Set-Piece Optimization

What Actually Makes a Corner Dangerous? Tactical Patterns Behind High-Threat Routines in Liga MX

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Why Does Set-Piece Optimization Matter?

*"There is a culture where many teams just **take** set plays. The best ones design them."*

— Gianni Vio, Set-Piece Coach Italy National Team (Euro 2020 interviews, The Athletic, 2021).

"Teams score off corners between 2–2.5% across the full dataset. We've seen certain teams double or treble that for multiple seasons."

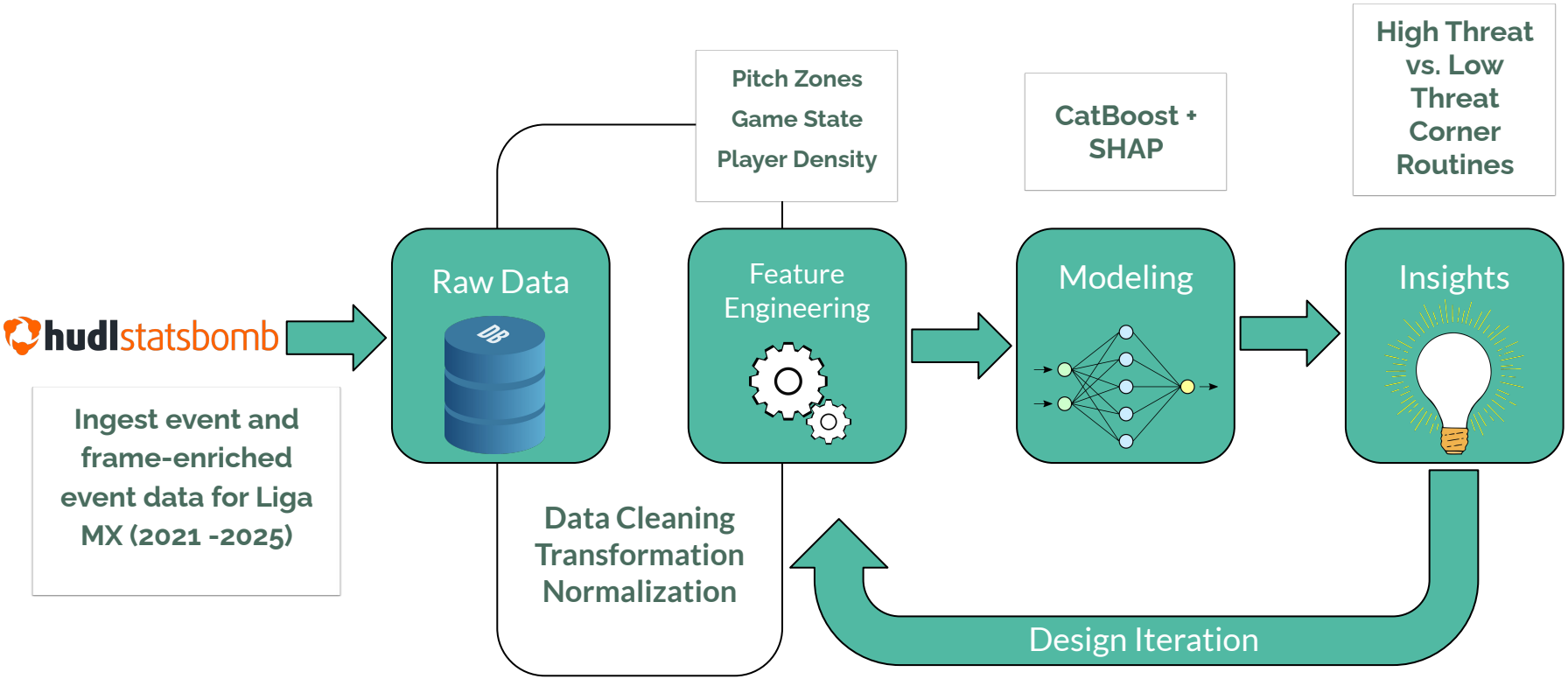
— StatsBomb (Set-Piece Trends Report, 2019)

Why Corners?

