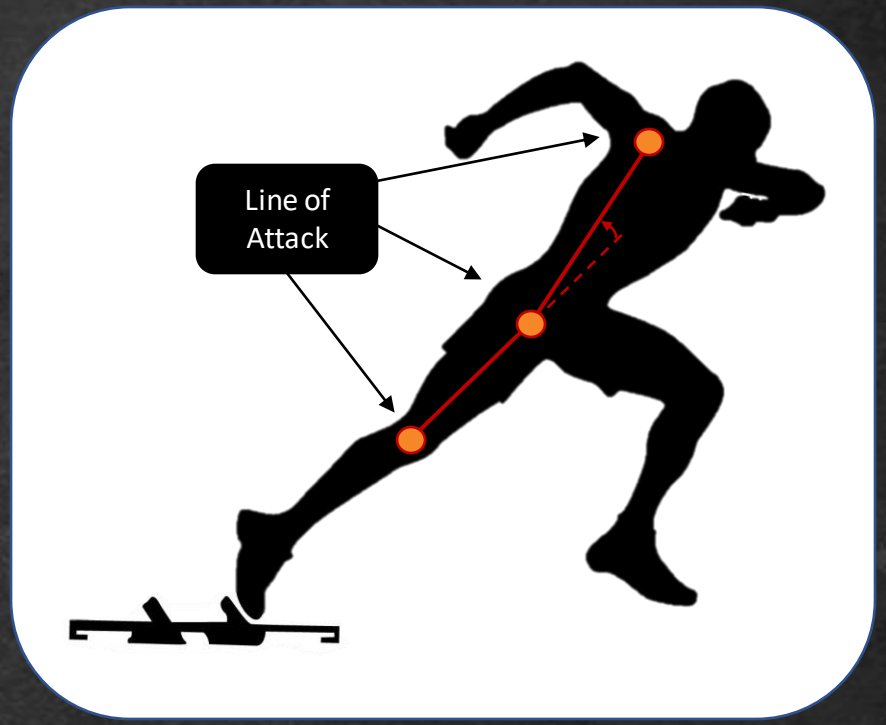
Coach

Scout

Functions and Targets

Measurement Functions

- Function: Gauge the line of attack
- Target: Accurate within 2%



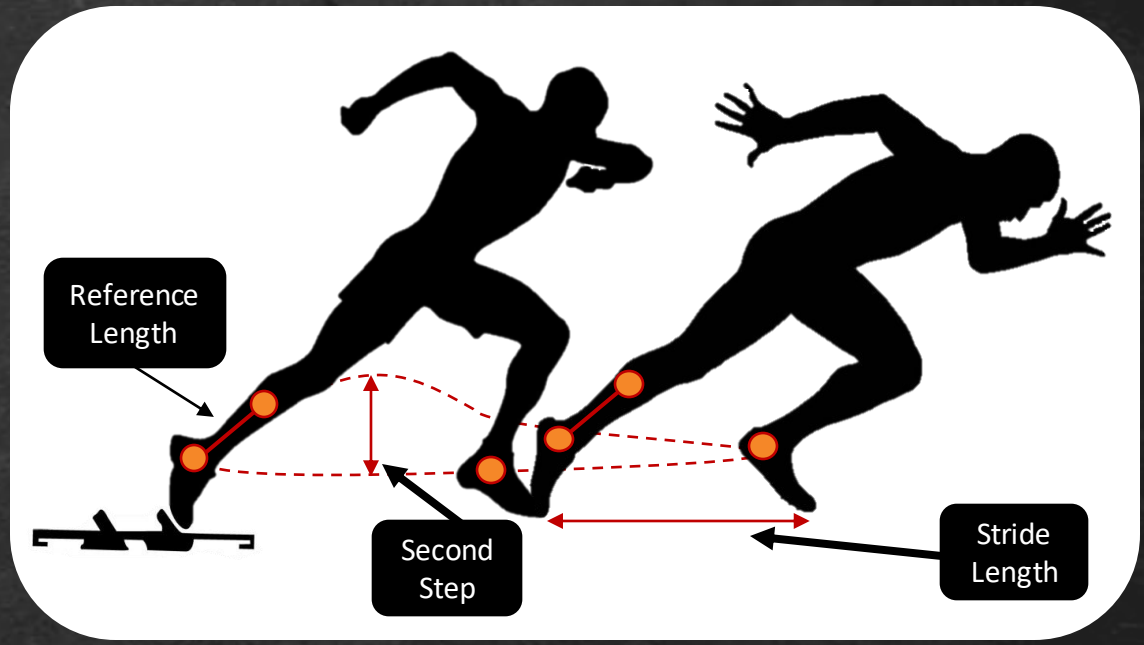
Angle between joints (degrees)

Jordan Noyes

Functions and Targets

Measurement Functions

- Function: Observe the second step and associated stride length
- Target: Accurate within 2%



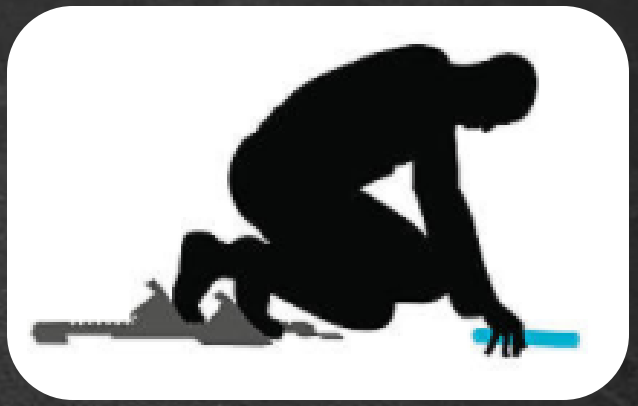
Length of stride and height of second step (meters)

Jordan Noyes

Functions and Targets

Measurement Functions

- Function: Calculate the impulse out of the block
- Target: Accurate within 2%



$$Impulse = Force * time\ (N * s)$$

Functions and Targets

Measurement Functions

- Function: Record the starter gun reaction time
- Target: Accurate within 2%

Time it takes to react (seconds)

Jordan Noyes

Functions and Targets

Measurement Functions

- Function: Track the average velocity throughout the race
- Target: Accurate within 2%

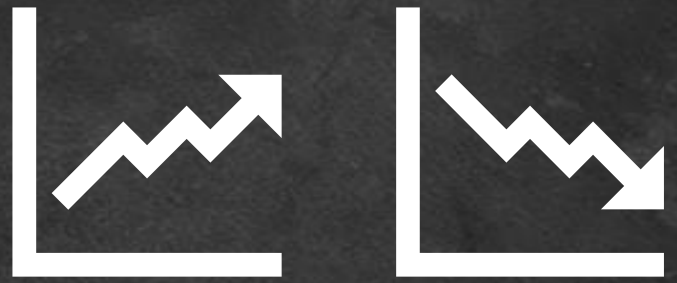
$$Velocity = \frac{length}{time}\left(\frac{m}{s}\right)$$

Jordan Noyes

Functions and Targets

Prediction Functions

- Function: Create trends
- Target: Find which measurements correlate to time



32 trials for accurate prediction

Functions and Targets

Prediction Functions

- Need: Product exposes sprinters' weaknesses
- Target: A measurement not correlated to time means inconsistency in form

Coaches and sprinters make final decision on how to analyze results

Functions and Targets

Basic Function

- Need: Technology has sufficient battery life
- Target: Device has a battery life of at least three hours

