GPS Study

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\[ T_{\text{round}} = 4:1000 \text{hours} \]
$T_{round} = 4:10:22 - 7:10$
\[ T_{\text{round}} = 4:00 + 0:12 - 0:10 \]
\[ T_{\text{round}}^i = T_{\text{round}}^{i-1} + \Delta T_{\text{finish}}^i - \Delta T_{\text{tee}}^i \]

Flow Out

Flow In
Cycle Time

\[ T_{\text{round}}^i = T_{\text{round}}^{i-1} + \Delta T_{\text{finish}}^i - \Delta T_{\text{tee}}^i \]
\[ T_{\text{round}}^6 = T_{\text{round}}^1 + \Delta T_{\text{finish}}^6 - 5\Delta T_{\text{tee}} \]

- Cycle Time
Recommendation #1: In order to have control over pace of play, we must be measuring and controlling the relevant parameters
Understanding the Fundamentals

Collect Data

Build Predictive Tools

Provide Tools for Improvement
Understanding the Fundamentals

- Build Predictive Tools
- Collect Data

Provide Tools for Improvement
Intro

• *About our GAME* Intern Program

• Data Collection Process

• Software Development

• Data Analysis

• Next Steps
Intern Program

- Summer intern program supported by Chevron STEM
- Had interns placed at 8 different regions around the United States
- Visited golf courses 2 – 3 times per week
- Each had 75 GPS loggers to record data
- They collected information about golfers (Handicap, Rounds Played, Drive Distance, etc…)
Intern Locations
Notable Courses Visited

- Chambers Bay, University Place, Wash.
- Rustic Canyon Golf Club, Moorpark, Calif.
- Colonial Country Club, Ft. Worth, Texas
- CommonGround Golf Course, Aurora, Colo.
- The Glen Club, Glenview, Ill.
- The Pines Course, Joint Base Langley-Eustis, Va.
- Huntingdon Valley (Pa.) Country Club
Data Collection

• Each golfer is handed a small GPS device

• GPS records position and time every 5 seconds on course

• Use of data sheets to collect additional information on golfers
Data Collection

### USGA Pace Data Research - Golf Course Data

**Course Name:**

- Address: 
  - Public
  - Private
  - Resort

**Course Type:**
- Public
- Private
- Resort

**Starter?:**
- Yes
- No

**Pace Policy?:**
- Yes
- No

#### Scorecard Data

<table>
<thead>
<tr>
<th>Hole</th>
<th>Par</th>
<th>Yards</th>
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</tbody>
</table>

### USGA Pace Data Research - Event Data

- **Event Type:**
  - Regular Play
  - Tournament

- **Format:**
  - Stroke
  - Match
  - Stableford

- **Tee Format:**
  - Straight
  - Split
  - Resort

- **Starting Tees:**
- **Green Fee:**

#### Weather Info

- **Sunny**
- **Partly Sunny**
- **Cloudy**
- **Overcast**

- **Temperature:**
  - F
  - °C

- **Humidity:**
  - %

- **Wind Speed:**
  - mph
  - km/h

### Course Setup

- **Firmness:**
  - Firm
  - Medium
  - Soft

- **Cut Heights:**
  - Fairway
  - Rough
  - Greens

- **Turfgrass:**
  - Fairway
  - Rough
  - Greens

### USGA Pace Data Research - Golfer Data

- **Group #:**
- **Tee Time:**
- **Cart #:**

<table>
<thead>
<tr>
<th>Golfer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS #</td>
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<tr>
<td>Tee</td>
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<tr>
<td>Handicap</td>
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<td></td>
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<td></td>
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<tr>
<td>Driver Dist</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>9-Iron Dist</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Rounds Last Year</td>
<td>(1 Under 25: 25 - 34: 35 - 44: 45 - 54: 55 - 64: 65 - 74: Over 75)</td>
<td></td>
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<tr>
<td>Gender</td>
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</tbody>
</table>

### Golfer Data

- **Group #:**
- **Tee Time:**
- **Cart #:**

<table>
<thead>
<tr>
<th>Golfer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
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<tbody>
<tr>
<td>GPS #</td>
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<td>Tee</td>
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<tr>
<td>Gender</td>
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</tbody>
</table>
USGA created software to database golfer information and GPS data.

Software analyzes GPS tracks to create key metrics.

Further research can be done using an array of plotting and analysis features.

Additionally reports are generated on pace metrics for events.
Software - Algorithm

- In order to process pace data we need reference markers to compare against.

