Target Separation at Throw and Arrival

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October 2025

Background

- NGS already utilizes separation of the receiver to the nearest defender at pass arrival for various metrics (tight windows, open targets, etc) as well as completion probability.
- 2026 NFL Big Data Bowl asks to analyze player movement while the ball is in the air - from the point the QB releases to pass arrival (catch, int, or lands incomplete).
- As part of my EDA, I was curious to analyze **how separation evolves while the ball is in the air**, and demonstrate my usage of tracking data for my portfolio.

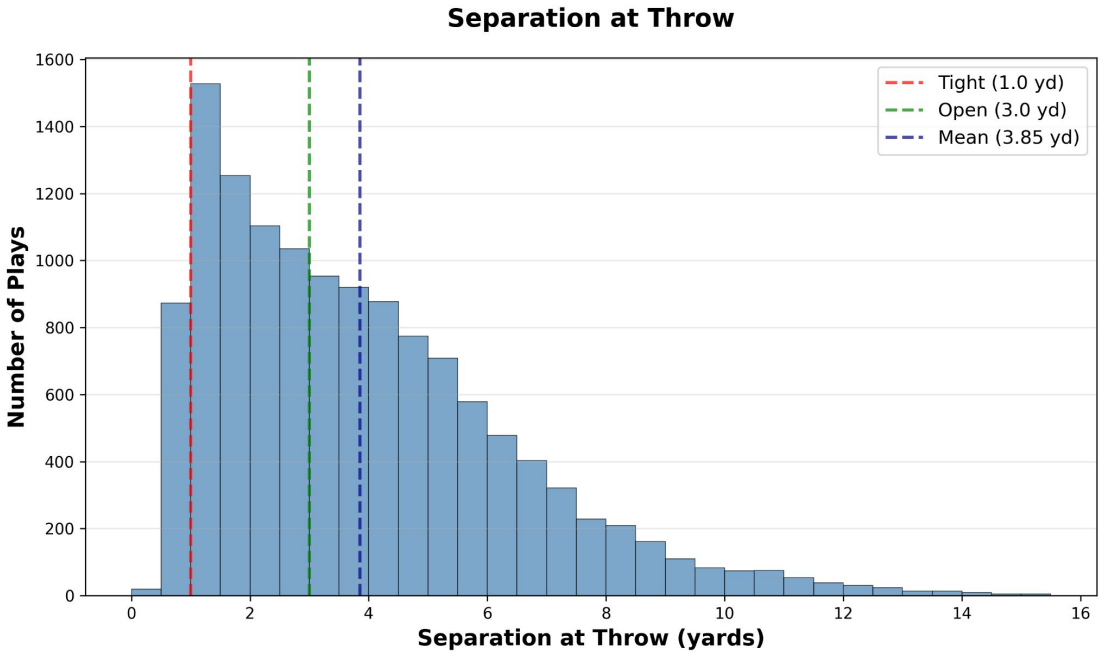
Research Questions

- We know that separation at arrival **correlates with higher comp probability**.
- However separation may not correlate with target rate - QB still throw to their guys, **even when covered**.
- Separation at throw may indicate the **decision making** of the QB - was the WR open or not when they decided to target them - but we also know how important timing is in the NFL. Elite quarterbacks often “throw guys open” by **anticipating** the receivers movement after the release.
- I’m interested in learning **how open target rates change while the ball is in the air - can we distinguish these elite quarterbacks who are able to “throw guys open” after this EDA?**

Data & Methodology

- Source: 2026 NFL Big Data Bowl Data
  - Subset of plays for “downfield attempts”, ruling out screens and quick passes etc.
  - Split between input (before ball is thrown) and output (after ball is thrown) data.
- Key metric: **sep_throw**
  - Calculates the separation of the WR from the nearest defender when ball is thrown
- Key metric: **sep_arrival**
  - Calculates the separation of the WR from the nearest defender when pass arrives
- Notably, the “nearest defender” is any defender - does not have to be the same defender at release or arrival, such that we are not tracking “assignments”