- Corners are one of the few repeatable attacking situations in football that remain massively **under-optimized** even though they deliver **outsized returns** when designed intentionally.

- Corners are a tactical laboratory: **structured, coachable, repeatable, and modelable**. This makes them the most efficient entry point for turning data into a measurable edge.

The Pipeline: From Data to Tactical Insight



Feature Selection

1

Corner characteristics

2

P0 player context

3

P1 player context

2. Feature Engineering

➔ Pitch Zones

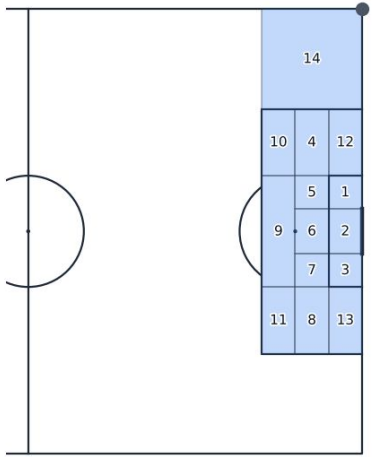
The backbone of the model is the feature engineering and the granular zones in the pitch that measure player density at two times:

- P0: The exact moment when the taker kicks the corner.
- P1: The immediate action that follows the kick.

Normalization is implemented to always frame the possession to the right side of the pitch. Pitch zones are mirrored so that the tactical meaning of each zone remains consistent.

The full set of engineered features is documented in the [data preprocessing appendix](#).

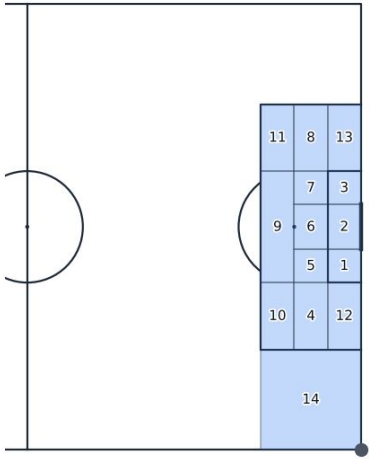
Pitch Zones: Left Corner Delivery (P0 & P1 Density Model)



Pitch Zones:

1 — Near-post low (6yd)
2 — Central (6yd/GK)
3 — Far-post high (6yd)
4 — Near-post channel (outside 6)
5 — Central corridor (outside 6)
6 — Far-post corridor (outside 6)
7 — Deep central (pen spot depth)
8 — Far-post high (deep back-post)
9 — Penalty-spot corridor
10 — Short return – near
11 — Short return – far
12 — Short return – central
13 — Far-post low (6yd, mid-height)
14 — Advanced wide return

Pitch Zones: Right Corner Delivery (P0 & P1 Density Model)



Pitch Zones:

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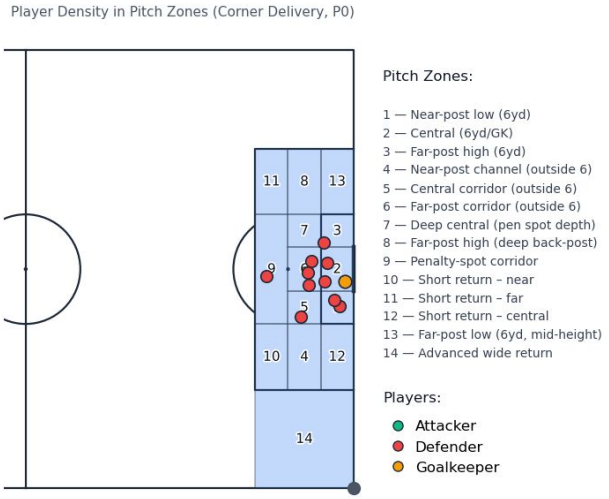
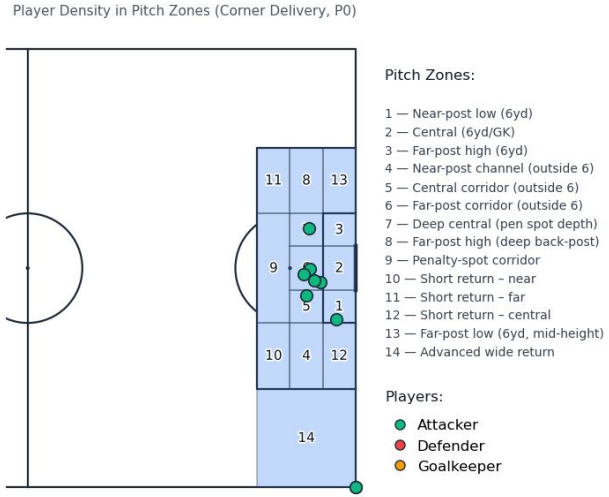
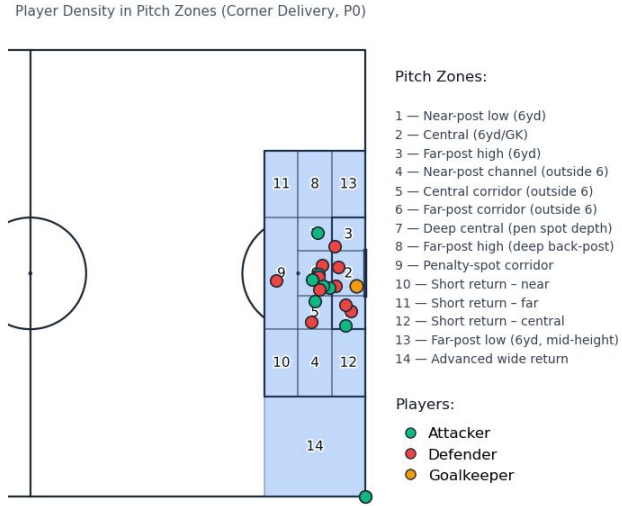
Player Density At P0

