TRACKMAN™ NEWS

ISSUE #10 JANUARY 2014

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TRACKMAN COMBINE

TOUR PRO STEVEN TILEY RECOUNTS WORLD RECORD

AN ESSAY BY TOUR PROFESSIONAL STEVEN TILEY...

It was a goal of mine, when I purchased TrackMan, to be at the top of the TrackMan Combine leaderboard by the end of the year. I am so happy to have reached that goal by October. It's been an interesting few months since I purchased my TrackMan. I would like to take a minute to describe them because it plays a part in achieving my high score the other day.

A NEW TRACKMAN COMBINE RECORD

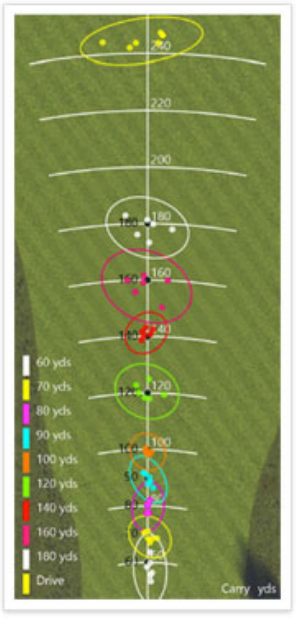
As soon as I received my TrackMan in July, my thought was it would only be beneficial practicing with the balls I use in competition, Pro V1x. I texted my friend who owns a driving range in the area called Stonelees Centre of Excellence. I asked if it was possible to use my Pro V1x's on the range. Luckily, the owner agreed.

During the first couple of months, I was constantly completing combines. I was getting a bit down achieving the same total score of around 89 points. I desperately wanted to break the 90 point barrier. I was slowly becoming more and more frustrated.

While taking these tests, I did however notice that the space between 85 and 100 yards was difficult! This is a huge gap to fill. I thought about how I could do it. I ordered a 56 degree Vokey wedge from Titliest shortly after. Not only did it fill the gap perfectly, 90 yards became one of my go to yardages. This also happens to be one of the combine yardages.

I worked with this new wedge for a few months and then decided to drop my 3 iron and add the wedge to make it 14! After that I decided not to do a combine for a while. Instead, I would concentrate on my own go to yardages which are 78, 93, 102, and 115 to name a few. Three of these are near combine yardages!

I used the Test Center application to setup specific tests to help me work on the distances that I wanted to focus on. After working on those distances for a couple months while away at tournaments and at the Stoneless range, I felt my wedge game was fast improving.



I noticed my wedge game was improving on the course, too. I found myself in contention after two rounds in both the Ukraine and Kazakhstan Challenge Tour events, but I was finding it difficult to put together four consecutive rounds.

We had a three week break from the schedule after Kazakhstan and my intention was to do a couple of combines during that time.

After a couple of weeks playing and working out in the gym, I thought to take the combine before leaving for China. It would be a great way to test my skills before leaving.

Also, a tweet I read a day or two earlier from Thomas Norret about his recent score prompted me to give it a go.

So...the afternoon of the combine...at first I wasn't sure I was going to even practice outdoors because the weather had just turned for the worse at home. However, after a few shots I soon noticed even though it was quite cold and raining quite heavily at times, there wasn't really a breath of wind. I was reaching my numbers much easier and on a much more consistent basis. I was "dialed in" right from the start. Even my 60 yard shots were good, despite this not being the best yardage for me! The only difficulty was the longer yardages were playing about a club longer.

> ***I hit possibly three of the best drives under pressure I have ever hit!***
>
> ***– Steven Tiley, TrackMan owner***

The Driver was the biggest difference because it was only 50 degrees Fahrenheit and raining. The ball was only carrying 250 yards and not the usual 265! So I knew a premium had to be placed on accuracy with the driver!

I had a different mindset this time because I was hitting my go to yardages the same as the TrackMan yardages. I decided to really, really focus on the target on every shot!

In past combines, I would not only have to get the line right but also add some "feel" to my go to yardages to get the distance correct. As we all know, "feel" can vary! So I think this was one of the biggest things I had going for me.

I started well, moving through the yardages quickly. The moment I realized how well I was doing was when I had hit my first 30 balls. I knew from the Open Championship, when I did my first combine, I could see my score to that point and know how well I was doing half way through. At that moment, I was on pace for a 95! It was then I started to think about what was possible.

My next two shots were bad 60 yard efforts! Because it's a majority feel shot adrenaline and nerves kicked in, but then I settled in on the 3rd shot. And did a good one!

Again, 70 was a bit hit and miss the second time round because, like the 60 yard shot, it is mainly "feel"! But then I got into my go to shots: 80, 90, 100, and 120. Things were back on track!

The last drivers were the most nervous I've been on a TrackMan Combine because at 250 carry I knew they had to be very, very straight.

Target	Score		Avg.	Shot 1	Shot 2	Shot 3	Shot 4	Shot 5	Shot 6
60	80.1	From Pin in ft	10.8	2.7	4.8	14.0	20.4	11.3	11.8
70	92.8	From Pin in ft	6.3	6.7	4.2	4.0	3.2	10.6	9.3
80	95.8	From Pin in ft	4.8	8.0	6.8	4.1	7.8	0.9	1.2
90	95.0	From Pin in ft	6.3	1.8	5.2	6.4	7.0	12.2	4.8
100	98.4	From Pin in ft	3.7	6.6	2.5	4.7	4.9	1.7	2.0
120	91.6	From Pin in ft	11.5	14.5	5.9	14.8	17.4	6.5	9.7
140	97.3	From Pin in ft	7.1	7.7	9.9	4.0	7.5	9.8	3.6
160	89.3	From Pin in ft	17.6	21.5	5.3	32.9	18.2	21.3	6.1
180	92.0	From Pin in ft	16.3	6.0	24.8	20.3	26.8	16.0	3.9
Drive	88.0	Total in yds	270	272	268	273	271	266	268
		Side in ft	7.9L	14.6R	17.4L	18.1R	17.2R	24.0L	55.7L

Once the last drive was recorded I pressed to see my score of 92.1. I didn't know at the time it was the winning score but because it was the best I had done and there was no one else on the range I was jumping and fist pumping with joy.

