Developing Spreadsheet-Based Pace of Play Models

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Tiger background

- Operations research / industrial engineering / analytics
- Modeled supply chains & manufacturing systems (3M, Aspentech, E&J Gallo)
- Professor/researcher – use supply chain simulation models to represent golf pace of play

Models

- Representation of reality
- Useful if …
  - Valid
  - Easy to use
  - Timely
- Benefits
  - Predicting/planning
  - Out-of-the-box thinking, safely and cheaply
- Requirements
  - Logic, math, programming
  - Data

Spreadsheet Simulation

- MS Excel
  - Widely used analytical tool
  - Capable of modeling uncertainty by generating random numbers
- Simulation (Monte Carlo)
  - Repeated random sampling (many trials)
  - Useful when it is difficult or impossible to obtain a closed-form expression

Two Spreadsheet Models

- #1 Hole design
  - Outputs
    - Time to play a golf hole (μ, σ, distribution)
    - Performance statistics (GIR, FWY hit, Lost ball %, …)
  - Inputs
    - Course design (length, width, features, rough length, …)
    - Golfer (group size, ability (distance & accuracy), transportation mode and policy, hitting/addressing times, movement times)
- #2 Course design
  - Outputs
    - Time to play a round, queues/bottlenecks
  - Inputs
    - Course design (length, width, features, green speed, par, distance to next hole)
    - Course policy (tee time interval, 1st and 10th tee start, shotgun)
    - Golfer (group size, ability, transportation model and policy, hitting/addressing times, movement times)
    - Hole design Outputs (see Model #1)

Hole Design Input

Course Scale Factors

Lie	Code	Distance SF	Distance Accuracy SF	Angle Accuracy SF	Time SF	Lost Ball %
green		1.00	1.00	1.00	1.00	0%
tee		1.00	1.00	1.00	1.00	0%
target		0.90	1.05	1.05	1.00	0%
fairway		0.90	1.05	1.05	1.00	0%
rough		0.50	1.50	1.50	2.00	10%
sand		0.60	1.20	1.20	2.00	0%
trees		0.50	1.50	1.50	2.00	10%
water		1.00	1.00	1.00	2.00	100%

Travel Time Parameters (yds/minute)

Mode	Avg	SD	Distribution	MPH (calc)
Walking	90	1	Normal	3.1
Cart	300	1	Normal	10.2

Other Time Parameters (seconds)

	Avg	SD	Distribution
Finding Lost Ball Time (seconds)	120	10	Normal
Hitting Time	30	6	Normal

Golfers

Type	Handicap	%	Planned Distance	Accuracy CV
Beginning	20+	0	210	18%
Bogey	15-20	0	230	15%
Decent	10-15	0	250	11%
Good	1-9	0	270	8%
Scratch (calculated)	Less than 2	100	290	5%

Hole Information

Course	Silverado GC, Durant OK
Number	1
Handicap	10
Par	4
Cart Path Y Coordinate	30
Green Stimp	11
Length (calculated)	415
Green Size (calculated)	7200

Andrew Tiger:
Scoring stats are based on Par. Don't forget to change this value.

Green and Teebox Regression Coefficients

	Green	TeeBox
Intercept	-0.05	3.42
Green Size (sqft)	0.00	
Green Speed	-0.02	
Avg Fairway Width (yards)		
Avg Rough Height (inches)		
Distance (yds)		
Fairway Features (sqyd)		
Green Features (sqyd)		
P4	-0.34	
P5	-0.32	
# of Golfers	0.71	
Avg Group Handicap		
Wind Speed (mph)	0.01	
Temperature		
Weather Conditions		
Cart Policy - 90 Degree		
Cart Policy - CPO		
Walking		
Standard Error	0.33	0.83

