Next Gen Stats: Going Beyond Top Speed

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University of Chicago
Master of Science in Analytics Capstone Showcase
March 2022

What Makes This Play Successful?

- Speed
- Acceleration
- Quick and Sharp Turn

How do we Determine Wide Receiver Skill?


Speed


Acceleration


Quick and Sharp Turn

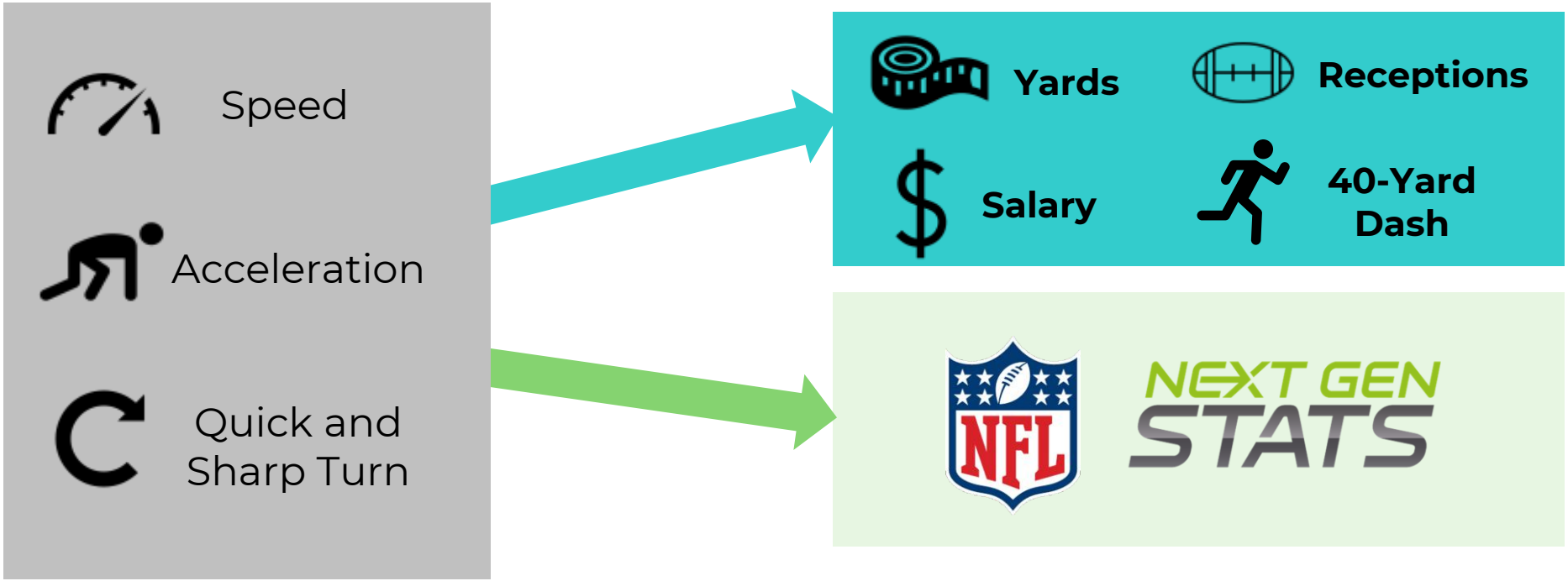

Yards


Receptions


Salary


40-Yard Dash

NFL Next Gen Stats Delivers Data Driven Insights from Player Tracking Technology



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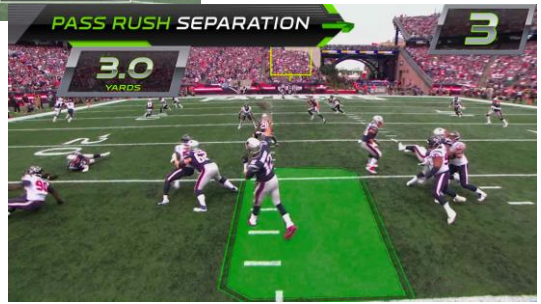
NEXT GEN STATS



Cutting Edge Technology

Advanced Analytics and Statistics

Direct Measurement of on-field Performance

Business Situation and Opportunity Statement

WR Performance Metrics from tracking data don't currently exist

NFL Next Gen Stats is looking for proof of concept in employing tracking data to create aggregated metrics in this fashion

+

Current Measurement of WR performance typically limited to traditional statistics

While useful to measure production, these types of statistics do not directly measure on field movements

→

Creation and validation of aggregate metrics derived from tracking data can revolutionize the way all players are measured and evaluated

Utilizing tracking data to assess composite kinesthetic on-field movements signals a more reliable, direct measurement of on-field player performance

Methodology

Metric Generation Process

1

Data Prep and Filtering

17MM Rows of Tracking Data filtered to only include WRs, and filter to include plays where player was exhibiting peak performance

2

Calculate and Aggregate

Calculate route-specific metrics and aggregate at the player-route type level, and aggregate at player-element level across all routes.
In total, 45 specific route metrics were created.

3

Validate and Analyze

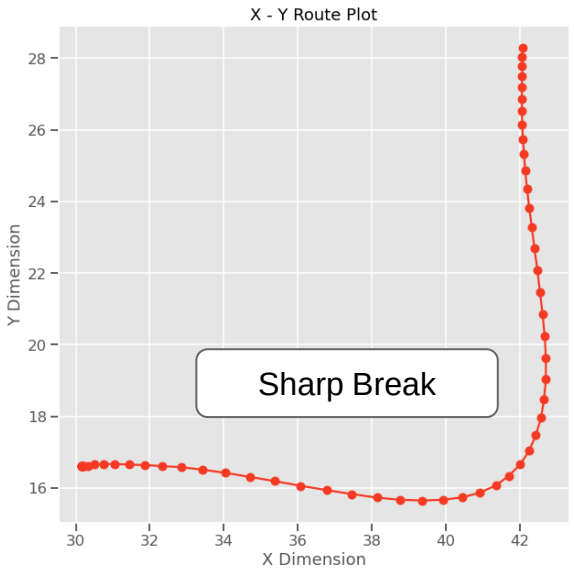
Conduct Validations to determine if tracking data can be used to produce differentiating, stable metrics that reflect on field performance

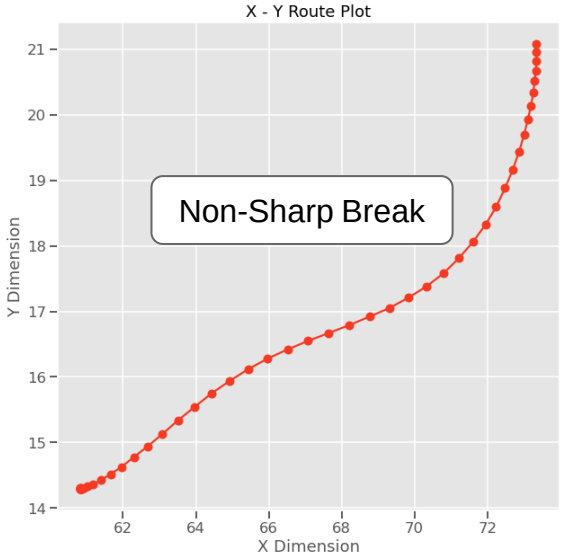
Isolating Peak Performance - Break

When players run a breaking route, often times the break run is not “sharp”

This effectively means a player was not exerting his maximum change-of-direction ability

Rules were developed to only measure plays when a player conducted a sharp break





Even though both routes are “In” routes, one was run as a sharp, fast break and another with a shallow, slow break