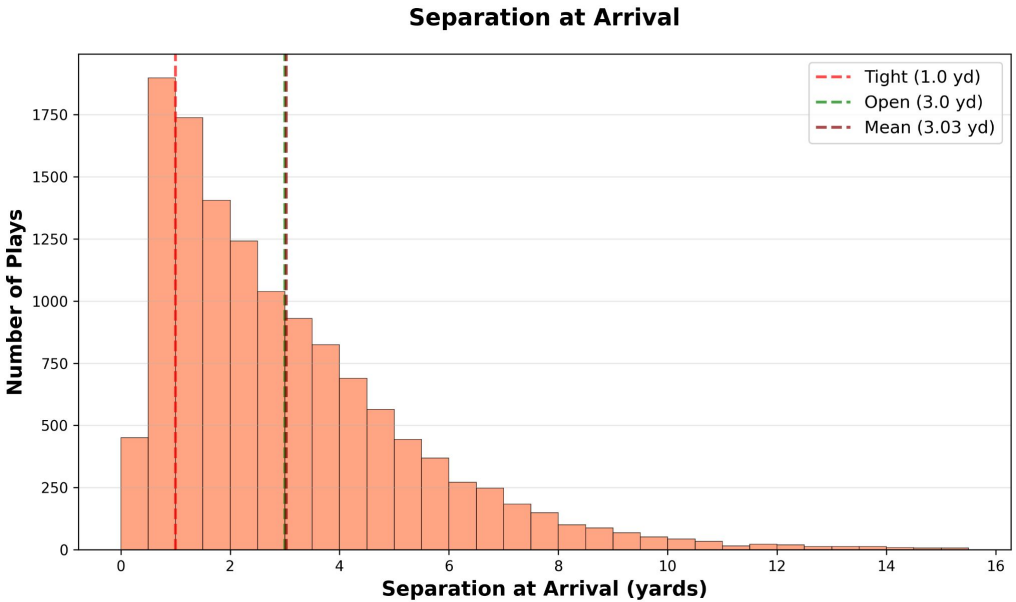
Separation at Throw EDA



Separation	Plays
<1 yd	829 (6.9%)
1-3 yds	4,920 (37.9%)
3+ yds	7,154 (55.2%)

Mean: 3.85 yds | Median: 3.34 yds | St Dev: 2.52 yds |Range: [0.22-22.63]