I then called a number of people on my phone, trying to explain what a TrackMan Combine was, and how I was on top of the world!

I think that is about it! I was totally dialed in for 40 minutes. The cold temp and rain with no wind helped loads. My 56 Vokey wedge was key and my Pro V1x golf balls helped as well!

I think I can and will try to improve this score!

Perhaps the next time it's raining! Ha ha!

Now it's up to me to stay on top! And hopefully see the results on course.

View Tiley's full TrackMan Combine report

Driver Statistics (avg.)	
Club Speed	102 mph
Ball Speed	151 mph
Attack Angle	2 deg
Launch Angle	13 deg
Spin Rate	2151 rpm

See www.MyTrackMan.com for more statistics

TRACKMAN UNIVERSITY

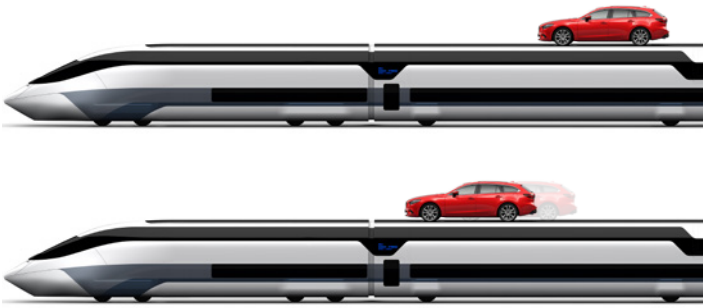
NORMALIZATION FEATURE EXPLAINED

Normalization is a feature available throughout the TrackMan platforms. This feature can be found in the TrackMan Performance Studio (TPS) software as well as the iPhone and iPad app. The purpose of Normalization is to provide the user and golfer standardized information about the golf shot's carry, side, and total. TrackMan measures every shot's actual trajectory from launch until landing; whereas, Normalization provides information on the trajectory assuming calm conditions at any altitude and temperature input by the user. Normalization assumes the golfer is using a "premium" golf ball. If "non-premium" golf balls are used, TrackMan's Ball Conversion feature will convert the launch data to a premium ball before applying Normalization.

Normalization tells you what would have happened if there was no wind at a certain altitude and temperature. This feature is extremely valuable for gapping, fitting, and finding a golfer's "normalized" distances. Let's look at some behind the scenes information on how Normalization works.

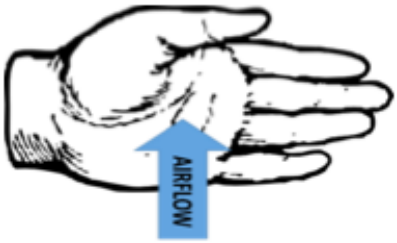
INTRODUCTION TO LIFT AND DRAG

Imagine you are sitting in a car on top of a train and it is a perfect day outside. There is not a breath of wind. The car and the train are not moving. You hold your hand out the window and you feel nothing. Then the train speeds up to 150 mph. As the train is increasing in speed you feel increasing pressure pushing your hand backwards. Now the train is moving at a steady speed of 150 mph and you feel a constant push on your hand. The force you are feeling is drag.



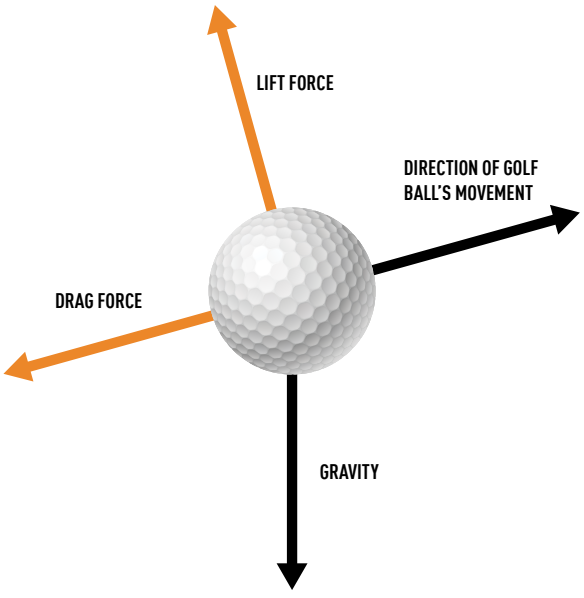
Now, the driver of the car starts to pick up speed as it drives on top of the train towards the front. As the car picks up speed you again begin to feel increasing pressure on your hand. The car levels out at 50 mph as it races to the front of the train. (It's a long train so you have nothing to be worried about.) Once the car reaches a constant speed you feel a constant pressure again. The pressure you feel now is more than when the car was sitting still but the train was moving. This is because the pressure created by the car moving is added to the pressure created by the train moving.

Lastly, as you are moving you slowly rotate your hand between pointing forwards and pointing down. As you rotate your hand, you will feel the air pushing your hand either straight back or up and back depending on the angle of your hand. When the angle of your hand creates the sensation of it moving up, you are creating lift. The faster that you are moving the more lift and drag your hand will feel.



This exercise should give you a basic understanding of lift and drag. Along with gravity, these are the three forces acting upon the golf ball as it flies through the air.

- The drag force will always act in the opposite direction of the golf ball's movement. In the above example your hand is moving forward because the train is moving forward. Therefore, the drag force is pushing your hand back in the opposite direction the train is moving.
- The lift force will act orthogonal (right angle) to the direction of the golf ball's movement. In the example above your hand is moving forward so the lift force is actually pointing straight up from the ground. In the case of a golf ball, the lift force is always orthogonal to the spin axis.



However, when you angle your palm you feel your hand move up and back in one motion. This is because your hand is feeling a combination of the drag and lift at the same time. Lift is the component of the force pushing up and drag is the component of the force pushing back.