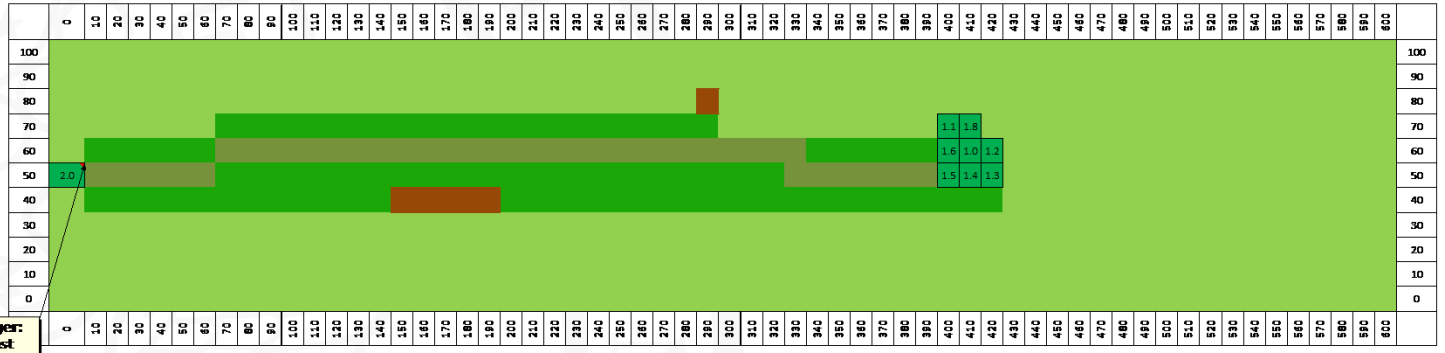
Hole Design Model Input con’d

Key		
1.0 - 1.8	green (1.0 = pin)	1.0
2	tee	2.0
3	target	
4	fairway	
5	rough	
6	sand	
7	trees	
8	water	

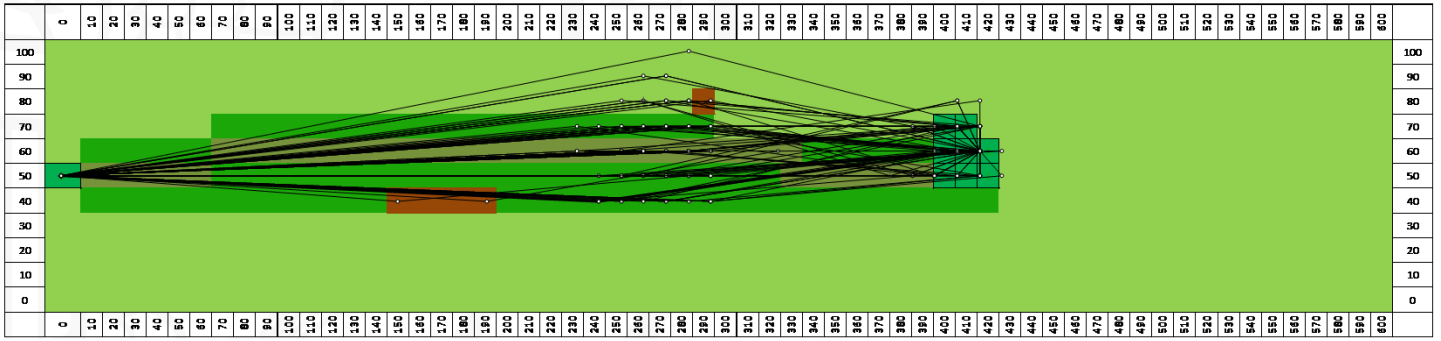
Simulate

Andrew Tiger: Teebox must always be here.

INPUT: Use numbers representing course features



OUTPUT: Resulting (direct) path to golf shots



Teebox and Green Coordinates (calc)	X	Y
Teebox	2.0	0	50
Pin (1.0)	1.0	410	60
Green	1.1	400	70
Green	1.2	420	60
Green	1.3	420	50
Green	1.4	410	50
Green	1.5	400	50
Green	1.6	400	60
Green	1.7		
Green	1.8	410	70