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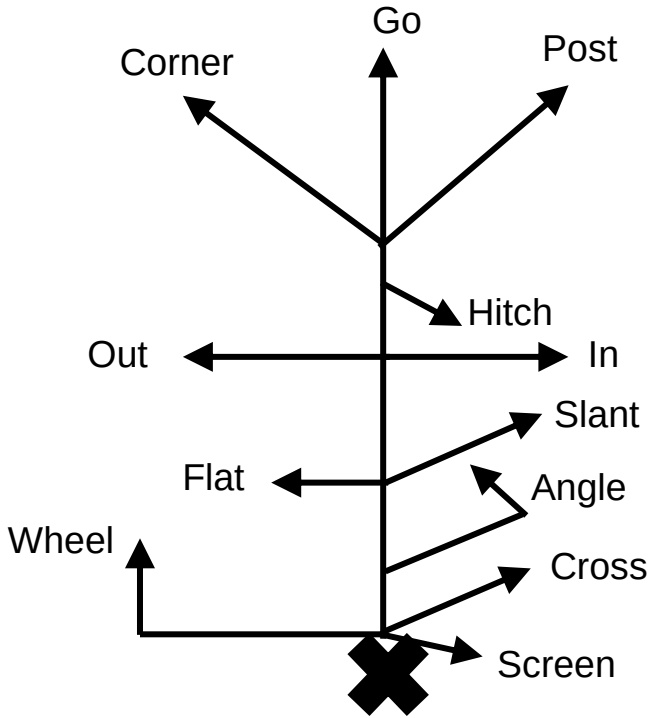
Wide Receiver Routes

A route is a pattern and direction a player runs during the play to deceive the defender and create space to allow for ample room to catch the ball

The tracking data contains information on which route a player was running on a given play

Each route is unique and requires different kinesthetic movements to run successfully



Common Route Types Run by Receivers

The Importance of Route Specific Metrics

Out Route

Initial Burst

Change of Direction

Post Route

Initial Burst

Second Gear Burst

Metric Generation Process

1	2	3
Data Prep and Filtering	**Calculate and Aggregate**	**Validate and Analyze**
17MM Rows of Tracking Data filtered to only include WRs, and filter to include plays where player was exhibiting peak performance	Calculate route-specific metrics and aggregate at the player-route type level, and aggregate at player-element level across all routes. In total, 45 specific route metrics were created.	Conduct Validations to determine if tracking data can be used to produce differentiating, stable metrics that reflect on field performance

Validation Framework

After creating and computing these metrics, it was imperative to validate these to ensure they are providing meaningful insights and correlate to traditional measures of wide receiver success

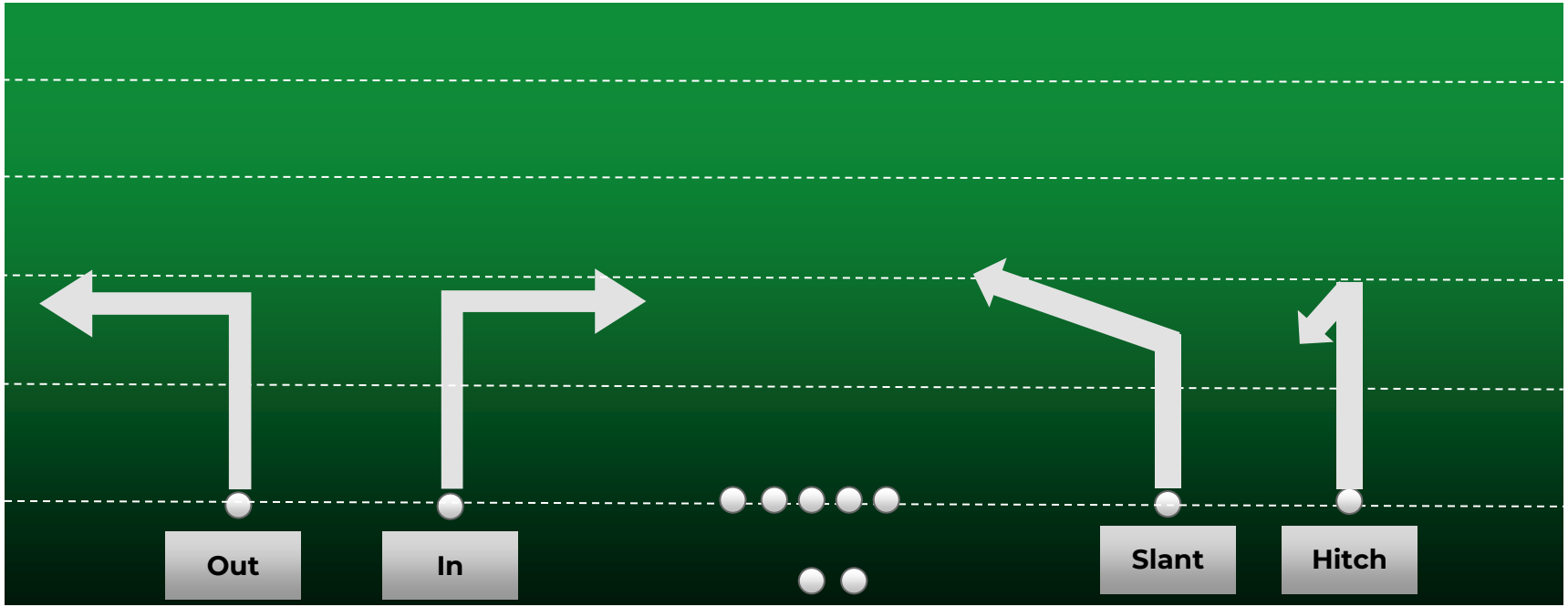
Discrimination	Stability	Independence
Determines if metrics are differentiating between players	Determines if metrics are stable over time	Determines if metrics correlate to traditional performance measurements
ANOVA Testing	**Coefficient of Variation Testing**	**Correlation Testing**

Viability of Tracking Data to Create Stable, Differentiating Metrics

Accurate Reflection of On Field Performance

Findings:
Key Performance Differentiators

Significant Validated Metrics for Breaking Routes



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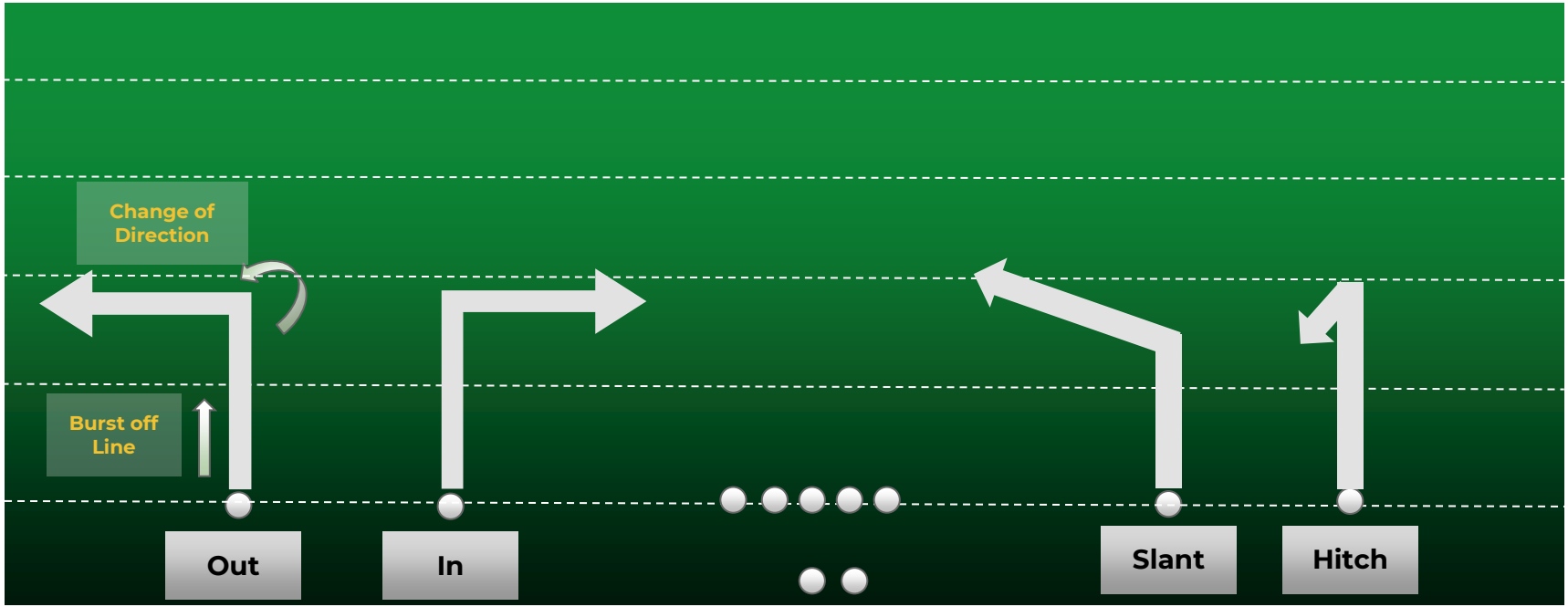