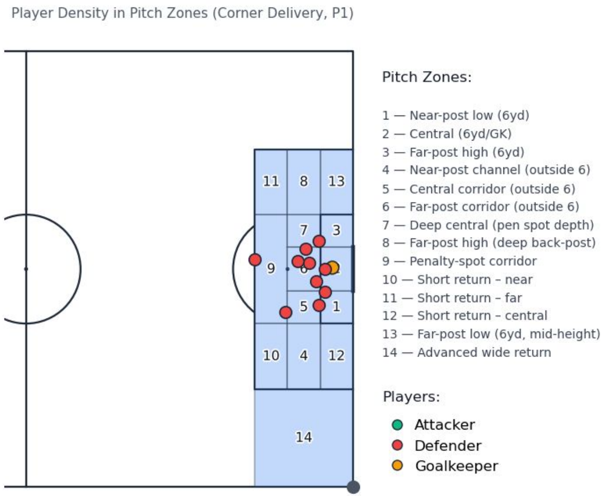


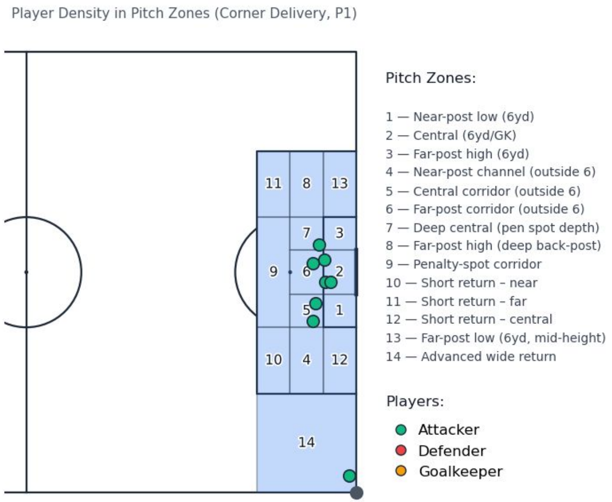


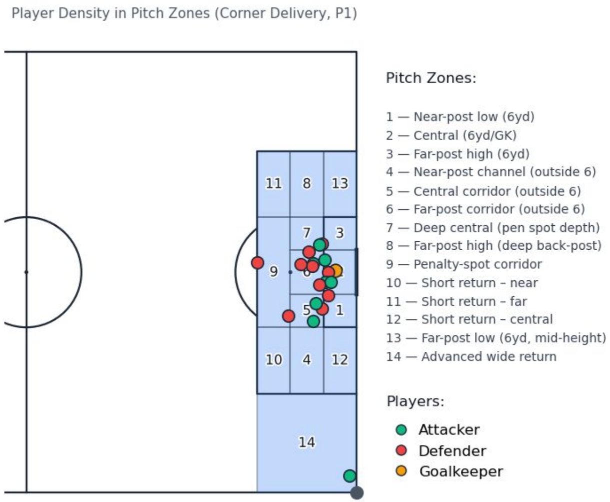


- ➔ **Attacker and defender occupation of each zone is measured at corner delivery (P0), with goalkeeper positioning tracked independently.**
- ➔ **Video illustration of the P0 moment.**

Player Density At P1







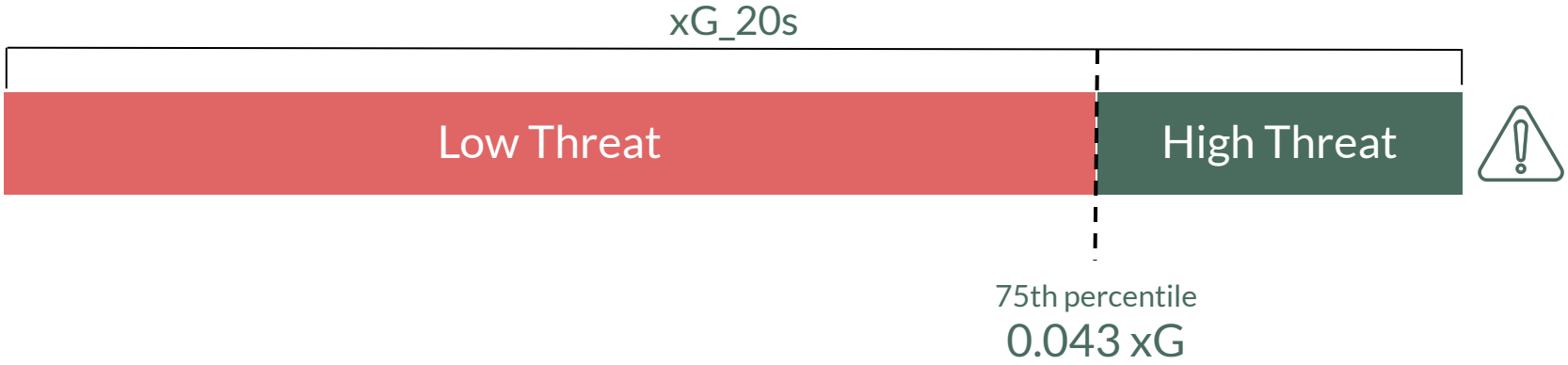
➔ Then attacker and defender occupation of each zone is measured at ball arrival (P1), with goalkeeper positioning, once again, tracked independently.

➔ Video illustration of the P1 moment.

With a rich set of engineered features, **how can dangerous corners be distinguished from those that are not?**

Target Variable: High-Threat Classification

The target variable, xG_20s, measures how much danger a corner creates in the 20 seconds after it is taken. Then, the problem is framed as a classification one: corners above the 75th percentile **(0.043 xG)** are labeled as **High Threat (1)**, while all others are labeled as **Low Threat (0)**.



A 20-second window captures the full **continuation** of the attacking phase that originates from the corner, including rebounds and second balls.

