The Coverage Pressure Index: Quantifying Receiver Freedom Using Tracking Data

How open is "open"?

Traditional NFL analytics measure separation as the distance between receiver and defender at the moment the ball is thrown. Three yards of space looks good on a stat sheet. But what if the defender's positioning means they can close that space before the ball arrives? What if that cushion was never really there?

The Problem with Static Separation

The NFL measures coverage with separation distance: how far apart the receiver and nearest defender are when the ball is thrown. Three yards of space? Open. Defender right on him? Covered. Simple enough.

But separation is a snapshot. It tells you where players are at one instant, not where they're going or whether that space will stay open. A receiver might have three yards of cushion at the throw, but if the defender has the right angle, that space disappears before the ball arrives. On the flip side, another receiver might look covered at the snap but have routes and leverage that keep him open the whole time. Distance can't tell you the difference.

Quarterbacks read more than just distances. They see angles, leverage, and whether defenders can actually get to the spaces their receivers are targeting. A safety sitting 8 yards deep looks far away, but if his positioning lets him break on anything in his zone, those passing windows don't really exist. We give quarterbacks credit for hitting "open" receivers without asking if that opening was ever real. What matters is where players can go, not just where they are.

A Different Approach: Measuring Reachable Space

The solution is to stop measuring where players are and start measuring where they can be. At the moment the ball is thrown, every player has a velocity, a direction, and the ability to accelerate or change course within physical limits. That creates a zone of reachable positions over the next second. For a receiver running a route, it's everywhere he could realistically cut, accelerate, or adjust. For a defender in pursuit, it's everywhere he could close to within the next few steps.

When you map these zones, something useful appears: overlap. If a receiver's reachable space and a defender's reachable space intersect, the defender can contest any route adjustment the receiver makes into that area. The more overlap, the more constrained the receiver. I call this the **Coverage Pressure Index (CPI)**. A CPI of 0% means the receiver has total freedom. A CPI of 64% means defenders can reach nearly two-thirds of his movement options. It answers the question separation can't: how much room does the receiver actually have, and how much can defenders take away?

CPI shows what's possible, not what happened. Physics and positioning determine the CPI. Skill and timing determine the outcome. A receiver with 60% CPI might still make the catch through perfect timing or athleticism. The CPI captures the structural advantage created by positioning at the throw.

Key Findings

The Data

This analysis uses NFL Next Gen Stats tracking data from Week 1 of the 2023 season, made available through the NFL Big Data Bowl 2026. The dataset captures every player's position, speed, and direction. I focused on the 819 passing plays where the targeted receiver was identified, analyzing each play at the exact moment the quarterback released the ball (the "throw frame"). This gives us a snapshot of positioning, velocity, and acceleration for all 22 players at the most critical moment for evaluating coverage. I will touch more on this in the methodology section further in the paper.

Position Patterns in Coverage Pressure

Analyzing all 819 plays revealed clear positional differences in how coverage pressure develops. The data shows that receiver position matters more than raw separation distance.

Receiver Position	Plays	Avg Time to Pressure	% Never Pressured	Avg Max CPI
TE	174	0.74s	18%	3.8%
RB	128	0.78s	8%	2.1%
WR	510	0.79s	27%	5.4%

Tight ends face pressure fastest (0.74s average), but wide receivers face the highest peak pressure when constraint does emerge (5.4% max CPI vs 3.8% for TEs). The explanation: tight ends operate in compressed spaces where defenders are close but rarely generate severe overlap, while wide receivers stretch the field vertically where defenders either have no angle (27% never face pressure) or have strong closing angles (higher max CPI when pressure exists).

Running backs show the lowest pressure overall (2.1% max CPI) but almost never stay completely free (only 8% never pressured). They operate in short-area spaces where defenders are always nearby but the plays develop too fast for defenders to generate significant overlap.

Defender Effectiveness

Not all defenders generate pressure equally. Position and alignment matter more than proximity:

Defender Position	Plays	Avg Time to Pressure	Avg Max CPI
OLB	64	0.71s	4.1%
ILB	102	0.76s	3.1%
CB	390	0.78s	6.4%
FS	97	0.83s	2.5%

Outside linebackers close space fastest (0.71s) when they're the nearest defender, likely reflecting their role in covering backs and tight ends in man coverage. Cornerbacks generate the highest peak pressure (6.4% max CPI), which makes sense given they're typically matched against wide receivers in space where correct angles allow them to threaten most of the receiver's options..