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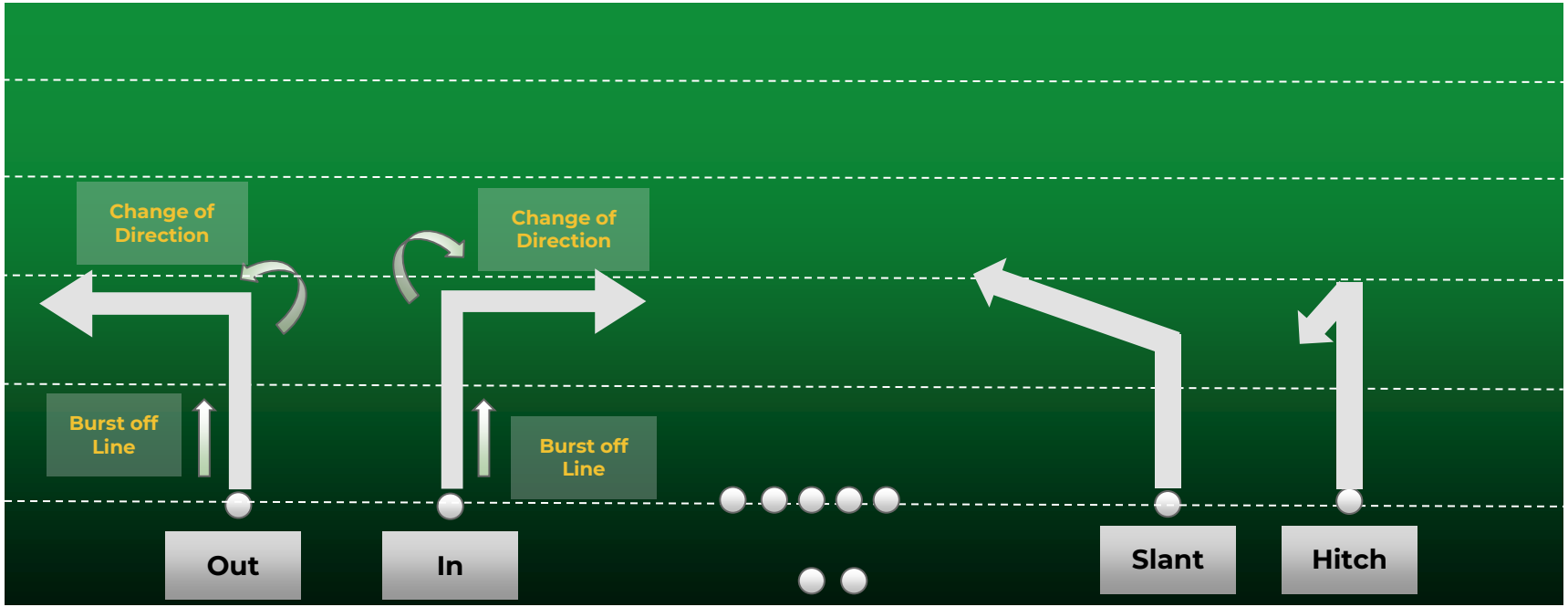

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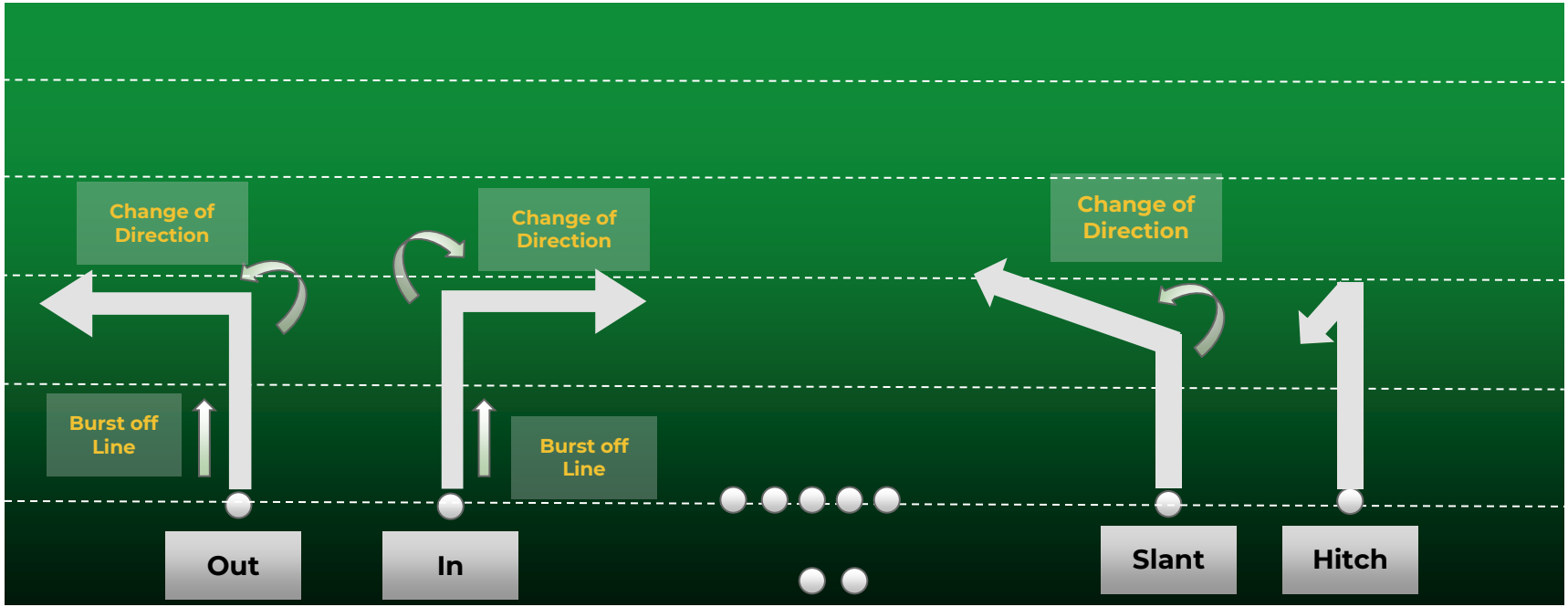

