# Introduction

A common refrain from coaches in press conferences and sideline interviews after poor performances is some variation on “we need to return to the fundamentals” to improve. This analytics project quantifies the fundamental elements of sound tackling at a play level so that each fundamental can be independently evaluated on a tackle and can be combined into an overall “score” that allows teams to incorporate personalized preference/weighting for each.

The proposed purpose of the component-level and overall metrics is first-pass analysis before more detailed film study and grading, used for in-season game retrospectives and scouting/player evaluation for roster construction. A first-pass analysis like this would identify plays and players of interest that may warrant further investigation, returning time back to team analysts and scouts.

# Tackle Fundamentals/Components

The phases of an ideal tackle can be broken up into three phases: moving into position/approach for contact, wrapping up the ball carrier, and driving through the tackle.

## Approach for Contact

A vital component of tackling is identifying the offensive play quickly and moving into the right position on the field to contact and tackle the ball carrier. For this analysis, the quality of this tackle component is quantified by looking at path efficiency, defined as:

<< insert formula and variable definitions here>>

The contact frameId definition is described in Section XX.

Since many plays in this dataset include less than 3 seconds of data leading up to tackle, and some plays the runner goes to the tackler with little tackler movement, the following rules are applied:

* If the contact frameId is less than 20 or <variable here> is less than 3 yards, use the median <variable here> for all plays, as there is not enough time or distance to properly evaluate path efficiency.
* In all other scenarios, calculate <variable here> between the contact FrameId and 3 seconds (30 frames) before contact. Start at frameId = 1 if contact frameId <= 30.

## Wrap up the Ball Carrier

Wrapping up the ball carrier is important to impede the ball carrier’s movement, either forcing them to the ground or allowing time for teammates to arrive and complete the tackle. The “wrap-up” component is quantified by looking at the distance between the ball carrier and tackler at the “tackle” event frameId:

<formula here>

Looking at the distance at the time of the tackle is a way to confirm the wrap up is maintained through the tackle, as not maintaining a wrap increases the chance of a broken tackle.

## Drive through the Tackle

A differentiator for grading tackles is how well the tackler changes the ball carrier’s momentum towards the offense’s end zone to minimize yards gained. This change in downfield momentum through the process of the tackle is the metric for driving through the tackle:

<formula definition here>

A neutral/baseline velocity is used as a standardization factor to control for player weights and downfield velocity at contact of each tackle scenario. From a physics standpoint, a bottled-up Austin Eckler (200 lb) hit by Dexter Lawrence (342 lb) is not equivalent to Travis Kelce (260 lb) running full speed into Tyrann Mathieu (190 lb), so grading the defender’s momentum transfer through the tackle must be compared against a “neutral” outcome.

<formula for v\_neutral>

<Explanation for neutral velocity>

## Supporting Definition: Contact FrameId

The contact frameId is determined with the following rules:

1. If the tackler is within 3 yards of the defender during the “first\_contact” event frame, use that frameId. 3 yards is used as a generous threshold to account for unknown (unpublished) sensor position error; the main purpose of this rule to eliminate any situation where the “first\_contact” event is triggered far earlier in the play by a different player than the eventual tackler.
2. If any of the first rule’s conditions are not met, set the contact frame as the first frameId where the tackler is within 1.8 yards or reaches the minimum distance to the ball carrier, whichever is larger. 1.8 yards is selected to account for the sensor error mentioned above and is the approximate distance for a 6’2” player’s shoulder pads to their feet. The comparison with the minimum distance is a failsafe in case the 1.8-yard threshold is not loose enough (like a hypothetical high-speed, high-angle trip tackle), as the minimum distance can be assumed to be the contact point.

The contact frameId logic intentionally errs on the early side since the involved metrics (approach and drive-through) are more dependent on the tackle lead up and outcome rather than precise identification of the contact moment.

# Overall Tackle Grade/Metric

## Metric Components

If applicable, the metrics are passed through a transfer function to ensure a value between 0 and 1 for more transparent application of component weightings on the result, where higher values are better.

The “vision metric” <insert name here> is between 0 and 1 by definition.

The “wrap up metric” <insert name here> is scaled using the following transfer function:

< function here>

A value of 1.2 yards or less translates to an ideal tackle. 1.2 yards was chosen because that is approximately the distance between the ball carrier’s shoulder pads (sensor location) to mid-thigh when laying on the ground, which would equate to the defender tackling from the knees or above and maintaining the wrap to the ground. The value scales linearly to 0 at a 2-yard gap, roughly an ankle tackle with wrap. Any gap larger than 2 yards likely means the tackler does not maintain a wrap on the ball carrier through the tackle.

The “drive through the tackle” metric <insert name here> uses a standard min-max scaler using the limits of <name here> from all solo tackles in the Week 1-9 dataset.

From there, weights can be applied to the 0-1 scaled component metrics to account for coach preference:

<formula here>

For demonstration purposes, the results section will assume equal weighting:

<formula here>

## Metric Validation

<high metric visualization and explanation>

<low metric visualization and explanation>

# Case Study: Proactive Solo Tackles

Proactive solo tackles are characterized in this analysis as tackles where the defender is taking a more aggressive path to stop the ball carrier and only one player is credited with the tackle, no assists. This is an applicable scenario to look at because it is a higher risk-reward tackle situation, so better fundamentals provide a higher chance of success on average.

## Defining Proactive Solo Tackles

This is defined as plays where the tackler’s downfield velocity component of 0.5 yds/sec or less at the contact frameId (towards the offensive backfield is negative), there is a distinct tackle event (not out of bounds or yielding like a QB slide), and no other player is credited with an assist. In general, this will capture decisive path decisions and is sufficient to demonstrate the metrics.

## Team Results

## Position Results

# Conclusions and Future Work

Make sure to mention that all tackles are better than missing tackles, so a low grade is a comparison of good situations.

The vision metric could be improved to grade the tackler’s ability to identify the play in a timely manner.

The metrics could be expanded to accommodate grading of all tackle opportunities, as this would add an additional aspect of a player’s tackling ability from a positioning perspective instead of only tackle mechanics.