- The golf course features are mapped out to compare points against.
Software - Algorithm

- Algorithm developed to divide GPS into segments by hole or other features
Software - Algorithm

End Point Identified
- Hole Time

Start Point Identified
- Tee Time
Once the start and end points are determined on each hole for every golfer we can calculate our metrics

• **Pace**
  \[ \text{Pace (Hole } n \text{)} = \text{Hole Time (Hole } n \text{)} - \text{Tee Time (Hole } n \text{)} \]

• **Cycle Time**
  \[ \text{Cycle Time (Group } n \text{)} = \text{Hole Time (Group } n + 1 \text{)} - \text{Tee Time (Group } n \text{)} \]
Metrics Generated

- Cycle Time
- Pace
- Tee Time
- Hole Time
- Round Times
- Time from X distance to green
Software Report

USGA Pace of Play Report

Name: Windy City Collegiate MD 1st
Course: Westmoreland CC
Date: 10/7/2014 9:08:05 AM

Weather Info: Sunny
Temperature: 0
Humidity: 0
Wind: 0 - 5

Graphs showing hole number versus score and group number versus score.
<table>
<thead>
<tr>
<th>Program Statistics</th>
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<tbody>
<tr>
<td>Number of Events</td>
</tr>
<tr>
<td>Total Golfers</td>
</tr>
<tr>
<td>Average Golfer Per Event</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
</tbody>
</table>
Data Analysis – Cycle and Round Times

• Visited multiple different courses types ranging from Military to Resort

• Average Tee Start Interval -10.4 minutes

• Average Round time – 4:09

• Longest Round Time – 5:48

• Average difference from first to last round – 29 minutes
Data Analysis – Cycle and Round Times

<table>
<thead>
<tr>
<th>Par</th>
<th>Cycle Time Average (Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10.5</td>
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<tr>
<td>4</td>
<td>10.3</td>
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<tr>
<td>5</td>
<td>10.1</td>
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</tbody>
</table>
Data Analysis – Round Times by Yardage

Round Time (minutes) vs. Yards

- Yards range from 2000 to 8000
- Round Time (minutes) range from 0 to 300

The graph shows a trend where round time increases with yardage, peaking around the 6000 yard mark and then stabilizing.
Data Analysis – Cycle Time by Par Yardage

• Group Par 3 and Par 4 by yardage

• Performed theoretical analysis of how cycle time would vary with distance

• Compared theory to collected data
Data Analysis – Cycle Time by Par Yardage

### Par 3

- **Hole Yards:** 150, 200, 225, 250
- **Cycle Time (min):** 8.00, 8.00, 10.00, 6.00

### Par 4

- **Hole Yards:** 350, 375, 400, 425, 450
- **Cycle Time (min):** 8.00, 8.00, 8.00, 5.00, 5.00
Data Analysis – Cycle Time by Par Yardage

**Par 3**

<table>
<thead>
<tr>
<th>Yardage</th>
<th>Cycle Time</th>
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</thead>
<tbody>
<tr>
<td>150</td>
<td>10.2</td>
</tr>
<tr>
<td>200</td>
<td>10.4</td>
</tr>
<tr>
<td>225</td>
<td>10.4</td>
</tr>
<tr>
<td>250</td>
<td>10.5</td>
</tr>
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</table>

**Par 4**

<table>
<thead>
<tr>
<th>Yardage</th>
<th>Cycle Time</th>
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</thead>
<tbody>
<tr>
<td>350</td>
<td>10.5</td>
</tr>
<tr>
<td>375</td>
<td>10.3</td>
</tr>
<tr>
<td>400</td>
<td>10.2</td>
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<tr>
<td>425</td>
<td>10</td>
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<tr>
<td>450</td>
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</tbody>
</table>
• The data presented is a course that we visited this summer

• The average cycle time for a hole on this course is 9.1 minutes

• The first group plays in 4:06 and the last group plays in 5:37
Data Analysis – Sample Golf Course

Round Time (Minutes) vs. Group Number
Data Analysis – Sample Golf Course

• Last group studied takes 1:30 longer to play than first group

• Relative stable periods when tee interval is above cycle time

• When tee interval is below cycle time we see sudden spikes in round time
Data Analysis – Green Speed

• Green speeds were collected for each round of golf

• Range of speeds collected from 7 – 11.5

• We look at the average round times for each bracket of green speed

• Note that some values are reported green speeds
Data Analysis – Green Speed

![Graph showing the relationship between Round Time (minutes) and Green Speed. The graph includes error bars indicating variability in the data. The x-axis represents Green Speed, ranging from 6.5 to 12.5, while the y-axis represents Round Time (minutes), ranging from 230 to 280. The data points show a general trend where Round Time increases with Green Speed, with some variability indicated by the error bars.]
Data Analysis – Green Speed

Cycle Time (minutes)

Green Speed

Graph showing the relationship between cycle time in minutes and green speed from 6.5 to 12.5, with cycle times ranging from 7 to 11 minutes.
Next Steps

• Continually adding events to the data set

• Studying other factors that may influence pace of play

• Use of L1 Technologies mapping database to study additional geographical and course design features

• Run more controlled studies at Robert Trent Jones Golf Trail in Alabama