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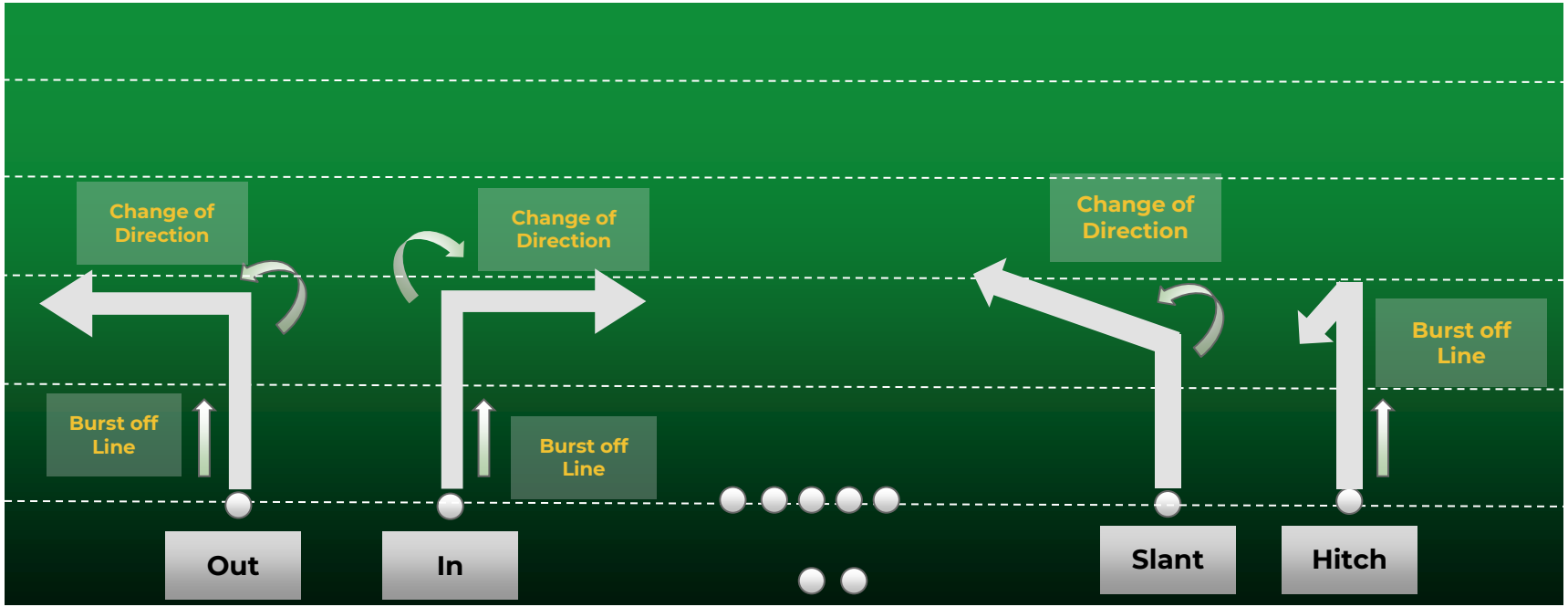

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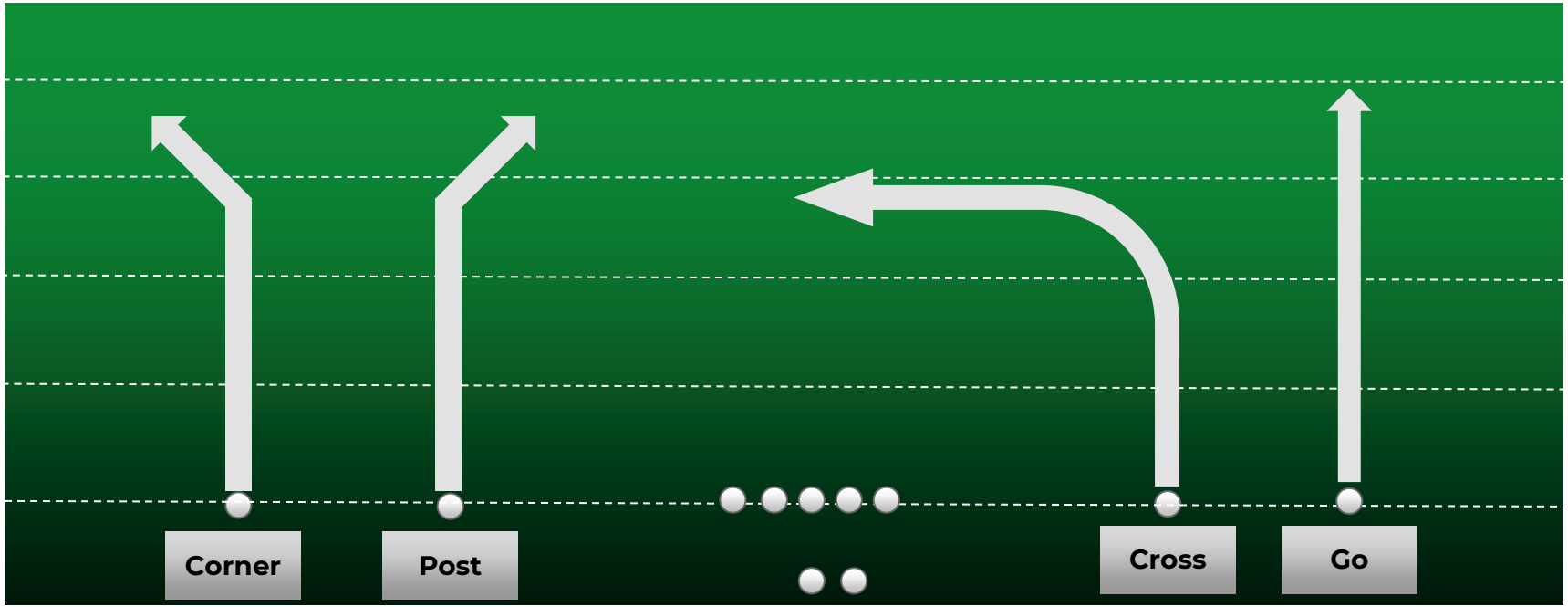

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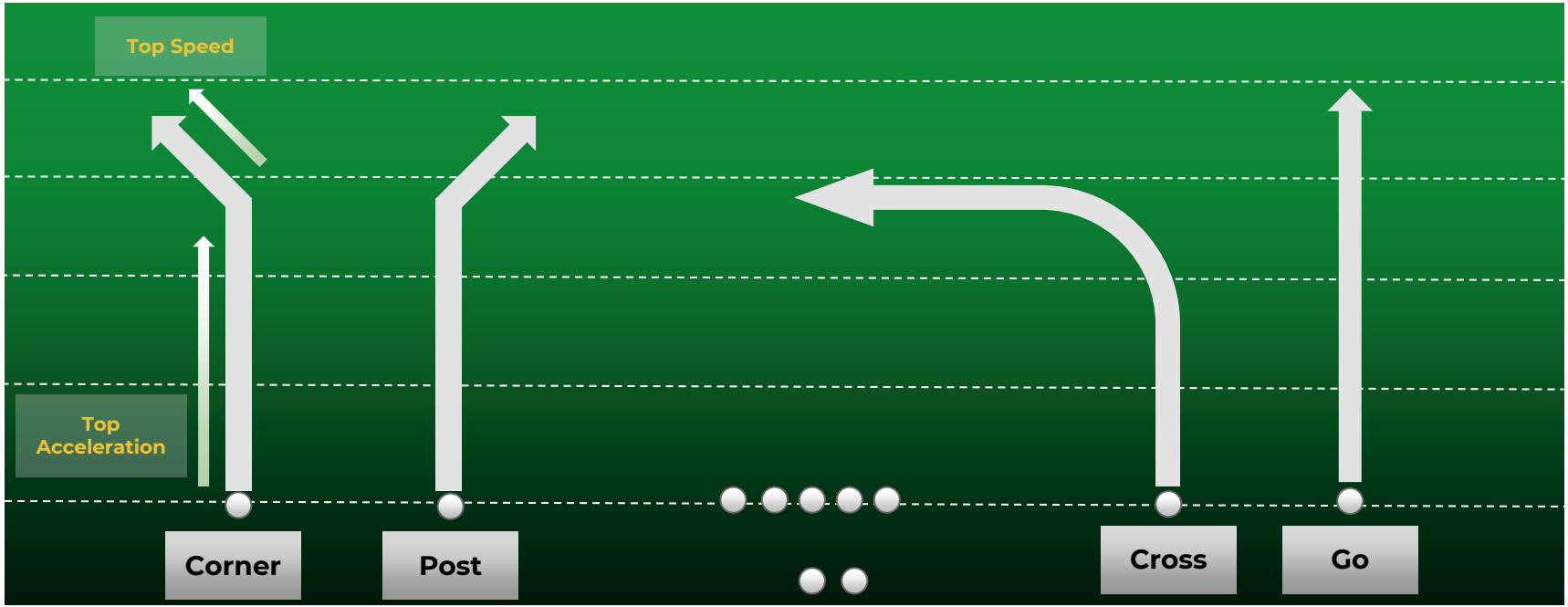