Track practices are daily for approximately 2 hours

Concept Generation and Selection

Concept Generation

Generated over 100 different ideas using

- Biomimicry
- Morphological Flow Chart
- Randomization

Selected 8 total concepts

- High Fidelity
- Medium Fidelity

Concept Generation and Selection

Concept Selection

Selected 8 total concepts

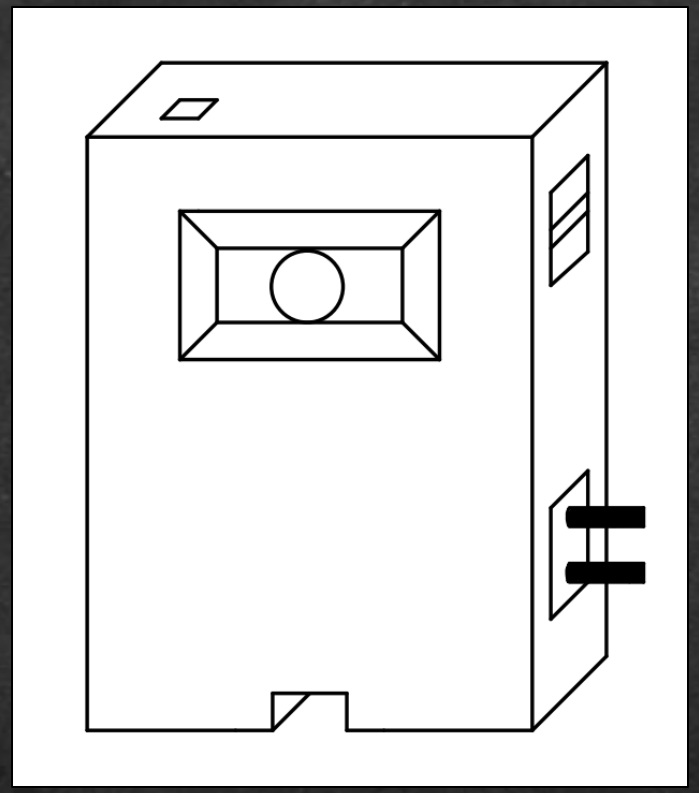
- High Fidelity
- Medium Fidelity

Objectively analyzed the concepts

- House of Quality
- Pugh Chart
- AHP

Concept Generation and Selection

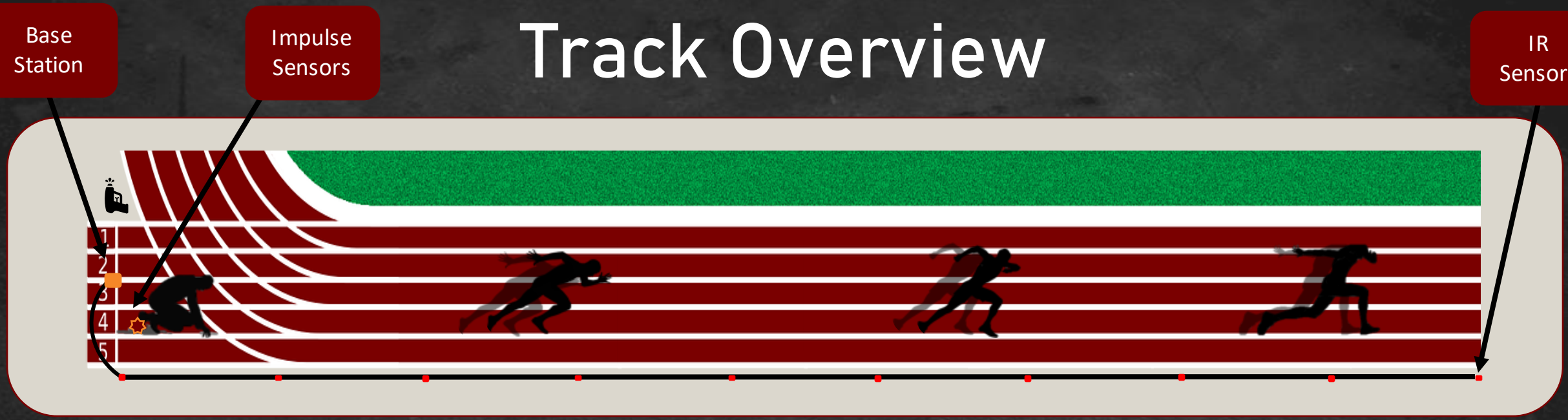
Selected Concept: Launch Monitor Pro



Detailed Design

Dylan Cedeno and Edwin Ulysse

Track Overview

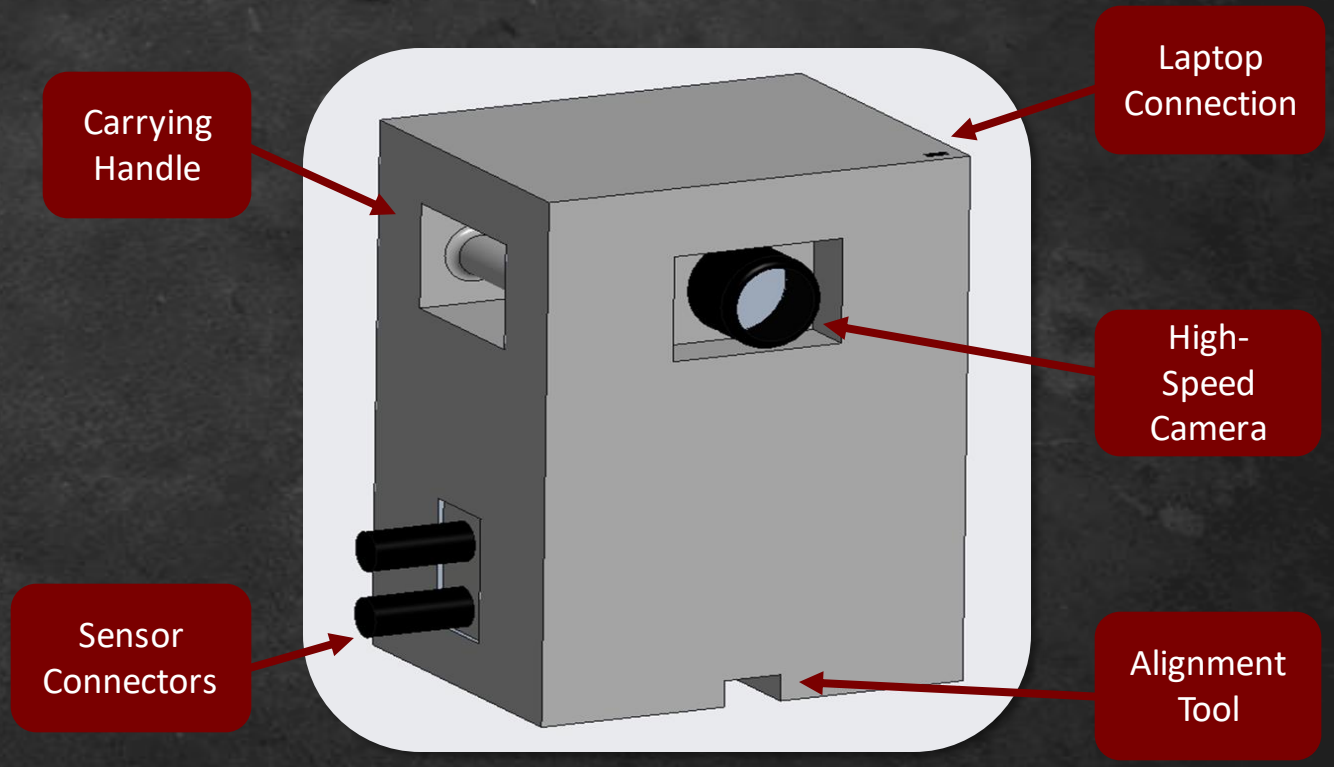


- Base Station
  - High Speed Camera
  - Processor
  - Power Supply
- Impulse Sensors
  - On the blocks
- Infrared Sensors
  - At 10m intervals along the track

Dylan Cedeno

Base Station

- High speed camera
  - Line of Attack
  - Stride Length
- Processor
  - Readings from IR Sensors
  - Readings from impulse sensors
- Power supply
  - No power drain from user laptop