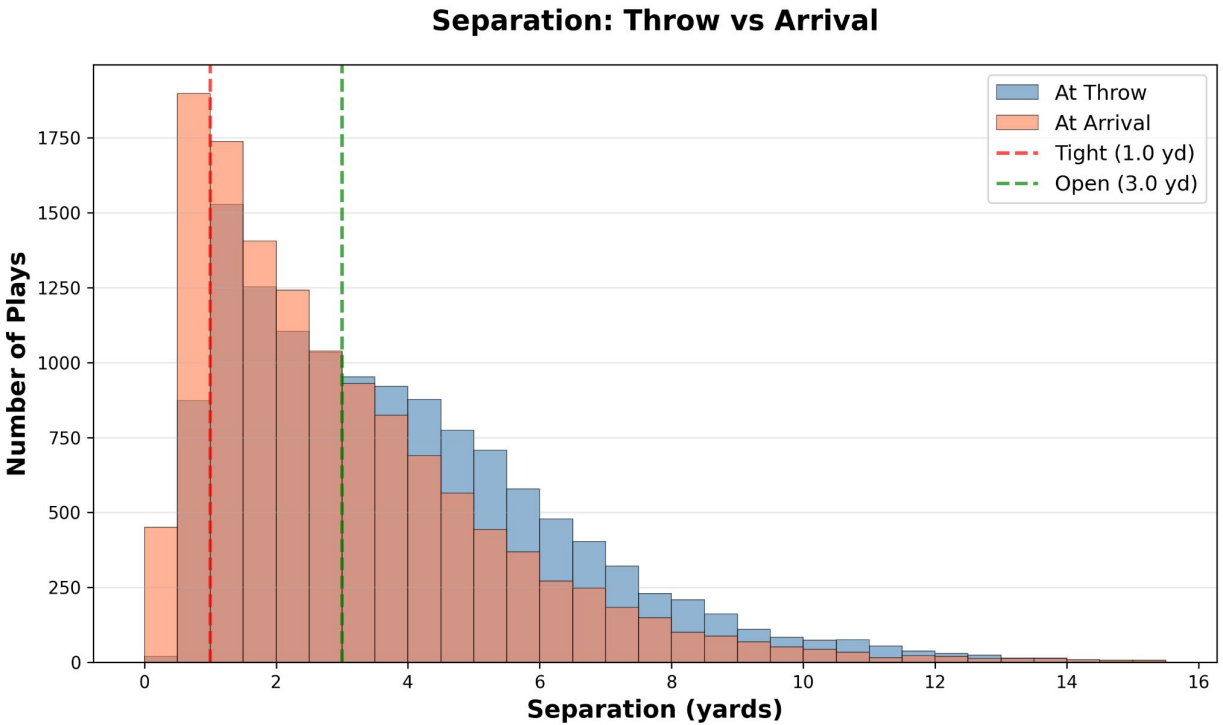
Separation at Arrival EDA



Separation	Plays
<1 yd	2,348 (18.1%)
1-3 yds	5,424 (41.8%)
3+ yds	5,194 (40.1%)

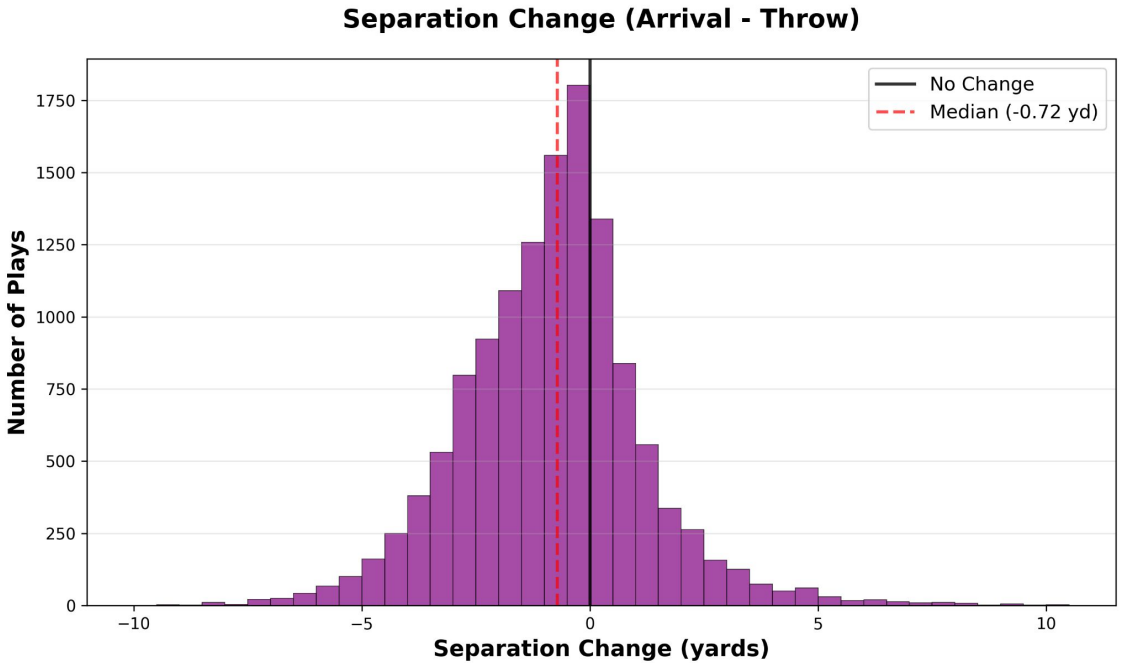
Mean: 3.03 yds | Median: 2.39 yds | St Dev: 2.40 yds |Range: [0.02-45.35]

Overlaying Separation at Throw vs Arrival



- Defenders recover in the 3+ yards of separation at throw range (**closing open targets**)
- Much smaller share of tight window targets at throw - **QB's avoid throwing to a receiver who's blanketed at release, except in special cases**

In Flight Separation Delta



- Distribution centered around small negative change, where defenders close the gap
- Very few cases of a receiver gaining 3+ yards of separation on the in flight portion of the play alone

