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1. Introduction

The goal of this project is to see how defensive alignment and field position affect the success of passing plays. This will help coaches better understand which defensive looks are more successful in specific situations, especially when it comes to field position. To support an interactive look at it, a custom dashboard was developed using Plotly Dash, allowing users to dynamically filter by field zone and defensive alignment and visualize the resulting changes in expected points added (EPA).

2. Data Preparation

2.1 Data Sources

This project utilizes two datasets:

- Plays.csv: contains play-level information including offensive formation, field position, and expected points added (EPA)
- Defense.csv: contains player-level defensive data including alignment and the targeted defender.

2.2 Data Quality and Cleaning

- Plays were flagged when is_no_play=1, indicating that they were nullified by penalty. These plays were excluded from the analysis.
- There were missing values in key columns, such as expected_points_added and alignment, which were removed to ensure clean aggregations.
- The datasets were merged on play_id to get a combined view of the offense and the defense on each play.

2.3 Features Engineering

To evaluate field positions, the continuous field_position variable was recoded into four field zones:

- Backed Up: ≤ -20 yards
- Own Territory: -20 to 0 yards
- Midfield: 0 to 40 yards
- Scoring Range: > 40 yards

3. Research Question

How does the effectiveness of passing plays vary by field position and defensive alignment?

This question was chosen due to its relevance in modern football strategy. Teams are starting to rely more on data-driven play calling and formation design, so understanding how defensive alignment affects passing success is critical for both offensive and defensive game planning.

4. Methodology

4.1 Data Categorization

The dataset was group by:

- Defense alignment (edge, slot corner, deep safety, etc.)
- Offensive formation (2x2, 3x1, 4x2, etc.)
- Field Zone

This helped frame alignment performance in terms of field context, which influences defensive play-calling.

4.2 EPA Aggregation Logic

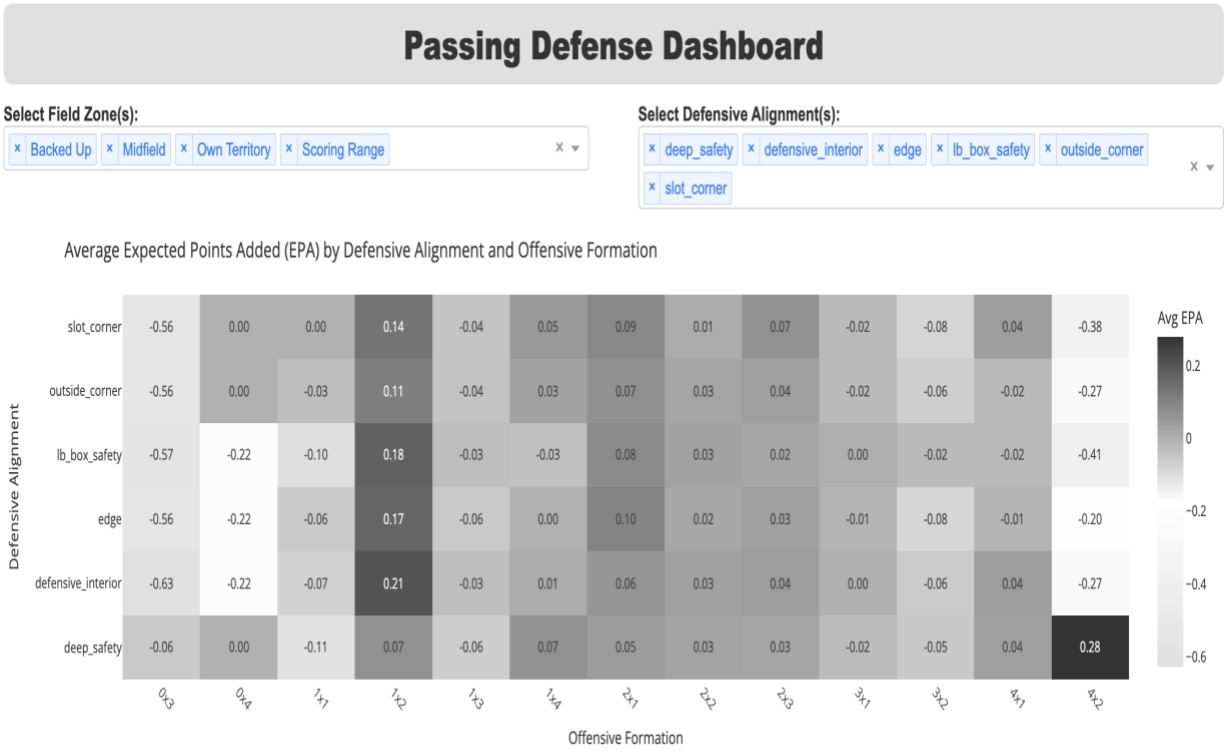
For each group, the average EPA was calculated. This value reflects the expected point value added or lost based on the outcome of the passing play. EPA was chosen because it provides a more complete context than just yards gained, it reflects the impact of play on expected scoring, factoring in field position, down, and distance.