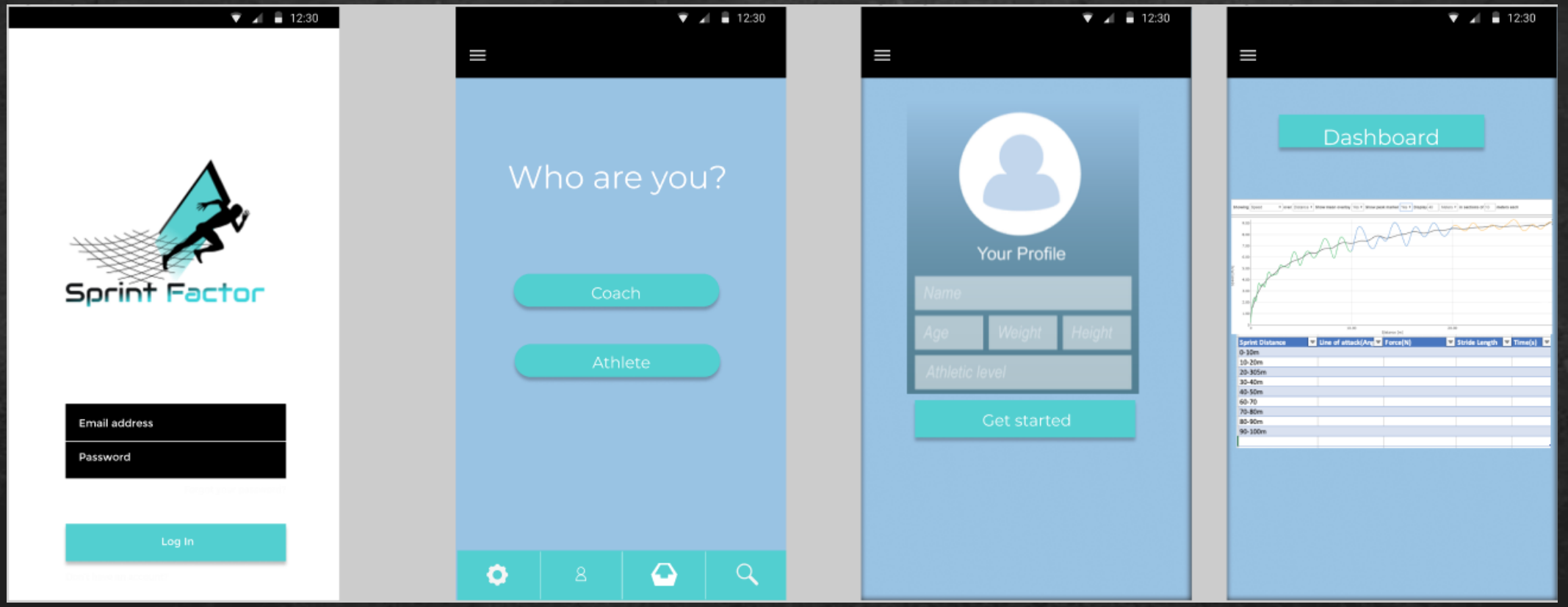
Dylan Cedeno

Prediction Model

- Personalized inputs
- Access and explore data
- Preprocess data
- Develop model
- Integrate analytics with systems

Prediction Model

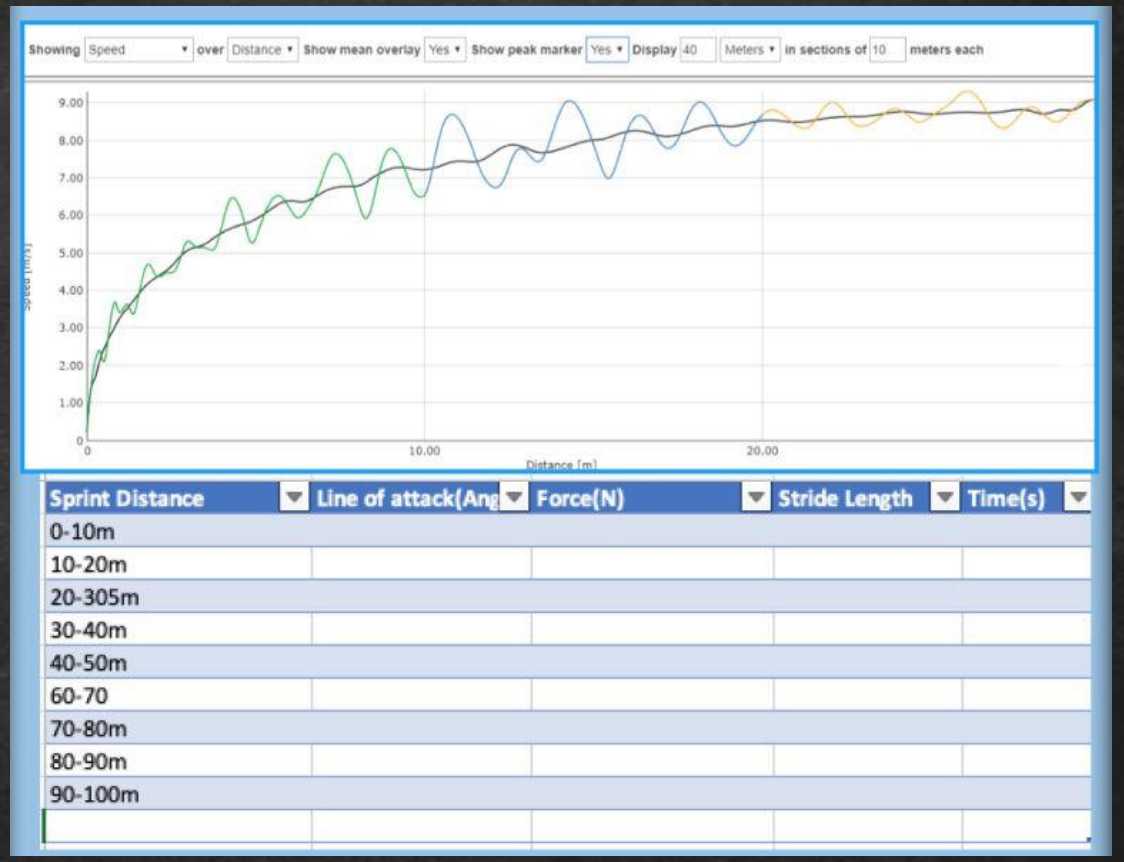
User Interface



Edwin Ulysse

Prediction Model

User Interface



Sprint Distance	Line of attack(Ang	Force(N)	Stride Length	Time(s)
0-10m				
10-20m				
20-305m				
30-40m				
40-50m				
60-70				
70-80m				
80-90m				
90-100m				

Edwin Ulysse

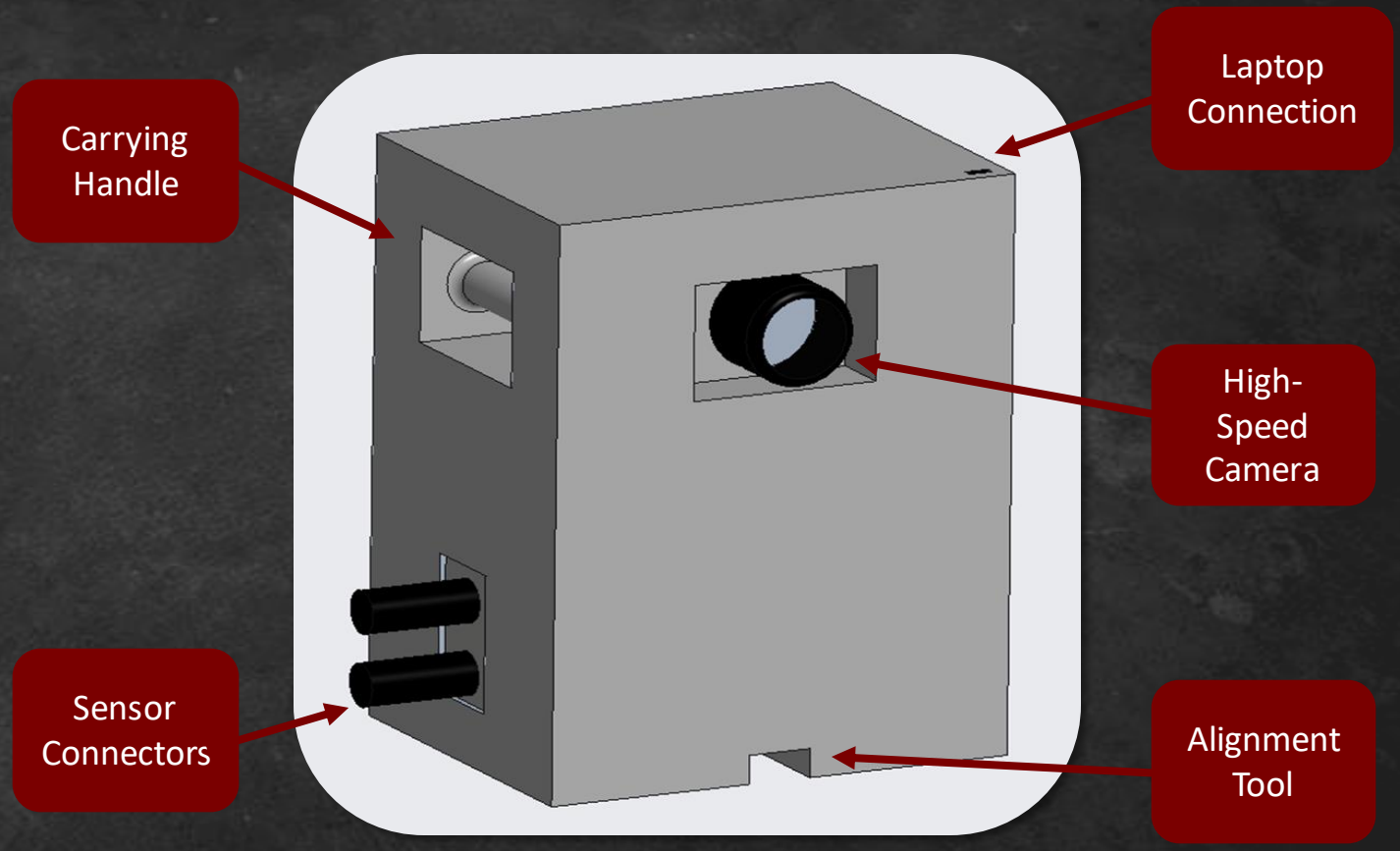
Concept Validation

Dylan Cedeno, Handy A Pierre, and Edwin Ulysse

Base Station

CAD Model – Preliminary Model

- Raspberry Pi 4b, wiring, high speed camera, Arduino and battery pack within housing
- Original plan: 3D print housing