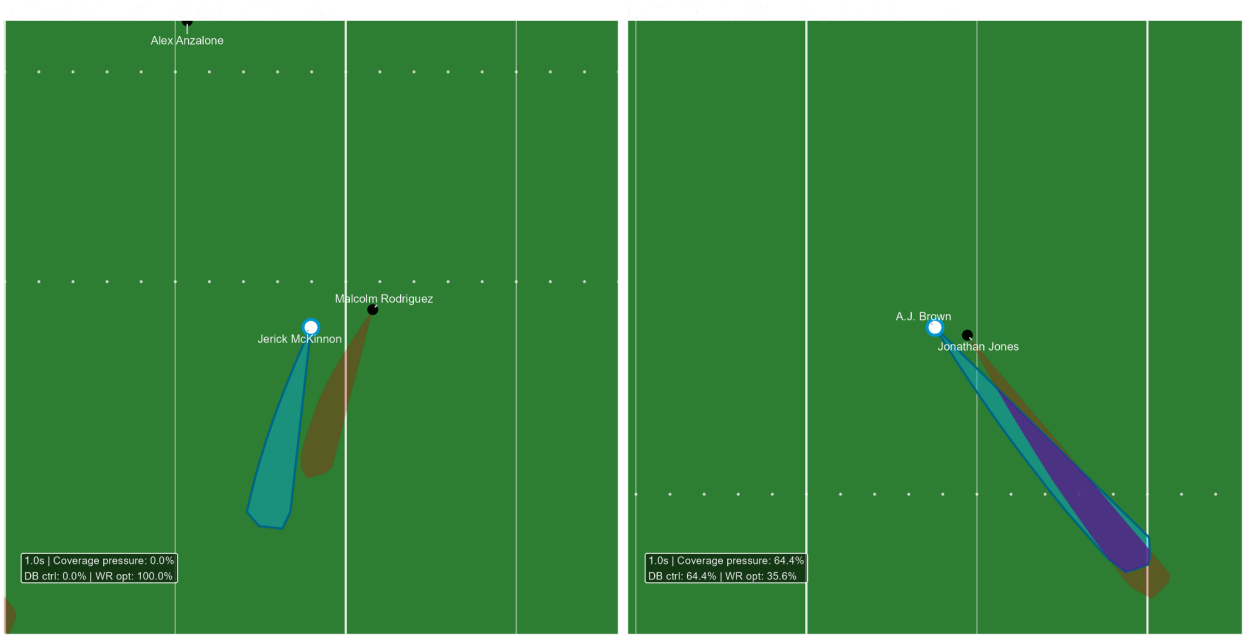
Free safeties take longest to generate pressure (0.83s) and produce the lowest peak constraint (2.5%). This reflects their deep positioning, they're rarely the nearest defender unless the play attacks deep zones, and even then their angles often leave receivers with escape options.

Case Studies: Coverage Pressure in Action

The aggregate statistics tell one story, but individual plays reveal how coverage pressure actually manifests on the field. These examples show the patterns that emerged across the dataset.

Two Plays, Two Realities

Two-Play Comparison: Spatial Optionality at 1.0s Horizon



These side by side snapshots show the same moment (1.0 seconds after the throw) on two different plays from Week 1 of 2023. Both receivers have defenders nearby. One is completely free. The other is severely constrained.

Left: Total Freedom (CPI: 0%)

Jerick McKinnon (white circle, blue cone) has complete spatial freedom. His blue cone shows everywhere he could move over the next second. Malcolm Rodriguez's brown cone sits right next to it but never touches. Rodriguez is close in distance but completely wrong in angle. His trajectory at the throw means he can't reach any of McKinnon's movement options. The window stays open.