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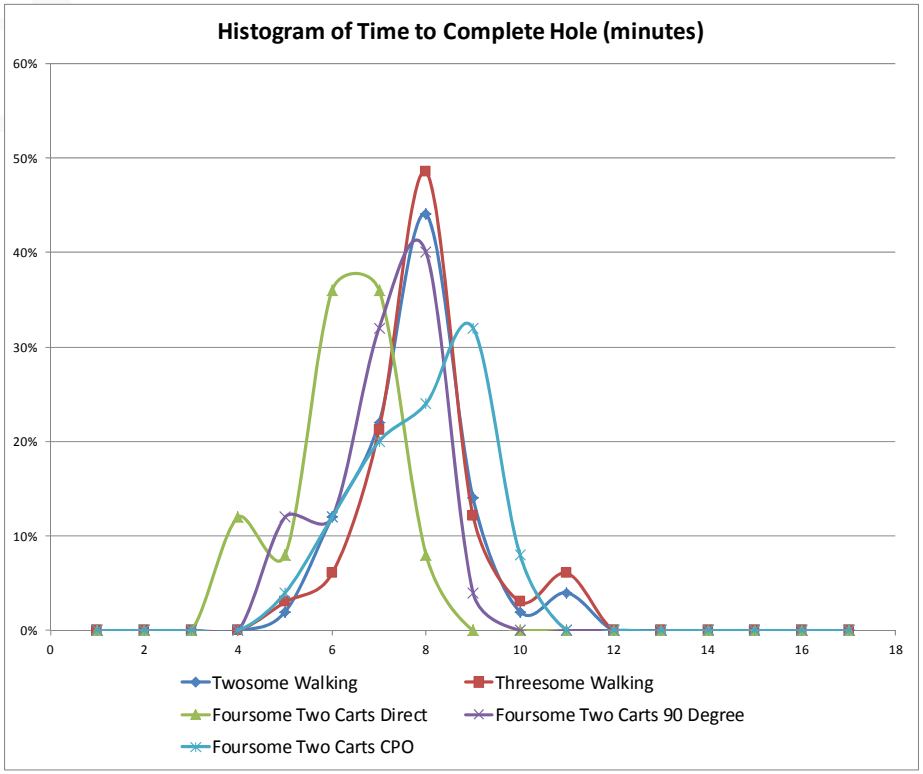
Hole Design Output

Scoring

Ball Striking		Strokes to Green	
Fairway Hit %	85%	Average	2.24
GIR %	76%	# of Strokes	%
Avg Bunker Hit %	0%	1	0%
Avg Water Hit %	0%	2	76%
Avg Lost Ball %	4%	3	24%
		4	0%
Average Handicap	0.0	5	0%
		6	0%
		7	0%
		8	0%

Times and Rates to Complete Hole

	Twosome Walking	Threesome Walking	Foursome Two Carts Direct	Foursome Two Carts 90 Degree	Foursome Two Carts CPO
Avg Total Time (minutes)	11.3	12.7	9.7	10.6	11.4
Std Dev Time (minutes)	1.2	1.6	1.0	1.1	1.3
Teebox Time (minutes)	4.0	3.7	4.1	4.1	4.1
Fairway Time (minutes)	6.1	7.0	2.9	3.8	4.6
Green Time (minutes)	1.2	1.9	2.7	2.7	2.7
Rate (YPM)	69	60	132	102	83
Rate (MPH)	2.3	2.0	4.5	3.5	2.8



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Course Design Model Input

Golf Pace of Play Simulator ©

This version of the 'Golf Course Pace of Play Simulator' models recreational golfers in carts,where all begin on #1. Four golfers per group. One hundred (100) golfers are twenty-five (25) groups.

Course	Humboldt Golf and Country Club
Location	Humboldt TN
Website	http://www.humboldtcountryclub.com/
Day Begins	7:00 AM
Cart Policy	90 Degree
Smallest Tee Time Interval (minutes)	8
Largest Tee Time Interval (minutes)	15

Andrew Tiger:
Must be at least 6 minutes

Andrew Tiger:
Must be greater than the smallest tee time interval and no more than 15 minutes.

Simulate

Golf Pace of Play Simulator ©

Handicap and Distance Breakdown %

Type of Golfer (Distance)	Maximum Distance *Drive*	Maximum Distance *Fairway*	Handicap *> 20*	Handicap *10 to 20*	Handicap *< 10*
Short	200	150	5%	5%	10%
Average	250	225	10%	20%	30%
Long	300	250	5%	5%	10%
	Time Scale	*Upper*	1.01	1.01	1.01
	Factors	*Lower*	0.99	0.99	0.99

These distances are used to determine when a golf can safely hit due to group in front is out of the way.