3. Modeling

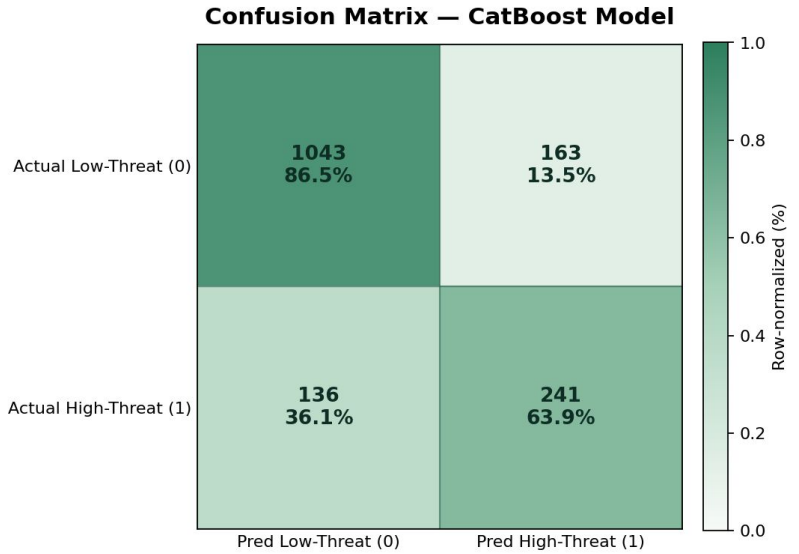
➔ CatBoost Classifier

- Model: CatBoostClassifier.
- Split: 80% train / 20% test (random holdout).

➔ Interpretation

- The model reliably identifies **low-threat corners** (Precision 0.88, Recall 0.86).
- It correctly detects 63% of **genuinely dangerous corners** (Recall 0.63, Precision 0.59).

Metric	Low-Threat	High-Threat
Precision	0.88	0.59
Recall	0.86	0.63
F1-score	0.87	0.61
Support	1206	377



➔ **SHAP Values: What the Model Learned**

- Absolute SHAP values reveal which inputs most strongly change the model's prediction, allowing us to identify the tactical levers that systematically create high-threat corners. When grouped, these effects form mechanisms:

1. Delivery target.
2. Goalkeeper displacement.
3. Occupation of advantage zones.

Top 10 features ranked by absolute SHAP	
end_location_x	0.52
P1_GK_x	0.33
pass_length	0.22
P1_n_att_zone_9	0.19
P1_GK_y	0.16
end_location_y	0.16
P0_GK_y	0.13
P0_GK_x	0.12
P1_n_def_zone_6	0.10
P1_n_att_zone_6	0.08

➔ SHAP Values: What the Model Learned

- Using the SHAP values it can be derived the tactical mechanisms that most reliably generate high-threat corners.