It produced a matrix that shows how certain alignments perform against specific formations. For example, if “edge” defenders consistently allow negative EPA against 3x1 formations, that suggests success. On the other hand, if deep safeties allow +0.21 EPA vs. 4x2, that is a red flag and not successful.

4.3 Visualization Design

To support user-driven analysis, the results were embedded in an interactive dashboard using the Dash framework. The dashboard allows users to select specific field zones and defensive alignments, with the heatmap updating in real time to reflect the average EPA by offensive formation and alignment.

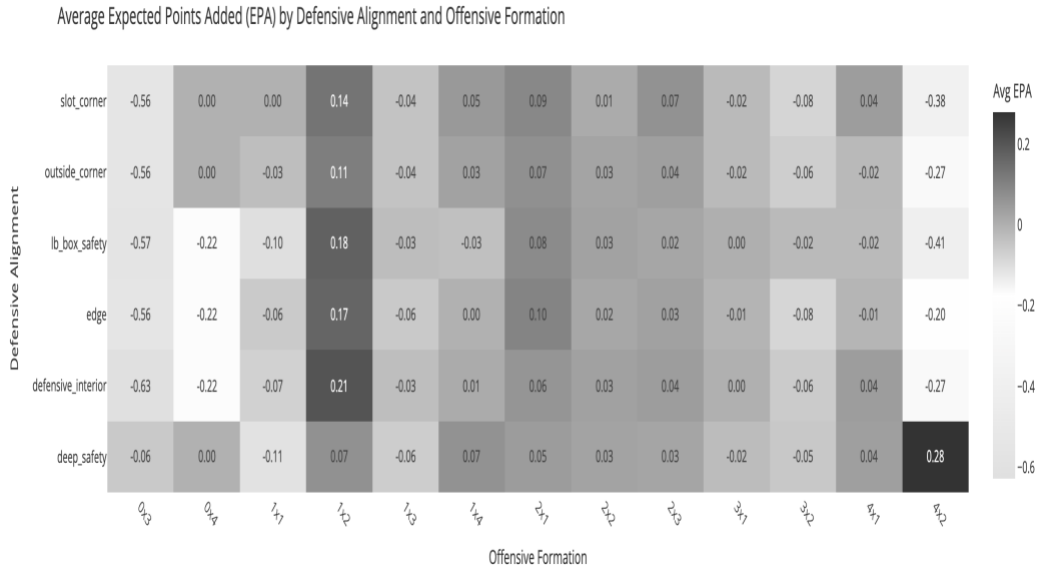
- X-axis: offensive formation
- Y-axis- defensive alignment
- Cell values- average EPA
- Color scale: Dark Gray (strong performance, low EPA) to Light Gray (poor performance, high EPA)



5. Results

5.1 Heatmap Overview

The heatmap below summarizes the average EPA allowed across defensive alignments and offensive formations. The darker the blue, the better the defense performed and the brighter the color, the more the offense gained:



5.2 Key Observations

- The most negative EPA, best defensive effectiveness, is observed in the defensive interior and box safety alignments, especially against formations like 0x3, 0x4, and 1x1.
- Deep safety alignment allows the height EPA (+0.28) against the 4x2 offensive formation, suggesting that when offenses spread the field with four receivers to one side, single high safety structures may be overly stressed.
- The 1x1 and 1x3 formations generate positive EPA against nearly all alignments, highlighting their general success against a variety of coverage looks. Edge defenders and outside corners consistently allow less EPA across formations compared to deep safety roles.

5.3 Alignment Summary Table

Defensive Alignment	Best Formation Matchup (Lowest EPA)	Worst Formation Matchup (Highest EPA)
Slot Corner	0x3 (−0.56 EPA)	4x2 (−0.38 EPA)
Outside Corner	0x3 (−0.56 EPA)	4x2 (−0.27 EPA)
LB Box Safety	0x3 (−0.57 EPA)	1x2 (+0.18 EPA)
Edge	0x3 (−0.56 EPA)	1x2 (+0.17 EPA)
Defensive Interior	0x3 (−0.63 EPA)	1x2 (+0.21 EPA)
Deep Safety	0x3 (−0.06 EPA)	4x2 (+**0.28 EPA**)

6. Implications

These finding suggest several strategic takeaways:

- Interior pressure is consistently effective in suppressing passing EPA across most formations.
- Spread formations, particularly 4x2, are highly effective against single-deep safety alignments, emphasizing the need for better over-the-top support of disguised coverages.
- Conservative alignments may offer coverage depth but are vulnerable to horizontal spacing and layered route combinations.

7. Future Work

With more data or time, the following enhancements would improve this analysis:
- Incorporate down/distance/score to account for actual play context.
- Analyze route combinations using tracking data to understand why certain alignment fail.
- Compare more team trends vs. league averages to benchmark effectiveness

8. Conclusion

This analysis demonstrates that EPA allowed on passing plays varies significantly by defensive alignment and offensive formation, with certain matchups proving consistently favorable or unfavorable. The results support the use of interior-heavy and multi-DB alignments against condensed sets and suggest caution when using deep-safety structures against modern spread formations like 4x2. The interactive dashboards built with Dash provides a scalable tool for future film study and in-game analytics.