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Course Design Model Input con'd

Golf Pace of Play Simulator ©																			
Hole	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Par
Par	4	4	3	3	4	5	5	4	3	4	3	5	4	5	3	4	4	4	71
Yards	380	340	190	200	380	475	470	321	190	440	165	520	400	530	150	380	310	310	6151
Gate Distance (Yards)																			
Teebox to Gate 1	275	225	0	0	275	275	275	225	0	275	0	225	225	225	0	275	250	200	
Teebox to Gate 2	280	250	0	0	300	300	300	230	0	300	0	250	250	225	0	300	275	250	
Teebox to Gate 3	290	325	0	0	325	325	325	300	0	325	0	275	275	225	0	325	275	320	
Gate 3 to Gate 4	0	0	0	0	0	200	200	0	0	0	0	200	0	200	0	0	0	0	
Gate 4 To Green	90	15	190	200	55	0	0	21	190	115	165	45	125	105	150	55	35	0	
To Next Hole	40	100	20	50	20	25	50	20	50	50	40	150	200	20	20	20	20	0	
Hole Features																			
Green Size (sqft)	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	
Green Speed	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	
Avg Fairway Width (yards)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	
Avg Rough Height (inches)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
Fairway Features: Fairway Ratio	0.5	0.8	0	0.5	0.2	0.2	0.3	0.3	0.1	0.7	0.1	0.8	0.8	0.9	0.2	0.6	0.2	0.8	
Green Features: Green Ratio	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0	0.5	0	0.5	0.5	0.9	0.9	0.5	0.5	0.5	
Time Scale Factors																			
Hole	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Hole Time SF	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
To Next Hole Time SF	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	

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Course Design Model Input con'd

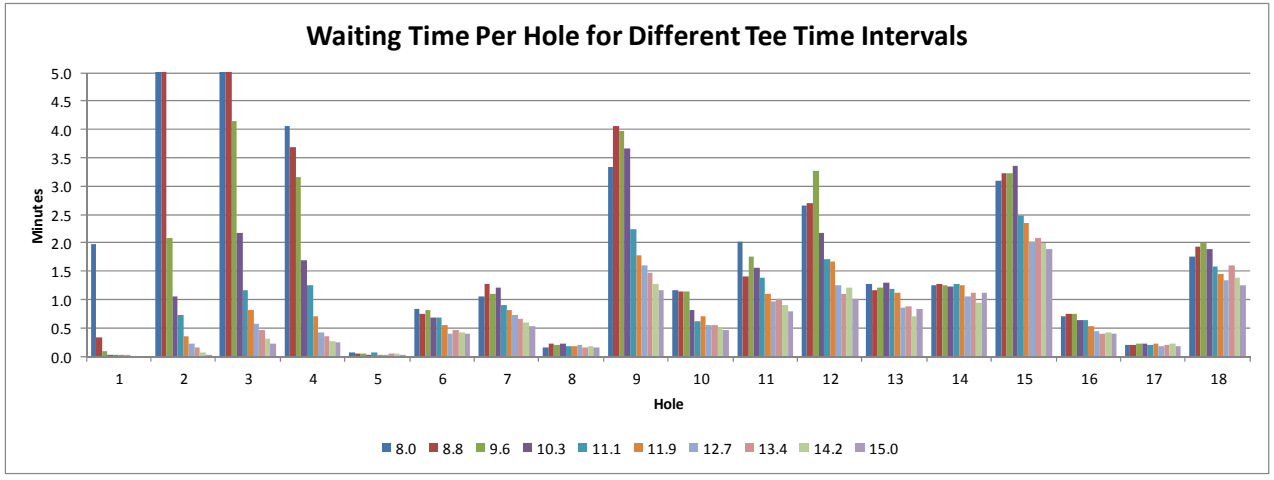
Golf Pace of Play Simulator ©						
Teebox	Teebox	Green	P3 Fairway	P4 Fairway	P5 Fairway	To Next Hole
Intercept	-0.050	3.420	54.825	65.127	65.127	80.000
Green Size (sqft)	0.000		0.004	0.002	0.002	
Green Speed	-0.024					
Avg Fairway Width (yards)				0.525	0.525	
Avg Rough Height (inches)			0.403	0.022	0.022	
Distance (yds)			0.029	-0.002	-0.002	
Fairway Features (sqyd)			0.000	-22.986	-22.986	
Green Features (sqyd)			-3.225	-1.366	-1.366	
P4	-0.336					
P5	-0.316					
# of Golfers	0.706					
Max Group Handicap			-1.002	-1.244	-1.244	
Wind Speed (mph)	0.010					
Temperature						
Weather Conditions						
Cart Policy - 90 Degree			-10.565	-10.203	-10.203	
Cart Policy - CPO			-18.077	-18.183	-18.183	
Walking						
Standard Error	0.333	0.830	10.000	7.000	7.000	10.000