QB Metrics Investigation

- **open_throw:** percent of attempts with 3+ yards of separation at pass release
- **open_arrival:** percent of attempts with 3+ yards of separation at pass arrival
- **open_delta:** open_throw - open_arrival
- **sep_delta:** mean change in separation (yards) from throw to arrival

Top 10 QBs - Separation Analysis

Sorted by % Open at Throw | 2023 Season

			PASSING STATS					SEPARATION METRICS			
RK	QUARTERBACK	TEAM	ATT	COMP	COMP%	YDS	TD/INT	% OPEN THROW	% OPEN ARR	Δ	SEP Δ
1	R.Wilson		325	242	74.5	2789	20/5	68.3	42.2	-26.2	−0.9
2	G.Smith		372	272	73.1	3186	18/8	65.6	36.8	-28.8	−1.2
3	P.Mahomes		438	303	69.2	3487	22/11	63.7	43.8	-19.9	−0.7
4	J.Love		451	304	67.4	3674	29/10	62.3	44.1	-18.2	−0.9
5	B.Purdy		353	265	75.1	3916	27/8	61.8	41.1	-20.7	−0.6
6	J.Allen		450	322	71.6	3846	25/14	60.2	40.9	-19.3	−0.6
7	T.Tagovailoa		430	303	70.5	4083	23/14	59.1	44.7	-14.4	−0.7
8	S.Howell		467	322	69.0	3447	20/16	58.7	30.6	-28.1	−0.8
9	J.Hurts		402	292	72.6	3484	19/10	58.2	33.3	-24.9	−1.1
10	D.Carr		439	321	73.1	3528	23/7	58.1	39.2	-18.9	−0.9

- **Russell Wilson** leads the league throwing to open receivers (**68.3% at releas**e), but shows one of the largest coverage collapse with a **-26.2%** drop by arrival.
- **Mahomes** demonstrates elite anticipation - despite lower open rate at throw (63.7%), he maintains a -19.9% delta, and shows minimal separation loss (-0.7 yds), indicating **superior timing.**
- **Separation erosion is universa**l - every QB averages -0.6 to -1.2 yards of separation loss, meaning defenders are closing 6-12 feet during ball flight across all passing strategies

WR Metrics Investigation

- **open_throw:** percent of attempts with 3+ yards of separation at pass release
- **open_arrival:** percent of attempts with 3+ yards of separation at pass arrival
- **open_delta:** open_throw - open_arrival
- **sep_delta:** mean change in separation (yards) from throw to arrival

Top 10 WRs - Separation Analysis

Sorted by Δ Open | 2023 Season

				RECEIVING STATS					SEPARATION METRICS			
RK		RECEIVER	TEAM	TGT	REC	CATCH%	YDS	TD	% OPEN THROW	% OPEN ARR	Δ	SEP Δ
1		T.Hill		133	91	68.4	1617	13	46.6	42.9	-3.8	−0.3
2		A.St. Brown		139	101	72.7	1401	9	46.8	40.3	-6.5	−0.4
3		C.Olave		124	78	62.9	1064	4	47.6	41.1	-6.5	−0.3
4		N.Collins		86	65	75.6	1157	8	40.7	31.4	-9.3	−0.3
5		C.Lamb		165	125	75.8	1717	12	43.6	32.7	-10.9	−0.4
6		K.Allen		129	95	73.6	1202	6	51.9	38.8	-13.2	−0.5
7		D.Moore		106	77	72.6	1276	8	47.2	33.0	-14.2	−0.7
8		D.Metcalf		96	60	62.5	1023	8	44.8	30.2	-14.6	−0.9
9		S.Diggs		127	84	66.1	1017	6	45.7	30.7	-15.0	−0.6
10		D.Adams		155	94	60.6	1075	7	45.2	29.0	-16.1	−0.6

- **Tyreek Hill** leads elite WRs in maintaining space (**-3.8% delta**), losing only 0.3 yards during ball flight - his speed forces defenders to respect deep threats even on shorter routes, preventing aggressive closing
- **Coverage collapse intensifies for deep threats** - Bottom 5 WRs show -13 to -16% delta (4x worse than Hill), with DK Metcalf (-14.6%), Diggs (-15.0%), and Adams (-16.1%) suffering the steepest drops despite strong catch rates
- **No 49ers?** Shanahan is known for his open target scheme, where is Aiyuk (1,300 yds in 2023)