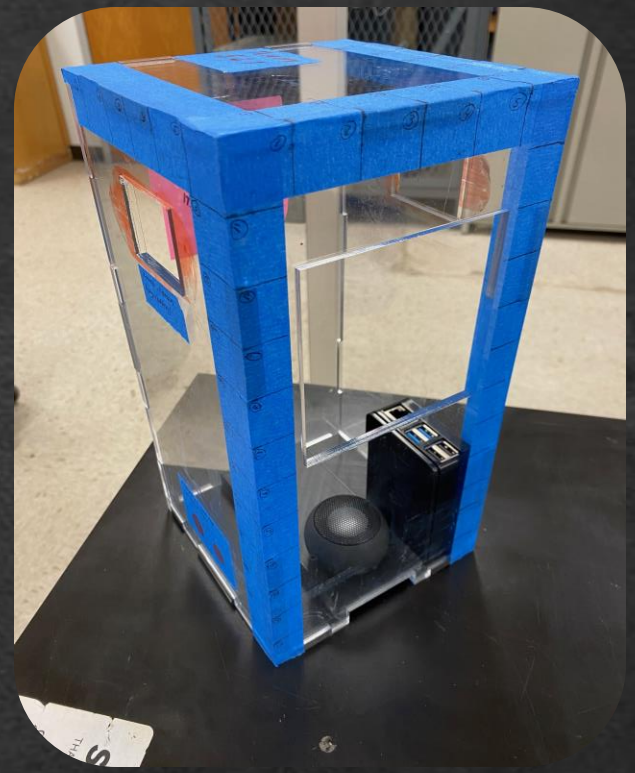


Dylan Cedeno

Base Station

Modular Prototype

- Created to get an idea of dimensions
- Modularity allowed for movement of shelves
- After tinkering, allowed for a more ideal final concept



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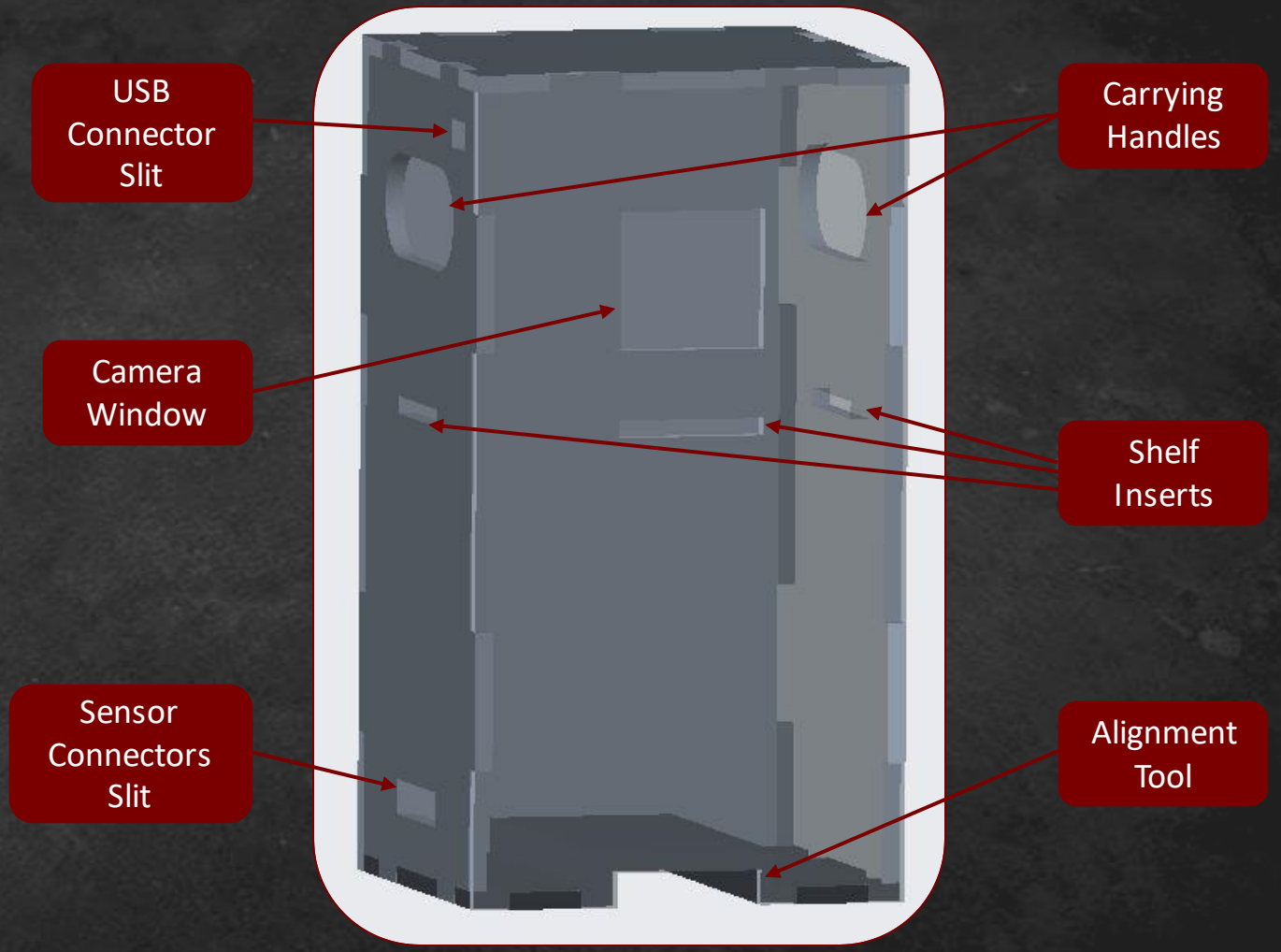
Base Station

CAD Model – Final Assembly

- Maintained same basic principles with small changes for functionality
- Main Changes
  - Proportions
  - Carry Handles
  - USB locations



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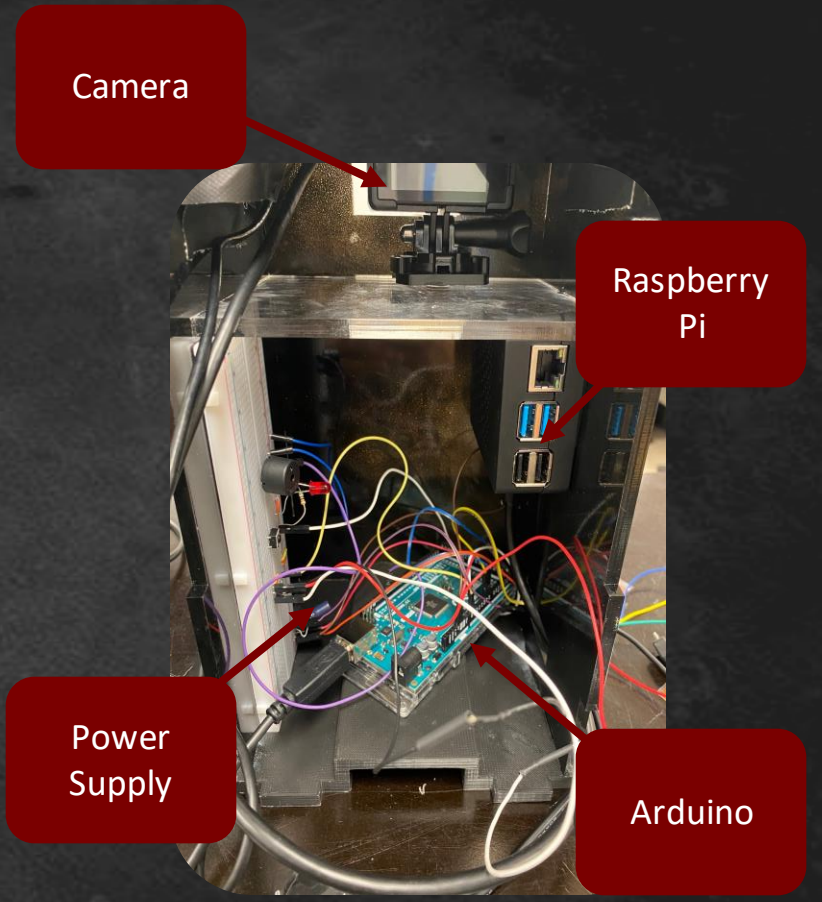
Base Station