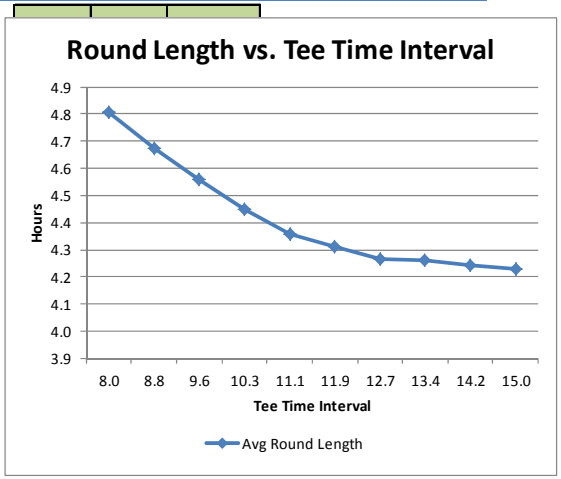
Course Design Model Output

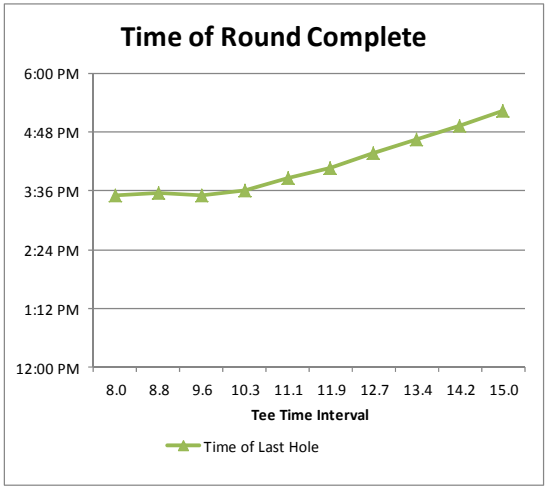
Golf Pace of Play Simulator ©																			
Hole	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Par
Par	4	4	3	3	4	5	5	4	3	4	3	5	4	5	3	4	4	4	71
Yards	380	340	190	200	380	480	490	321	190	440	165	520	400	530	150	380	310	310	6151
	Averge Non-Waiting Playing Time Per Group (minutes)																		Total
Time	13.2	13.4	9.7	9.8	12.2	14.7	15.1	11.3	9.5	15.3	9.2	17.8	14.9	18.8	9.2	13.5	11.0	13.0	232
	Averge Time to Next Hole (minutes)																		Total
Time	0.5	1.3	0.3	0.6	0.3	0.3	0.6	0.3	0.6	0.6	0.5	1.9	2.5	0.3	0.3	0.3	0.3	0.0	11

Round Length Without Waiting 4:03

Tee Time	Averge Waiting Time Per Group (minutes)																		Total
8.0	2.0	10.3	9.5	4.1	0.1	0.8	1.1	0.2	3.3	1.2	2.0	2.7	1.3	1.3	3.1	0.7	0.2	1.7	45
8.8	0.3	5.7	7.5	3.7	0.0	0.7	1.3	0.2	4.1	1.1	1.4	2.7	1.2	1.3	3.2	0.7	0.2	1.9	37
9.6	0.1	2.1	4.1	3.2	0.1	0.8	1.1	0.2	4.0	1.1	1.8	3.3	1.2	1.2	3.2	0.7	0.2	2.0	30
10.3	0.0	1.0	2.2	1.7	0.0	0.7	1.2	0.2	3.7	0.8	1.6	2.2	1.3	1.2	3.3	0.6	0.2	1.9	24
11.1	0.0	0.7	1.2	1.3	0.1	0.7	0.9	0.2	2.2	0.6	1.4	1.7	1.2	1.3	2.5	0.6	0.2	1.6	18
11.9	0.0	0.4	0.8	0.7	0.0	0.5	0.8	0.2	1.8	0.7	1.1	1.7	1.1	1.2	2.3	0.5	0.2	1.4	16
12.7	0.0	0.2	0.6	0.4	0.0	0.4	0.7	0.2	1.6	0.5	1.0	1.2	0.8	1.1	2.0	0.4	0.2	1.3	13
13.4	0.0	0.1	0.5	0.3	0.0	0.5	0.7	0.2	1.5	0.5	1.0	1.1	0.9	1.1	2.1	0.4	0.2	1.6	13
14.2	0.0	0.1	0.3	0.3	0.0	0.4	0.6	0.2	1.3	0.5	0.9	1.2	0.7	0.9	2.0	0.4	0.2	1.4	11
15.0	0.0	0.0	0.2	0.2	0.0	0.4	0.5	0.2	1.2	0.5	0.8	1.0	0.8	1.1	1.9	0.4	0.2	1.2	11