HOW DO LIFT AND DRAG CREATE NORMALIZATION?

Every golf ball has its own aerodynamic model. Depending on dimple pattern, size, shape, etc., each golf ball will react a little differently (have different lift and drag) depending on how fast the air is moving around it and how fast it is spinning. Because TrackMan can accurately measure the entire ball flight and can also accurately measure how the spin rate changes throughout the ball flight, the data collected over thousands of shots can be used to generate an aerodynamic model of a particular golf ball.

TrackMan creates this aerodynamic model for the golf ball under calm conditions. A robot or air cannon is used to slowly change the ball speed and spin rate. Then data is collected for all possible combinations. This way TrackMan knows how a golf ball will fly under calm conditions for any golfer and/or shot type.

Once TrackMan creates this model under calm conditions it is then possible to calculate what will happen under calm conditions or any other type of condition. This means that TrackMan does not need to know the wind conditions when a golfer hits a shot. TrackMan will always measure the actual trajectory real-time. Then TrackMan can use the baseline aerodynamic model as well as the launch data (ball speed, launch angle, and spin rate) to determine how the ball would have flown under calm conditions; the same conditions that TrackMan tested the ball under. The user can change the altitude and temperature within the TPS software to the desired values. Normalization will always calculate the ball flight based on the launch data, initial trajectory, calm conditions, and the altitude and temperature listed in TPS. Default values are 77°F and sea level (0 feet altitude).

WHAT OTHER LESSONS CAN BE LEARNED?

First, let's review the following key points:

1. The faster the airflow around the golf ball the larger the drag force
2. The higher the spin rate of the golf ball the larger the lift force
3. The faster the airflow around the golf ball the larger the lift force

It is important to think in terms of airflow and not ball speed. Remember when you felt more pressure on your hand as the car sped up on top of the train that was already moving? You can associate the train as ball speed and the car as wind. Both the movement of the train and the movement of the car created a drag force on your hand. The train and car example is the same as hitting into a headwind. Using points one and three from above, we now know that this situation will create more drag and more lift. That is why you hit it shorter into a headwind and it is also why you see the ball "balloon" more into a headwind. The additional airflow generated by the wind creates additional lift. The ball DOES NOT spin more when hit into a headwind.

As mentioned in point two, a higher spin rate does generate more lift. This is likely the reason many golfers believe that their golf ball spins more in a headwind than calm conditions. Assume that the wind is zero for two (almost) identical shots. The only difference is that one shot has 2500 rpm and the other has 5000 rpm. The shot with 5000 rpm will create more lift which will make the ball rise more, apex higher, land steeper, and in most cases carry shorter. Next, let's hit the above shot with 2500 rpm into a headwind. The headwind will also create lift which will make the ball perform similar to the shot with 5000 rpm under calm conditions. Even though the two shots may look similar, the headwind did not change the spin rate of 2500 rpm.

REAL WORLD SCENARIOS

The following tables look at how wind affects carry, max height, and land angle for a stock 6 iron on the PGA and LPGA Tour. HW represents a headwind and TW represents a tailwind. We will look at the PGA TOUR data first.

PGA TOUR 6 iron (-3.1 deg Attack Angle)

	Calm	10 mph HW	20 mph HW	10 mph TW	20 mph TW
Ball Speed (mph)	130	130	130	130	130
Launch Angle (deg)	14.7	14.7	14.7	14.7	14.7
Spin Rate (rpm)	6088	6088	6088	6088	6088
Carry (yds)	184	166	143	198	207
Max Height (yds)	33.8	38.1	42.8	29.7	26.1
Land Angle (deg)	48.0	58.1	69.5	39.5	32.7

**Table assumes a constant wind throughout the entire ball flight*

Recall that the launch data does not change due to wind. The golfer might change their swing because of the wind. A different swing changes the launch data, but if the golfer swings the same the launch data will be the same whether or not there is wind.

Notice how max height increases with shots into the wind and decreases downwind. Also, look at how the landing angle is affected. Not only is carry severely affected, but landing angle (bounce and roll) is also significantly affected. Shots hit into the wind will stop more quickly (or even backup); whereas, shots hit downwind will release (forward) more because of the change (flattening) in landing angle.

If can also be seen from the above table that headwinds affect distance more severely than tailwinds. The following table focuses on how these two wind directions affect carry.

	Calm	10 mph HW	20 mph HW	10 mph TW	20 mph TW
Carry (yds)	184	166	143	198	207
Landing Angle (deg)	48.0	58.1	69.5	39.5	32.7
Yards Lost/Gained	--	-18	-41	+14	+23

Table assumes a constant wind throughout the entire ball flight

At a 20 mph constant wind, a headwind hurts almost twice as much as a tailwind helps. This is something to keep in mind when you are playing next time! The following charts show the same data for an LPGA Tour 6 iron.

LPGA Tour 6 iron (-1.5 deg Attack Angle)

	Calm	10 mph HW	20 mph HW	10 mph TW	20 mph TW
Ball Speed (mph)	110	110	110	110	110
Launch Angle (deg)	18.6	18.6	18.6	18.6	18.6
Spin Rate (rpm)	5950	5950	5950	5950	5950
Carry (yds)	152	139	121	161	167
Max Height (yds)	27.7	31.3	35.3	24.5	21.7
Land Angle (deg)	45.6	55.6	67.4	37.7	31.7

Table assumes a constant wind throughout the entire ball flight

	Calm	10 mph HW	20 mph HW	10 mph TW	20 mph TW
Carry (yds)	152	139	121	161	167
Landing Angle (deg)	45.6	55.6	67.4	37.7	31.7
Yards Lost/Gained	--	-13	-31	+9	+15

Table assumes a constant wind throughout the entire ball flight

From these two tables, it is easy to see why Normalization is such an important feature for TrackMan users. Wind affects a golf shot much more than most golfers think. The above tables can be considered extremes since it is assuming that the wind is a constant speed throughout the entire ball flight. Also, most golfers will intuitively react to the wind and change their trajectory whether they realize it or not. This assumption is where Normalization has even more power. Normalization does not care what the wind is, whether it is gusting or swirling, whether the wind is faster above the tree line, or any other variations. Normalization will give the golfer a standardized value for how far they hit the golf ball with every club in their bag. Playing in the wind is difficult for even the best golfers in the world. So if a golfer doesn't know their yardages under calm conditions then calculating for wind is a complete guessing game.