Final Prototype

- Laser cut acrylic
- Houses all components
  - Camera
  - Raspberry Pi
  - Arduino
  - Power Supply
  - Wires



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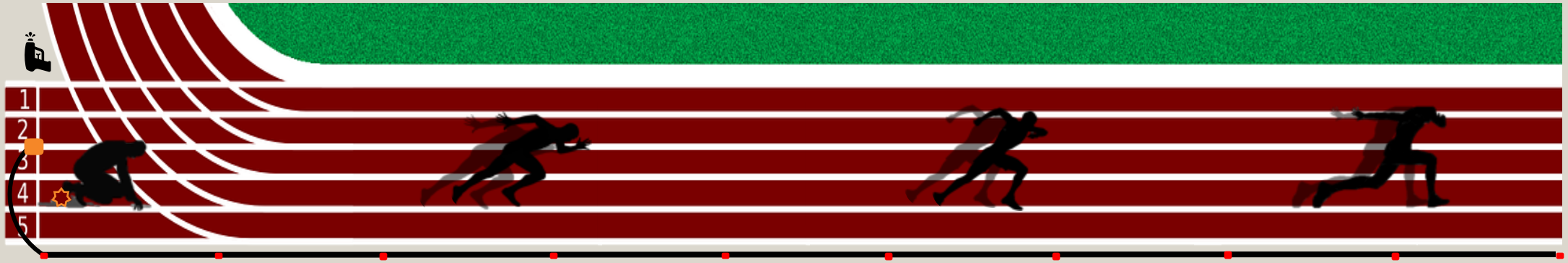
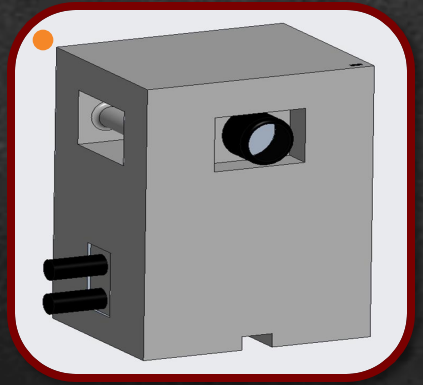
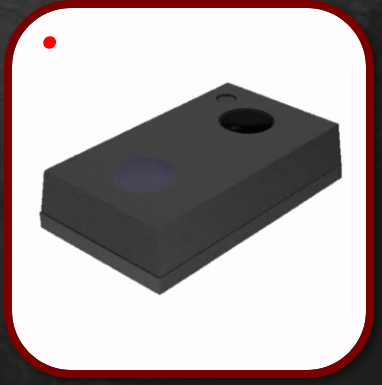
Measurements



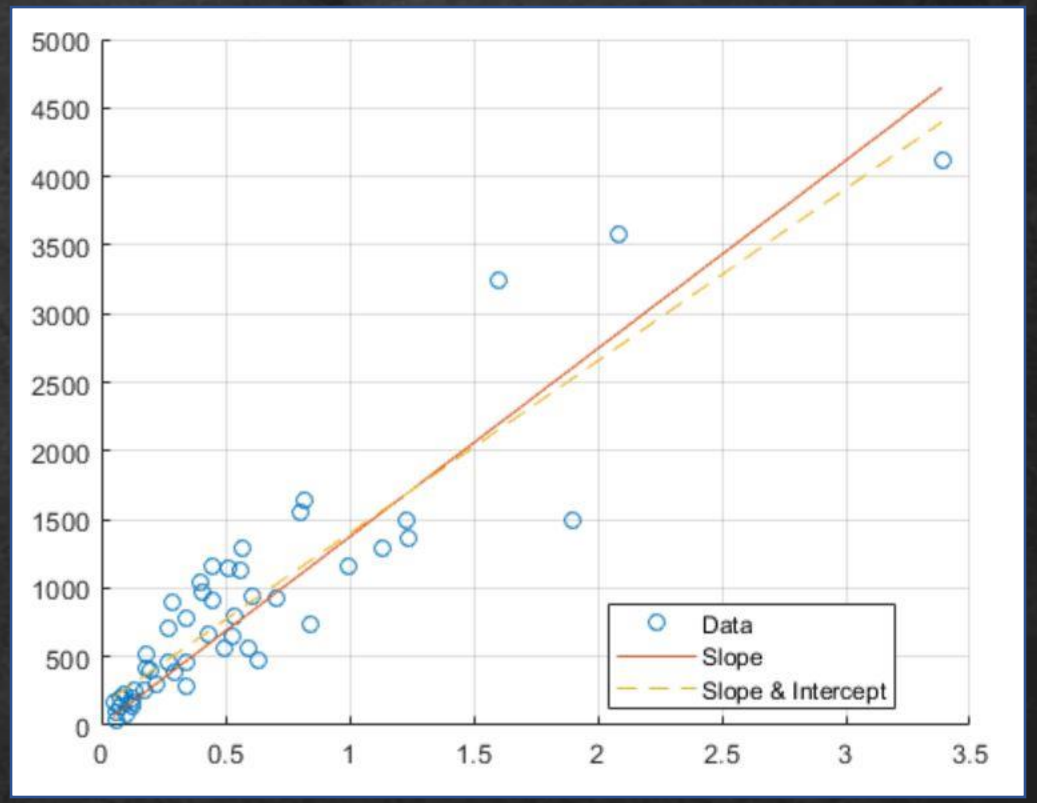




Prediction Model

Linear Regression Model

- Use correlating independent variables from ANOVA test for linear regression prediction



Edwin Ulysse

Prediction Model

Insignificant Data: Impulse and Time

Regression Statistics								
Multiple R	0.01981335							
R Square	0.00039257							
Adjusted R Square	-0.0 40767							
Standard Error	0.61409925							
Observations	31							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	0.00429498	0.00429498	0.01138897	0.91574667			
Residual	29	10.9364189	0.37711789					
Total	30	10.9407139						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	10.3060086	3.52873665	2.92059442	0.00669742	3.08893177	17.5230854	3.08893177	17.5230854
Impulse (N)	-0.0021089	0.01976096	-0.1067191	0.91574667	-0.0425246	0.03830683	-0.0425246	0.03830683

Strong negative relationship

Not a good fit

Not a good fit

Not significant

Edwin Ulysse

Prediction Model

Significant Data: Line of Attack and Time

SUMMARY OUTPUT									
Regression Statistics									
Multiple R	0.41529809								
R Square	0.1724725								
Adjusted R Square	0.14488825								
Standard Error	0.57915113								
Observations	32								
ANOVA									
	df	SS	MS	F	Significance F				
Regression	1	2.09721279	2.09721279	6.25257176	0.018094				
Residual	30	10.0624809	541603						
Total	31	12.1596936							
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%	
Intercept	10.3149909	0.19341522	53.3308135	2.7607E-31	9.91998436	10.7099975	9.91998436	10.7099975	
line of attack(angle)	-0.022717	0.00908493	-2.5005143	0.018094	-0.0412709	-0.0041631	-0.0412709	-0.0041631	

Edwin Ulysse

Incomplete Work

Dylan Cedeno

Incomplete Work

Incomplete Work

Reason for Incompleteness

Future Work for Completion

Base Station Prototype

- Does not have fully functioning camera

- Power supply and camera never came in
  - Used an old camera from the lab
  - Used a personal power supply

- All components will work as intended

Dylan Cedeno

Measurements Validation

- All, refined measurements were not fully obtained
  - Most rough proof of concept measurements were gathered

- Raspberry pi came in much later than planned
  - Lack of expertise in computer programming led to difficulty with implementation
  - Lack of knowledge about Raspberry Pi's led to unpolished system of taking measurements

- Fully gathered and refined measurements packed for the user's easy visualization

Dylan Cedeno

Prediction Model

- Did not run 32 tests for true validation of prediction model

- Not all measurements were able to be obtained in a usable manner
  - We could not develop a final model based on real measurements

- Run 32 trials of true measurements through the ANOVA software for accurate prediction

Dylan Cedeno

Lessons Learned

Marc Griffiths

Lessons Learned

Obstacle encountered

What we should have done to avoid it

How we overcame it

Marc Griffiths

Processor Selection

- We were not knowledgeable in Raspberry Pi or its coding system, Python
  - Wanted to use Arduino, but Raspberry Pi is better for complex systems
- Raspberry Pi 4b came in very late

- Should have gotten help sooner and decided on processing system earlier
  - More time to learn about coding on the system

- Used Arduino through the Raspberry Pi
  - C programming rather than Python

Material Selection

- 3D printing did not go well
  - Prints were inaccurate with CAD measurements, scaling was off

- Should have done more research to save time and energy

- Laser cut the material in Acrylic
  - Created perfect measurements, scaling, and tolerances
  - Very aesthetically pleasing

Marc Griffiths

Market in Entrepreneurship

- Our market size is too small for entrepreneurship
  - Believed reason to have lost the InNOLEvation Challenge

- Should have explored market research sooner
- Should have considered a more general product to expand market to other sports

- Plan to modify product to be used for other athletes

Summary

In Conclusion…

- Started design from nothing
  - Only given a project brief for the project, no preceding project to work off
  - Had to conceptualize targets, metrics, markets, etc.
- Designed and began validating a revolutionary product
  - Made it to the Semi-Finals of the InNOLEvation Challenge
- Created a product that we are proud of
  - Learned more than anticipated in the process
- Set up our project to be completed by future groups

Marc Griffiths

Thank You – Contact Us!