Right: Severe Constraint (CPI: 64.4%)

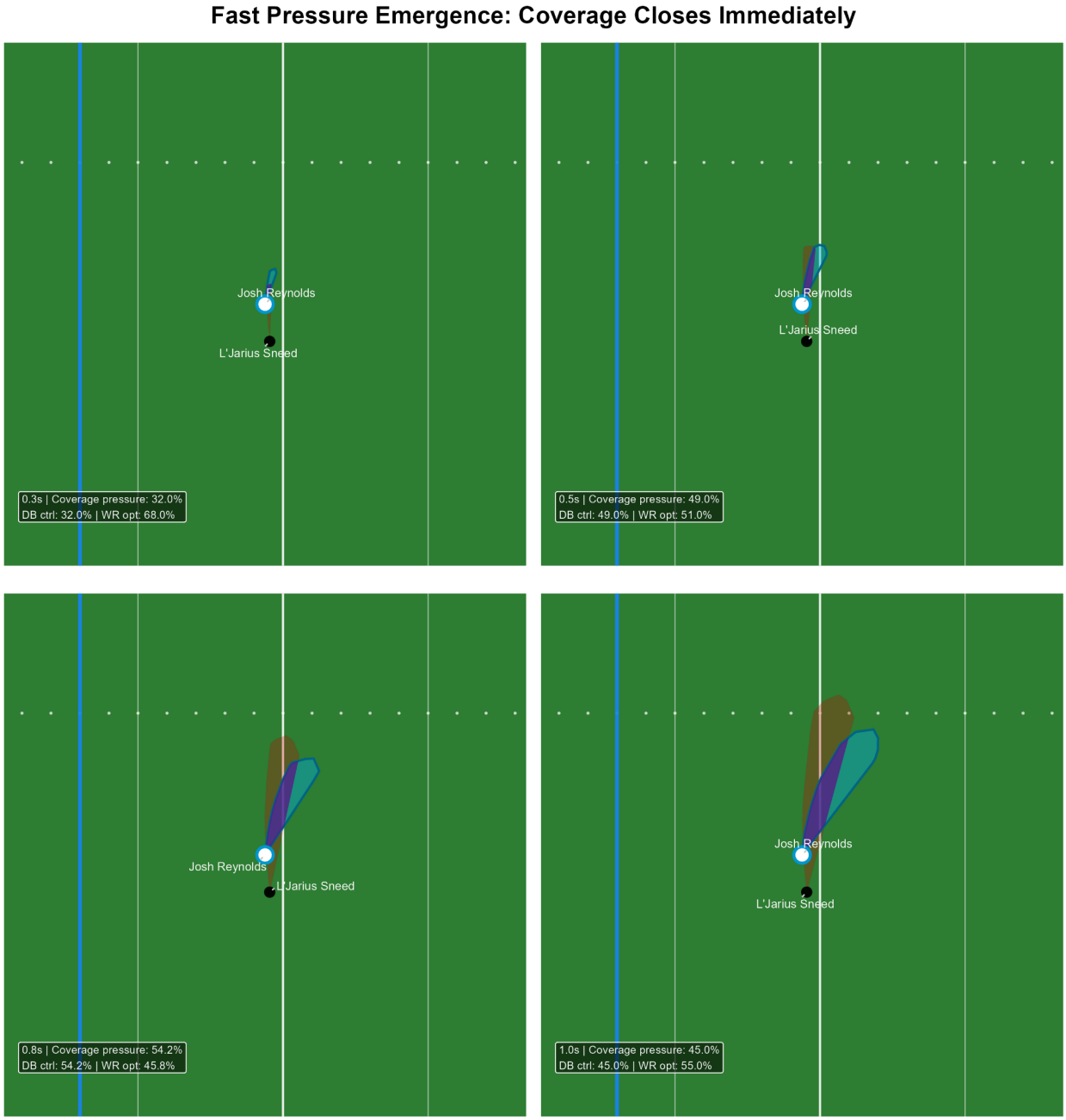
A.J. Brown (white circle, blue cone) faces the opposite situation. Jonathan Jones's brown cone overlaps most of Brown's blue space. That purple region shows the overlap: 64.4% of the positions Brown could reach, Jones can reach too. Jones isn't draped on Brown, but his positioning at the throw gives him geometric control. The quarterback has to thread the ball into the remaining 35.6% of uncontested space.

Why It Matters

Both plays have defenders within a few yards at the throw. Traditional separation metrics might call both "open." But geometry tells a different story. McKinnon's defender is close but can't converge. Brown's defender has the angle to contest most options despite the distance.

This is what the Coverage Pressure Index reveals: leverage beats proximity. Good positioning at the snap creates constraint over time, regardless of how far apart players are at release.

Fast Pressure Emergence: When Windows Close Immediately



This four panel sequence shows how coverage pressure can build instantly. Each panel captures a different moment after the throw: 0.3s, 0.5s, 0.8s, and 1.0s.