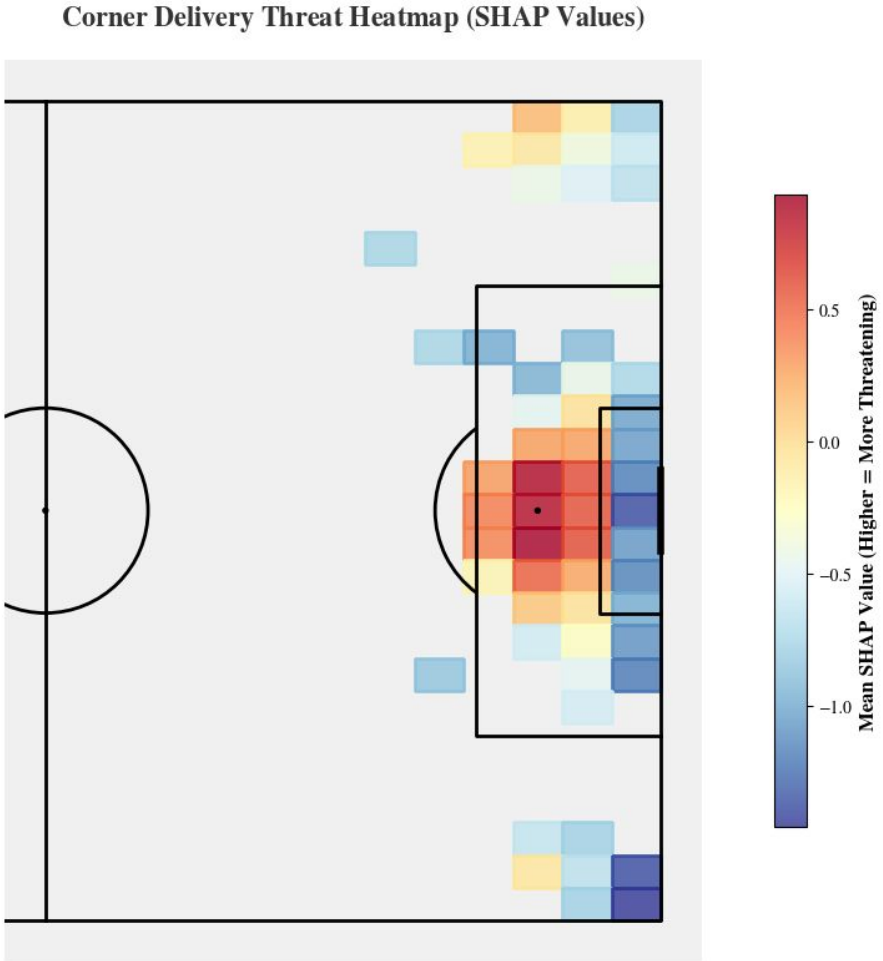
➔ High-Threat Corner Routines

- **Delivery Target: Where the ball arrives.**

end_location_x, end_location_y, pass_length

This is the main driver of threat. Dangerous corners are defined by where the ball is delivered, not necessarily who shoots it.

Short corners (<10 yards) consistently show negative SHAP contribution; they move the ball but do not move the goalkeeper.