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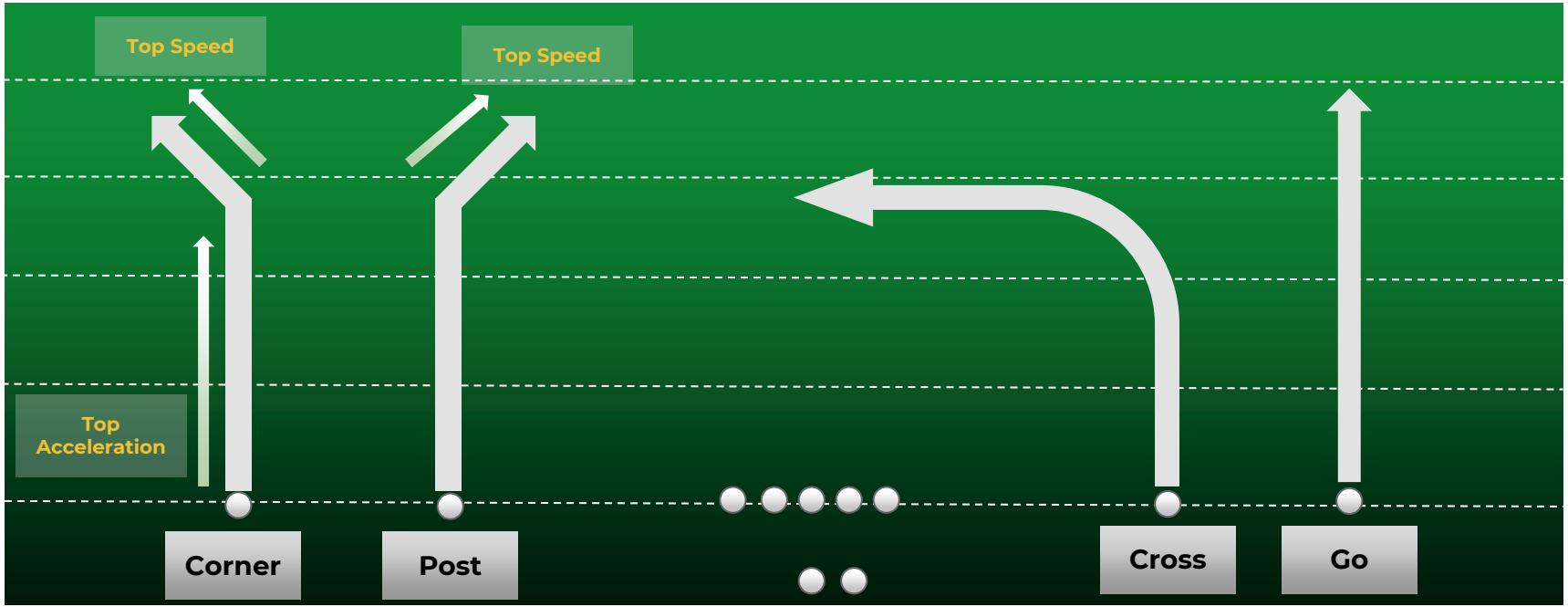

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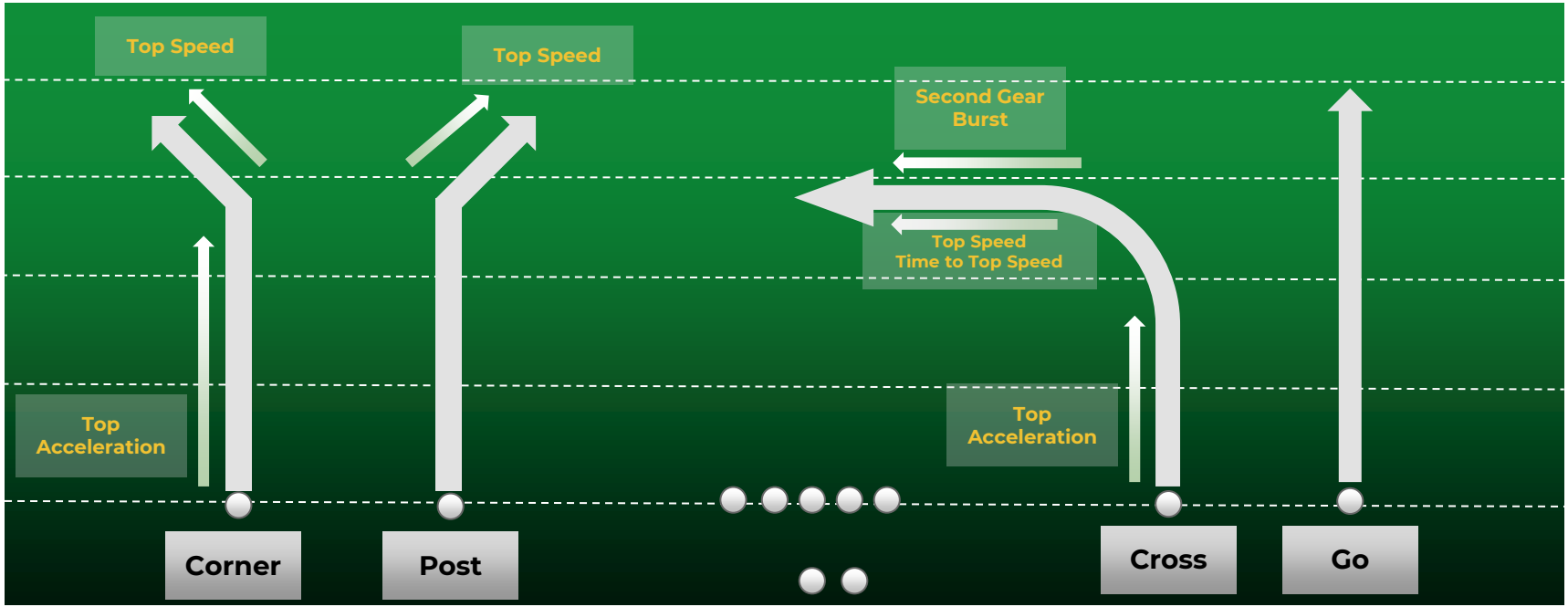