WR Adanced Metrics Investigation

- **sep_creation_rate -** Separation gained divided by flight time
- **speed_maintenance -** Final speed divided by initial speed
- **route_efficiency -** Straight-line distance divided by total distance traveled
- **true_burst -** Early-route speed divided by average speed.
- **speed_sep_score -** Average speed multiplied by (separation gained + 2)

Top 10 WRs - Advanced Speed Metrics

Sorted by Speed+Sep Score | 2023 Season

				STATS			IN-FLIGHT METRICS				
RK		RECEIVER	TEAM	REC	YDS	TD	SEP RATE	SPEED %	ROUTE EFF	BURST	SPEED+SEP
1		N.Collins		65	1157	8	−0.31	101.1	0.96	1.02	24.05
2		T.Hill		91	1617	13	−0.25	84.3	0.96	1.08	23.66
3		B.Aiyuk		74	1355	7	−0.29	106.1	0.98	1.00	21.16
4		C.Olave		78	1064	4	−0.22	110.7	0.96	0.99	20.55
5		C.Lamb		125	1717	12	−0.50	117.3	0.95	1.00	20.01
6		A.St. Brown		101	1401	9	−0.51	101.9	0.97	1.00	19.89
7		G.Pickens		59	1103	5	−0.48	95.2	0.96	1.04	19.61
8		M.Evans		76	1218	12	−0.63	98.3	0.98	1.01	19.45
9		D.Moore		77	1276	8	−0.75	116.2	0.95	1.01	19.37
10		P.Nacua		88	1367	6	−0.56	107.2	0.97	0.98	19.17

- **Speed maintenance separates elite from good** - Nico Collins (101%), C.Lamb (117%), and C.Olave (111%) maintain/gain speed through routes, while Tyreek Hill drops to 84%, suggesting Hill's burst comes early while others accelerate late

- **Nico Collins' elite SPEED+SEP score (24.05) explained** - He uniquely combines THREE advantages: (1) actually gains speed through routes (101.1% maintenance), (2) has a strong separation creation rate (-0.31 yds/sec vs. -0.50+ for others), and (3) high average speed throughout flight. The formula rewards sustained speed + minimal separation loss perfectly

Top 10 WRs - Advanced Speed Metrics

Sorted by Speed+Sep Score | 2023 Season

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5		C.Lamb		125	1717	12	−0.50	117.3	0.95	1.00	20.01
6		A.St. Brown		101	1401	9	−0.51	101.9	0.97	1.00	19.89
7		G.Pickens		59	1103	5	−0.48	95.2	0.96	1.04	19.61
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10		P.Nacua		88	1367	6	−0.56	107.2	0.97	0.98	19.17

- **Tyreek Hill's 84% speed maintenance reveals strategic deceleration** - Hill's explosive burst (1.08 ratio, 8% faster at release) creates early separation so effectively that he can afford to decelerate by 16% during ball flight while losing less separation (-0.25 yds/sec) than most receivers. His speed is a weapon used strategically, not sustained throughout

- **Route efficiency near-perfect league-wide** (0.95-0.98) - Modern WRs run incredibly direct paths, with minimal wasted motion. Aiyuk (0.98) and St. Brown (0.97) lead, maximizing every yard traveled

- **Burst vs Speed %** - we see the constructed negative relationship, as those with high burst have lower speed % at arrival

- **Separation rate fall off** - after Olave, separation rate falls off dramatically

Future Research

- Separation at throw may not be as distinguishable as arrival
- We focused on open as those with 3+ yards of separation
  - But for looking at separation change while the ball is in the air, this may be a high barrier (hard to gain 3+ yards of separation during this segment).
  - Often a WR only needs a “step” on a defender to have an advantage - would some sort of rate of change make more sense? Looking at how the WR is able to “pull away” during the in flight segment?
- “Throwing guys open”
  - Similarly, separation at throw vs arrival alone may not suffice.
  - Can we gauge the receiver's motion vector when the ball is thrown, compared to the landing spot, to see how well the QB “put it on” the receiver?