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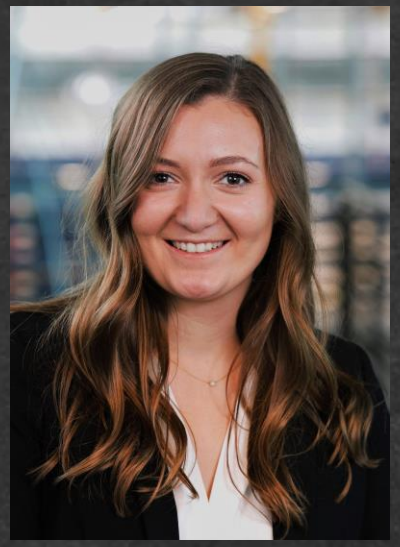

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Backup Slides

Competition

Affordable

Limited

Versatile

Expensive

TRACKMAN

1080 SPRINT™

Assumptions

- Range of sprinter heights from 5’6” to 6’4”
- User has prior experience with sprinting
- Sprinter starts in a standard starting block
- Device is used in fair weather
- User will not have access to a power outlet
- Device used on a collegiate approved track
- Consumer is more concerned about accuracy than price

Markets

- Collegiate Track Teams
- Highschool Track Teams
- Fans/Parents
- Professional Running Teams
- Masters Sprinters
- Other Sports

Key Goals

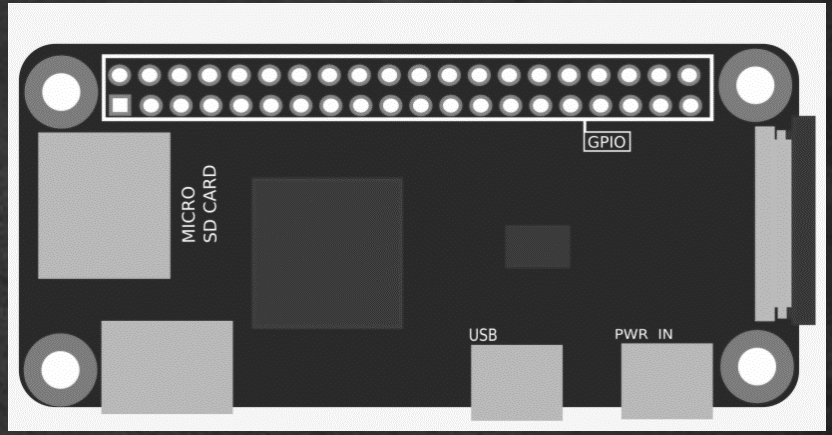
A product that will be desirable for purchase
- Cost effective
- Self-contained
- Minimal hinderance to performance

Predict a sprinter's performance
- Personalized inputs
- Creating trends based on inputs

Objectively measure a sprinter's performance
- Takeoff form
- Instantaneous velocity

Functions and Targets

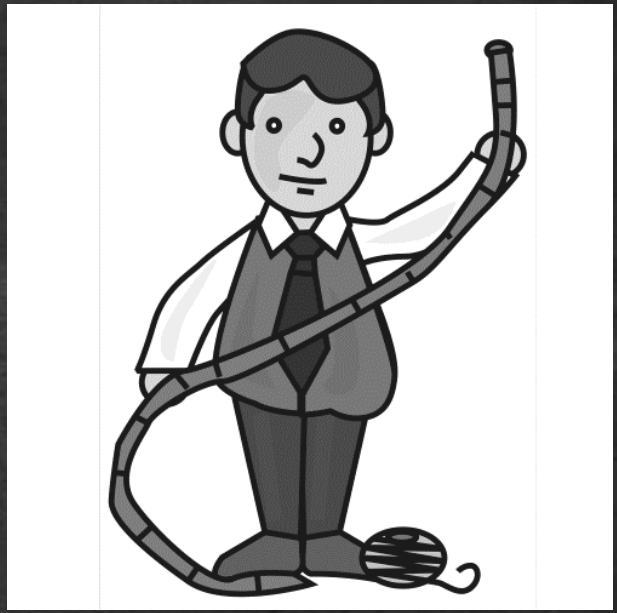
- Function: Store data
- Targets:
  - Video quality of 720 pixels at 60 frames per second
  - Storage uses a maximum of 10 megabytes per trial



Keep user's laptop storage usage to a minimum

Functions and Targets

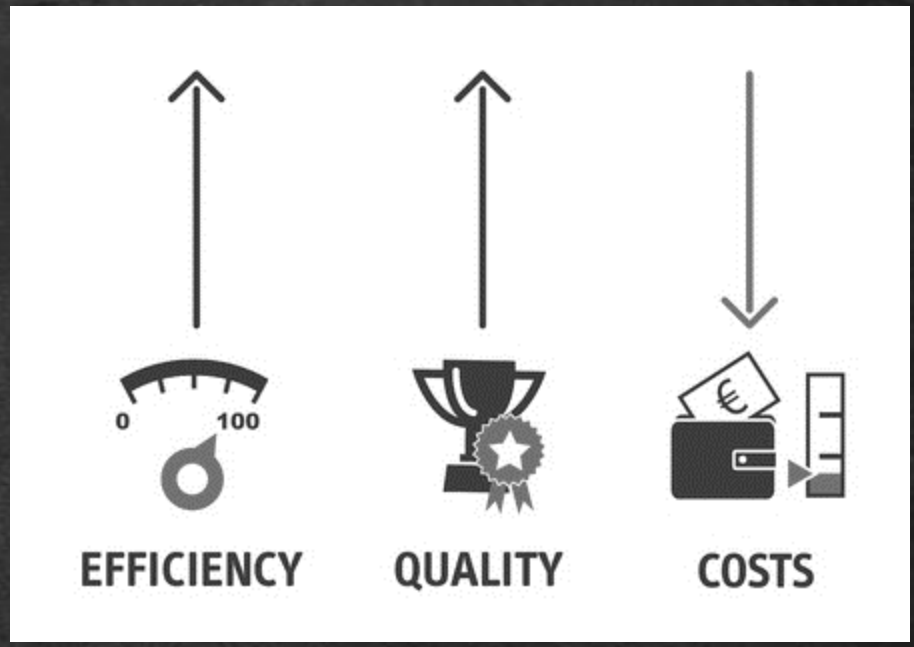
- Function: Retrieve personalized inputs
- Target: Inputs stored in under 5 seconds



User's input their weight and height for customized results

Functions and Targets

- Function: Make product cost-effective
- Target: Keep purchase price under $15,000



Affordable for high school and university track teams

Jordan Noyes

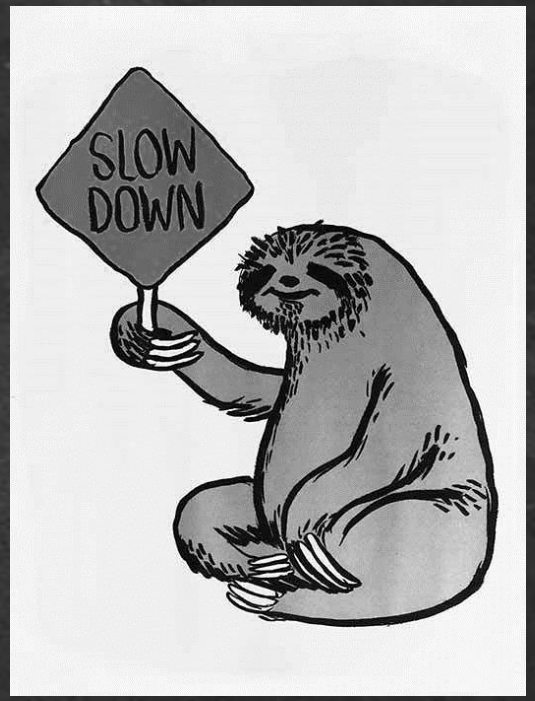
Functions and Targets

- Function: Product is self-contained
- Target: $0.00 spent outside of product purchase

