Target Separation at Throw, and Arrival

Samuel Fraley
Barcelona School of Economics
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.

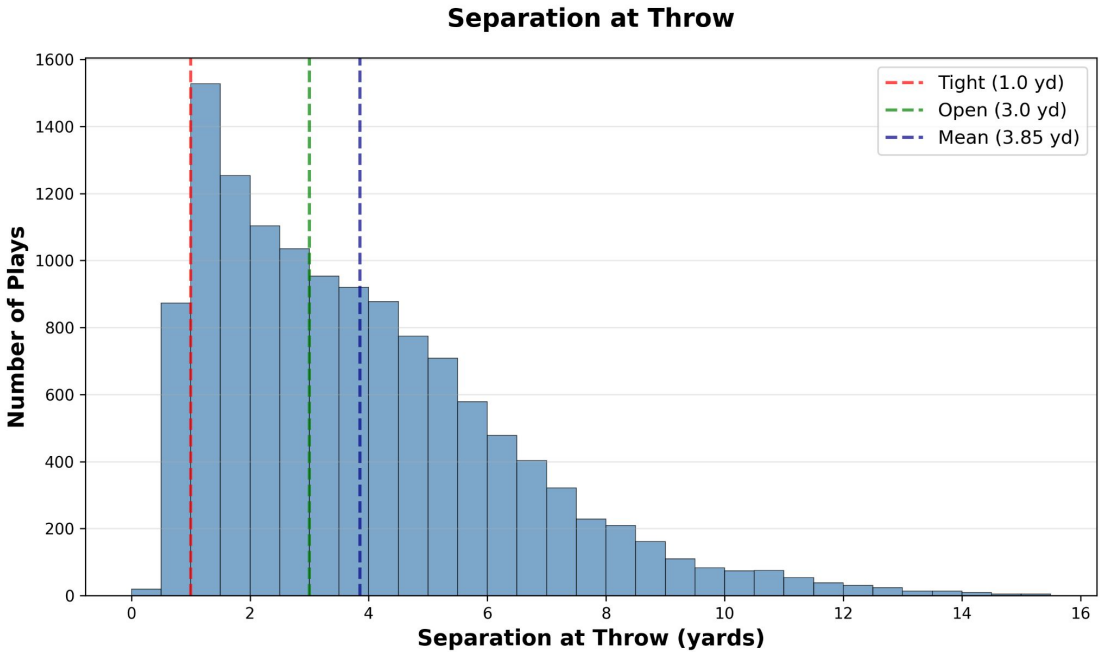
Research Questions

- 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”

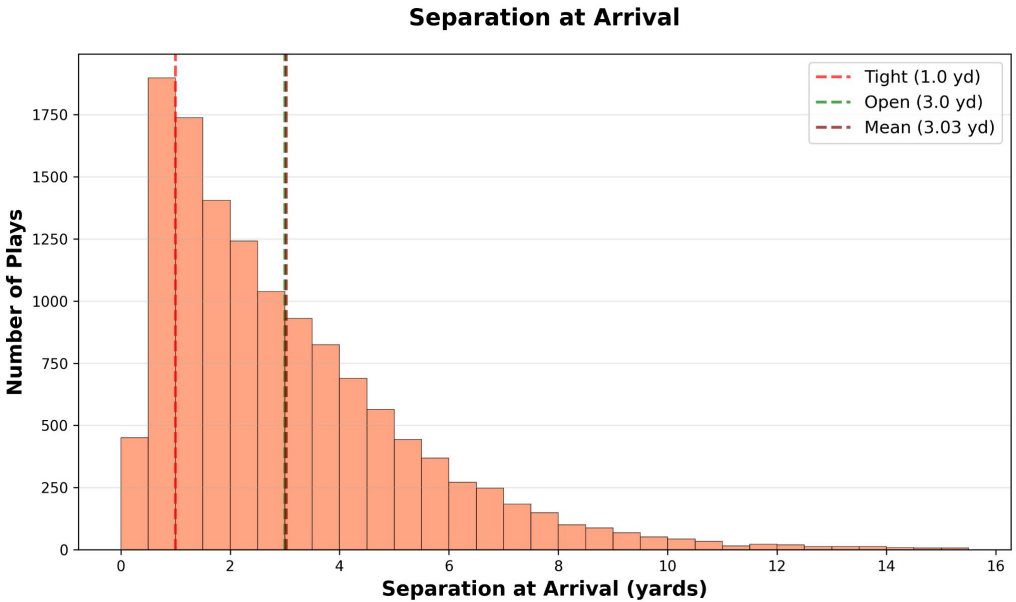
Separation at Throw EDA



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]