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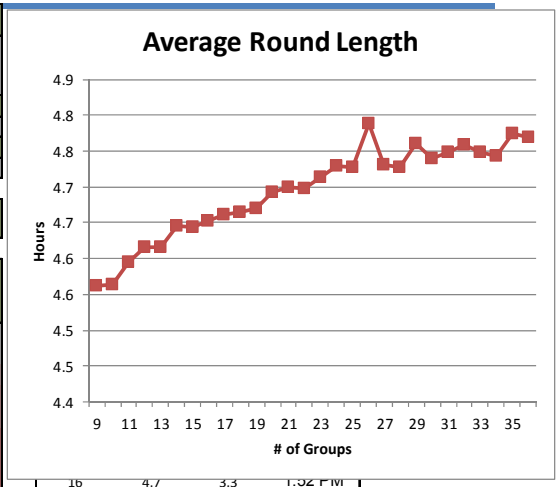
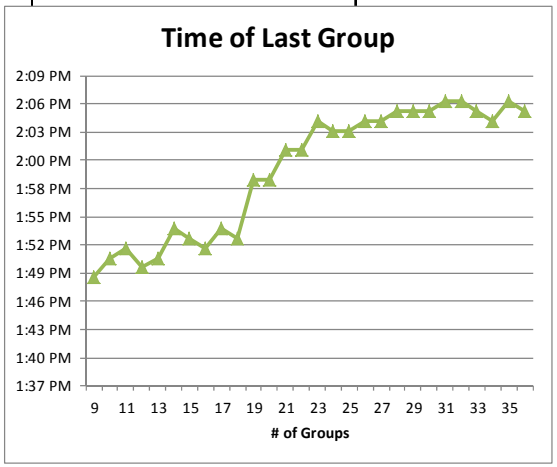
Course Design Model Shotgun Output

Golf Pace of Play Simulator ©																			
Hole	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Par
Par	4	4	3	3	4	5	5	4	3	4	3	5	4	5	3	4	4	4	71
Yards	380	320	190	200	440	550	570	350	120	460	170	580	450	530	200	380	400	350	6640
	Averge Non-Waiting Playing Time Per Group (minutes)																		Total
Time	14.5	13.1	10.5	10.9	15.7	18.2	18.8	13.8	9.2	16.4	10.2	19.2	16.1	18.0	10.9	14.5	14.9	13.8	259
	Averge Time to Next Hole (minutes)																		Total
Time	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	12