TRACKMAN INNOVATION

FIRST LOOK AT THE NEW TRACKMAN OPTIMIZER

Since TrackMan began measuring attack angle and demonstrating its importance relative to driver distance, the lines between fitting and teaching have become increasingly blurred. In early 2007, TrackMan added club delivery measurements as an output parameter in the (TrackMan) software. Around the same time, TrackMan introduced its first "driver fitting" application. This release was the first known software to incorporate attack angle into the algorithms used to determine optimal carry and total distance. Today, it is becoming common knowledge that having a positive attack angle (hitting up on the ball) with the driver creates the potential to hit the ball further with the same club speed.

The NEW TrackMan Optimizer takes this understanding to the next level. Now a golfer can optimize their trajectory for EVERY club in the bag. Not only will the golfer be able to choose their desired ball flight (high, mid, low), but they will also be given the attack angle and spin loft necessary to generate that ball flight. From there, coaches will be able to fine-tune a golfer's swing and equipment to produce the correct launch and landing (angle) conditions. The TrackMan Optimizer equips the coach with the information necessary to help the student/customer more effectively and efficiently.

HOW IT WORKS

Over the years, TrackMan has collected hundreds of thousands of shots from the best male and female golfers around the world. Armed with this information, TrackMan is capable of revealing how elite ball strikers perform. This performance not only goes for the driver, but for every club and shot type.

First, when collecting data it is important to tag each shot with the correct club and ball type. The optimizer uses known information about the club and ball selected to provide the most accurate feedback. For example, when a 6-iron is chosen the optimizer knows information such as club head weight, static loft, and collision properties for the standard 6-irons available on the market. The same goes for the golf ball. If the user selects a "medium" ball, then the optimizer knows how this ball performs relative to a "premium" golf ball.

The user must also enter the desired altitude and temperature that the optimal trajectory is to be calculated at. When the TrackMan Optimizer is turned on, the software will use TrackMan's Ball Converter and Normalization to determine the optimal values and compare the golfer's shot(s) to those values. The default values listed in the TPS software are 77°F, 0 feet altitude, and premium golf ball. All default values can be changed within the TPS settings. Ball type can be selected within a session by clicking on player, club, or tag and then selecting ball.

Once the TrackMan Optimizer has been turned on, the user will have additional options depending on the club selected.

Driver

- Max Carry
- Max Total
- Max Carry and Total

Fairway woods, hybrids, irons, and full wedges

- High Trajectory
- Mid Trajectory
- Low Trajectory

Partial wedges (Pitch Shots)

- High Trajectory
- Mid Trajectory
- Low Trajectory

Based on the club, ball, and desired trajectory chosen, the TrackMan Optimizer will compare either a single shot or group of shots vs. the optimal values. Immediately, the user and golfer will be able to numerically and graphically see how the actual data compares to the optimized data. At any time, the user can change the desired trajectory type to see how the shot(s) compare to the other optimal values. A "score" is given to each shot(s) for distance and max height based on how well it matches the optimal trajectory.

NOTE: The optimizer only considers the vertical component of the trajectory. Offline and shot shape are NOT taken into account when calculating optimal values or grading how well a shot(s) matches the desired values. The optimizer assumes that no distance is sacrificed on shots with a non-zero spin axis. In actuality, little distance is lost due to shot curvature if the face-to-path is kept reasonably low (less than ±3 degrees).

DRIVER

Assumption: Optimizing the driver is maximizing distance based on a given club speed and attack angle. As with the original TrackMan Driver Fitting application, the user can still decide whether they want to optimize for CARRY or TOTAL distance. A third, "CARRY AND TOTAL" option has been added to the TrackMan Optimizer to allow for the best of both worlds.

	OPTIMIZE FOR		
Data Parameter	CARRY	CARRY AND TOTAL	TOTAL
Carry Distance	Longest	Median	Shortest
Total Distance	Shortest	Median	Longest
Land Angle	Steepest	Median	Flattest

**Total uses "normal" PGA TOUR fairway conditions to calculate optimal values*

Based on the shot or group of shots selected, the optimizer will calculate the optimal values based on the club speed and attack angle. The user will be presented with the necessary spin loft, ball speed, launch angle, and spin rate necessary to achieve the desired ball flight. Only the driver optimization takes the golfer's attack angle and keeps it unchanged as part of the calculations. This procedure is due to the driver being optimized for distance. A more positive attack angle creates a greater potential for distance at the same club speed. Therefore, if the optimizer were allowed to adjust attack angle to maximize distance, then attack angle would be the maximum value obtainable using a 4" tee.

INPUTS = (Club Speed + Attack Angle + "Optimized For")
OUTPUTS = (Spin Loft, Ball Speed, Launch Angle, Spin Rate)

A great element of the optimizer is that each time a different shot is selected, the optimizer will recalculate optimal values based on the club speed and attack angle for that particular shot. This benefit allows the instructor to work with the student until they can produce the desired attack angle. Then the instructor can use the optimizer to 1) show the student what they are capable of and 2) see what the necessary spin loft and launch conditions are to help the student achieve their (maximum distance) potential. This type of insight will allow the coach and student to set objective goals together. Also, the coach knows exactly where the student needs to go in order to achieve their potential.