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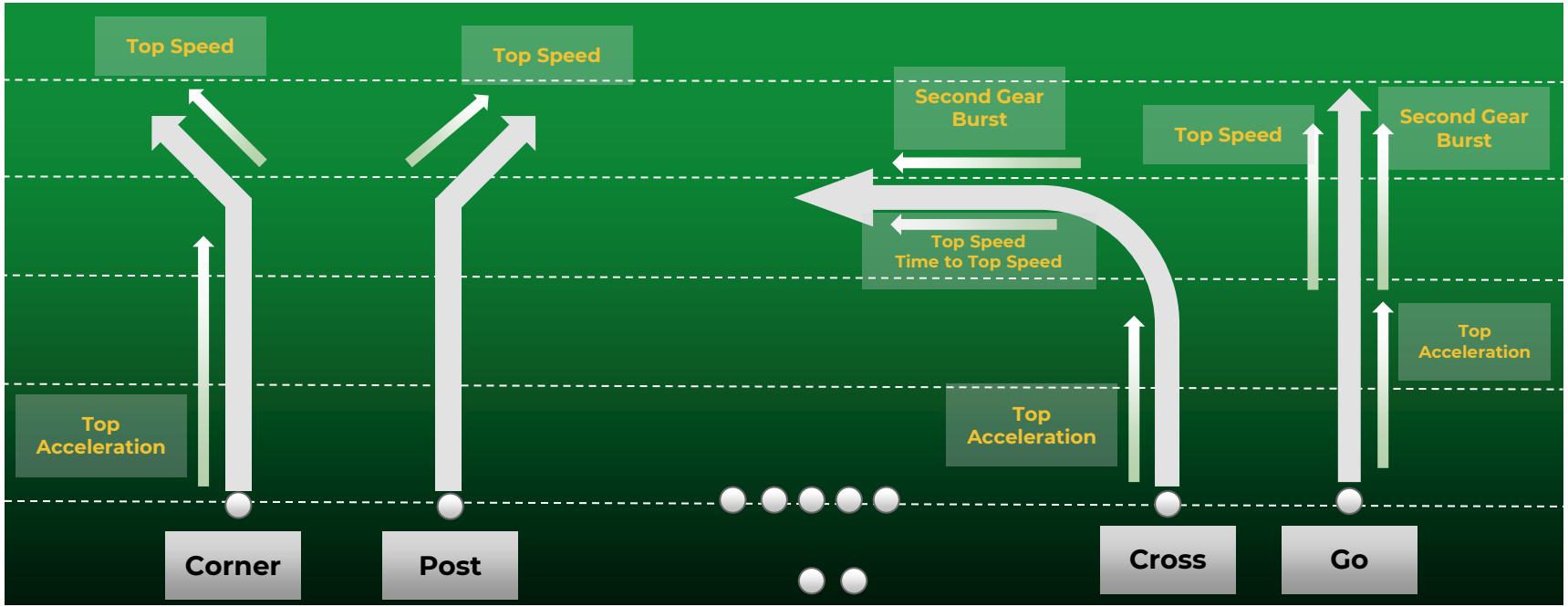


Key Findings

Created Metrics show Significant Correlations with Key Traditional Measures of WR Performance

Burst

Speed

Change of Direction

Traditional Measure	r
Yards per Reception	0.25
3 Cone Drill Time	-0.37

Traditional Measure	r
Yards per Reception	0.27
40 Yard Dash Time	-0.48

Traditional Measure	r
Receptions	0.31
Total Yards	0.22
Catch Percentage	0.37

*All significant at 5% Significance Level

Players are Paid Less in Early Years Despite Better Performance

NFL Contracts: Lower salaries for rookies, restructure to larger contracts after proving success in the league

Younger players perform better on the new created metrics



	Burst	Speed	Change of Direction
Salary (All Players)	-0.17	-0.06	-0.04
Salary (Seasoned Players)	0.14	0.67	-0.08
Years in League	-0.31	-0.29	-0.01

Seasoned player defined as those in their 5th or later year in the NFL

Overall, Metrics Reflect On-Field Performance as Expected

Burst

Burst off Line not differentiating on Slant routes, but often times receivers do not accelerate on slant routes prior to conducting their break

Strong overall correlation to yards per reception

Speed

Speed is a significant differentiator for all non-breaking speed dependent routes

Strong overall correlation to yards per reception and 40 yard dash time, the predominant existing measure of how fast a player is

Change of Direction

Change of Direction is a significant differentiator for In, Out, and Slant routes, which are all hard breaking routes

Strong overall correlation to Catch Percentage, which is partly a function of how open a player is

Final Remarks

Project Limitations

One Season of Data

Despite the large number of observations in one season, the NFL limited us to only using the 2018 season of data

Due to the intense filtering required to isolate peak performance, some metrics had a small number of observations per player

Additional seasons of data can help build a more robust set of metrics & help with validation (specifically stability, can use season vs. season rather than week vs. week)

Route Classification

The NFL's current route classification algorithm may need to be updated to account for more specific nuances in some routes

In some instances, routes were inaccurately classified, leading to outliers in the metrics we created due to the specific calculations per route type

Some nuances of non-standard routes, such as a player running a Pivot (fake in, and then pivot out) not captured in the tracking data and hard to detect from this data alone

Conclusion

Advanced Technology & Tracking is the Future of Sports

Many other sports (such as basketball and golf) are implementing RFID/video technology to track and measure player performance

With Next Gen Stats, NFL has the data necessary to revolutionize the way teams scout new players & maximize the output of current players

Our metrics proved to be overall successful indicators of wide receiver performance.

Change of Direction is a Novel Quantitative Metric

Metrics related to change of direction are novel quantitative measures of performance, generally coaches need to watch film to get these sorts of insights

Applying additional physics principles, such as those we used for angular velocity, can help the Next Gen Stats create more differentiating metrics that quantify the kinesthetic aspects of football

The framework we created can be directly applied to other players running receiving routes, as well as used as a base to build upon for metrics for other position players, such as understanding similar kinesthetic movements for defensive backs covering wide receivers

Questions?

Appendix

Definition of Metrics

Change of direction time	How long it takes for a player to complete his break
Change of direction radius	The radius of the break
Burst off the line: acceleration	Peak acceleration in pre-break segment
Burst off the line: speed	Peak speed in pre-break segment
Time to top speed off the line	Time to reach peak speed in pre-break segment
Top Speed	Top speed during the play
Top Acceleration	Top acceleration during the play
Time to top speed	Seconds to reach top speed metric
Low speed acceleration	Top acceleration during low-speed portion of route
High speed acceleration	Top acceleration during high-speed portion of route

Route Specific Metrics

	In	Out	Cross	Go	Hitch	Slant	Post	Corner
Change of direction time	X	X				X	X	X
Change of direction radius	X	X				X		
Burst off the line: acceleration	X	X			X	X	X	X
Burst off the line: speed	X	X			X	X	X	X
Time to top speed off the line	X	X			X	X	X	X
Top Speed			X	X			X	X
Top Acceleration			X	X			X	X
Time to top speed			X	X				
Low speed acceleration			X	X				
High speed acceleration			X	X				
Top speed burst			X	X				
Change of direction combined (angular velocity)	X	X				X		

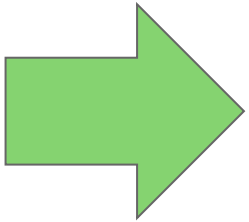
Overview of Data

33 Average Pass Attempts per Game

21 Average Pass Completions per Game

5 Eligible Receivers per Pass Play

2.4 Average Time (s) before a QB throws the ball



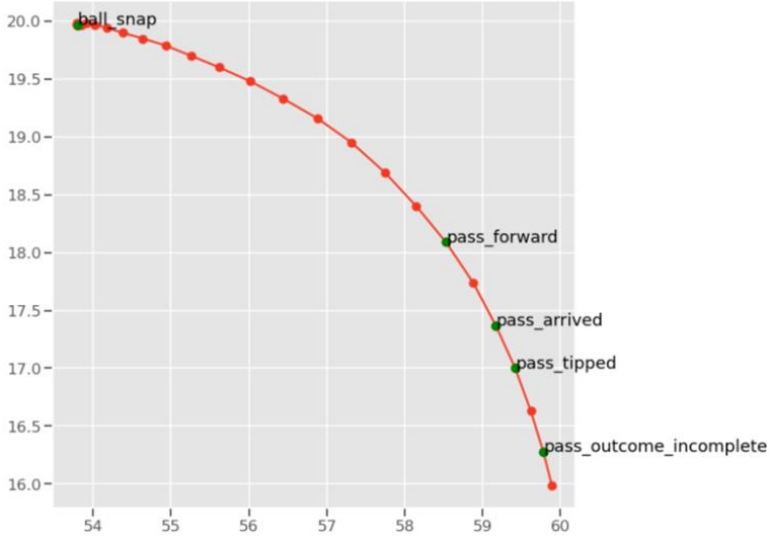
165 Receiver-Play Combinations per game

87% of routes run do not result in a caught pass

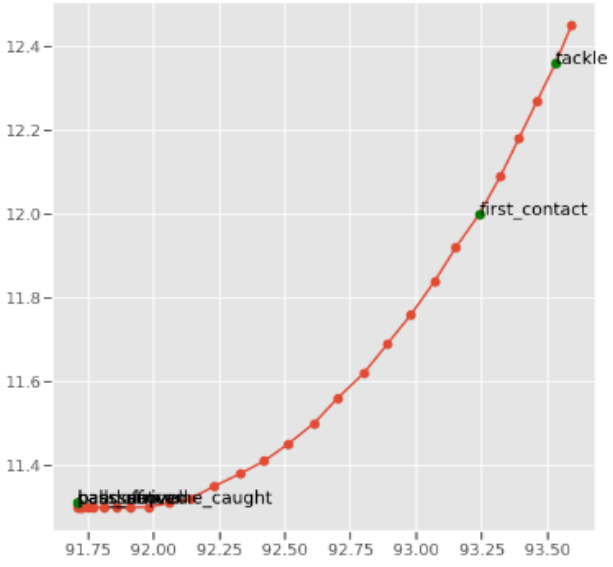
Measurement of peak performance from a wide-receiver is heavily dependent on identifying players where a player exerted maximum effort, and intensive filtering of tracking data must be conducted to isolate these events