Round Length Without Waiting 4:31

# Groups	Averge Waiting Time Per Group (minutes)																		Total
9	0.2	0.1	0.2	0.1	0.0	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.0	0.1	0.1	3
10	0.2	0.1	0.2	0.1	0.0	0.2	0.2	0.0	0.2	0.2	0.2	0.1	0.2	0.3	0.3	0.1	0.1	0.2	3
11	0.3	0.2	0.3	0.2	0.1	0.4	0.6	0.1	0.3	0.2	0.2	0.1	0.3	0.4	0.5	0.1	0.2	0.2	5
12	0.4	0.2	0.4	0.4	0.1	0.4	0.5	0.1	0.3	0.3	0.4	0.2	0.4	0.4	0.6	0.1	0.2	0.4	6
13	0.3	0.2	0.3	0.3	0.1	0.6	0.6	0.2	0.4	0.3	0.4	0.2	0.4	0.4	0.7	0.1	0.2	0.3	6
14	0.5	0.3	0.7	0.4	0.1	0.5	0.7	0.2	0.5	0.5	0.7	0.2	0.6	0.4	0.9	0.1	0.3	0.3	8
15	0.5	0.3	0.6	0.3	0.1	0.5	0.7	0.2	0.4	0.3	0.6	0.2	0.6	0.7	0.8	0.1	0.3	0.4	8
16	0.5	0.3	0.7	0.7	0.1	0.5	0.7	0.1	0.4	0.3	0.6	0.3	0.5	0.7	0.9	0.1	0.2	0.3	8
17	0.5	0.3	0.9	0.5	0.1	0.8	0.7	0.2	0.5	0.4	0.6	0.2	0.6	0.6	0.9	0.1	0.3	0.4	9
18	0.5	0.4	0.9	0.4	0.2	0.6	0.8	0.1	0.5	0.5	0.7	0.2	0.6	0.6	1.0	0.2	0.3	0.3	9
19	0.5	0.4	1.3	0.6	0.1	0.7	0.7	0.2	0.6	0.4	0.7	0.2	0.6	0.6	0.9	0.1	0.3	0.3	9
20	0.5	0.8	0.9	0.6	0.2	0.8	0.8	0.2	0.5	0.8	0.9	0.2	0.7	0.7	1.1	0.2	0.3	0.4	11
21	0.6	0.8	1.0	0.9	0.2	0.7	0.9	0.2	0.5	0.8	0.7	0.2	0.7	0.7	1.0	0.2	0.3	0.4	11
22	0.6	0.7	1.0	1.0	0.2	0.7	0.7	0.1	0.5	0.8	0.8	0.2	1.1	0.7	1.0	0.1	0.3	0.3	11
23	0.6	0.7	1.0	1.0	0.1	0.7	1.2	0.2	0.5	0.9	0.8	0.3	1.1	0.8	1.1	0.2	0.3	0.3	12
24	0.6	0.7	1.0	0.9	0.2	0.8	1.3	0.2	0.6	0.9	0.9	0.3	1.1	0.8	1.0	0.5	0.4	0.4	13
25	0.6	0.7	1.0	0.8	0.2	0.8	1.2	0.2	0.9	0.9	0.9	0.3	1.1	0.8	0.9	0.5	0.3	0.4	13
26	0.8	0.9	1.4	1.1	0.2	1.1	1.6	0.3	1.0	1.0	1.1	0.3	1.3	1.2	1.3	0.5	0.4	0.8	16
27	0.9	0.7	1.1	1.0	0.2	0.8	1.0	0.1	0.8	0.8	0.9	0.2	1.0	0.7	1.0	0.5	0.4	0.7	13
28	0.9	0.7	1.1	1.0	0.2	0.8	1.1	0.2	0.8	0.7	1.1	0.3	0.9	0.7	0.9	0.5	0.3	0.6	13
29	1.0	0.8	1.5	1.0	0.2	0.8	1.3	0.2	1.0	0.8	1.1	0.3	1.1	0.7	1.1	0.5	0.5	0.7	15
30	0.9	0.6	1.5	0.9	0.2	0.8	1.1	0.1	0.8	0.7	1.1	0.5	0.9	0.7	1.1	0.4	0.3	0.6	13
31	0.8	0.6	1.4	1.0	0.5	0.8	1.0	0.1	0.8	0.8	1.1	0.5	0.9	0.8	1.2	0.4	0.4	0.6	14
32	1.0	0.7	1.4	1.0	0.4	0.8	1.2	0.2	0.9	0.7	1.2	0.5	0.9	1.1	1.1	0.4	0.4	0.7	14
33	0.9	0.6	1.4	1.0	0.4	0.9	1.0	0.2	0.8	0.7	1.2	0.5	1.0	1.0	1.1	0.4	0.3	0.6	14
34	0.8	0.6	1.5	0.9	0.4	0.9	0.9	0.2	0.8	0.7	1.0	0.4	0.9	0.9	1.5	0.3	0.3	0.6	14
35	0.9	0.7	1.6	1.0	0.4	0.9	1.2	0.4	1.0	0.7	1.4	0.5	0.9	1.1	1.5	0.3	0.3	0.6	15
36	0.9	0.6	1.4	1.0	0.5	1.1	1.1	0.4	0.9	0.7	1.2	0.5	0.9	0.9	1.4	0.4	0.5	0.6	15
Average	0.6	0.5	1.0	0.7	0.2	0.7	0.9	0.2	0.6	0.6	0.8	0.3	0.8	0.7	1.0	0.3	0.3	0.4	
Hole	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Par
Par	4	4	3	3	4	5	5	4	3	4	3	5	4	5	3	4	4	4	71
Yards	380	320	190	200	440	550	570	350	120	460	170	580	450	530	200	380	400	350	6640





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Model Status

- Verified, but not validated
- Professional golfers: ShotLink
- Recreational golfers: ???