0.3s: Already Constrained

Josh Reynolds (white circle, blue cone) faces 32% coverage pressure right away. Most plays at this horizon show zero overlap. Here, L'Jarius Sneed's brown cone is already cutting into

Reynolds' space (purple region). Sneed's positioning at the throw gives him immediate access to a third of Reynolds' options.

0.5s: Pressure Climbs to 49%
Half a second in, the purple overlap region has nearly doubled. Reynolds retains 51% optionality, but barely. Sneed's cone is closing faster than Reynolds can expand his options.

0.8s: Majority Constraint at 54%
At 0.8 seconds, Sneed controls more than half of Reynolds' reachable space. This is peak pressure. The defender's brown cone dominates the visual. Reynolds has less freedom than constraint.

1.0s: Sustained at 45%
Pressure drops slightly to 45% but remains high. Reynolds' cone has grown at this longer horizon (more possible positions), but Sneed's has grown too. The defender maintains control.

What This Shows

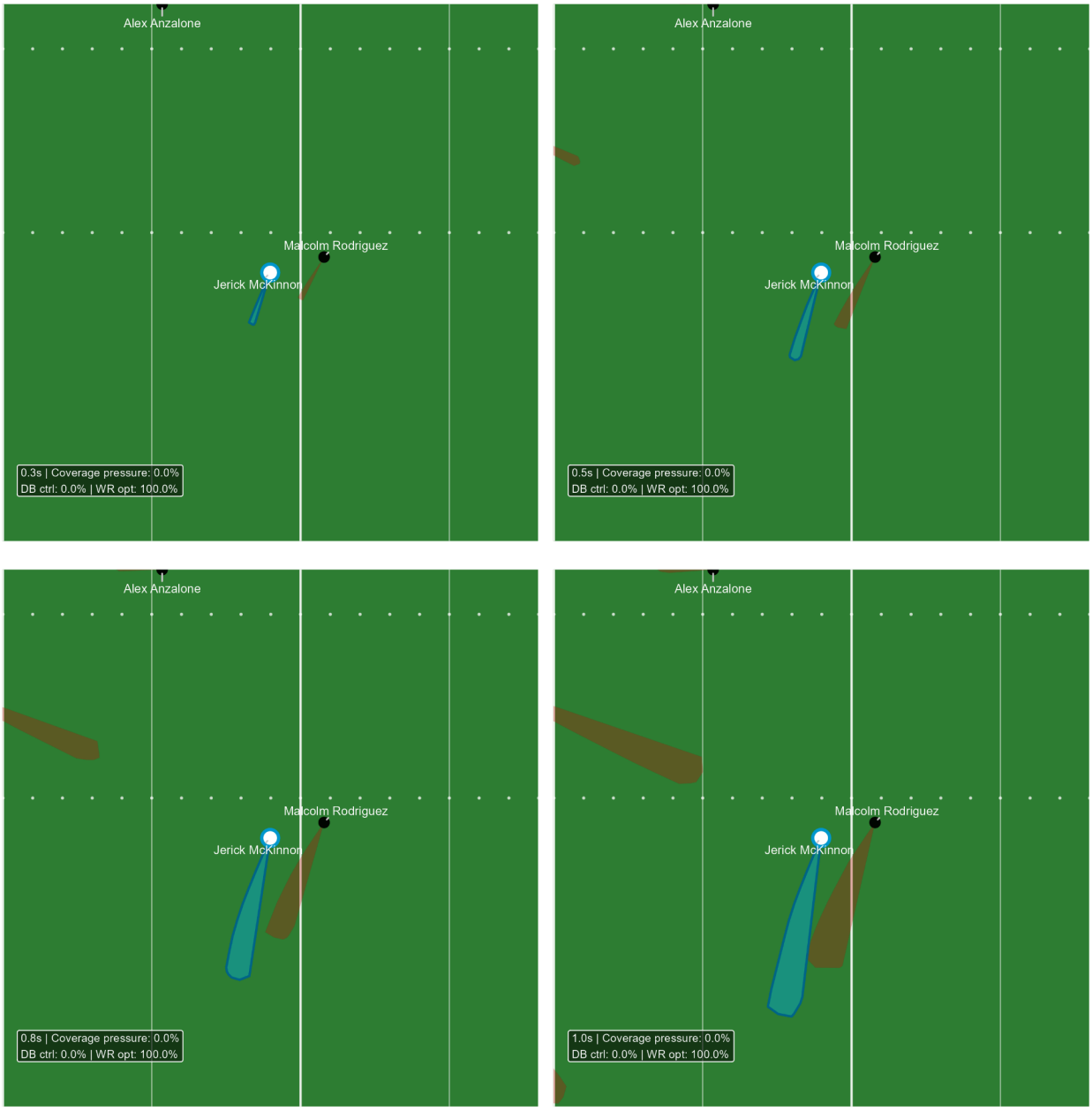
Most plays start with zero pressure at 0.3s and build gradually. This play jumps straight to 32% pressure immediately, then climbs another 22 points in half a second. Sneed didn't chase Reynolds down, he was already there.