Data Filtering Example- Length of Play

Defined the length of play as 0.3 seconds post-snap to ball arrival



Player must move at least 1 yard and a total of 2.5 seconds to be included in analysis

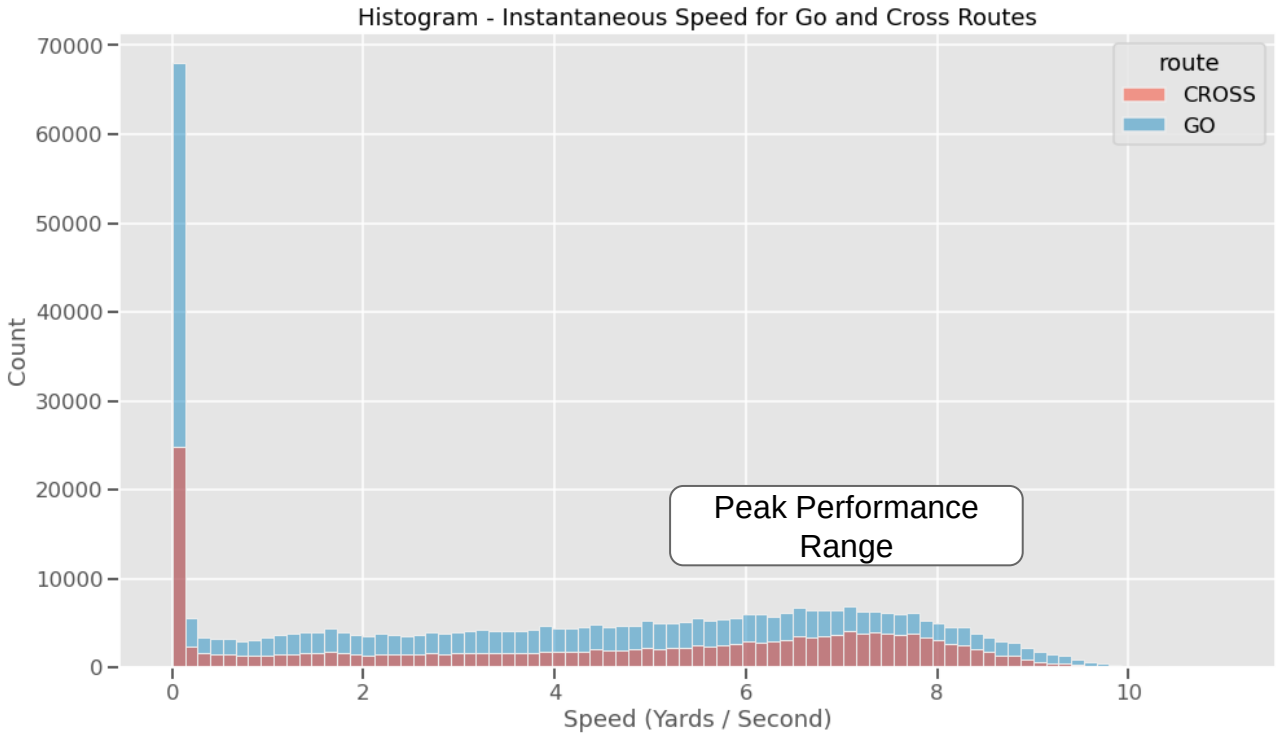


Data Filtering Example - Speed

Tracking Data provides instantaneous speed during play

A large amount of these observations are extremely low speed moments

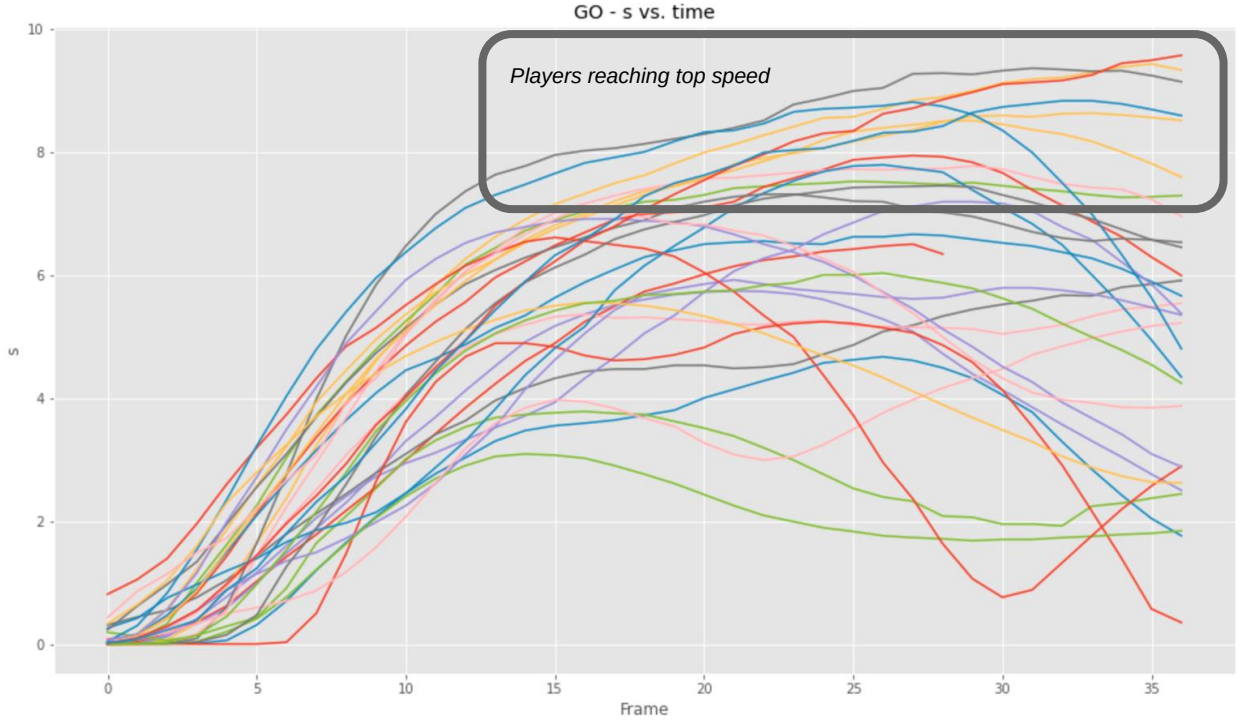
“Rules” developed to identify peak speed performance during route to remove below-peak performance at a player level



Data Filtering Example - Speed

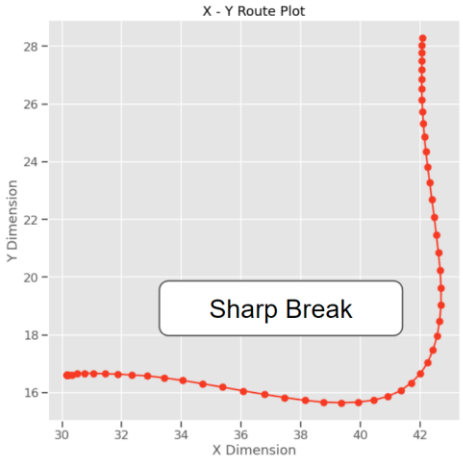
Each line represents a single play, with the y-axis representing speed and the x-axis each frame of the tracking data