➔ **High-Threat Corner Routines**

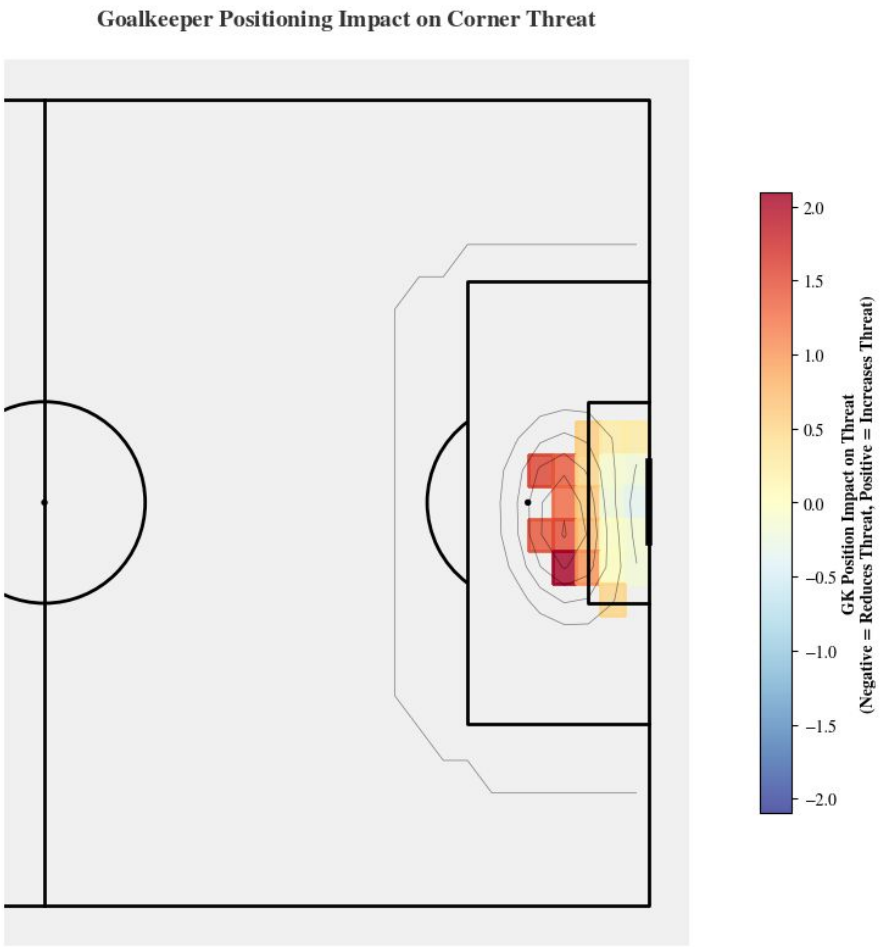
- **Goalkeeper Displacement**

P1_GK_x, P1_GK_y

The heatmap represents the average SHAP contribution of goalkeeper displacement where higher values indicate positions where forcing the GK off his line contributed more to threat.

Hence, moving the goalkeeper matters more than where attackers stand. Threat is created by provoking GK commitment.

Video example of GK displacement.



➔ **High-Threat Corner Routines**

- **Overload Architecture**

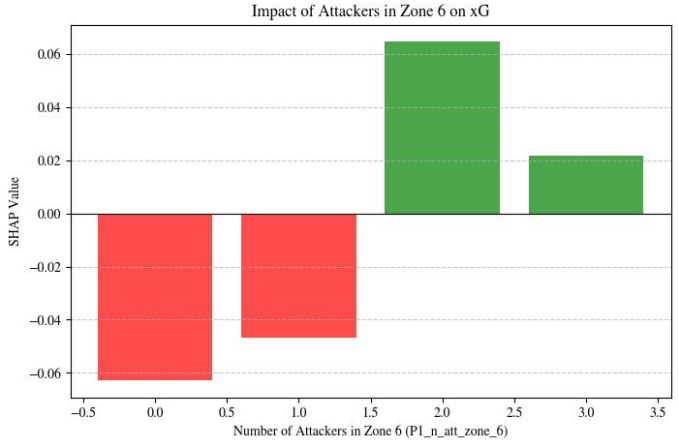
P1_n_att_zone_6

Threat is created by strategically stacking players in the right zones to force defensive collapse.

Zone 6 is one of the most influential overload zones in our model, so the optimal overload here is strategic:

- Two players is enough to force a structural reaction.
- Three maintains some threat.
- Beyond that, there is no added payoff.

Zone 6	
No. Attackers	**SHAP**
0 players	-0.06
1 players	-0.04
2 players	0.06
+3 players	0.02