Let's use a shot from 2013 PGA Champion Jason Dufner to see how the optimizer works for his Driver. In the following example, Dufner had a club speed of 110.5 mph and an attack angle of -1.8. We have chosen to optimize his trajectory for max carry. As you can see from the graph and graphic, Dufner is almost perfectly optimized for this particular shot. In fact, Dufner's normalized carry of 277 yards is 5 yards more than the optimal value of 272 yards. This is due to Dufner impacting the ball slightly above the driver's center of gravity causing for a slightly higher launch angle and lower spin rate than expected.

Figure 1. Driver optimized for Max Carry based on 110.5 mph club speed and -1.8 degree attack angle.

Keep in mind that the club speed and attack angle are used to determine optimal values. If Dufner were to maintain his club speed, but change his attack angle to +2.0 degrees in the above example, his potential max carry would increase by 9 yards. However, it is not as simple as simply changing attack angle to a more positive value. With an attack angle of +2.0 degrees, a spin loft of roughly 2.5 degrees less (than the optimal value listed above) would be needed to hit the "new" ideal numbers. As attack angle goes up, spin loft will need to go down to achieve optimal launch and spin. The important point is that the TrackMan Optimizer application will tell the user what spin loft is needed based on club speed and attack angle. Then the coach can use equipment or swing changes (if needed) to achieve the proposed values.

Everyone should know that more club speed increases potential distance. Increasing club speed by 1 mph will increase carry by approximately 3 yards (3.3 yards at 70 mph and 2.9 yards at 125 mph club head speed). Also, for any given club speed, a more positive attack angle increases potential distance. Nearly equally as important, increasing attack angle by 1 degree will increase distance by approximately 2 yards (1.8 yards at 70 mph and 2.6 yards at 125 mph club head speed).

FAIRWAY WOODS, HYBRIDS, IRONS, FULL WEDGES

Non-driver shots are optimized based on carry and max height. Max height is highly correlated to land angle, so it can be assumed that a shot with a greater max height will have a steeper land angle. Because carry AND max height are the criteria used for optimizing non-driver shots, we are able to determine the launch and impact conditions necessary to generate the ideal trajectory.

	OPTIMIZE FOR		
Data Parameter	HIGH TRAJECTORY	MID TRAJECTORY	LOW TRAJECTORY
Carry Distance	Shortest	Median	Longest
Max Height	Highest	Median	Lowest
Land Angle	Steepest	Median	Flattest

**Non-driver shots are optimized based based on Carry and Max Height*

Club Speed, club type, and preferred trajectory (high, mid, low) are the only elements required to determine the optimal attack angle, spin loft, ball speed, launch angle, and spin rate.

INPUTS = (Club Speed + Club Type + "Optimize For")
OUTPUTS = (Attack Angle, Spin Loft, Ball Speed, Launch Angle, Spin Rate)

For any full swing shot other than driver the purpose is to achieve a selected trajectory height (low, mid, high) and execute it in an efficient way. An efficient trajectory height is achieved by the correct combination of attack angle and spin loft. For example, choosing a low trajectory will result in a more negative attack angle and a smaller spin loft. This combination will create a shot with more carry (relative to the other trajectory options), but also a flatter landing angle. The goal of the optimizer is to create three trajectory options that represent "playable" ball flights based on what the pros do (male and female) as well as data collected over the last 10 years. Solving for the precise balance of carry and land angle at all club speeds was a demanding task when creating the optimizer.

The following two examples show the same shot from an elite LPGA Tour player. The first example compares her trajectory versus the optimal high trajectory. The second example compares her trajectory versus the optimal low trajectory. It can be seen that her trajectory matches quite well with the low trajectory but not the high trajectory. If low is her desired ball flight, then she is well optimized.

Figure 2. LPGA Tour player 6-iron optimized for high trajectory. Club speed is 76.5 mph.

Figure 3. LPGA Tour player 6-iron optimized for low trajectory. Club speed is 76.5 mph.

The optimizer assumes the ball is resting on a level fairway. This means...not on a tee or on an uphill/downhill lie. When the ball is resting on the fairway, there is no other option than to hit down on the ball (negative attack angle) in order to impact the middle of the club face. Impacting the ball close to the middle of club face is the most efficient way to achieve the potential carry distance and max height.

The following example looks at a 6-iron shot from Ben Crane. Crane is very efficient at hitting a mid-height trajectory. You will notice he is actually obtaining a slightly longer carry than expected, but this is due to the spin loft being slightly on the low side. This lower spin loft agrees with the higher ball speed (more compression) and lower spin rate. The lower spin loft could be due to the fact that Crane's 6-iron is a little stronger than the assumed 31 degrees by the optimizer. An alternative explanation is Crane is simply de-lofting his 6-iron slightly more than the average on the PGA TOUR.

Figure 4. Ben Crane 6-iron optimized for mid trajectory. Club speed is 86.0 mph.

PARTIAL WEDGES – PITCH SHOTS

A more recent hot topic has been understanding the characteristics of good partial wedge shots. Having recorded thousands of strokes from the best players in the world has given TrackMan a unique baseline for determining the DNA of these types of shots.

A good pitch shot has a launch angle of approximately 30 degrees (±5 degrees depending on club loft and preference for trajectory) and an attack angle around -4.5 degrees (±3 degrees depending on preference for trajectory). Another key finding is that the primary influence on carry distance is ball speed. For every 1 mph higher ball speed, the carry of a good pitch shot will increase by approximately 5 feet (1.7 yards).

Wedge	Club Loft [deg]	Ball Speed [mph]	Launch Ang.[deg]	Spin Rate [rpm]	Carry [yds]
PW	47	60.8	25.6	5642	62.7
SW	55	54.3	30.9	6178	53.3
LW	60	51.8	33.4	5916	49.7
50°	50	58.4	27.6	6002	59.3
52°	52	56.7	28.9	6232	56.9
54°	54	54.9	30.5	6236	54.1
56°	56	53.9	31.5	6129	52.8
58°	58	52.9	32.4	6023	51.3
60°	60	51.9	33.4	5919	49.7

Figure 5. Optimal launch data for 50 mph club speed and mid trajectory. Carry determined at 77°F and sea level (0 feet altitude).