Sneed doesn't need to be faster or closer than Reynolds. His angle at the snap means his reachable space overlaps Reynolds' options from the moment the ball leaves the quarterback's hand. By the time the ball arrives (typically 0.5 to 0.8 seconds for this route depth), the window is already closing.

This is what leverage looks like. The defender wins before the receiver even moves.

Sustained Freedom: When Defenders Never Converge

Sustained Optionality: Receiver Remains Free



This four-panel sequence shows the opposite extreme: a play where coverage pressure never materializes. At every time point (0.3s, 0.5s, 0.8s, 1.0s), the CPI stays at 0%.

All Four Panels: Zero Overlap
Jerick McKinnon (white circle, blue cone) has complete freedom at every moment. Two defenders are nearby (Malcolm Rodriguez and Alex Anzalone), but their brown cones never touch McKinnon's blue space. No purple overlap appears in any panel.

Rodriguez is the closest defender, but look at where his brown cone points in the bottom panels. It extends away from McKinnon, not toward him. His angle at the throw was wrong. Whether he was keying on another receiver, reacting to play action, or just caught in the wrong leverage, his trajectory gives him no access to McKinnon's movement options.

Anzalone sits even deeper and further out of position. Neither defender can threaten the space McKinnon is attacking.

What This Shows

This isn't just an open receiver. This is a receiver who stays open. McKinnon's cone grows larger at the 0.8s and 1.0s horizons (more possible positions), but the defenders' cones still don't converge. They're not closing. They're not even headed in the right direction.

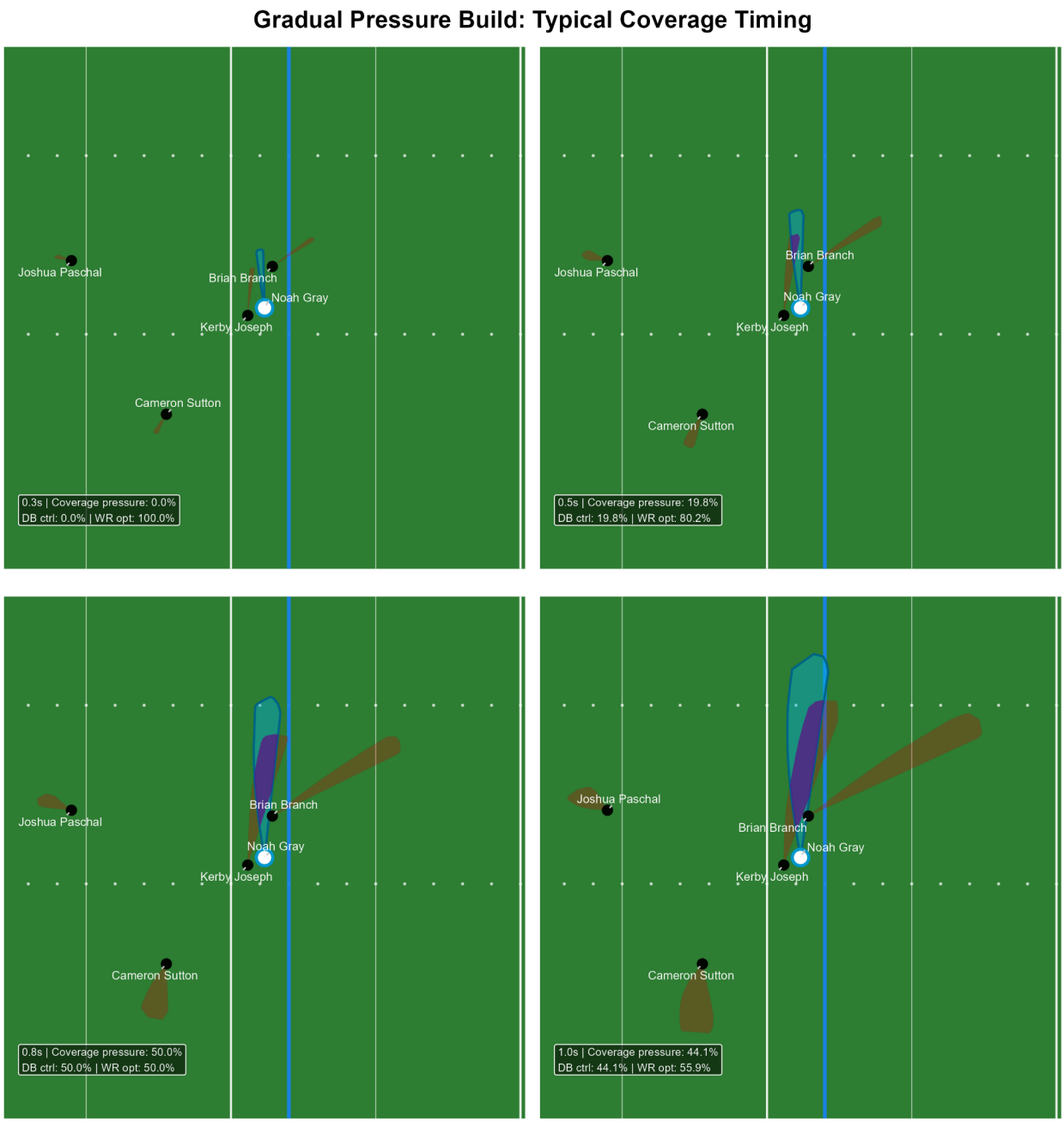
Compare this to the fast pressure play:

Metric	Fast Pressure	Sustained Freedom
0.3s CPI	32%	0%
Peak CPI	54%	0%
1.0s CPI	45%	0%

In the fast pressure play, the defender started in the right spot and controlled space immediately.. These defenders never had a chance. This is either an excellent offensive scheme (McKinnon running into a coverage void) or a defensive breakdown (zone gap, man coverage bust, or complete leverage failure).

For the quarterback, this is the dream scenario. Throw it anywhere near McKinnon and multiple completion windows exist. McKinnon can adjust his route however he wants. The space isn't closing.

Gradual Pressure Build: The Most Common Pattern



This four-panel sequence shows what happens on most NFL passing plays. Pressure doesn't hit immediately and doesn't stay at zero. It builds steadily as defenders close their angles.

0.3s: Wide Open

Noah Gray (white circle, blue cone) has 100% freedom. Four defenders are on the field

(Joshua Paschal, Brian Branch, Kerby Joseph, Cameron Sutton), but none of their cones touch Gray's space. CPI: 0%.

0.5s: Pressure Appears
By half a second, a small purple region emerges. Brian Branch's brown cone has started overlapping Gray's blue space. CPI jumps to 19.8%. Gray still has 80% optionality, but the window is narrowing.

0.8s: Fifty-Fifty
At 0.8 seconds, the purple overlap consumes half of Gray's cone. CPI: 50%. This is the peak. Branch's brown cone dominates the visual, and a second defender cone (upper right) adds to the constraint. Gray's freedom has been cut in half.

1.0s: Slight Relief
Pressure drops slightly to 44.1% at the one-second mark. Gray's cone has grown larger at this horizon, giving him more lateral options that partially escape the defender coverage. But the constraint is still substantial.

What This Shows

This is typical coverage. Defenders don't start with immediate leverage (like Sneed did), but they're positioned to close space as the route develops. The CPI climbs from 0% to 50% in half a second. That's zone coverage working as designed. Defenders flow to their spots and the window closes.

Compare the three patterns:

Metric	Fast Pressure	Gradual Build	Sustained Freedom
0.3s CPI	32%	0%	0%
0.5s CPI	49%	20%	0%
Peak CPI	54%	50%	0%

The gradual build sits in the middle. It starts like sustained freedom (0% at 0.3s) but escalates like fast pressure (50% by 0.8s). This is what good zone coverage looks like. Defenders give the impression of openness early, then close the window before the ball arrives.