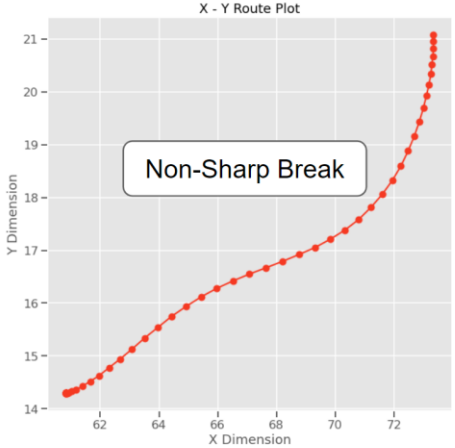
Only during a fraction of these plays does it appear players have enough time to fully accelerate and increase their speed to reach their peak level



Data Filtering Example – Break Threshold

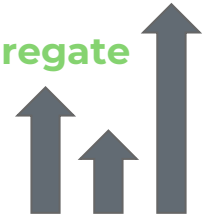
Route	Threshold (in degrees)
In	60-120
Out	60-120
Hitch	130-210
Slant	>= 30
Post	20-90
Corner	20-90





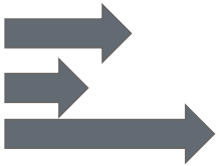
Aggregation & Indexing

Aggregate



- Aggregated at the player & route level to determine season-long performance
- Player must have run at least 5 plays of route type to be included

Index



- Min/Max Scaler
- 50-100 scale to keep in line with current NFL practices

Metric	Percentile: Non-Targeted	Percentile: Targeted
Change of direction time	10th	25th
Change of direction radius	10th	25th
Burst off the line: acceleration	90th	75th
Burst off the line: speed	90th	75th
Time to top speed off the line	10th	25th
Top Speed	90th	75th
Top Acceleration	90th	75th
Time to top speed	10th	25th
Low speed acceleration	90th	75th
High speed acceleration	90th	75th

Validation:
ANOVA Test for Discrimination

	In	Out	Cross	Go	Hitch	Slant	Post	Corner
Change of direction time	<.001	0.001				0.013	0.958	0.320
Change of direction radius	<.001	0.003				0.041		
Burst off the line: acceleration	0.083	0.438			0.002	0.709	0.612	0.134
Burst off the line: speed	<.001	<.001			<.001	0.142	0.065	0.085
Time to top speed off the line	<.001	<.001			<.001	0.412	0.350	0.207
Top Speed			<.001	<.001			0.005	<.001
Top Acceleration			<.001	<.001			0.087	0.010
Time to top speed			0.002	0.062				
Low speed acceleration			<.001	<.001				
High speed acceleration			<.001	<.001				
Top speed burst			<.001	<.001				
Change of direction combined (angular velocity)	0.009	<.001				0.095		

Indicates null hypothesis was rejected at 0.05 significance level

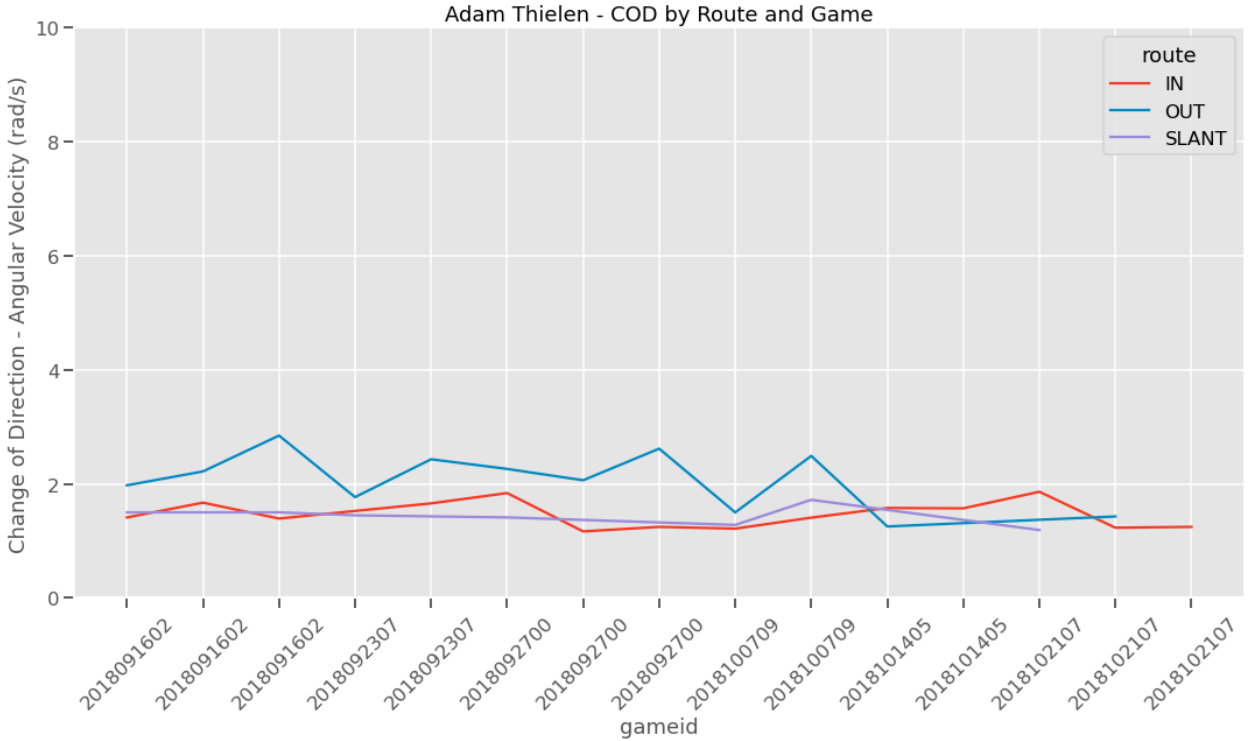
Validation:
Coefficient of Variation

	In	Out	Cross	Go	Hitch	Slant	Post	Corner
Change of direction time	15.28	18.09				10.36	11.67	9.50
Change of direction radius	37.81	44.12				26.38		
Burst off the line: acceleration	21.17	23.64			17.75	21.83	18.17	19.53
Burst off the line: speed	17.87	21.51			14.45	18.68	11.72	14.97
Time to top speed off the line	19.81	20.94			17.49	15.69	21.41	20.06
Top Speed			7.40	7.01			8.81	7.55
Top Acceleration			19.08	18.01			15.77	16.06
Time to top speed			14.72	11.69				
Low speed acceleration			20.71	18.57				
High speed acceleration			19.14	17.41				
Top speed burst			11.29	9.66				
Change of direction combined (angular velocity)	23.78	28.52				13.93		
CV Scores Key:	0-10: Very Good		10-20: Good		20-30: Acceptable		30: Not Acceptable	

Week to Week Stability: Change of Direction

Metrics should be stable week over week, indicating that a player's top performance is generally repeatable, especially for top tier players

Adam Thielen, known as a good route runner who changes directions effectively, has consistent performance through the season



Validation:
Correlation for Independence

	Burst	COD	Speed	Total
Salary: Cash Spent	-0.17	-0.04	-0.06	-0.13
Receptions	-0.04	0.31	-0.12	0.08
Catch Percentage	-0.11	0.37	-0.25	0.00
Total Yards	0.02	0.22	-0.02	0.12
Yards per Reception	0.25	-0.20	0.27	0.16
Touchdowns	-0.02	0.15	0.08	0.14
40-yard dash time	-0.18	-0.01	-0.48	-0.40
3 Cone Drill Time	-0.37	-0.03	-0.03	-0.19

Indicates Statistically Significant Correlation at 90% Level