When club type is a wedge the optimizer has a special "Pitch" mode in addition to the normal Full Swing mode. Pitch mode also allows the user to select between low, mid, and high trajectory. Pitch mode is viewed as partial wedge shots.

Figure 6. A 78 yard pitch shot using a 56° wedge by Edoardo Molinari. Optimized for mid trajectory.

REVIEW

The NEW TrackMan Optimizer allows the user to optimize every club in the bag (excluding putter). The golfer can decide between Max Carry, Max Total, or Max Carry & Total when optimizing the driver. They can choose a high, mid, or low trajectory with all other full swing clubs (fairway wood through wedges). Finally, the golfer can also optimize their partial wedge shots (Pitch mode) by selecting a high, mid, or low trajectory.

1. Set the preferred temperature and altitude within the TPS settings.
2. Collect data (or load existing shots from the Shot Library).
3. If collecting new data, input the club and ball type being used.
4. Press the TrackMan Optimizer icon found in the bottom right of the TPS software (shortcut key = 'O').
5. Select the shot or group of shots you want to optimize and then select the desired trajectory.

These five steps provide the coach and golfer with the information necessary to achieve their desired trajectory goals. The coach will now know the required spin loft and attack angle necessary to attain the optimal values and desired trajectory. The coach and student will have quantified data and can create an individualized practice/training plan for reaching the goals set. Whether swing, setup, and/or club adjustments are required to achieve the individualized goals, the TrackMan data and TrackMan Optimizer can be used to measure progress.

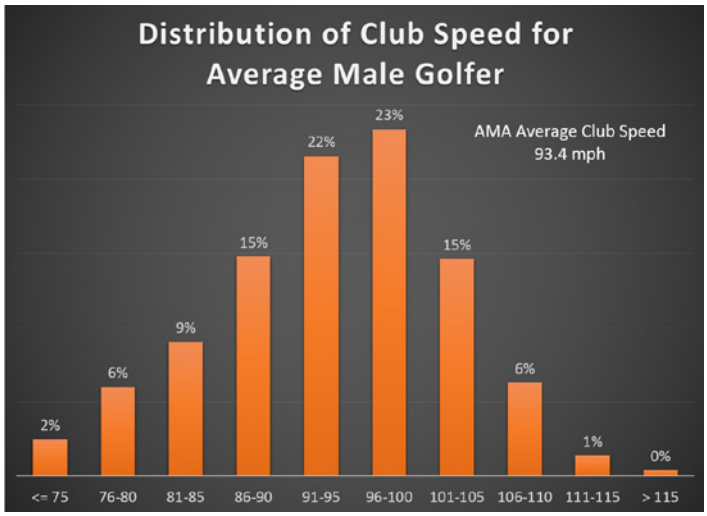
The TrackMan Optimizer is an innovative feature available in TrackMan Performance Studio v3.1 *(estimated release date: March 2014).*

TRACKMAN COMBINE

PERFORMANCE OF THE AVERAGE MALE AMATEUR

The average USGA handicap for male golfers has been between 14.0 and 15.0 since 2005. GHIN reported the average male handicap at 15.3 in 2003 and 14.3 in 2012. Although there is a slow trend towards improvement, many in the golf industry wonder why progress has not been faster. To make such large scale improvements, we must first better understand the "patient" in order to diagnose the problems. As such, this article will focus on the performance of the average male amateur (AMA). The AMA has a reported handicap of 14 or 15. There is no age or nationality restriction for the AMA. The TrackMan Combine data collected from over 10,000 golfers of all levels from around the world will be used to analyze his performance in hopes of better understanding where improvement(s) can be made.

When looking at how the AMA performs, let's start with the drive. The AMA has an average club speed of 93.4 mph and an average total distance of 214 yards. The following graph shows the distribution of AMA Driver club speeds. As you can see, 45% have a club speed between 91 and 100 mph.



The AMA is far from efficient with his driver. He has an average attack angle of -1.6 degrees. The following table looks at the AMA versus what is optimal.

Club Speed = 93.4 mph	AMA (Actual)	AMA (Optimal)
Ball Speed (mph)	132.6	140.1
Launch Angle (deg)	12.6	14.7
Spin Rate (rpm)	3275	2300
Carry (yds)	204 (normalized)	228
Landing Angle (deg)	34.8 (normalized)	34.1
Total (yds)	226 (normalized)	255

**Carry, Landing Angle, and Total were normalized under 0 altitude, 75°F, and 75% humidity for the AMA to create an apples to apples comparison*

The AMA is capable of carrying the ball much further than his current total distance. He is giving up 30 yards of total distance off of the tee, which makes his approach shots more difficult. Let's consider the (average) approach shot distance that the AMA will have on an "average" par 4.

First we have to determine the average length of the par 4's at your course from the different tees available.

The following is Torrey Pines South, where golfers line up each morning for a chance to play one of America's 100 Greatest Public Courses (Golf Digest). The calculated distances for the approach shot are based on actual driver data and optimized driver data for the AMA is also listed.

Tee	Average Par 4 Length	Approach After Actual (226 yards)	Approach After Optimal (255 yards)
Black	450 yards	224 yards	195 yards
Blue	428 yards	202 yards	173 yards
White	410 yards	184 yards	155 yards
Green	391 yards	165 yards	136 yards
Red	328 yards	102 yards	73 yards