User does not need to purchase anything outside of product

Functions and Targets

- Function: Product has low hinderance on performance
- Target: Wearable must weigh less than 1 kilogram

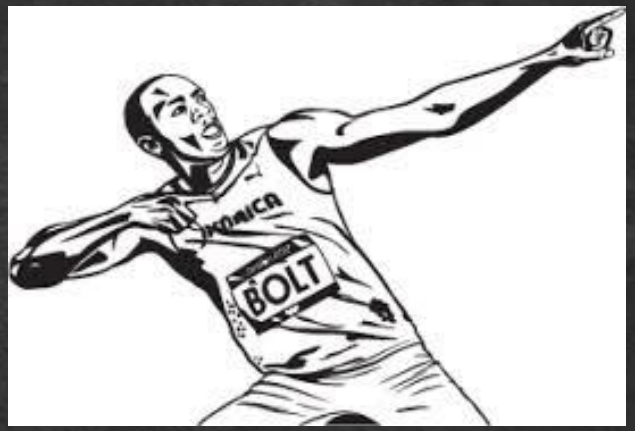


The wearable must not slow down the sprinter

Jordan Noyes

Functions and Targets

- Need: The tool incorporates professional sprinters for comparison
- Target: At least 5 different professionals

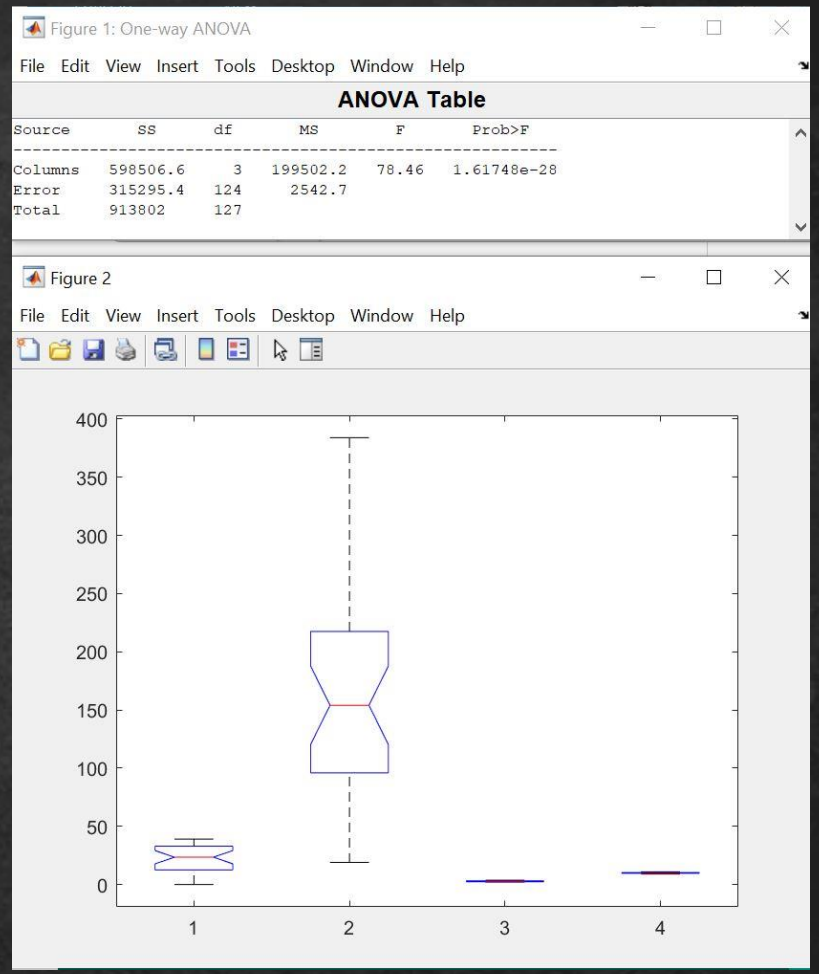


Professional sprinters of different sizes for custom comparison

Prediction Model Plan

ANOVA Model

- Will use ANOVA to validate statistical analysis
- Will do 32-36 tests on each sprinter to get accurate results
- Will compare each measurement to time to find correlations



Edwin Ulysse

Prediction Model

1. Personal database
2. Historical data
3. Data cleaning & remove outliers
4. Statistics software (Power BI, Minitab, Python)
5. Software application (UI/UX)

Prediction Model

Access and Explore Data

- Import data
- Historical data
- Database or spreadsheets

Prediction Model

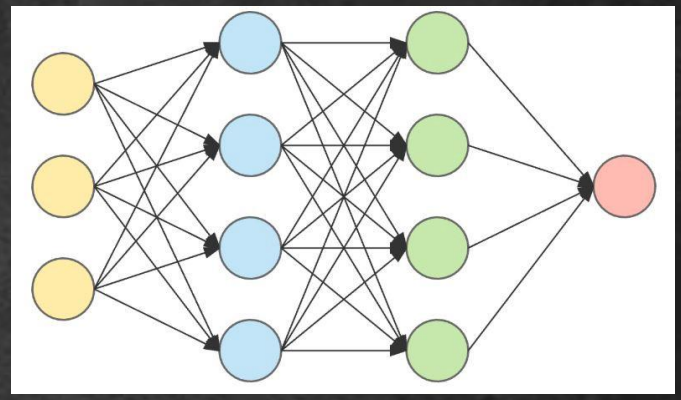
Preprocess Data

- Data cleaning & remove outliers
- Combine data sources
- ANOVA testing
- Correlation between independent variables and dependent variable
  - Dependent variable: time
  - Independent variables: measurements (line of attack, stride length, etc.)

Prediction Model

Develop Model

- Statistics software (Power BI, Minitab, Python)
- Access historical data
- Train model with neural networks



Prediction Model

Integrate Analytics with Systems

- Python
- Software application (UI/UX)
- Hardware (Raspberry Pi)

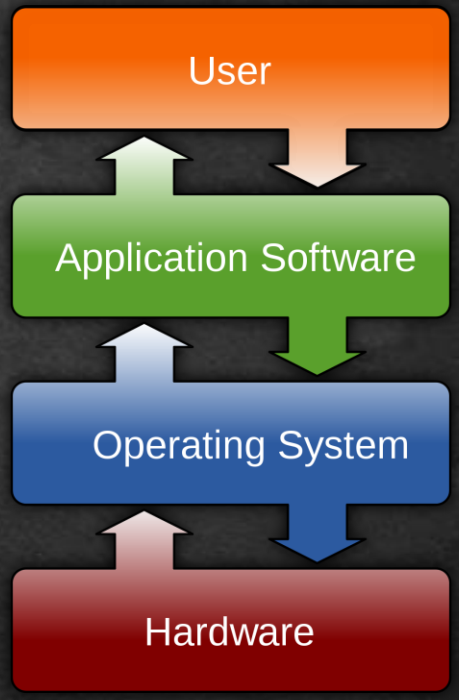


Table 2: Pugh Chart 1									
Selection Criteria	**1080 Sprint**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gauge Line of Attack	DATUM	+	+	+	+	+	S	+	+
Observe Second Step		S	-	+	S	+	S	+	+
Calculate Kickoff Force from the Block		S	+	+	+	+	S	+	S
Record Starter Gun Reaction Time		+	+	+	+	+	+	+	+
Track Instantaneous Velocity		S	-	S	+	-	S	+	-
Retrieve Personalized Inputs		+	S	+	+	+	+	+	+
Collect Data		S	-	-	-	+	S	+	+
Store Data		+	+	+	+	+	S	+	+
Create Trends		+	+	+	+	+	S	+	+
Make Product Cost Effective		+	-	-	-	+	S	+	-
Product is Self-Contained		+	-	-	-	+	S	-	-
Product has Low Hinderance on Performance		+	+	+	+	+	S	+	-
# of pluses		8	6	8	8	11	2	11	7
# of Minuses		0	5	3	3	2	0	1	4

Table 3: Pugh Chart 2							
Selection Criteria	**8**	**1**	**3**	**4**	**5**	**6**	**7**
Gauge Line of Attack	DATUM	S	-	S	S	-	S
Observe Second Step		S	-	-	S	-	S
Calculate Kickoff Force from the Block		S	-	S	-	-	S
Record Starter Gun Reaction Time		S	-	S	-	-	S
Track Instantaneous Velocity		-	-	-	-	-	-
Retrieve Personalized Inputs		S	-	-	-	+	S
Collect Data		S	S	S	S	S	S
Store Data		S	-	+	S	+	S
Create Trends		-	-	+	S	S	+
Make Product Cost Effective		+	+	S	S	S	+
Product is Self-Contained		S	S	S	S	S	S
Product has Low Hinderance on Performance		-	-	S	S	-	S
# of pluses		1	1	2	0	2	2
# of Minuses		2	9	3	4	6	1