For quarterbacks, the target is that 0.3s to 0.5s window. Gray is open at release and still has 80% optionality at half a second. Wait until 0.8s and the completion window shrinks to half its size. Timing matters.

Methodology

What I'm Measuring

Instead of just looking at how far apart a receiver and defender are when the ball is thrown, I measure something more useful: how much space does the receiver actually have to work with over the next second?

I call this the **Coverage Pressure Index (CPI)**, the percentage of a receiver's possible movement options that defenders can also reach. If a receiver has 100 square yards of space they could run to, but defenders can reach 60 of those square yards, that's a CPI of 60%.

Think about how meteorologists predict weather. They don't simulate the exact raindrop that hits your head, they model probable zones where rain will fall. I'm doing the same thing with football players using Monte Carlo simulation, running hundreds of possible paths to create a "reachable zone" rather than predicting one single line.

The Data and Simulation

The data comes from the Big Data Bowl 2026 competition. I analyzed all 819 passing plays with targeted receivers from Week 1 of the 2023 season. The NFL tracks every player's position, speed, and direction for every play.

For each player at the throw moment, I simulate where they could be at 0.3s, 0.5s, 0.8s, and 1.0s later. These simulations use position specific movement capabilities. Wide receivers accelerate between 0.66 and 5.62 yards per second squared (calculated from the data), while cornerbacks have a similar range of 0.55 to 5.18. Each path can veer up to 30 degrees left or right from the player's current direction. These are constraints I wanted to have as to not show weird or unrealistic movements when simulating where a receiver or defender could go.

This visualization shows what those simulations look like. Each colored dot represents one possible position at a specific time step (purple = 0.1s, teal = 0.2s, yellow = 0.5s). The player (red dot, bottom right) could move to any position in the yellow cloud by 0.5 seconds, depending on acceleration and directional choices.

I run 80-200 simulations per player, creating a cloud of possibilities. The outer boundary becomes the reachable cone shaped zone showing everywhere the player could physically be at that time.

Computing the Coverage Pressure Index

I create these reachable zones for the receiver and the nearest 4-6 defenders, then measure where they overlap. The overlap shows what percentage of the receiver's options defenders can also reach.

- **CPI of 0%** = total freedom
- **CPI of 50%** = half the receiver's space is contested
- **CPI of 100%** = completely smothered

What CPI Measures and What It Doesn't

The Coverage Pressure Index measures spatial constraint, not outcomes. A receiver facing 60% CPI doesn't necessarily fail to get open, it means 60% of their possible movement options overlap with where defenders could also be. CPI shows what's possible given positioning and physics, not who wins the rep.

A receiver with high CPI might still make the catch through perfect timing, route precision, or simply being more athletic than the simulation assumes. A receiver with 0% CPI might drop the ball, the ball might be overthrown or the quarterback might get sacked before throwing.

CPI reveals the advantage or disadvantage built into the alignment at the throw. What happens after that depends on the players. Think of it like this: CPI is the size of the window, not whether the quarterback hits it or the receiver catches it.

What I Analyzed

By calculating CPI at four time points, I track how quickly defenders close space. After running 819 plays, I compared:

- How fast CPI increases by receiver position (WR, TE, RB)
- Which defender positions generate higher CPI most effectively (CB, S, LB)
- How initial separation relates to CPI timing

The Visualizations

Field diagrams show 18×18 yard windows centered on receivers. Blue zones show receiver reachable space, brown shows defender space, purple shows overlap (the CPI). Four-panel sequences show how CPI evolves from 0.3s to 1.0s.

Conclusion

Traditional separation metrics measure distance at a single moment. The Coverage Pressure Index shows whether that space stays open or closes down. That matters because coverage doesn't freeze at the throw. A receiver with 3 yards of space might have total freedom or 60% constraint depending on defender angles.

The key insight: leverage beats proximity. Defenders 5 yards away with the right angle generate more constraint than defenders 2 yards away with poor positioning. Good coverage comes from occupying positions at the snap that guarantee spatial control as routes develop, not from chasing receivers after the throw.

This framework has immediate applications. Scouts can separate scheme created separation from receiver created separation. Coordinators can identify which coverages produce favorable matchups. Coaches can teach why positioning matters more than proximity.

Coverage isn't about where players are. It's about where they can go