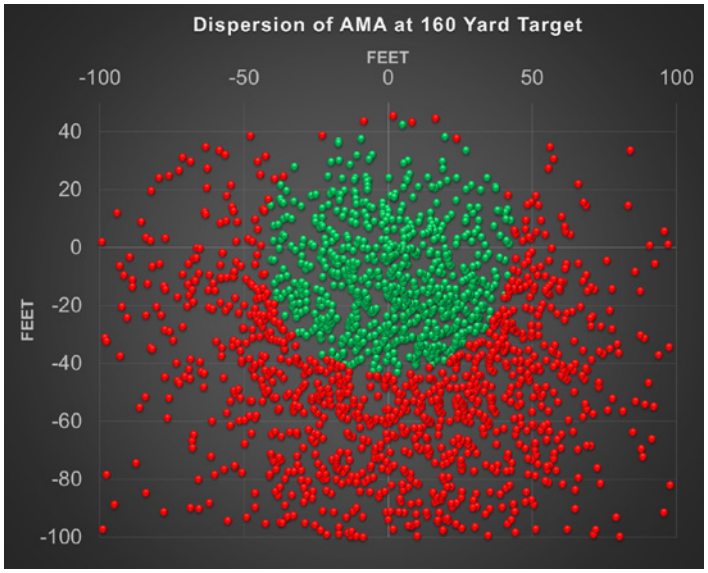
**Normalized data was used to calculate approach shot distances*

Even when playing from the green tees at Torrey Pine South, the AMA is left with 165 yards for his approach shot. Hitting long irons or hybrids into all of the par 4's does not set the AMA up for an enjoyable day on the golf course. Golf critics talk about technology making golf courses obsolete because of distance, but what they fail to clarify is that this only pertains to 0.1% of the golfing population. In truth, the vast majority of golfers are playing from tees that are too long based on their club speed and skill level. If golfers are to continue playing the same length tees, then optimizing their driver distance is going to be key to enhancing their performance.

The previous table looked at the approach distance the AMA will have based on hole length and average drive distance. Let's go one step further and use the TrackMan Combine data to see what kind of proximity to hole the AMA will be able to achieve at the various approach distances. The next table uses the approach distances from the previous and calculates the proximity to hole. Because of the trends and correlations found in the TrackMan Combine data, it is possible to calculate the proximity to hole for nearly any handicap or approach distance with high confidence.

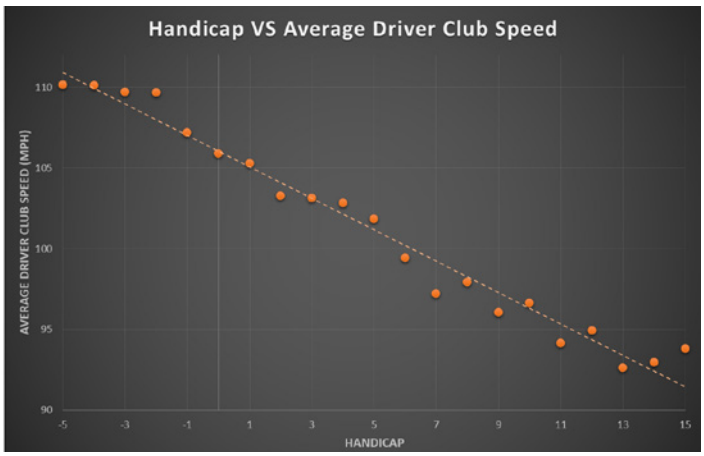
Approach After Actual	Distance to Target	Approach After Optimal	Distance to Target
224 yards	157 feet	195 yards	114 feet
202 yards	124 feet	173 yards	87 feet
184 yards	100 feet	155 yards	69 feet
165 yards	78 feet	136 yards	53 feet
102 yards	33 feet	73 yards	26 feet

The average green size at Torrey Pines South is 6,000 square feet. That means the distance from the center of the green to the edge averages just under 44 feet. This data further confirms the need for most golfers to aim towards the center of the green on all approach shots. Or when hazards are present, it may be even wiser to aim for the opposite edge of the green. Once AMA understands the likely outcomes for various shots, then he can most effectively implement course strategy for the benefit of improving his golf performance. Knowing what club to hit based on distance and the safest place to aim based on dispersion tendencies will undoubtedly benefit the golfer. The following graph shows a plot of the AMA's shots from 160 yards. Notice how few balls landed past the target.



By adding 10 yards to every shot hit by the AMA from 160 yards, the percentage of shots that would hit the green increases from 38.5% to 44.0% and the average distance from the target decreases from 71.8 feet to 60.6 feet. This demonstrates that without changing technique and only changing strategy, the AMA can improve their performance. Before it is assumed that the AMA should simply "club up", actual distances with each club should be determined. Does the AMA truly know how far each of their clubs carries? The strategy implemented to create 10 additional yards of carry could be from lack of knowledge regarding how far each club goes.

Course length, driver optimization, and course strategy are three key components to improving the performance of the AMA. Of course, playing shorter courses seems very obvious if you want to improve performance. However, it is more the fact that golfers are playing courses that are too long relative to club speed and skill level. The following chart shows average handicap versus average club speed. There is a very obvious relationship between these two variables. As club speed increases, those golfers tend to have lower handicaps. It is not to suggest that a golfer should simply play a shorter course to shoot better scores, but that a golfer should play a course length that is appropriate.



Optimizing a golfer's distance with the driver (using their existing club speed) is an alternative way to effectively shortening a golf course. With the AMA averaging 30 yards less than his potential, there is a lot of room for improvement. As he becomes more efficient, the AMA has shorter approach shots which lead to closer proximity to the hole. One suggestion could be to setup course length based on club speed and optimal driver efficiency. For example, based on the average club speed of the AMA (93.4 mph) he should be able to hit his driver 255 yards (assuming certain ground conditions). If a 50% greens in regulation (GIR) stat was desired for the AMA, then the approach shot would need to be approximately 140 yards. That means the par 4's would average 395 yards. Going back to Torrey Pines South, that is somewhere between the Green and White tees. This course setup for the AMA is assuming a perfectly optimal drive by the golfer so in theory 395 yards would be a maximum length for the AMA based on 50% GIR.