Table 4: Pugh Chart 3				
Selection Criteria	**4**	**6**	**7**	**8**
Gauge Line of Attack	DATUM	-	S	S
Observe Second Step		S	S	S
Calculate Kickoff Force from the Block		S	S	S
Record Starter Gun Reaction Time		S	+	+
Track Instantaneous Velocity		-	S	S
Retrieve Personalized Inputs		+	S	S
Collect Data		S	S	S
Store Data		S	-	-
Create Trends		-	S	-
Make Product Cost Effective		+	+	-
Product is Self-Contained		S	S	S
Product has Low Hinderance on Performance		-	S	S
# of pluses		2	2	1
# of Minuses		4	1	3

Concept Generation and Selection

Handy A Pierre

Concept Generation

Generated over 100 different ideas using

- Biomimicry
- Morphological Flow Chart
- Randomization

Selected 8 total concepts

- High Fidelity
- Medium Fidelity

House of Quality

-

Pugh Chart

Competitor – 1080 Sprint

- Accuracy (most concepts)
- Performance
- Data storage
- Traveling

Concept 8
7 (+)
4 (-)

Non-Fidelity Concept

- Creation of trends
- Data storage

Concept 4
2 (+)
3 (-)

Medium Fidelity Concept

- Starter Gun Reaction Time
- Collecting inputs

Concept Generation

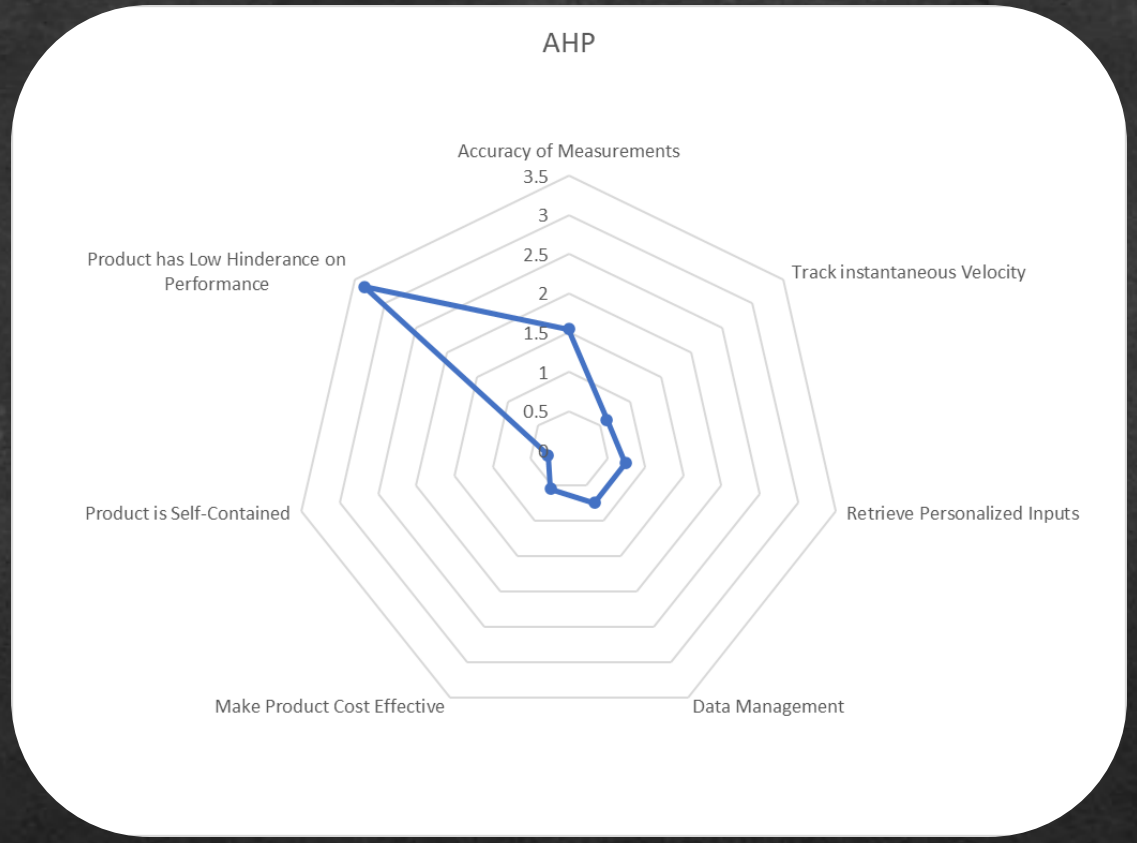
Selected 8 total concepts

- High Fidelity
- Medium Fidelity

Objectively analyzed the concepts

- House of Quality
- Pugh Chart
- AHP

AHP


AHP
Accuracy of Measurements
3.5
3
2.5
2
1.5
1
0.5
0
Track instantaneous Velocity
Retrieve Personalized Inputs
Data Management
Make Product Cost Effective
Product is Self-Contained
Product has Low Hinderance on Performance

Tension Cord Training Mechanism

Functions	Solutions
Average velocity	Tension cord and encoder
Gauge the line of attack	Analyze frames
Product has low hinderance on performance	Lightweight tension cord
Store data	Server
Create trends	Line graphs
Make the product cost effective	Compare to other markets & lay-away

Handy A Pierre

All Inclusive Technology

Functions	Solutions
Average velocity	Laser sensor
Gauge line of attack	Dots on the sprinter
Starter gun reaction time & kickoff force from the blocks	Force sensor on the blocks
Collect data & create trends	Personalized inputs & line graphs
Store data	Compressed folder
Make the product cost effective	Cheaper parts & renting option
Product is self-contained	All parts included
Product has low hinderance on performance	Lightweight wearable

Handy A Pierre

Launch Monitor Pro

Functions	Solutions
Average velocity	Infrared sensor
Gauge line of attack	Dots on the sprinter & take a video
Kickoff force from the blocks	Impulse sensor on the blocks
Observe the second step	Measuring tape
Store data	User's device
Make the product cost effective	Cheaper parts & renting option
Product is self-contained	Default apps on phone/laptop
Product has low hinderance on performance	Lightweight wearable

Handy A Pierre

Concept Selection

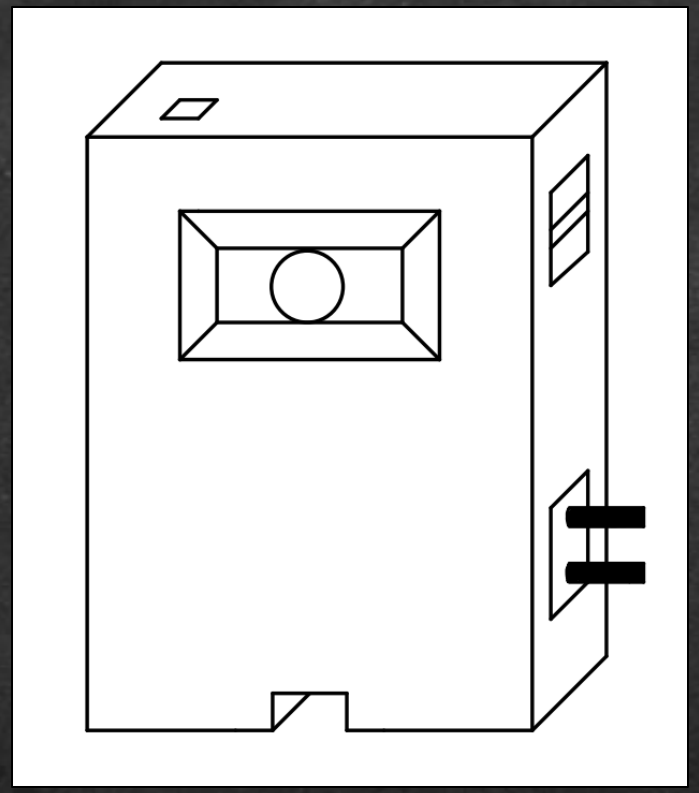
Selected the best 3

- Tension Cord Training Mechanism
- All Inclusive Technology
- Launch Monitor Pro

Selected a concept

Selected Concept

Launch Monitor Pro



Ordering Parts

- Many of our parts came in late or not at all
- Led to a bigger time constraint than planned

- Should have discussed with subject matter experts sooner
- Should have ordered parts immediately

- We worked with old parts we could find in the lab
- Did the best we could given the time constraint

Marc Griffiths

Team Communication & Time Management

- Did not communicate effectively at first
- Did not use time efficiently

- Should have communicated expectations clearly to the team
- Should have delegated tasks to split up work
- Should have stuck better to personal deadlines

- We improved our communication and time management skills
- We learned what is effective in a team and what ineffective

Marc Griffiths