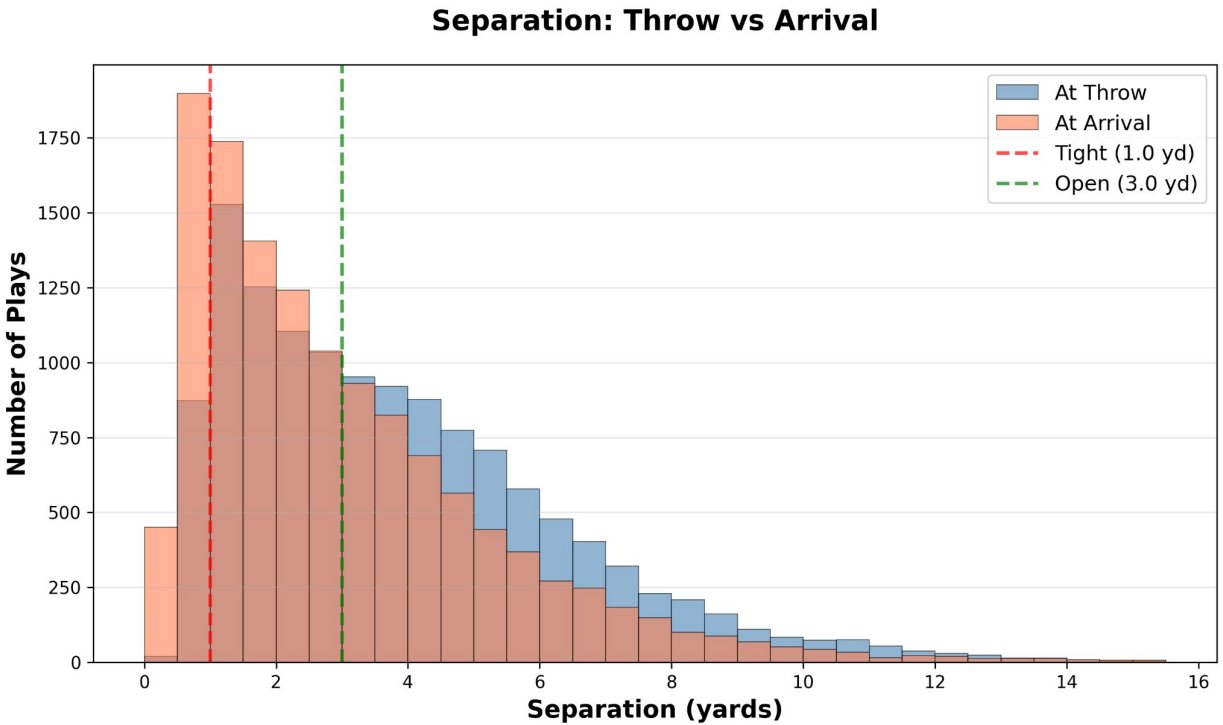
Separation at Arrival EDA



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

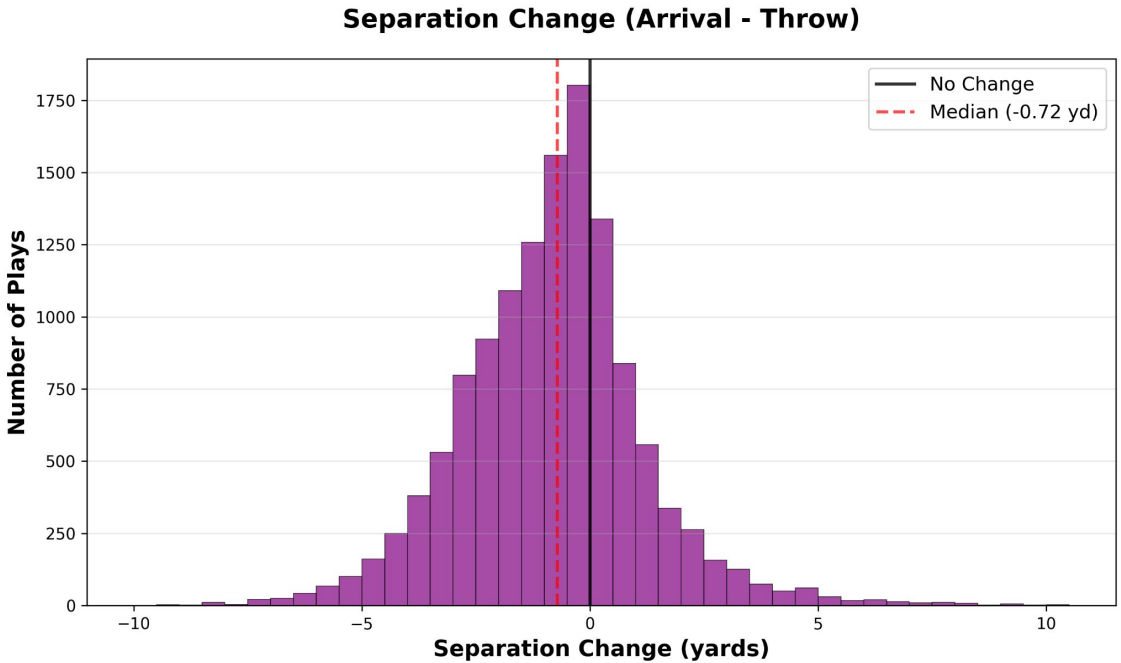
Mean: 3.03 yds | Median: 2.39 yds | St Dev: 2.40 yds |Range: [0.02-45.35]

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

				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

- **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 consistency defines volume receivers** - True burst ratios near 1.00 (Pickens 1.04, Hill 1.08, Lamb 1.00) indicate elite WRs maintain consistent speed throughout routes rather than relying on explosive first steps, enabling high target volumes

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?