Finally, course strategy is an improvement that can be made without having to change anything relating to the swing, technique, or other physical items. By understanding simple averages and probabilities, a golfer can choose the best club and target for each shot. And this is where taking the TrackMan Combine and going through a "Find Your Distance" session is so valuable. Yes, the TrackMan Combine data is extremely valuable for identifying weaknesses that can be improved, but it is just as (arguably more) important for identify strengths that the golfer can "play to" without having to spend any additional time practicing. This instant gratification can be achieved through the 30-45 minute TrackMan Combine process! And for those golfers looking to make more substantial improvements to their game, the TrackMan Combine provides a roadmap for the improvement journey and accurate, immediate feedback at all checkpoints/stops along the way.

As golf instruction and coaching continue to move more towards "verifiable data" (what the instructor/coach knows) and further away from "guess and check" (what the instructor/coach thinks), we expect to see more improvement in the golf community. Acting upon real data, not opinion, takes a giant step in that direction.

TRACKMAN SIMULATOR

COMBINING PERFORMANCE AND ENTERTAINMENT

TrackMan is the established leader in the golf industry for accuracy, reliability, and ease of use. With over 100 of the top 200 Tour Professionals around the world as customers, TrackMan leads the way forward in practice and training. Whether being used for measuring club delivery at impact or benchmarking skills through the TrackMan Combine or Test Center, TrackMan provides a suite of applications that can improve your golf game.

Merge these game improvement benefits with high definition 3D graphics from over 85 of the best courses around the world and you have the TrackMan Simulator. Take your game online to compete in worldwide competitions or challenge your friends real-time from halfway around the globe.

TrackMan measures the full flight of golf shots from 4 feet to 400 yards with an accuracy of 1 foot at 100 yards. The percise measurements developed by TrackMan have been fine-tuned for the indoor environment offering the most authentic game play available on the market.

Learn more about the game improvement and entertainment benefits available at **www.trackmangolf.com**

INDOORS OR OUTDOORS

TrackMan is a completely portable solution that can be used indoors AND outdoors. Setup and calibration of the system takes less than 2 minutes, allowing the user to take TrackMan from their home or business to their club or favorite practice facility. Connect your TrackMan to your iPhone or iPad for maximum portability. Now you can collect valuable, accurate feedback no matter where you practice or play.

TRUGOLF'S E6 SIMULATOR SOFTWARE

Play courses such as Pebble Beach, St Andrews, Bethpage Black, Royal Melbourne, and more from the comfort of your home.

- 18 courses are ranked in the "Top 100 Courses in America" by Golf Digest
- 23 courses are ranked in the "Top 100 Courses in the World" by Golf Digest
- 32 courses host televised tour events

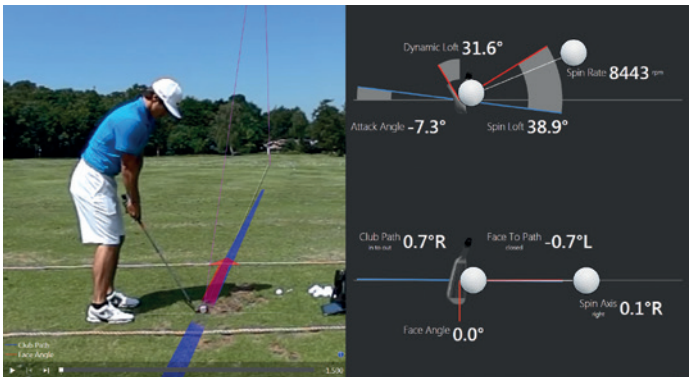
Other built-in features include Closest to the Pin and Long Drive competitions, 36 Modes of Play (Stroke, Play, Scramble, Skins, etc.), up to 8 players on one simulator, wind and weather options, and much more.

Businesses and individuals will love the online tournament feature, allowing golfers to compete for prizes in global events without having to travel. TruGolf's online platform allows the golfer to compete in virtual tournaments or challenge another golfer anywhere in the world in a real-time match. Yes, a golfer can compete against another player halfway around the world at the exact same time in the same foursome. Each shot's result is communicated through the cloud to the competitor's computer and projector!

TRAINING ENVIRONMENT

Every simulator installation includes the TrackMan Performance Studio (TPS) software. The TPS software is the perfect companion allowing owners to toggle between the preeminent simulator and the world's finest player development lab.

By layering in the TPS Video Analysis software and one or more cameras, your setting becomes an elite golf swing training environment. With TPS's 3D graphics overlay, golfers will easily recognize and immediately improve the most important part of the golf swing…impact.

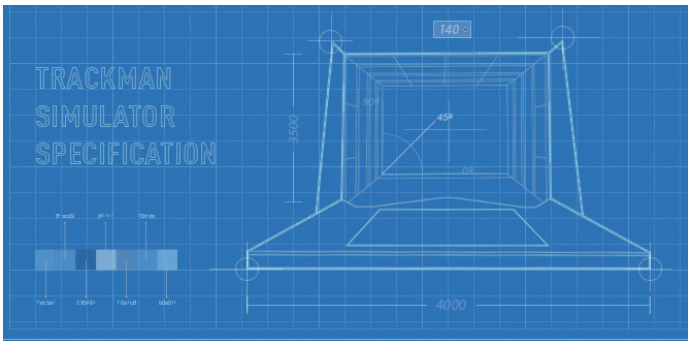


TPS Video Analysis with 3D Graphics Overlay

SIMULATOR DESIGN AND INSTALLATION

Let TrackMan walk you through the process of designing your personalized simulator and golf training/improvement environment. The system can be scaled to fit your needs.
Whether your goal is training, entertainment, or both, our team will design your environment to meet your needs.

Upgrade your design and create a multipurpose space that can operate as a home theatre and/or gaming room for friends and family.



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TRACKMAN SIMULATORS
STARTING AT $39,995

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- TrackMan Pro IIIe Indoor
- TPS Training Software
- E6 Simulator Courses
- Quadcore 3+ GHZ PC
- 16:10 Touchscreen Monitor
- 3000+ Lumen HD Projector
- Full Simulator Enclosure
- HQ Impact/Viewing Screen
- Premium Hitting Turf

Space Requirements:
Minimum room length is 18.5 feet (5.6 meters)
No height or width requirements.