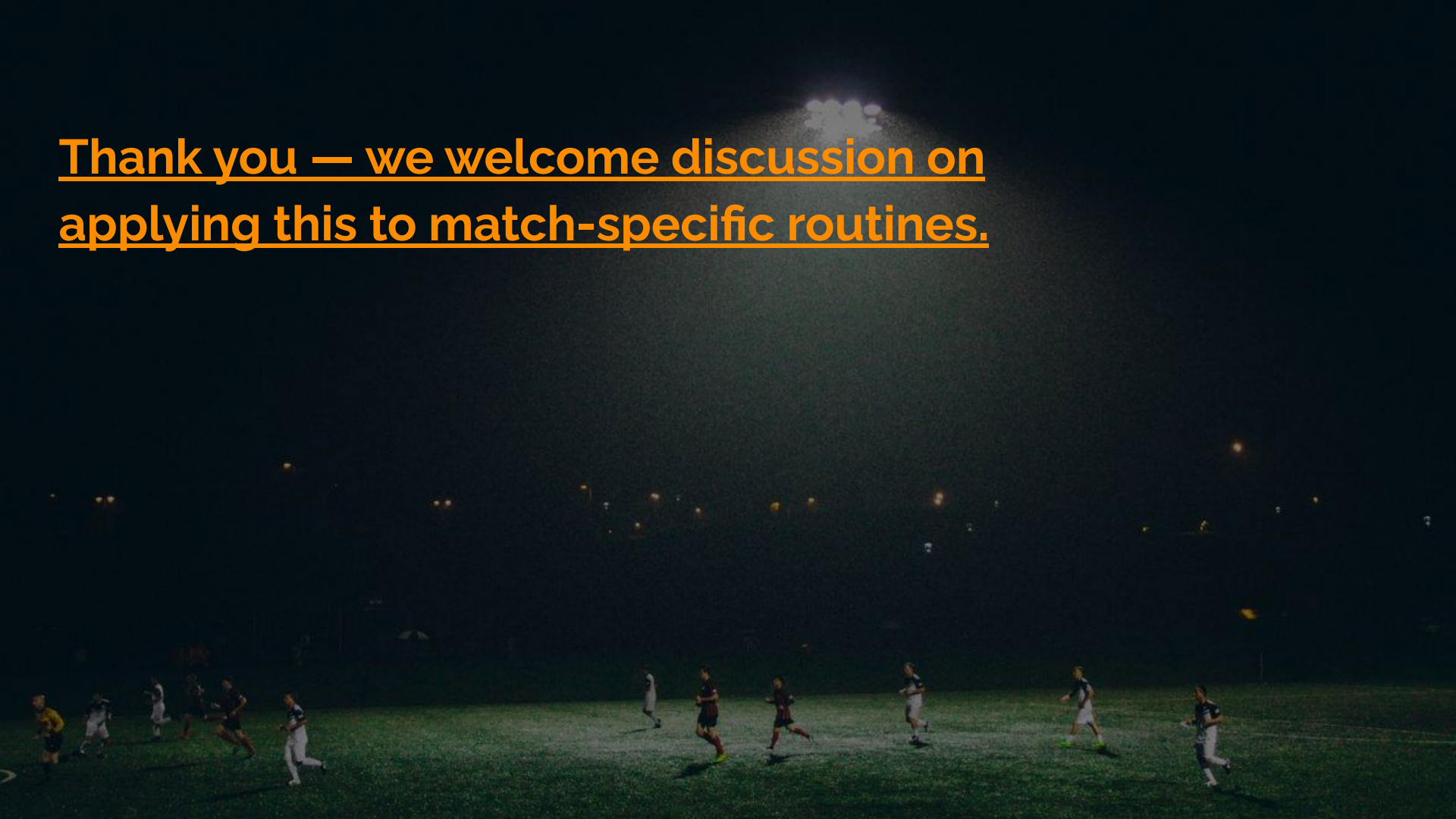


From Model to Training Ground:

- The delivery target is the single biggest driver of threat. Repetition should focus on **precision into zones**.
- **Direct deliveries > short corners (for xG)**. Short routines still have tactical value — but mainly as disguise or to unbalance the block before the cross, not as the default option.
- **Two attackers arriving = peak threat**. Two late arrivals create overload and chaos. Three or more players generate diminishing returns — crowding reduces timing and run quality.
- Trigger early GK movement. Disguise + timing forces the keeper to **step or shift before contact**; this increases threat before the ball is even struck.

Conclusions & Further Refinements:

- ➔ Threat is not random. **High-threat** corners are engineered, not improvised.
- ➔ Our enriched modeling approach, using freeze-frame positioning and zone-based context features, allows us to identify which structural patterns consistently lead to high-threat corners. Instead of analysing isolated outcomes, we can now extract **repeatable routines that maximise xG**.
- ➔ Access to more data (leagues and seasons) may allow to spot other patterns or confirm the current findings.
- ➔ Add **second phase** (P2) to capture whether rebounds or knockdowns keep the threat alive.
- ➔ Add **marking style** (zonal vs hybrid vs man-to-man) to understand how overloads interact with coverage.



Thank you — we welcome discussion on applying this to match-specific routines.

Sources of Information:

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- Classifying Corner Kicks in Football by Alexander Nesheim, Casper Kjærhus Leth & Jakob Faarbæk Gregersen (2024). Master’s Thesis, Aalborg University, Denmark. URL: https://vbn.aau.dk/ws/files/715590408/Classifying_Corner_Kicks_in_Football.pdf